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GEOTECHNICAL DATA REPORT

Stanford Center Liquefaction Monitoring Array

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SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

Stanford Center Liquefaction Monitoring Array
Seattle, Washington

Geotechnical Data Report

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1 INTRODUCTION

This geotechnical data report (GDR) describes the geotechnical borings, in situ and laboratory testing data, and the subsurface conditions at the United States Geological Survey (USGS) Stanford Center liquefaction monitoring array. The array consists of three downhole seismometers and six piezometers. The purpose of the array is to provide ground motion and porewater pressure information at various depths within a thick sequence of potentially liquefiable Holocene-age fill, alluvium, and estuarine deposits in the South Downtown (SODO) area of Seattle. The ground motion and porewater pressure data will be collected by USGS to develop a better understanding of the liquefaction potential of the SODO-area Holocene soils.

The array is located in the parking lot of the Seattle School District's John Stanford Center, at 2445 Third Avenue South (Figure 1). This site was selected for the array because:

- Much of SODO and this site is underlain by relatively loose Holocene fill, estuarine, and alluvial deposits of the Duwamish River delta.
- Historic reports of liquefaction in SODO and the Duwamish River Valley during the 1949 Olympia, 1965 SeaTac, and 2011 Nisqually earthquakes.
- Liquefaction around the array site during the 2001 Nisqually Earthquake (Exhibit 1-1).

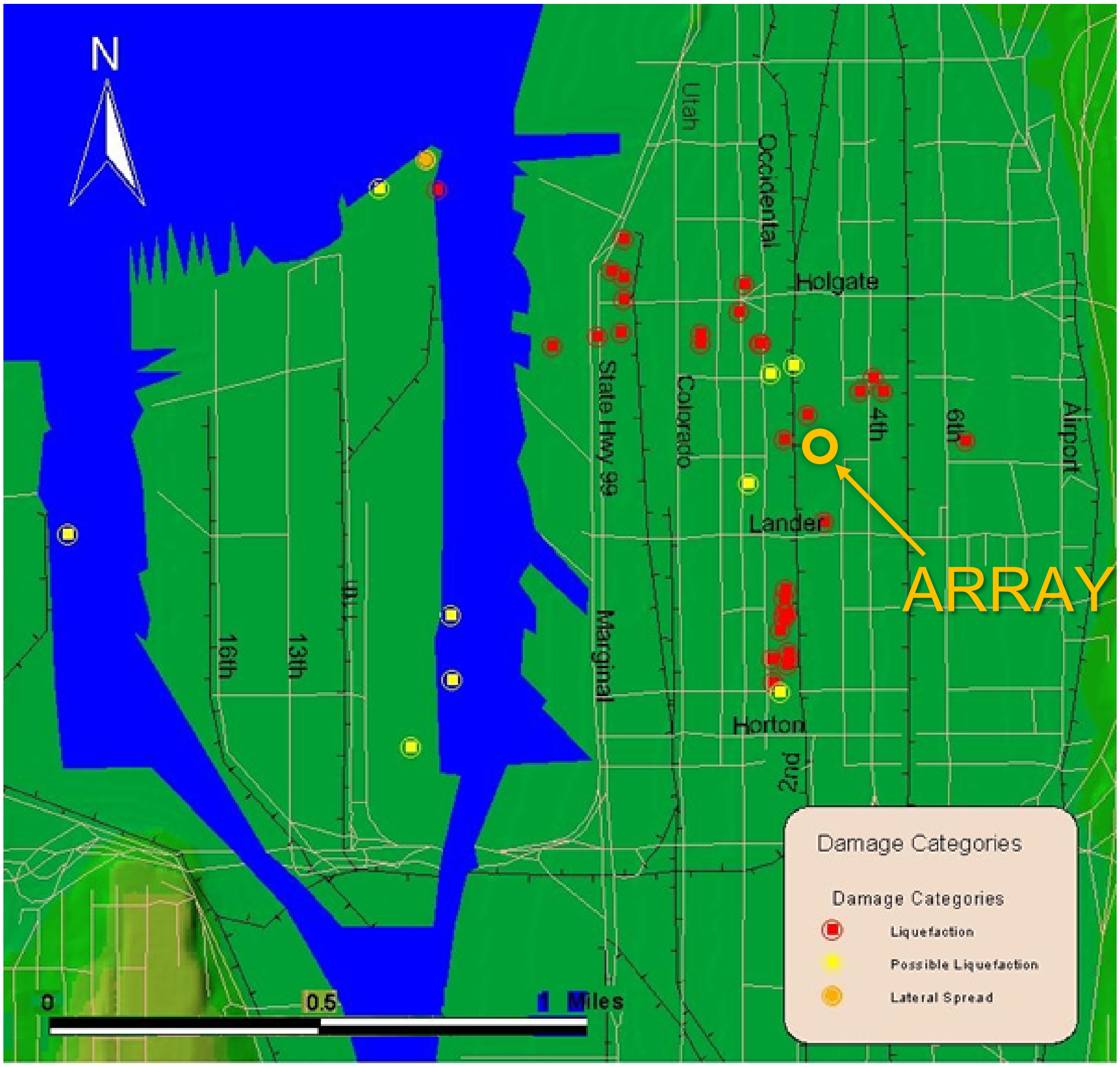

Exhibit 1-1: 2001 Nisqually Earthquake SODO Liquefaction (PEER, 2001) and Array Location

1.1 Purpose and Scope

This GDR describes and provides the geotechnical borings, in situ and laboratory testing data, and the subsurface conditions at the liquefaction monitoring array (Figure 2). Nine borings were drilled to depths of 23 to 201 feet to characterize the subsurface conditions and install the array instrumentation; three borings were completed for downhole seismometer installation and six were completed with piezometers. The array borings were drilled for the USGS by Gregory Drilling, Inc., of Redmond, Washington, under subcontract to the USGS. Shannon & Wilson provided field coordination, drilling/installation observation, piezometer development and readings, geotechnical laboratory testing, and a characterization of the subsurface conditions at the array. Fulcrum Consulting, of Groveland, California, performed downhole video logging of the completed piezometers and installed the instrumentation in the piezometer and seismometer borings. The Seattle School District maintenance department provided assistance throughout the array installation process.

Shannon & Wilson also provides in Appendix D of this GDR the logs of nearby Seattle Monorail Project (SMP) field explorations and other data related to selected nearby field explorations.

1.2 Content and Organization of Geotechnical Data Report (GDR)

The GDR contains four sections: (a) Introduction, (b) Subsurface Explorations and Testing, (c) Geotechnical Laboratory Testing, and (d) Subsurface Conditions. The collected data are presented in figures, tables, logs, and appendices.

1.3 Limitations

This report presents data from field explorations, including the results of field and laboratory testing of subsurface conditions and samples at the specific locations and depths indicated, using the means and methods described in this report. No other representation is made. This report contains characterizations and interpretations of the subsurface conditions encountered in the explorations, field and laboratory tests, professional opinions, and local experience. The subsurface characterization and interpretations contained herein cannot be construed as a guarantee or warranty of subsurface conditions.

This report also includes reference data that were not specifically collected for this project. These reference data include exploration logs and associated field and laboratory data collected by Shannon & Wilson for the SMP. These data are provided as reference information only, and they are not considered part of the contractual portion of this study.

2 SUBSURFACE EXPLORATIONS AND TESTING

The subsurface exploration program included the drilling and sampling of nine soil borings, the installation of six piezometers and three seismometer casings, and the development of the piezometers. We did not perform a survey of the completed borings; however, we made measurements of the array borings in relationship to other site features. We estimated the elevation of the array (approximately 18 feet) based on a previous survey of nearby SMP boring SD-122. The approximate ground elevation is referenced to the North American Vertical Datum of 1988 (NAVD 88). Figure 2 displays the approximate locations of the array elements and boring SD-122. Table A-1 summarizes additional details for the explorations performed for this project.

This section includes a description of the drilling and sampling methods and other field procedures used to perform the subsurface explorations. Results of the explorations are included in Appendix A of this report.

2.1 Drilling Methods

The drilling was performed by Gregory Drilling, Inc., under subcontract to the USGS. Shannon & Wilson coordinated and observed the installation of the array borings under subcontract to the USGS. Shannon & Wilson's field representatives also collected soil samples and prepared preliminary field logs of the explorations.

Gregory Drilling completed the borings between December 4 and 21, 2010. The explorations were drilled using mud rotary drilling techniques, with the exception of shallow piezometer boring P-1, which was completed using hollow-stem auger drilling techniques. The drilling method and completion dates for each exploration are indicated on the boring logs and in Table A-1. The following sections describe the drilling methods that were used.

2.1.1 Mud Rotary Drilling

Gregory Drilling performed mud rotary drilling using a CME 75 truck-mounted drill rig, equipped with tricone bits ranging from approximately 6 to 8 inches in diameter. The upper approximately 4 to 5 feet of each mud rotary boring was first advanced using a 9-inch outside-diameter (O.D.) hollow-stem auger. The mud rotary drilling used bentonite drilling mud to carry soil cuttings up the borehole; the mud helped to maintain borehole stability and reduce the potential for soil heave at the borehole bottom. Soil samples were obtained by replacing the tricone bit with a split-spoon sampler (used in conjunction with a Standard Penetration Test [SPT]).

2.1.2 Hollow-Stem Auger Drilling

Gregory Drilling advanced boring P-1 using hollow-stem auger drilling techniques, using a CME 75 truck-mounted drill rig. The technique involved advancing a 9-inch O.D., 4-¼-inch inside diameter (I.D.) hollow-stem auger with a center plug in place to block slough from entering the auger. A soil sample was obtained by replacing the center plug with a split-spoon sampler (used in conjunction with an SPT). Following retrieval of the split-spoon sample, the center plug was placed back in the auger, and the auger was advanced to the bottom of the boring. No soil heave occurred during drilling at boring P-1.

2.2 Soil Sampling Methods

Soil samples were collected from each exploration for purposes of geologic evaluation and geotechnical testing. Split-spoon samplers were used in each of the borings. Split-spoon soil samples were obtained using a standard, 2-inch O.D., 18-inch split-spoon sampler (without a liner) in conjunction with the SPT. A discussion of the SPT is included in Section 2.4.1.

2.3 Piezometer and Seismometer Casing Installation

Wells with short-screened intervals (piezometers) or blank casings (seismometers) were installed in each of the borings. The installation details for the piezometers and seismometer casing installed for this study are summarized in Table A-1 and on the boring logs.

2.3.1 Piezometer Installation

For this study, Gregory Drilling constructed each piezometer using threaded, 2-inch I.D., polyvinyl chloride (PVC) well casing with a slotted portion (screen) to allow for inflow of water. The width of the screen slots was 0.010 inch (No. 10 slot), and each screen length was approximately 0.9 foot. An end cap, or sump, approximately 0.7 foot in length, was attached to the bottom of each piezometer screen. A filter pack consisting of No. 10-20 Colorado silica sand was used around each screen. We selected the installation depth for each screen based on soil units encountered in the boring in coordination with the USGS.

2.3.2 Seismometer Casing Installation

Gregory Drilling constructed each seismometer casing using threaded, 4-inch I.D., PVC blank well casing. An end cap was attached to the bottom of each casing. Each seismometer casing was grouted in place using tremied bentonite-cement grout.

2.3.3 Piezometer Development

The drilling process disturbs native sediments and typically results in a residual coating of fine sediment that clogs the pore spaces at the borehole wall and within the screen and filter pack of a newly installed piezometer. Disturbed sediment from the drilling process also typically settles out of the water column within a newly installed piezometer, often filling a portion of the casing and screen. This accumulated sediment can potentially inhibit the hydraulic connection between the piezometer and the surrounding soils. Therefore, we developed the six piezometers with the goal of removing the fine sediment from the screens, sumps (blank pipe below the screen), and borehole wall, thereby opening pore spaces and improving the hydraulic connection with the surrounding aquifer soils.

A Shannon & Wilson hydrogeologist developed the piezometers by surge blocking and pumping, using a hand-actuated, check-valve-type, inertial pump (Waterra) that consisted of an acetal plastic check valve attached to high-density polyethylene tubing. An acetal surge block was attached to the check valve to facilitate the rapid movement of water back and forth through each piezometer screen during the development process. For each piezometer, development continued until the accumulated sediment had been removed from the casing and screen. Each piezometer was developed on September 27, 2011. At the request of Fulcrum, we performed additional development on February 21, 2012, at piezometer P-5, in order to clear murky water from the screen. A summary of piezometer development activities is presented in Appendix A, Table A-2. Additionally, we and Fulcrum independently observed that the seismometer casings were clear of sediment using a weighted measuring line.

2.3.4 Groundwater Monitoring

A Shannon & Wilson hydrogeologist measured groundwater levels in the six piezometers using an electronic water level indicator. Groundwater readings are presented on the boring logs and in Table A-2 in Appendix A; they are presented as depths below final grade. Water levels prior to piezometer development were similar to those measured following development, so they are included in Table A-2. For the previous explorations associated with the SMP, groundwater levels obtained by Shannon & Wilson are included in Appendix D both on the generalized subsurface profile and on the boring logs.

2.4 Geotechnical Field Testing Methods

Geotechnical field testing for this project included SPTs in each boring, downhole geophysics in two of the completed seismometers, and downhole video logging in each of the completed piezometers. These tests were performed to check the piezometer screens for sediment and to evaluate soil density, soil modulus, soil compression and shear wave velocity, and other related soil parameters.

2.4.1 Standard Penetration Tests (SPTs)

SPTs were performed in accordance with ASTM Designation: D 1586, Test Method for Penetration Test and Split-Barrel Sampling of Soils, but without a liner. In the SPT, a 2-inch O.D., 1.375-inch I.D., split-spoon sampler is driven with a 140-pound hammer, falling freely from a height of 30 inches. The number of blows required to achieve each of three 6-inch increments of sampler penetration is recorded. The number of blows required to cause the last 12 inches of penetration is termed the Standard Penetration Resistance or N-value. When penetration resistances exceeded 50 to 100 blows for 6 inches or less of penetration, the test was terminated and the number of blows along with the penetration distance was recorded on the boring log. The presence of gravels or cobbles larger than the sampler may impact measured penetration resistances and result in artificially high values. A soil sample is collected in conjunction with the test. The results of the SPTs are provided in the exploration logs included in Appendix A and on the Generalized Subsurface Profile (Figure 4). A Profile Legend and Geologic Unit Explanation is provided as Figure 3.

2.4.2 Downhole Geophysics

Fulcrum performed suspension shear and compressional wave velocity measurements in borings S-2 and S-3, under subcontract to the USGS. Fulcrum also performed natural gamma logging in boring S-3. The primary purpose of this testing was to obtain estimates of the soil shear and compression wave velocities and to assist in identifying transitions between stratigraphic units.

Fulcrum performed this work after the PVC casings had been grouted in place. The test results and a description of the procedures used for collecting the downhole measurements are included in Fulcrum's report, presented in Appendix B. The shear wave velocity test results are also included on the boring logs in Appendix A.

Shear and compression wave velocity measurements were also made in SMP explorations SD-110 (suspension shear and compression) and SD-203/203A (shear) within 300 feet of the array. These measurements are included in Appendix D.

2.5 Handling and Disposal of Investigation-Derived Waste

The drilling waste (drilled soil cuttings, drill mud, and groundwater) was contained in a roll-off container that was periodically emptied by Bravo Environmental of Tukwila, Washington, and removed from the site for proper disposal. No sign of contamination was apparent during the array installation process.

2.6 Review and Classification of Soil Samples

2.6.1 Field Observations

The borings were observed by a Shannon & Wilson field hydrogeologist who collected, classified, stored, and transported soil samples and prepared logs of the explorations. In addition to observing and collecting soil samples, the field hydrogeologist also noted drill action, problems during drilling or installation, and other issues.

2.6.2 Soil Classification System

Soil classification for this project was based on ASTM Designation: D 2487, Standard Test Method for Classification of Soil for Engineering Purposes, and ASTM Designation: D 2488, Standard Recommended Practice for Description of Soils (Visual-Manual Procedure). The system is called the Unified Soil Classification System (USCS) and is summarized in Figure A-1.

2.6.3 Sample Review

The jar samples obtained from the borings were returned to the Shannon & Wilson laboratory, where they were reviewed by Shannon & Wilson geologists, who selected samples for geotechnical laboratory testing.

2.6.4 Exploration Logs

The logs for the current project explorations are presented in Appendix A. A log is a written record of the subsurface conditions encountered in the exploration. It shows the soil layers encountered in the exploration and the USCS symbol of each layer. The logs presented in Appendix A include a graphical depiction of the uncorrected blow counts measured in the penetration tests as well as results of selected laboratory index tests. These index tests include natural water content, percent fines (particle sizes less than 0.075 millimeter [mm]), and Atterberg Limits (plasticity), which were performed on soil samples at various depths within the boring. Other information shown in the boring logs includes groundwater level measurements, approximate surface elevation, and types and depths of sampling. In boreholes where downhole geophysics testing was performed, the measured shear wave velocities are also shown on the boring logs in Appendix A.

2.7 Non-Project Borings

Shannon & Wilson collected historic subsurface information in the vicinity of the array. These included previous explorations performed by Shannon & Wilson for the SMP. Copies of maps, a profile, and other data associated with selected SMP explorations are included in Appendix D. Appendix D contains detailed exploration logs, geotechnical laboratory data, and geophysical data for selected SMP explorations located in the vicinity of the array. The SMP information was excerpted from the SMP 100% Draft Geotechnical Data Report (Shannon & Wilson, 2003), Addendum No. 095-1 to the SMP Draft GDR (Shannon & Wilson, 2004c), the SMP 100% Draft Geotechnical Characterization Report (GCR) (Shannon & Wilson, 2004a), Addendum No. 110-1 to the SMP GCR (Shannon & Wilson, 2004d), and Addendum No. 110-5 to the SMP GCR (Shannon & Wilson, 2004e).

3 GEOTECHNICAL LABORATORY TESTING

Samples were transported from the field to our laboratory in accordance with ASTM Designation: D 4220, Standard Practices for Preserving and Transporting Soil Samples. The following sections present discussions of the geotechnical index tests. The results of the geotechnical laboratory tests for the current explorations are presented in Appendix C and summarized in the appendix Table C-1.

3.1 Geotechnical Index Tests

Laboratory index tests were performed on the soil samples retrieved from the borings in accordance with ASTM standards. The laboratory testing program was performed to provide data for engineering studies and to classify the materials into similar geologic groups. Classification and index laboratory tests include visual classification and tests to determine natural water content, grain size distribution, and plasticity.

3.1.1 Sample Preparation and Handling

Jar samples were stored in cardboard boxes and logged into the Shannon & Wilson laboratory for tracking and testing. Shannon & Wilson geologists examined and classified the soil samples and assigned laboratory testing in accordance with our scope of services.

3.1.2 Classification

According to the USCS, coarse-grained soils (greater than 50 percent coarser than 0.075 mm) are classified based on particle-size distribution. Fine-grained soils (greater than 50 percent finer than 0.075 mm) are classified based on Atterberg Limits. A summary of this classification system is shown in Figure A-1 in Appendix A. Classification of the samples was based on ASTM Designation: D 2487, Standard Practice for Classification of Soils for Engineering Purposes, and ASTM Designation: D 2488, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). These classification methods allow for convenient and consistent comparison of soils from widespread geographic areas. Visual classifications were checked by the results of the index testing when performed.

3.1.3 Water Content Determination

The water contents of the samples retrieved from the explorations were determined in accordance with ASTM Designation: D 2216, Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass. The water contents are shown graphically on the exploration logs presented in Appendix A and are also summarized in Table C-1.

In a small number of cases, a soil sample to be tested was found to have dried due to a poor seal on the storage jar. The water contents for samples that appeared desiccated were not reported on the exploration logs in Appendix A or in the figures or table in Appendix C.

3.1.4 Grain Size Analyses

The grain size distribution of selected samples was determined in accordance with the ASTM Designation: D 422, Standard Test Method for Particle-Size Analysis of Soils. Two procedures were used to determine the grain size distribution of soil, including sieve analysis and combined analysis (sieve analysis and hydrometer analysis).

Grain size analysis results could potentially be affected by drilling method (hollow-stem auger versus mud rotary). Additionally, the I.D. of the SPT sampler directly impacts the maximum particle size that can be sampled. For example, the largest diameter particle that can be sampled by a 2-inch SPT sampler (1.375-inch I.D.) is approximately 1.3 inches, regardless of the maximum particle size of the soil unit being sampled. The drilling method can also potentially impact grain size analysis data. During mud rotary drilling, drilling mud can infiltrate open deposits of sand and gravel. This process can affect the sample by "cleaning" the sample (removing fines), adding bentonite clay (contained in the drilling mud) to the sample, or varying degrees of both. Field staff removed drilling mud from mud rotary borings to the extent practical; however, it is often impossible to completely clean the sample.

Grain size analysis results are presented as grain size distribution curves in Appendix C. The result of tests performed during previous exploration phases are presented in Appendix D. Each gradation sheet provides the USCS group symbol, the sample description, water content (unless the sample appeared to be desiccated), and the Atterberg Limits (if performed). The USCS for samples with fewer than 50 percent fines (smaller than 0.075 mm) were classified in accordance with ASTM Designation: D 2488, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). Summaries of the test results (presented as the percent gravel, sand, and fines) from the project borings are included in Table C-1. The percent passing the No. 200 sieve (0.075 mm) are also shown on the exploration logs in Appendix A. Summaries of the results (presented as the percent gravel, sand, and fines) from nearby non-project borings are included in Appendix D.

3.1.5 Atterberg Limits Determination

Soil plasticity was determined by performing Atterberg Limits tests on selected fine-grained samples or samples with greater than 50 percent passing the No. 200 sieve. The tests were performed in accordance with ASTM Designation: D 4318, Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils. The Atterberg Limits include Liquid Limit (LL), Plastic Limit (PL), and Plasticity Index (PI=LL-PL).

The LL, PL, and PI values determined from the Atterberg Limits tests are summarized in Table C-1 and are shown in plasticity charts included in Appendix C. The result of tests performed for the SMP are presented in Appendix D. The plasticity charts provide the USCS group symbol, the sample description, water content, and percent passing the No. 200 sieve (if a grain size analysis was performed). The results of the Atterberg Limits determinations from the array borings are also shown graphically on the boring logs in Appendix A.

4 SUBSURFACE CONDITIONS

Troost and others (2005) map the SODO area where the array is located as an anthropogenic-filled tidal estuary where the Duwamish River delta extends into Elliott Bay. The delta is in a pre-existing glacial trough that was carved into glacially overridden soils deposited during previous glacial and interglacial episodes. The trough has been subsequently filled with predominantly Holocene estuarine and alluvial sediments deposited as the mouth of the Duwamish River has prograded northward in the trough since the retreat of the last glacial incursion. Based on subsurface explorations in the SODO area, the top of glacially overridden soil is deepest at 255 feet below grade or about elevation -215 feet, in the vicinity of Colorado Avenue S., which is about 3,000 feet southwest of the array.

Our interpretation of subsurface conditions in the vicinity of the liquefaction array is shown in the Generalized Subsurface Profile, Figure 4. Our characterization of the subsurface geology and conditions is based primarily on soils encountered in the borings performed for the array installation (P-1 through P-6 and S-1 through S-3) and nearby SMP boring SD-122; these borings are shown in Figure 4. A generalized subsurface profile developed for the SMP GCR is included in Appendix D (Figure 5, sheet 17 of 50). Only borings that we considered to have useful and reliable data are shown in these profiles.

For the SMP, we collected and considered for inclusion in our evaluation of subsurface conditions the logs of previous borings drilled for other projects near the SMP alignment. Among these previous explorations are eight shallow Geoprobe borings that were completed within about 100 feet of the liquefaction array site; these are indicated on the SMP GCR site plan (Appendix D, Figure 3, sheet 17 of 50). These eight shallow borings were completed to depths of about 5 to 7.5 feet deep and are designated on the SMP GCR site plan as 414-3847 through 414-3851, 414-3854, 414-3855, and 414-3883. Information regarding these shallow borings is available in a report prepared by Dames & Moore (1998). Apparent from the SMP GCR site plan (Appendix D) and the array site plan (Figure 2) is that sometime between 2004 and 2010, the west boundary fence of the Seattle School District site was relocated to the east in order to accommodate expansion of the adjacent rail lines; railroad tracks now occupy the location of the abandoned SMP boring SD-122. During this time period, the westward extent of the Seattle School District maintenance shop was also reduced.

The discussion below summarizes our interpretation of subsurface conditions and geologic units. Additional details regarding the subsurface conditions encountered in the vicinity of the array are included in the logs of the array borings and nearby SMP borings, presented in Appendices A and D, respectively. In addition to the stratigraphy and soil characteristics, groundwater conditions are discussed for the array vicinity. A description of the site geology and subsurface conditions excerpted from the SMP GCR is also provided in Appendix D.

4.1 Soil Conditions

Soils underlying the array consist of a thick sequence of recent fill (Hf), alluvium (Ha), and estuarine (He) deposits that are very loose to dense and very soft to stiff. These deposits are typically underlain by very dense or very stiff to hard, Holocene beach (Hb) or reworked glacial soils (Hrw), Vashon glacial recessional soils, or pre-Vashon glacially overridden soils. The depth to the very dense soils ranges from about 175 to 177 feet (about elevation -157 to -159 feet) at array borings S-3 and P-6, respectively, and about 191 feet (elevation -173 feet) at SMP boring SD-122.

In the vicinity of the array, we have interpreted the encountered glacially overridden soils to consist largely of pre-Vashon glaciolacustrine deposits (Qpgl) overlain by interbedded pre-Vashon glacial outwash (Qpgo) and till (Qpgt). The Qpgl deposits are comprised of very stiff to hard, silty clay to clayey silt with minor amounts of sand and gravel. The Qpgo deposits consist of very dense, slightly silty to silty sand to sandy gravel/gravelly sand with minor amounts of silt. The Qpgt deposits consist of very dense, sandy, gravelly silt to hard, slightly sandy, slightly gravelly, clayey silt.

The glacially overridden soils are overlain by a soil layer up to about 10 feet thick that is less dense or softer than the underlying glacially overridden soils. This layer represents a transition from the glacially overridden deposits to the overlying He and Ha deposits. This transition layer is comprised of soils that we have interpreted to be Vashon recessional glacial deposits (Qvrl), Hrw, and Hb deposits, none of which are glacially consolidated. These deposits range from very soft to very stiff, silty clay with varying amounts of sand and gravel to very loose to very dense, sandy gravel/gravelly sand with varying amounts of silt and clay.

Most of the non-glacially overridden soils filling the trough consist of recent He and Ha deposits. The sequence of deposits grades from predominantly fine-grained cohesive He soils at the base to Ha sand deposits near the top. In the array vicinity, He soils at the base of these recent deposits are in contact with the Hrw, Hb, and/or glacial soils between about elevations -155 (boring S-3) and -164 (boring SD-122) feet. These deep He soils consist primarily of very soft, trace to slightly fine sandy, clayey silt with trace to scattered fine organics and shell fragments. Sand and sandy silt layers are present within this zone near the base of the He soils.

Array borings encountered He soils situated between about elevations -130 and about -113 (boring P-5) to -117 (boring S-3) feet. These soils are typically less plastic than the deeper He soils, consisting of loose to medium dense, slightly sandy to sandy silt, trace of clay, trace to scattered fine organics and shells, and interbedded with silty, fine sand.

Above the He soils, the array explorations encountered mixed Ha and He soils up to about elevation -60 (boring P-5) to -62 (boring S-3) feet. The Ha/He soils consist predominantly of interbedded very loose to loose, slightly fine sandy to fine sandy silt, trace of clay, and loose to dense, trace of silt to silty, fine sand. We observed trace to scattered fine organics and shell fragments throughout these soils.

The native soils above the He/Ha layer consist largely of Ha with scattered seams and layers of He soils. The top of the Ha deposits is situated between about elevations +1 and -3 feet at the base of the overlying Hf deposits. Like the underlying Ha/He soils, the Ha soils were likely deposited in a deltaic environment and reworked by tidal processes and meandering streams, resulting in laterally discontinuous lenses of alluvial and estuarine soils. The Ha soils predominantly consist of loose to dense, trace of silt to silty, fine and fine to medium sand with trace to scattered organics and shell fragments. The He seams and layers interbedded within the Ha unit consist of silt with trace clay and fine sandy silt.

The surficial soils underlying the array consist of approximately 17 to 21 feet of fill (Hf). Mixing of Hf, Ha, and He soils may have occurred, at least within the upper foot or so of the Ha or He deposits, based on soils observed in boring P-5. The lower fill soils at the array consist of about 9 to 10 feet of very soft, silty clay with trace to scattered wood, fine organics, shells, and sand seams. This clay is overlain by about 6 feet of very loose to loose, fine sandy silt, trace of clay and shell fragments. Above the silt, the explorations encountered about 2 to 3 feet of silty, sandy gravel, which may have been placed as railroad ballast. The ground surface was paved with about 0.5 to 1 foot of asphalt prior to the start of the array explorations.

The fill in the SODO area was placed primarily between 1895 and 1902 on the tide flats in order to raise the grade from near sea level to its current elevation of approximately 18 feet. Fill was placed using a variety of methods and materials. Evidence of fill soils at the array was encountered as deep as 21 feet (coal and clinker mixed with Ha sand, boring P-5).

4.2 Groundwater Conditions

The array borings encountered saturated soils starting at about 5 to 7 feet below ground surface. Table A-2 in Appendix A presents the groundwater levels we measured in the six piezometers; groundwater levels vary between about 6 and 8 feet below the existing ground surface at the piezometers. Based on the measurements we obtained at the piezometers, seasonal and/or tidal variation in the depth to groundwater is at least 1.5 feet.

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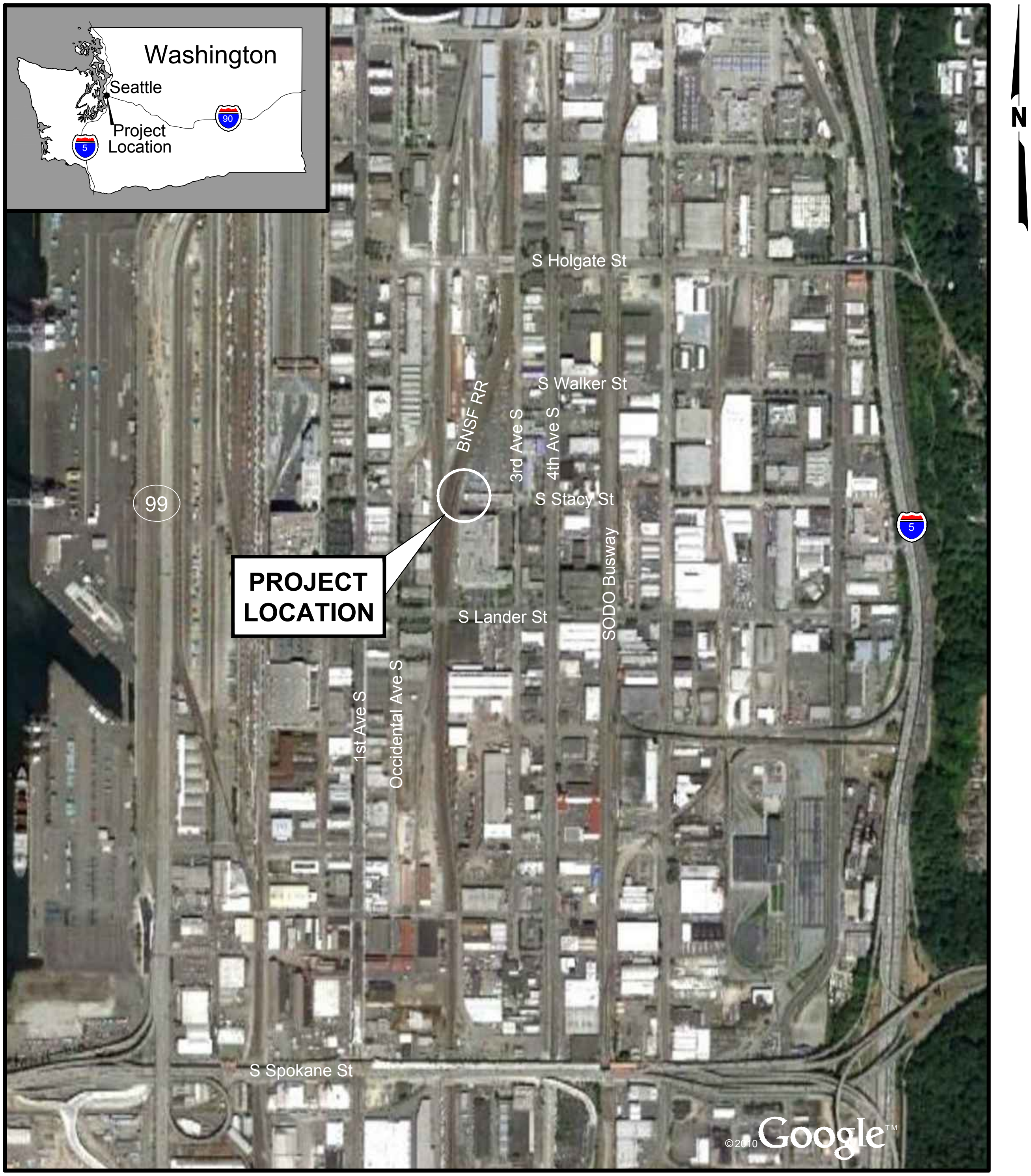

0 1000 2000

Approximate Scale in Feet

NOTE

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Seattle, Washington

VICINITY MAP

May 2018 21-1-21441-001

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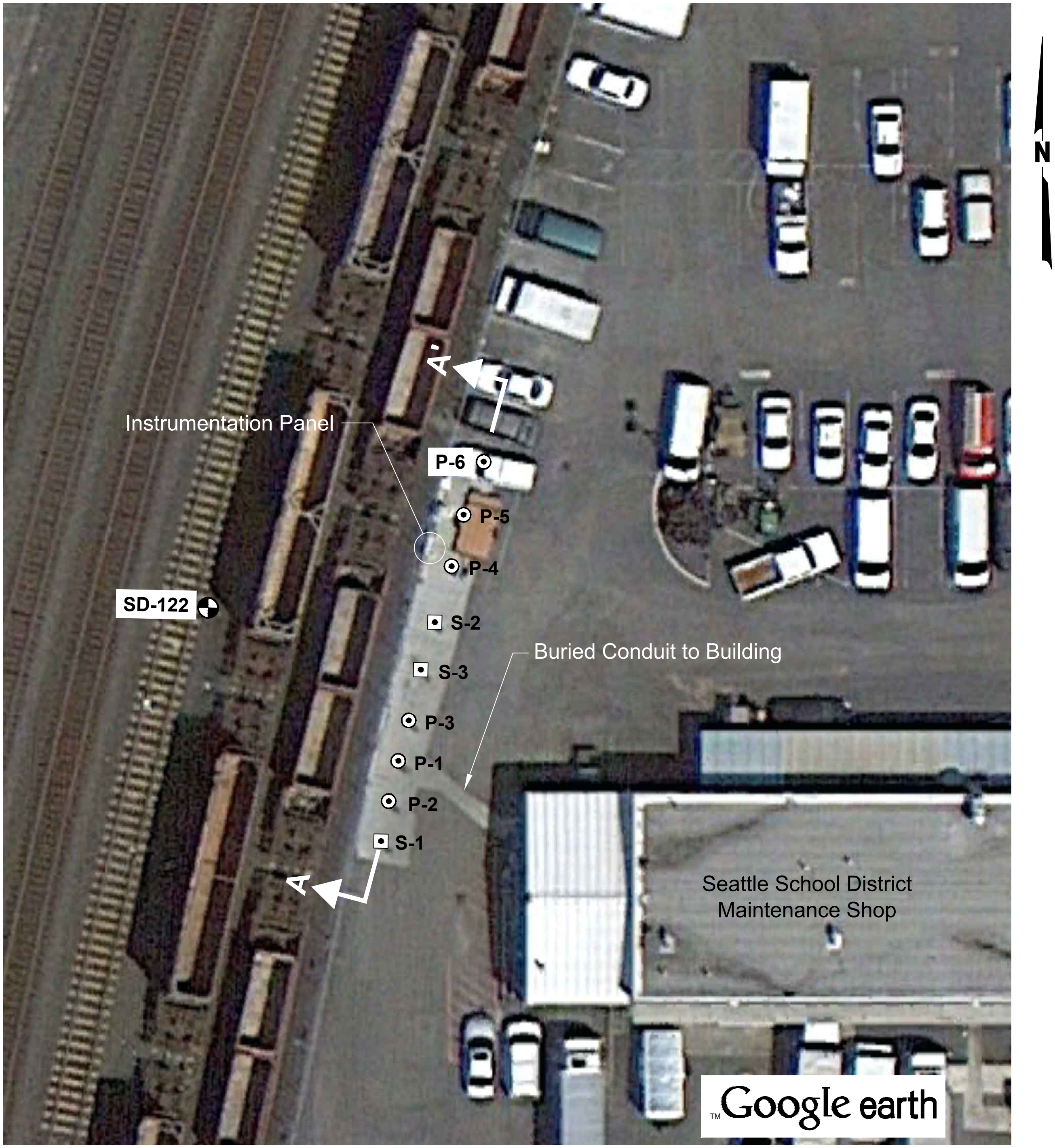
FIG. 1

Filename: J:\211\21441-001\21-1-21441-001 Fig 1.dwg Date: 01-09-2013 Login: SAC



LEGEND

P-1	⊙	Piezometer
S-1	⊡	Seismometer
SD-122	◕	Boring Designation and Approximate Location
A	↱	Generalized Subsurface Profile (See Figure 4)

NOTE

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0 30 60

Approximate Scale in Feet

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SITE AND EXPLORATION PLAN

May 2018 21-1-21441-001

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FIG. 2

Filename: J:\211\21441-001\21-1-21441-001 Site Plan.dwg Date: 01-09-2013 Login: SAC

GEOLOGIC UNITS

NON ORVERRIDDEN

HOLOCENE DEPOSITS

▨	Ha	ALLUVIUM: River or creek deposits, normally associated with historical streams, including deltaic and overbank deposits. Sand, silty Sand, gravelly Sand; very loose to very dense.
▨	Hb	BEACH DEPOSITS: Deposits along present and former shorelines of Puget Sound and tributary river mouths. Silty Sand, sandy Gravel, gravelly Sand, wood and shell debris common; loose to dense.
▨	He	ESTUARINE DEPOSITS: Fine-grained sediments deposited in brackish water associated with rivers and streams located along the present and former Puget Sound shoreline. Clayey Silt, silty Clay, Silt, and fine Sand; organics and shell fragments common; very soft to very stiff or very loose to medium dense.
☐	Hf	FILL: Fill placed by humans, both engineered and nonengineered. Various materials, including debris; cobbles and boulders may be common; commonly dense or stiff if engineered, but very loose to dense or very soft to stiff if nonengineered.
▨	Hrw	REWORKED GLACIAL DEPOSITS: Glacially deposited soils that have been reworked by fluvial or wave action. Sand, silty Sand, gravelly Sand; lies on top of glacially overridden soils, loose to dense.

QUATERNARY VASHON DEPOSITS

▤	Qvrl	RECESSIONAL LACUSTRINE DEPOSITS: Glaciolacustrine sediment deposited as glacial ice retreated. Fine Sand, Silt, and Clay; dense to very dense, soft to hard.

GLACIALLY OVERRIDDEN

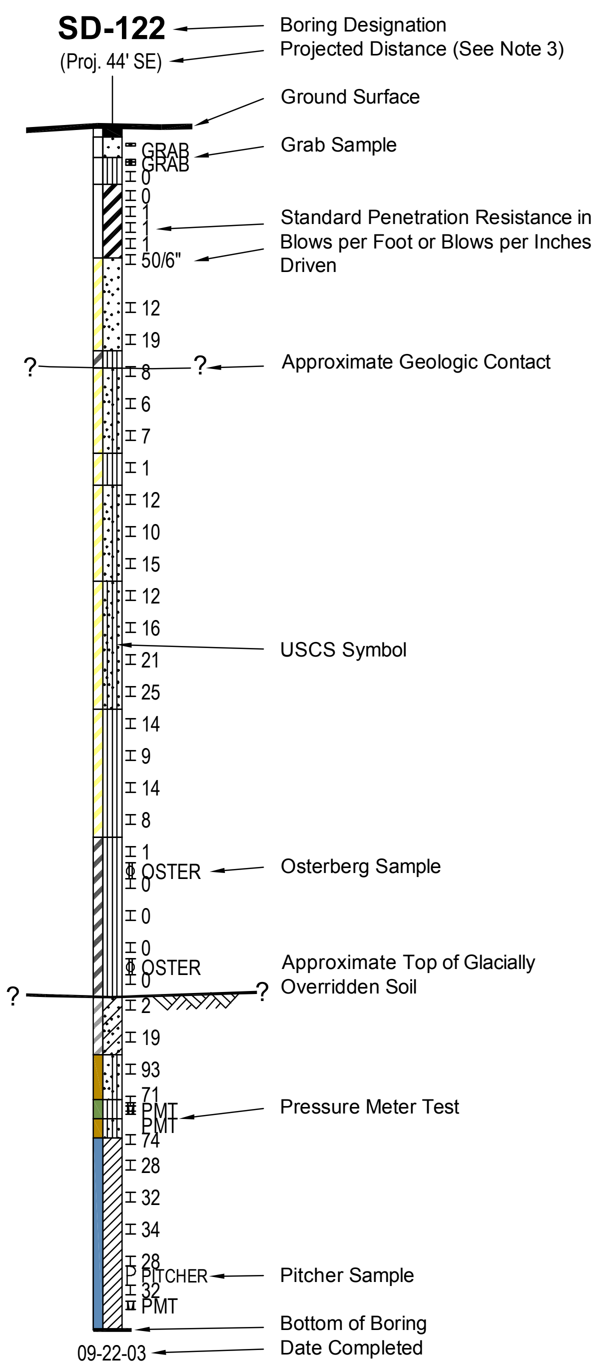
QUATERNARY PRE-VASHON DEPOSITS

🟦	Qpgl	GLACIOLACUSTRINE DEPOSITS: Fine-grained glacial flour deposited in proglacial lake in Puget Lowland. Silty Clay, clayey Silt, with interbeds of Silt and fine Sand; very stiff to hard or very dense.
🟪	Qpgm	GLACIOMARINE DEPOSITS: Till-like deposit with clayey matrix deposited in proglacial lake by icebergs, floating ice, or gravity currents. Variable mixture of Clay, Silt, Sand, and Gravel; scattered shells locally; cobbles and boulders common; very dense or hard .
🟫	Qpgo	OUTWASH: Glaciofluvial sediment deposited as the glacial ice advanced or retreated through the Puget Lowland. Clean to silty Sand, gravelly Sand, sandy Gravel; very dense.
🟩	Qpgt	TILL: Lodgment till laid down along the base of the glacial ice. Gravelly, silty Sand, silty, gravelly Sand ("hardpan"); cobbles and boulders common; very dense.

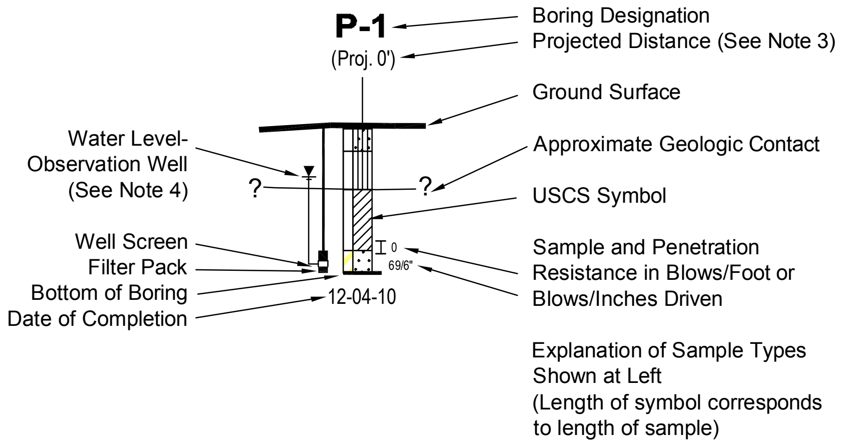
PROFILE LEGEND

PREVIOUS BORING

(By Shannon & Wilson or others)



PROJECT BORING



NOTES

1. Elevation Datum: North American Vertical Datum 1988 (NAVD88).
2. Subsurface conditions shown are generalized from soils encountered in project borings and from logs of borings previously completed for other projects in the vicinity. Variations between the profile and actual conditions may exist.
3. Projections are taken from the array alignment.
4. See Appendix A, Table A-2, for groundwater fluctuations.
5. The description of each geologic unit includes only general information regarding the environment of deposition and basic soil characteristics. See text of report for additional discussion of geologic units.

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PROFILE LEGEND AND GEOLOGIC UNIT EXPLANATION

May 2018
21-1-21441-001

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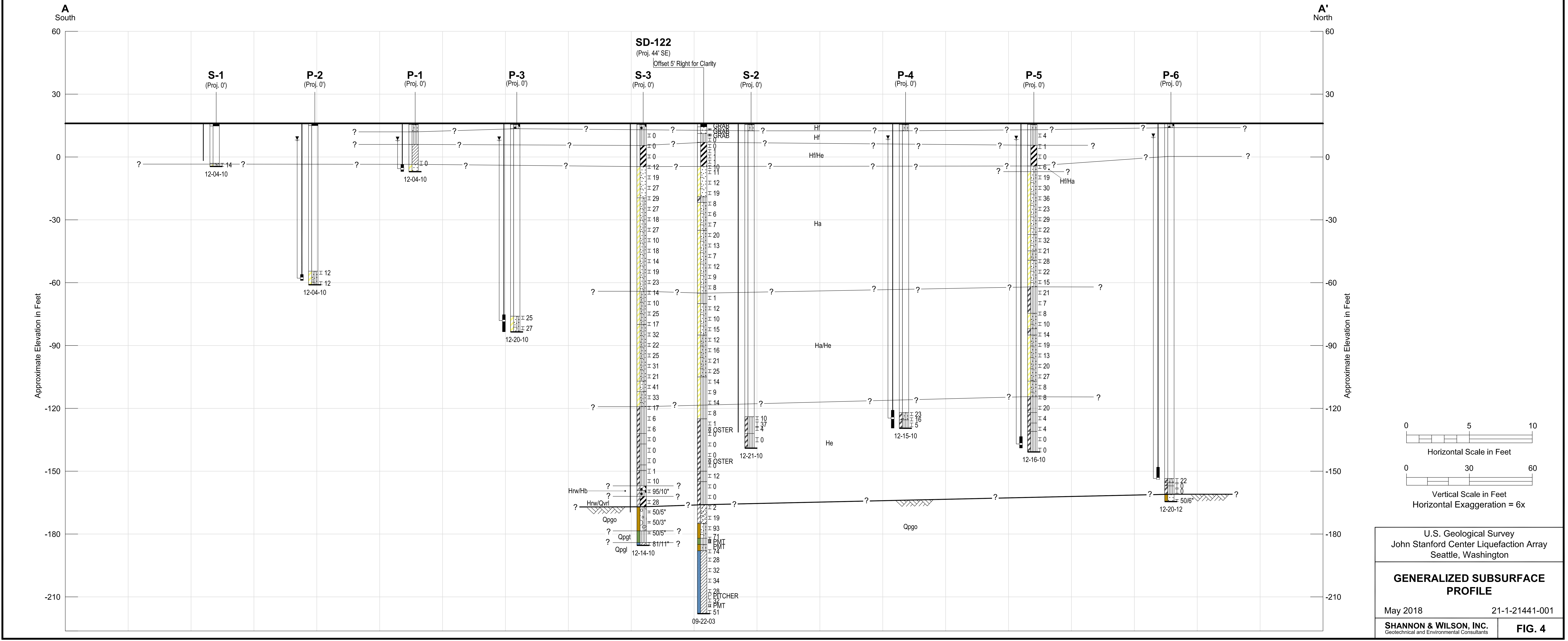
FIG. 3

Filename: J:\211\21441-001\21-1-21441-001 Legend.dwg Date: 01-09-2013 Login: Sandy Cottrell



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GENERALIZED SUBSURFACE PROFILE

May 2018
21-1-21441-001

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FIG. 4

Filename: J:\211\21441-001\21-1-21441-001 profile.dwg Date: 01-09-2013 Login: SAC

APPENDIX A: PROJECT EXPLORATION LOGS

APPENDIX A

Project Exploration Logs

CONTENTS

TABLE A-1
SUMMARY OF PIEZOMETER AND SEISMOMETER INSTALLATION DATA

Boring No.[a]	Ecology Tag	Well Installation Date	Drilling[b] Method	Boring Depth (feet)	Estimated Ground Surface and Monument Lid Elevation[b] (feet)	Casing Elevation[c] (feet)	Top of Filter Pack Depth[d] (feet)	Bottom of Filter Pack Depth[d] (feet)	Estimated Filter Pack Elevation Range[c] (feet)	Top of Screen Depth[d] (feet)	Bottom of Screen Depth[d] (feet)	Estimated Screen Elevation Range[c] (feet)	Screen Length[d] (feet)	Sump Length[d] (feet)	Casing Depth Below Grade[d] (feet)	Estimated Casing Bottom Elevation[c] (feet)	Approximate Borehole Diameter[d] (inches)	Inside Casing Diameter[d] (inches)
P-1	BBT 892	12/4/2010	HSA	23.0	18	17.8	19.5	23.0	-1.5 - -5.0	21.1	22.0	-3.1 - -4.0	0.9	0.7	22.7	-4.7	9.0	2
P-2	BBT 893	12/4/2010	MR	77.0	18	17.8	72.0	75.0	-54.0 - -57.0	73.4	74.3	-55.4 - -56.3	0.9	0.7	75.0	-57.0	6.0	2
P-3	BBT 651	12/20/2010	MR	99.5	18	17.8	91.2	99.5	-73.2 - -81.5	93.7	94.5	-75.7 - -76.5	0.9	0.7	95.3	-77.3	6.0	2
P-4	BBT 897	12/15/2010	MR	145.5	18	17.6	136.8	145.5	-118.8 - -127.5	140.2	141.1	-122.2 - -123.1	0.9	0.7	141.8	-123.8	6.0	2
P-5	BBT 898	12/16/2010 (Topped off grout on 12/17/2010)	MR	156.8	18	17.6	149.4	155.0	-131.4 - -137.0	152.6	153.4	-134.6 - -135.4	0.9	0.7	154.2	-136.2	6.0	2
P-6	BBT 899	12/20/2010	MR	180.5	18	17.6	164.0	170.0	-146.0 - -152.0	169.0	169.9	-151.0 - -151.9	0.9	0.7	170.6	-152.6	6.0	2
S-1	BBT 894	12/4/2010	MR	20.5	18	17.7	No filter pack			No screen				17.6	17.9	0.2	6.3	4
S-2	BBT 896	12/13/2010 (Topped off grout on 12/21/2010)	MR	155.0	18	17.8	No filter pack			No screen				147.3	147.5	-129.5	8.0	4
S-3	BBT 895	12/9/2010 (Topped off grout on 12/14/2010)	MR	201.4	18	17.8	No filter pack			No screen				185.6	185.8	-167.8	6.3	4

Notes:

(a) Boring No. corresponds to Piezometer No. (for P-1 through P-6) or Seismometer No. (for S-1 through S-3).

(b) HSA = hollow-stem auger, MR = mud rotary

(c) Based on the estimated elevation of the ground surface and flush-mounted monument lid at each location. The reference vertical datum is the North American Vertical Datum (NAVD 88).

(d) Value shown was determined by hand measurements during piezometer/seismometer construction and during piezometer development on 9/27/2011.

TABLE A-2
SUMMARY OF PIEZOMETER DEVELOPMENT AND GROUNDWATER READINGS

Piezometer No.	Ecology Tag	Estimated Ground Surface and Monument Lid Elevation[a] (feet)	Development Dates	Approximate Volume Purged[b] (gallons)	Groundwater Reading Date	Depth to Water Below Grade (feet)	Estimated Groundwater Elevation[a] (feet)
P-1	BBT 892	18	9/27/2011	3	9/27/2011	7.3	10.7
					10/27/2011	8.0	10.0
P-2	BBT 893	18	9/27/2011	3	9/27/2011	7.8	10.2
					10/27/2011	7.9	10.1
P-3	BBT 651	18	9/27/2011	3	9/27/2011	7.8	10.2
					10/27/2011	8.0	10.0
P-4	BBT 897	18	9/27/2011	3.5	9/27/2011	7.0	11.0
					10/27/2011	7.5	10.5
P-5	BBT 898	18	9/27/2011	4.5	9/27/2011	6.5	11.5
			2/21/2012	6.5	10/27/2011	7.6	10.4
					2/21/2012	6.1	11.9
P-6	BBT 899	18	9/27/2011	4.5	9/27/2011	6.7	11.3
					10/27/2011	6.6	11.5

Notes:

(a) Based on the estimated elevation of the ground surface and flush-mounted monument lid at each location.
The reference vertical datum is the North American Vertical Datum (NAVD 88).

(b) Piezometer development within the screened zone was performed using a hand-actuated, check-valve-type, inertial pump equipped with a surge block.

Shannon & Wilson, Inc. (S&W), uses a soil classification system modified from the Unified Soil Classification System (USCS). Elements of the USCS and other definitions are provided on this and the following page. Soil descriptions are based on visual-manual procedures (ASTM D 2488-93) unless otherwise noted.

S&W CLASSIFICATION OF SOIL CONSTITUENTS

- MAJOR constituents compose more than 50 percent, by weight, of the soil. Major consituents are capitalized (i.e., SAND).
- Minor constituents compose 12 to 50 percent of the soil and precede the major constituents (i.e., silty SAND). Minor constituents preceded by "slightly" compose 5 to 12 percent of the soil (i.e., slightly silty SAND).
- Trace constituents compose 0 to 5 percent of the soil (i.e., slightly silty SAND, trace of gravel).

MOISTURE CONTENT DEFINITIONS

Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, from below water table

ABBREVIATIONS

ATD	At Time of Drilling
Elev.	Elevation
ft	feet
FeO	Iron Oxide
MgO	Magnesium Oxide
HSA	Hollow Stem Auger
ID	Inside Diameter
in	inches
lbs	pounds
Mon.	Monument cover
N	Blows for last two 6-inch increments
NA	Not applicable or not available
NAD	North American Datum (year)
NAVD	North American Vertical Datum (year)
NGVD	National Geodetic Vertical Datum (year)
NP	Non plastic
OD	Outside diameter
OVA	Organic vapor analyzer
PID	Photo-ionization detector
ppm	parts per million
PVC	Polyvinyl Chloride
SS	Split spoon sampler
SPT	Standard penetration test
USC	Unified soil classification
WOH	Weight of hammer
WOR	Weight of drill rods

GRAIN SIZE DEFINITION

DESCRIPTION	SIEVE NUMBER AND/OR SIZE
FINES	< #200 (0.08 mm)
SAND*	
- Fine	#200 to #40 (0.08 to 0.4 mm)
- Medium	#40 to #10 (0.4 to 2 mm)
- Coarse	#10 to #4 (2 to 5 mm)
GRAVEL*	
- Fine	#4 to 3/4 inch (5 to 19 mm)
- Coarse	3/4 to 3 inches (19 to 76 mm)
COBBLES	3 to 12 inches (76 to 305 mm)
BOULDERS	> 12 inches (305 mm)

* Unless otherwise noted, sand and gravel, when present, range from fine to coarse in grain size.

RELATIVE DENSITY / CONSISTENCY

COARSE-GRAINED SOILS		FINE-GRAINED SOILS	
N, SPT, BLOWS/FT.	RELATIVE DENSITY	N, SPT, BLOWS/FT.	RELATIVE CONSISTENCY
0 - 4	Very loose	Under 2	Very soft
4 - 10	Loose	2 - 4	Soft
10 - 30	Medium dense	4 - 8	Medium stiff
30 - 50	Dense	8 - 15	Stiff
Over 50	Very dense	15 - 30	Very stiff
		Over 30	Hard

WELL AND OTHER SYMBOLS

▧	Bent. Cement Grout	⁂	Surface Cement Seal
▨	Bentonite Grout	■	Asphalt or Cap
▩	Bentonite Chips	▨	Slough
⁘	Silica Sand	▩	Bedrock
▤	PVC Screen		
▮	Vibrating Wire		

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SOIL CLASSIFICATION AND LOG KEY

May 2018 21-1-21441-001

SHANNON & WILSON, INC.
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FIG. A-1
Sheet 1 of 2

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)
(From USACE Tech Memo 3-357)

MAJOR DIVISIONS			GROUP/GRAPHIC SYMBOL		TYPICAL DESCRIPTION
COARSE-GRAINED SOILS *(more than 50% retained on No. 200 sieve)*	Gravels *(more than 50% of coarse fraction retained on No. 4 sieve)*	Clean Gravels *(less than 5% fines)*	GW		Well-graded gravels, gravels, gravel/sand mixtures, little or no fines.
			GP		Poorly graded gravels, gravel-sand mixtures, little or no fines
		Gravels with Fines *(more than 12% fines)*	GM		Silty gravels, gravel-sand-silt mixtures
			GC		Clayey gravels, gravel-sand-clay mixtures
	Sands *(50% or more of coarse fraction passes the No. 4 sieve)*	Clean Sands *(less than 5% fines)*	SW		Well-graded sands, gravelly sands, little or no fines
			SP		Poorly graded sand, gravelly sands, little or no fines
		Sands with Fines *(more than 12% fines)*	SM		Silty sands, sand-silt mixtures
			SC		Clayey sands, sand-clay mixtures
FINE-GRAINED SOILS *(50% or more passes the No. 200 sieve)*	Silts and Clays *(liquid limit less than 50)*	Inorganic	ML		Inorganic silts of low to medium plasticity, rock flour, sandy silts, gravelly silts, or clayey silts with slight plasticity
			CL		Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
		Organic	OL		Organic silts and organic silty clays of low plasticity
	Silts and Clays *(liquid limit 50 or more)*	Inorganic	MH		Inorganic silts, micaceous or diatomaceous fine sands or silty soils, elastic silt
			CH		Inorganic clays of medium to high plasticity, sandy fat clay, or gravelly fat clay
		Organic	OH		Organic clays of medium to high plasticity, organic silts
HIGHLY-ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor		PT		Peat, humus, swamp soils with high organic content (see ASTM D 4427)

NOTE: No. 4 size = 5 mm; No. 200 size = 0.075 mm

BORING_CLASS2 21-21441.GPJ SWNEW.GDT 1/10/13

NOTES

1. Dual symbols *(symbols separated by a hyphen, i.e., SP-SM, slightly silty fine SAND)* are used for soils with between 5% and 12% fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.
2. Borderline symbols *(symbols separated by a slash, i.e., CL/ML, silty CLAY/clayey SILT; GW/SW, sandy GRAVEL/gravelly SAND)* indicate that the soil may fall into one of two possible basic groups.

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SOIL CLASSIFICATION AND LOG KEY

May 2018 21-1-21441-001

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FIG. A-1
Sheet 2 of 2

Total Depth:	23 ft.	Northing:	~ 215,902 ft.	Drilling Method:	Hollow Stem Auger	Hole Diam.:	9 in.
Top Elevation:	~ 18 ft.	Easting:	~ 1,270,691 ft.	Drilling Company:	Gregory	Rod Diam.:	AWJ 1-3/4"
Vert. Datum:		Station:	~	Drill Rig Equipment:	CME 75 Truck	Hammer Type:	Automatic
Horiz. Datum:		Offset:	~	Other Comments:	9" HSA to 23 feet		

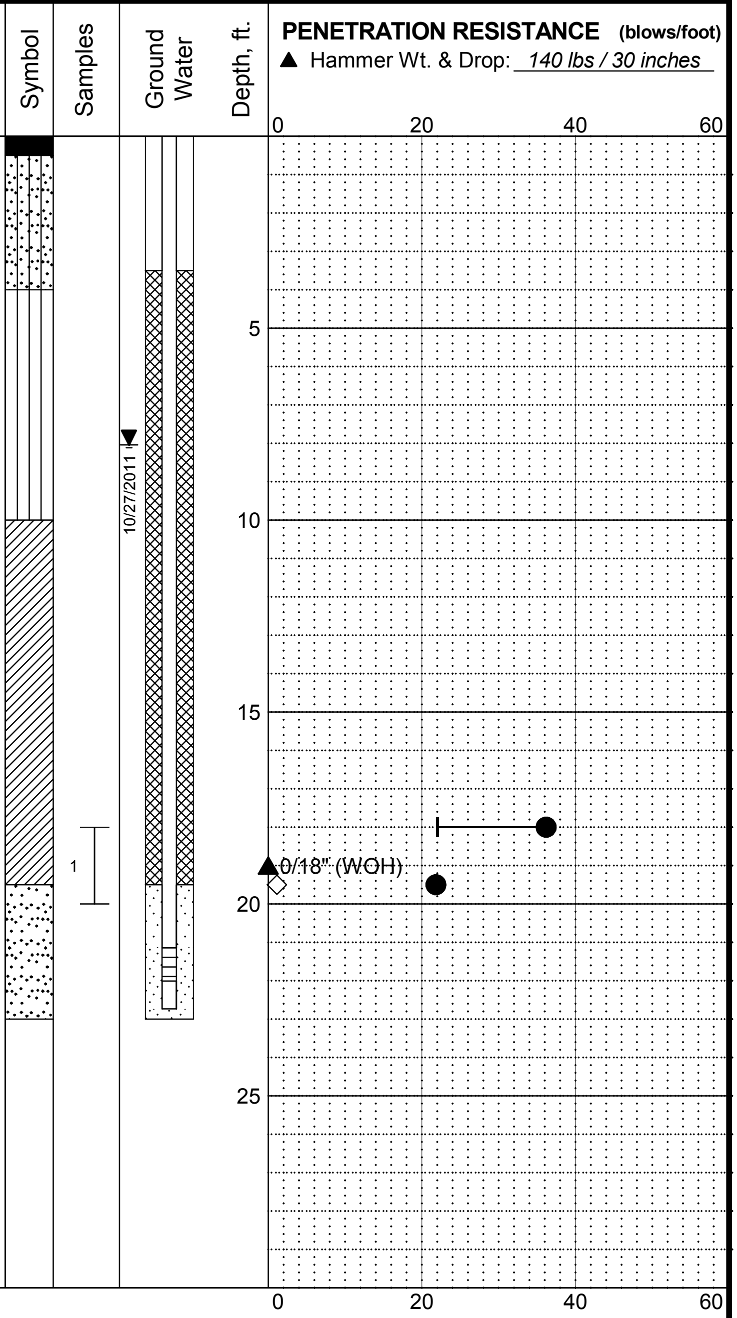
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

SOIL DESCRIPTION	Depth, ft.
ASPHALT	0.5
Brown, gravelly, silty SAND; moist; (Hf) SM.	4.0
Dark gray, slightly sandy, slightly clayey SILT; moist to wet; (Hf) ML. (See log of nearby boring S-3 for additional soil descriptions above 18 feet.)	10.0
Very soft, gray, silty CLAY; wet; with abundant seams of black, silty, fine sand and dark gray, slightly clayey, slightly sandy silt, scattered to abundant fine organics, scattered fine shell fragments; (Hf/He) CL.	19.5
Loose, black, fine to medium SAND, trace of silt; wet; (Ha/Hf) SP.	23.0

BOTTOM OF BORING
COMPLETED 12/4/2010

Notes:
1. Contacts above the sampling zone were estimated based on adjacent borings, cuttings, and drill action.
2. Driller used hollow stem auger drilling techniques; no heave was encountered.



% Fines (<0.075mm) ◇
% Water Content ●
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
⌶ Standard Penetration Test

⊞ Piezometer Screen and Sand Filter
▧ Bentonite-Cement Grout
⊠ Bentonite Chips/Pellets
▨ Bentonite Grout
▼ Ground Water Level in Well

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

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LOG OF BORING P-1

May 2018 21-1-21441-001

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FIG. A-2

REV 3

Total Depth: 77 ft.
Top Elevation: ~ 18 ft.
Vert. Datum:
Horiz. Datum:
Northing: ~ 215,894 ft.
Easting: ~ 1,270,690 ft.
Station: ~
Offset: ~
Drilling Method: Mud Rotary
Drilling Company: Gregory
Drill Rig Equipment: CME 75 Truck
Other Comments: 9" HSA to 4 feet
Hole Diam.: 6 in.
Rod Diam.: NWJ 2-5/8"
Hammer Type: Automatic

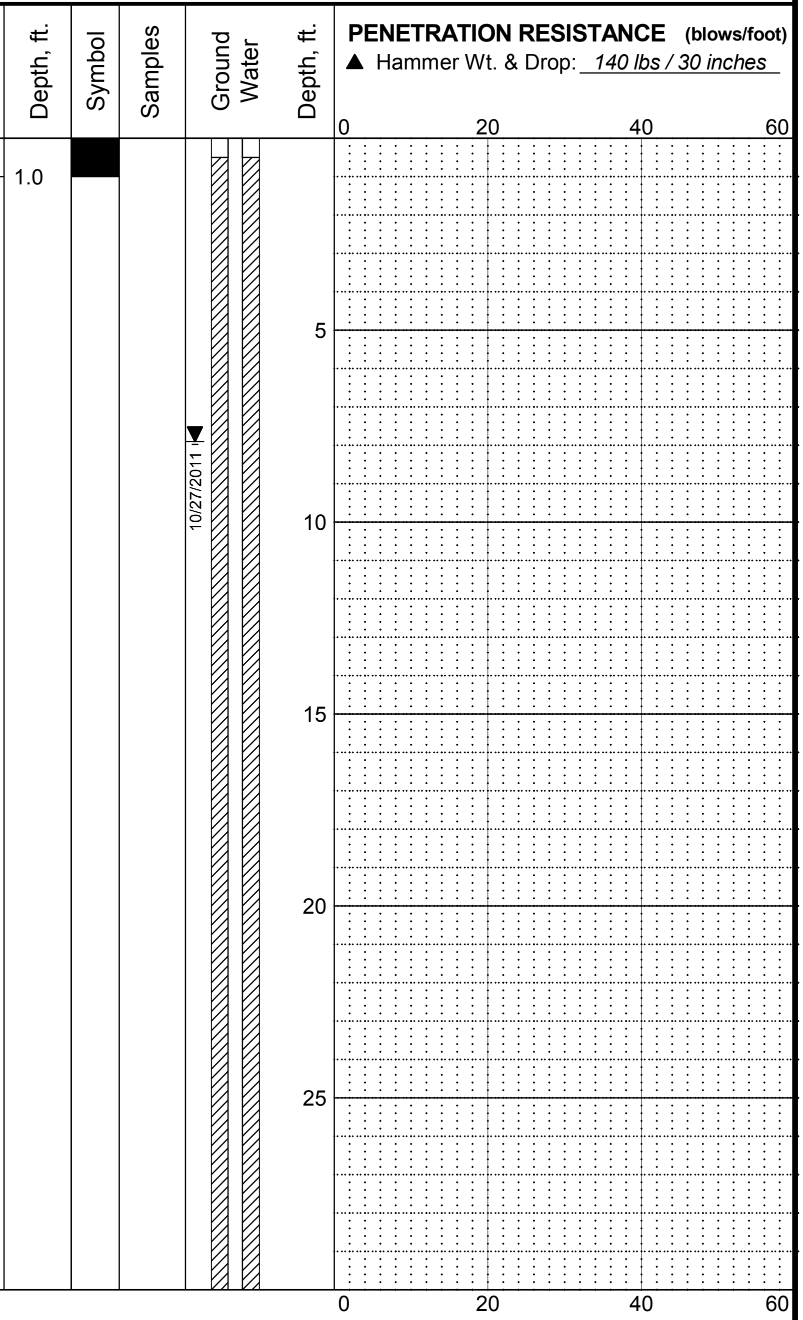
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

ASPHALT with incorporated railroad ballast. School district removed these, then placed gravel to 0.5 foot below ground surface.

See logs of nearby borings P-1, S-1, S-2, and S-3 for soil descriptions above 70.5 feet.

CONTINUED NEXT SHEET



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

- * Sample Not Recovered
- ⌶ Standard Penetration Test
- ⊡ Piezometer Screen and Sand Filter
- ▧ Bentonite-Cement Grout
- ⊠ Bentonite Chips/Pellets
- ▨ Bentonite Grout
- ▼ Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

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LOG OF BORING P-2

May 2018
21-1-21441-001

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FIG. A-3
Sheet 1 of 3

REV 3

Log: PVH Rev: PHZ Typ: CLP

MASTER_LOG_E 21-21441.GPJ SHAN_WIL.GDT 5/3/18

Total Depth: 77 ft.
Top Elevation: ~ 18 ft.
Vert. Datum:
Horiz. Datum:

Northing: ~ 215,894 ft.
Easting: ~ 1,270,690 ft.
Station: ~
Offset: ~

Drilling Method: Mud Rotary
Drilling Company: Gregory
Drill Rig Equipment: CME 75 Truck
Other Comments: 9" HSA to 4 feet

Hole Diam.: 6 in.
Rod Diam.: NWJ 2-5/8"
Hammer Type: Automatic

SOIL DESCRIPTION

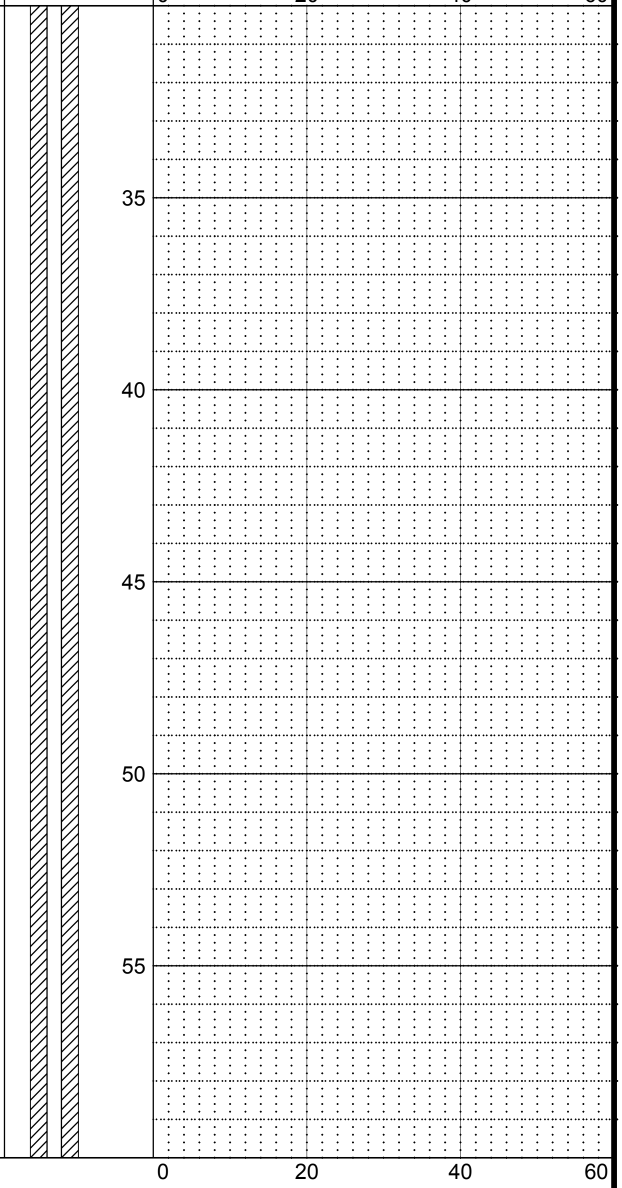
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Depth, ft. | Symbol | Samples | Ground Water | Depth, ft.

PENETRATION RESISTANCE **(blows/foot)**
▲ Hammer Wt. & Drop: *140 lbs / 30 inches*

- Possible SILT layer at approximately 56 to 60 feet, based on drill action.

CONTINUED NEXT SHEET



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
⌶ Standard Penetration Test

▨ Piezometer Screen and Sand Filter
▧ Bentonite-Cement Grout
⊠ Bentonite Chips/Pellets
▨ Bentonite Grout
▼ Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

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LOG OF BORING P-2

May 2018 21-1-21441-001

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FIG. A-3
Sheet 2 of 3

REV 3

Log: PVH Rev: PHZ Typ: CLP

MASTER_LOG_E 21-21441.GPJ SHAN_WIL.GDT 5/3/18

Total Depth:	77 ft.	Northing:	~ 215,894 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	6 in.
Top Elevation:	~ 18 ft.	Easting:	~ 1,270,690 ft.	Drilling Company:	Gregory	Rod Diam.:	NWJ 2-5/8"
Vert. Datum:		Station:	~	Drill Rig Equipment:	CME 75 Truck	Hammer Type:	Automatic
Horiz. Datum:		Offset:	~	Other Comments:	9" HSA to 4 feet		

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

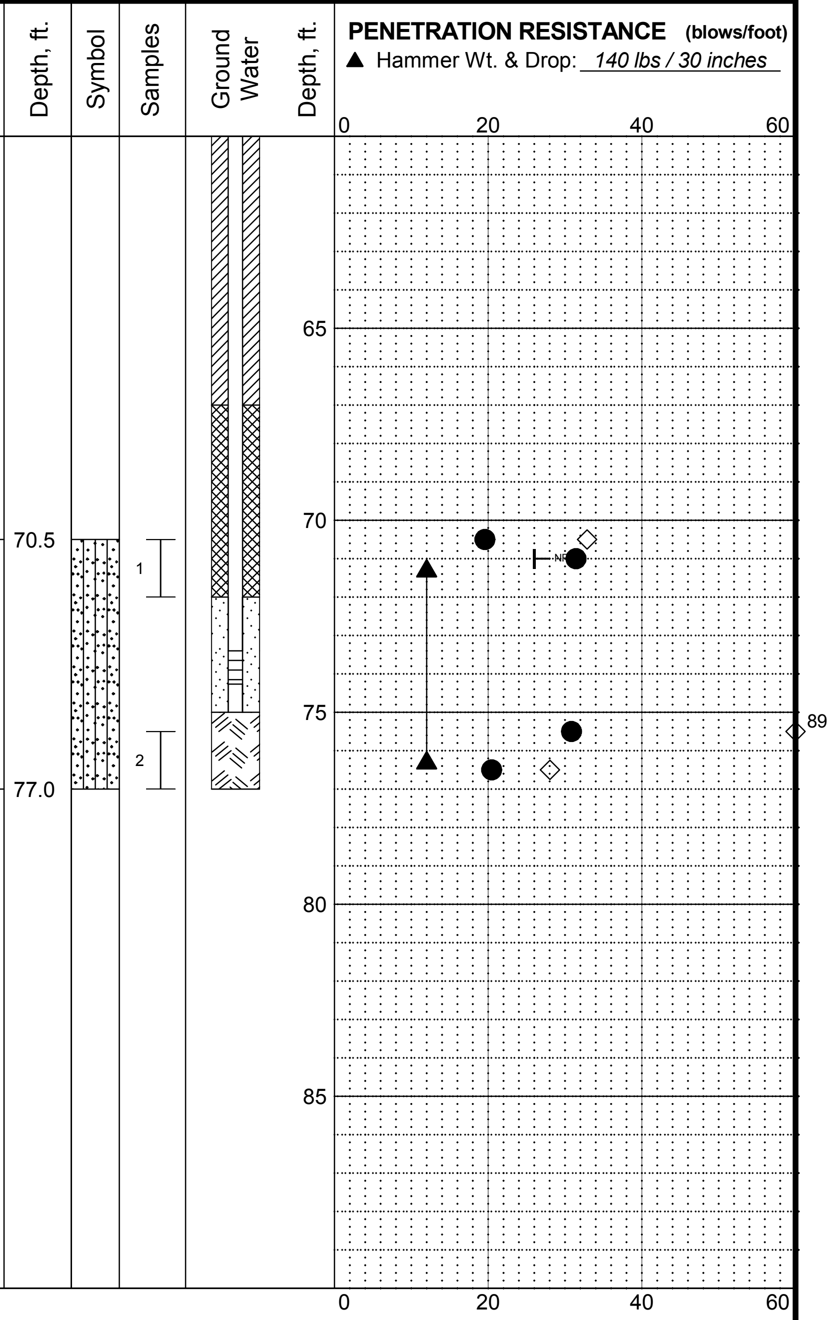
Medium dense, dark gray, interbedded silty, fine SAND and slightly fine sandy to fine sandy SILT, trace of clay; wet; scattered fine organics and pumice grains, trace of shell fragments; (Ha/He) SM/ML.

- Silt layers observed at approximately 71 to 71.5 and 75.5 to 76.5 feet.

BOTTOM OF BORING
COMPLETED 12/4/2010

Note:

1. Contacts above the sampling zone were estimated based on adjacent borings, cuttings, and drill action.



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
⌶ Standard Penetration Test

⁝ Piezometer Screen and Sand Filter
▧ Bentonite-Cement Grout
⊠ Bentonite Chips/Pellets
▨ Bentonite Grout
▼ Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

U.S. Geological Survey
John Stanford Center Liquefaction Array
Seattle, Washington

LOG OF BORING P-2

May 2018 21-1-21441-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-3
Sheet 3 of 3

REV 3

MASTER LOG E 21-21441.GPJ SHAN WIL.GDT 5/3/18

Log: PVH Rev: PHZ Typ: CLP

Total Depth: *99.5 ft.*
Top Elevation: *~ 18 ft.*
Vert. Datum:
Horiz. Datum:

Northing: *~ 215,910 ft.*
Easting: *~ 1,270,694 ft.*
Station: *~*
Offset: *~*

Drilling Method: *Mud Rotary*
Drilling Company: *Gregory*
Drill Rig Equipment: *CME 75 Truck*
Other Comments: *9" HSA to 4 feet*

Hole Diam.: *6 in.*
Rod Diam.: *NWJ 2-5/8"*
Hammer Type: *Automatic*

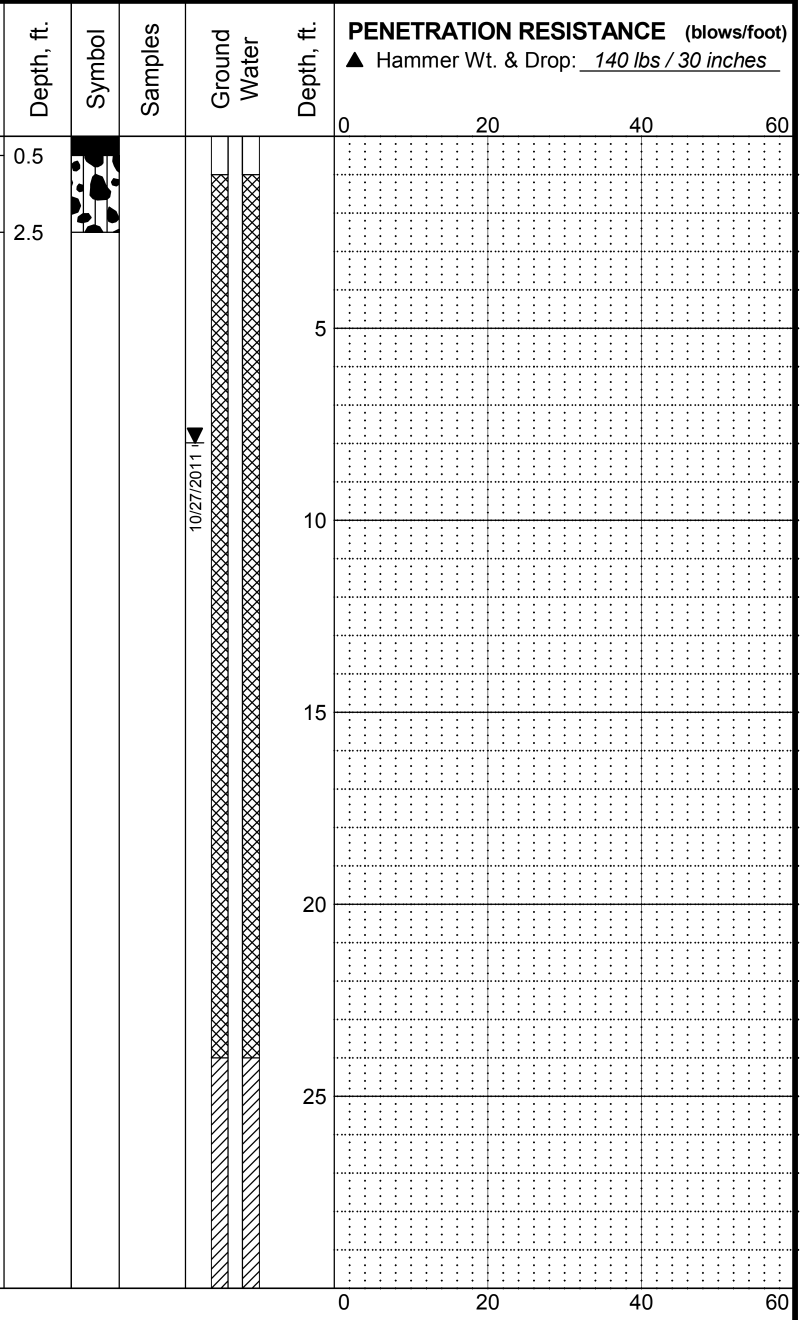
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

ASPHALT pavement. — 0.5

Brown, silty, sandy, fine to coarse GRAVEL; moist; (Hf) GM. — 2.5

See logs of nearby borings P-1, P-2, and S-3 for soil descriptions above 92 feet.



CONTINUED NEXT SHEET

◇ % Fines (<0.075mm)
● % Water Content

LEGEND

* Sample Not Recovered
⌶ Standard Penetration Test

⊡ Piezometer Screen and Sand Filter
▧ Bentonite-Cement Grout
⊠ Bentonite Chips/Pellets
▨ Bentonite Grout
▼ Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

U.S. Geological Survey
John Stanford Center Liquefaction Array
Seattle, Washington

LOG OF BORING P-3

May 2018
21-1-21441-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-4
Sheet 1 of 4

REV 3

Log: PVH Rev: PHZ Typ: CLP

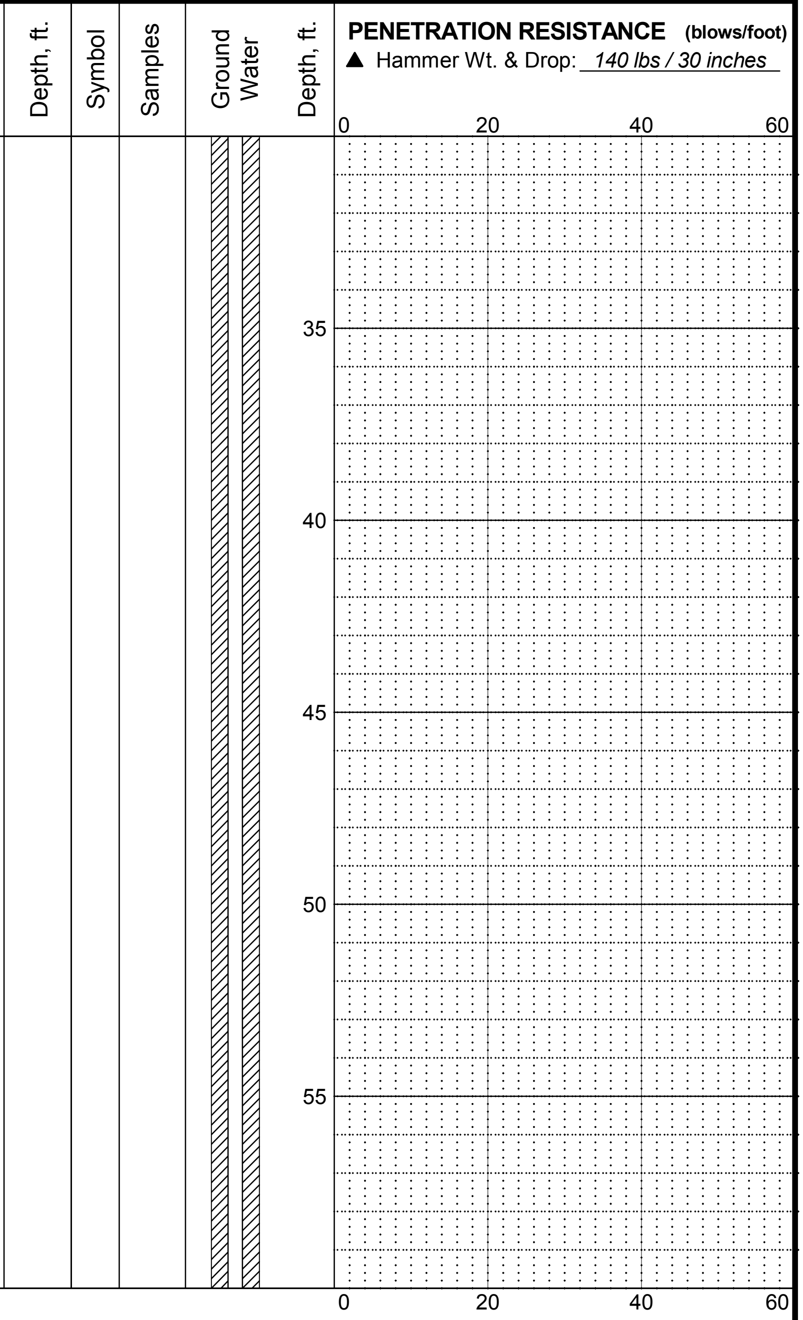
MASTER_LOG_E 21-21441.GPJ SHAN_WIL.GDT 5/3/18

Total Depth:	99.5 ft.	Northing:	~ 215,910 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	6 in.
Top Elevation:	~ 18 ft.	Easting:	~ 1,270,694 ft.	Drilling Company:	Gregory	Rod Diam.:	NWJ 2-5/8"
Vert. Datum:		Station:	~	Drill Rig Equipment:	CME 75 Truck	Hammer Type:	Automatic
Horiz. Datum:		Offset:	~	Other Comments:	9" HSA to 4 feet		

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

CONTINUED NEXT SHEET



◇ % Fines (<0.075mm)

● % Water Content

LEGEND

* Sample Not Recovered

⌶ Standard Penetration Test

▦ Piezometer Screen and Sand Filter

▧ Bentonite-Cement Grout

⊠ Bentonite Chips/Pellets

▨ Bentonite Grout

▼ Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

U.S. Geological Survey
John Stanford Center Liquefaction Array
Seattle, Washington

LOG OF BORING P-3

May 2018 21-1-21441-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-4
Sheet 2 of 4

REV 3

Total Depth: 99.5 ft.
Top Elevation: ~ 18 ft.
Vert. Datum:
Horiz. Datum:

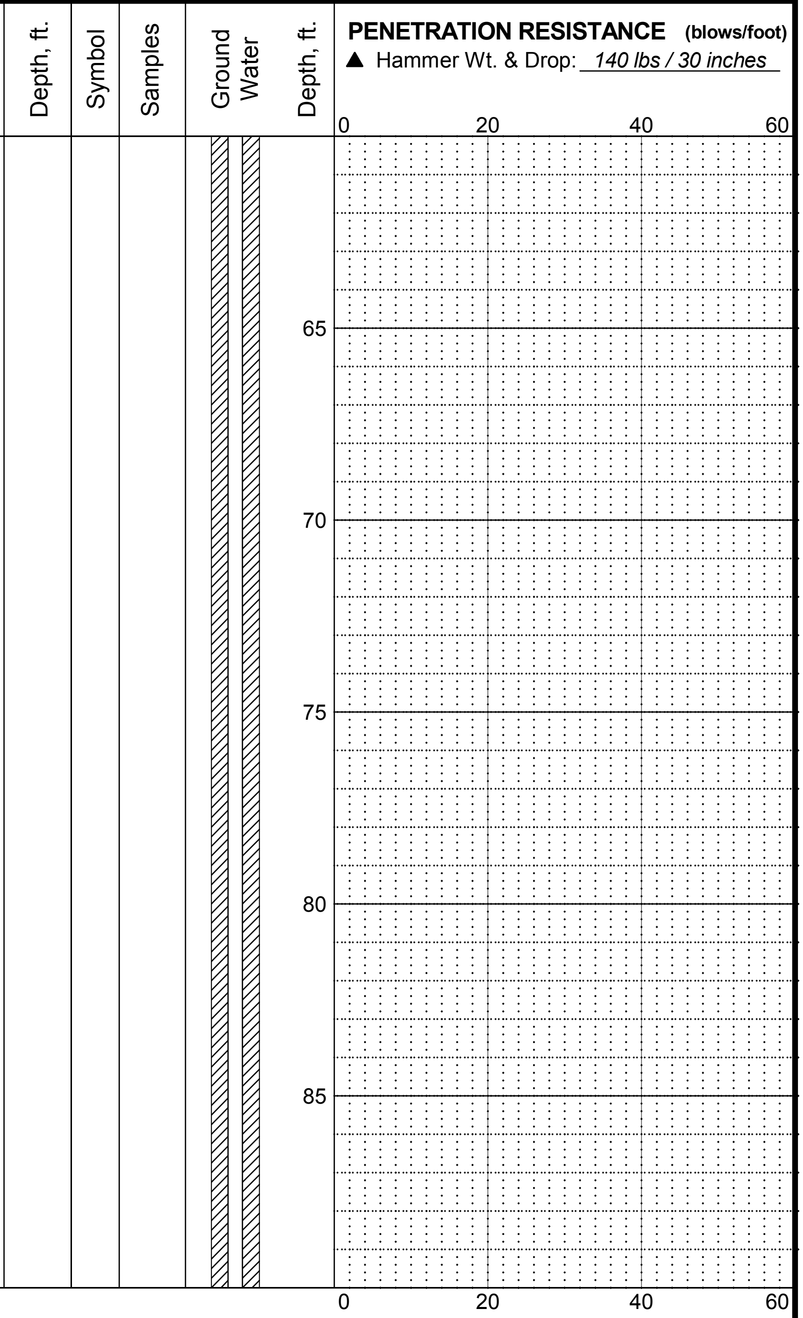
Northing: ~ 215,910 ft.
Easting: ~ 1,270,694 ft.
Station: ~
Offset: ~

Drilling Method: Mud Rotary
Drilling Company: Gregory
Drill Rig Equipment: CME 75 Truck
Other Comments: 9" HSA to 4 feet

Hole Diam.: 6 in.
Rod Diam.: NWJ 2-5/8"
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
⌶ Standard Penetration Test

▦ Piezometer Screen and Sand Filter
▧ Bentonite-Cement Grout
⊠ Bentonite Chips/Pellets
▨ Bentonite Grout
▼ Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

U.S. Geological Survey
John Stanford Center Liquefaction Array
Seattle, Washington

LOG OF BORING P-3

May 2018 21-1-21441-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-4
Sheet 3 of 4

Total Depth: *99.5 ft.*
Top Elevation: *~ 18 ft.*
Vert. Datum:
Horiz. Datum:

Northing: *~ 215,910 ft.*
Easting: *~ 1,270,694 ft.*
Station: *~*
Offset: *~*

Drilling Method: *Mud Rotary*
Drilling Company: *Gregory*
Drill Rig Equipment: *CME 75 Truck*
Other Comments: *9" HSA to 4 feet*

Hole Diam.: *6 in.*
Rod Diam.: *NWJ 2-5/8"*
Hammer Type: *Automatic*

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

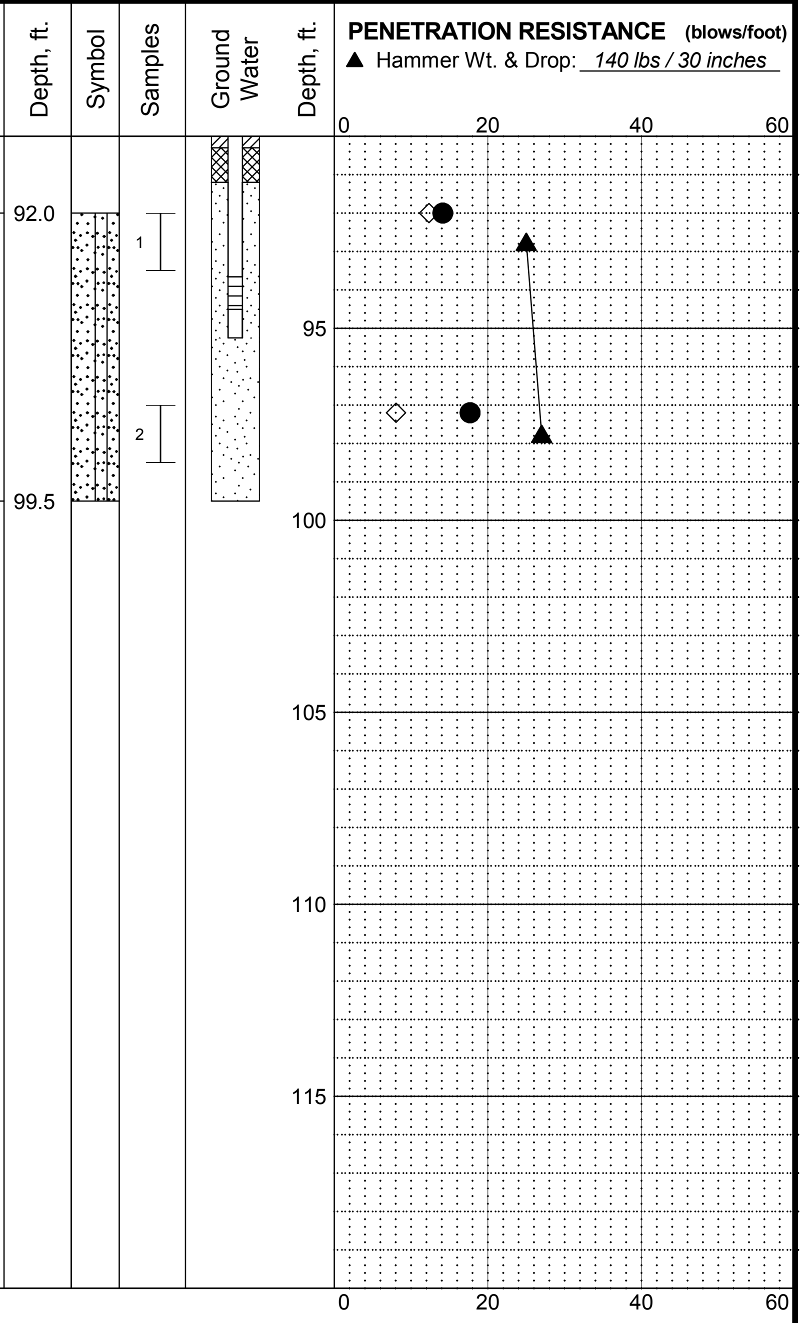
Medium dense, black, slightly silty to silty, fine to medium SAND; wet; (Ha) SP-SM/SM.

- Scattered black, sandy silt and gray-brown, clayey silt seams and layers at about 92.7 to 97.2 feet.

- Scattered organic seams below about 97.2 feet.

BOTTOM OF BORING
COMPLETED 12/20/2010

Note:
1. Contacts above the sampling zone were estimated based on adjacent borings, cuttings, and drill action.



◇ % Fines (<0.075mm)
● % Water Content

LEGEND

* Sample Not Recovered
⌶ Standard Penetration Test

▤ Piezometer Screen and Sand Filter
▧ Bentonite-Cement Grout
⊠ Bentonite Chips/Pellets
▨ Bentonite Grout
▼ Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

U.S. Geological Survey
John Stanford Center Liquefaction Array
Seattle, Washington

LOG OF BORING P-3

May 2018 21-1-21441-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-4
Sheet 4 of 4

REV 3

Total Depth: 145.5 ft.
Top Elevation: ~ 18 ft.
Vert. Datum:
Horiz. Datum:

Northing: ~ 215,939 ft.
Easting: ~ 1,270,702 ft.
Station: ~
Offset: ~

Drilling Method: Mud Rotary
Drilling Company: Gregory
Drill Rig Equipment: CME 75 Truck
Other Comments: 9" HSA to 4 feet

Hole Diam.: 6 in.
Rod Diam.: NWJ 2-5/8"
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Depth, ft.

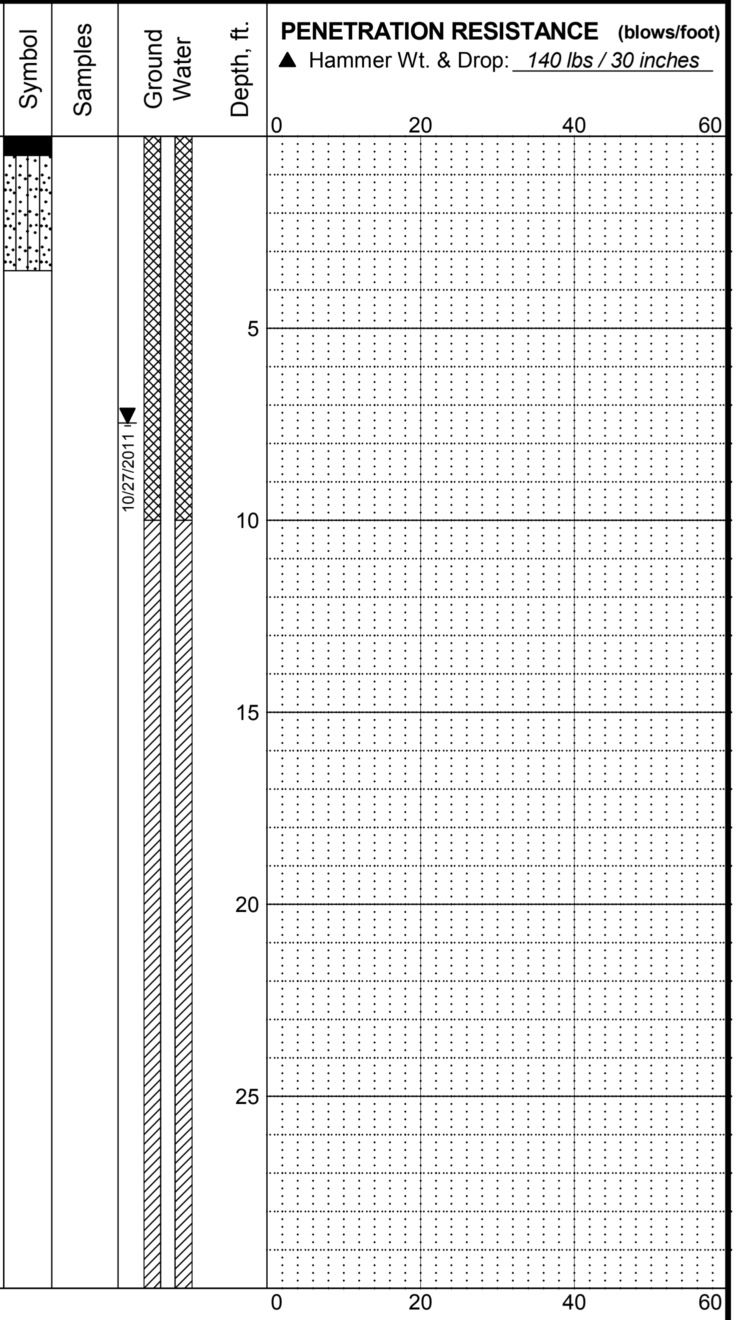
ASPHALT — 0.5

Brown, silty, gravelly, fine to medium SAND; moist; (Hf) SM. — 3.5

Easy drilling. See logs of nearby borings S-2, S-3, and P-5 for soil descriptions above 138 feet.

- SAND below about 18.5 feet, based on drill action.

CONTINUED NEXT SHEET



LEGEND

* Sample Not Recovered
⌶ Standard Penetration Test
▤ Piezometer Screen and Sand Filter
▧ Bentonite-Cement Grout
▩ Bentonite Chips/Pellets
▨ Bentonite Grout
▼ Ground Water Level in Well

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

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John Stanford Center Liquefaction Array
Seattle, Washington

LOG OF BORING P-4

May 2018 21-1-21441-001

SHANNON & WILSON, INC.
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FIG. A-5
Sheet 1 of 6

REV 3

Log: PVH Rev: PHZ Typ: CLP

MASTER_LOG_E 21-21441.GPJ SHAN_WIL.GDT 5/3/18

Total Depth: 145.5 ft.
Top Elevation: ~ 18 ft.
Vert. Datum:
Horiz. Datum:

Northing: ~ 215,939 ft.
Easting: ~ 1,270,702 ft.
Station: ~
Offset: ~

Drilling Method: Mud Rotary
Drilling Company: Gregory
Drill Rig Equipment: CME 75 Truck
Other Comments: 9" HSA to 4 feet

Hole Diam.: 6 in.
Rod Diam.: NWJ 2-5/8"
Hammer Type: Automatic

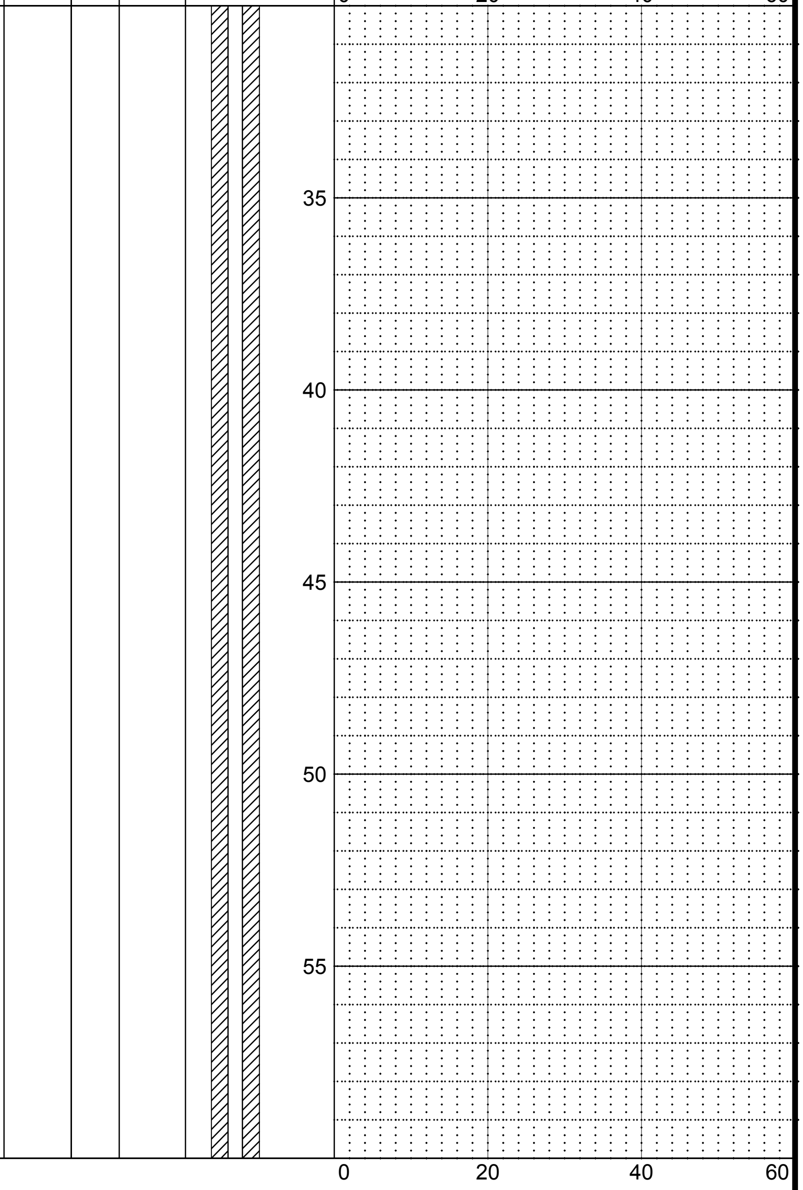
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Depth, ft. | Symbol | Samples | Ground Water | Depth, ft.

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: 140 lbs / 30 inches



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
⌶ Standard Penetration Test

Piezometer Screen and Sand Filter
▧ Bentonite-Cement Grout
⊠ Bentonite Chips/Pellets
▨ Bentonite Grout
▼ Ground Water Level in Well

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

U.S. Geological Survey
John Stanford Center Liquefaction Array
Seattle, Washington

LOG OF BORING P-4

May 2018
21-1-21441-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-5
Sheet 2 of 6

REV 3

Total Depth:	145.5 ft.	Northing:	~ 215,939 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	6 in.
Top Elevation:	~ 18 ft.	Easting:	~ 1,270,702 ft.	Drilling Company:	Gregory	Rod Diam.:	NWJ 2-5/8"
Vert. Datum:		Station:	~	Drill Rig Equipment:	CME 75 Truck	Hammer Type:	Automatic
Horiz. Datum:		Offset:	~	Other Comments:	9" HSA to 4 feet		

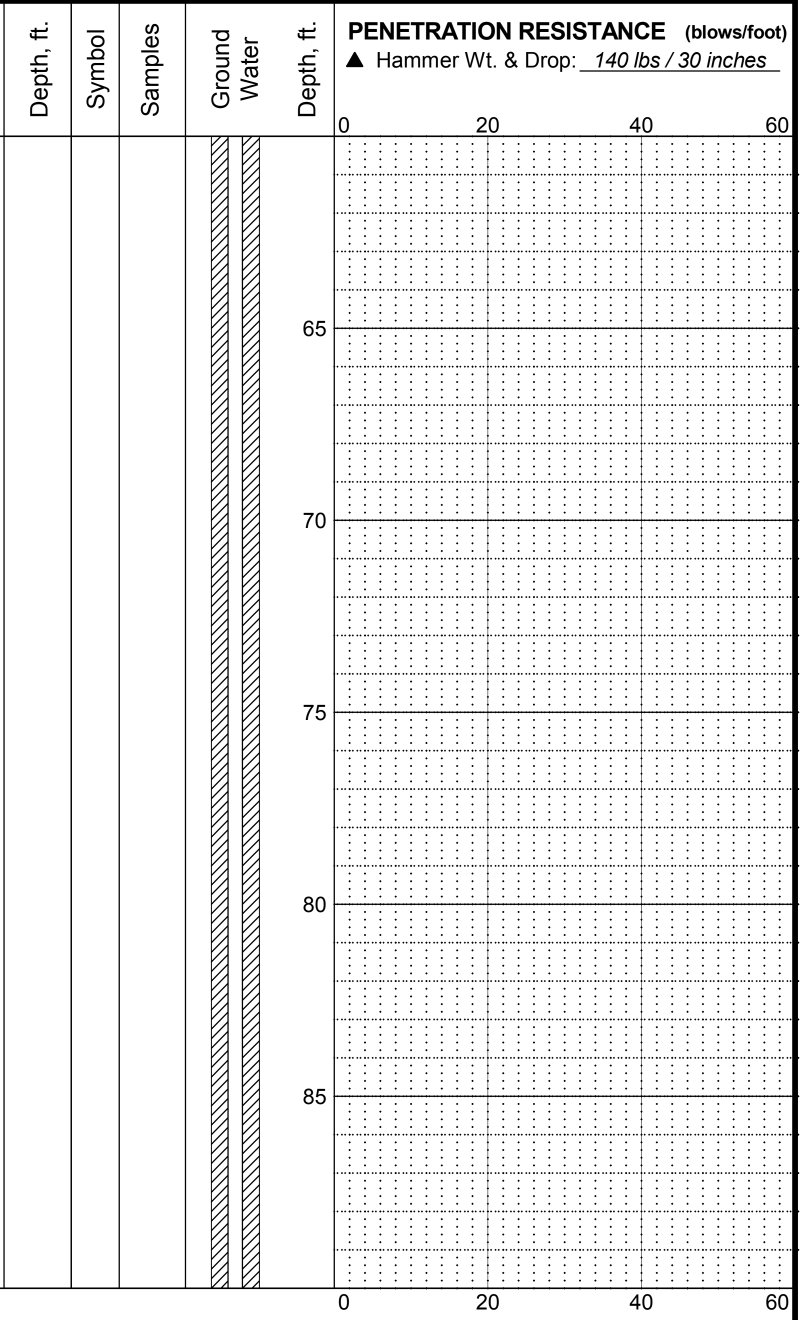
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

- Denser at about 74.5 to 78.5 feet, based on drill action.

- Drilled like interbedded sand and silt below about 78.5 feet.

CONTINUED NEXT SHEET



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├──●──┤ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
⌶ Standard Penetration Test

Piezometer Screen and Sand Filter
▧ Bentonite-Cement Grout
⊠ Bentonite Chips/Pellets
▨ Bentonite Grout
▼ Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

U.S. Geological Survey
John Stanford Center Liquefaction Array
Seattle, Washington

LOG OF BORING P-4

May 2018 21-1-21441-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-5
Sheet 3 of 6

REV 3

Total Depth: 145.5 ft.
Top Elevation: ~ 18 ft.
Vert. Datum:
Horiz. Datum:

Northing: ~ 215,939 ft.
Easting: ~ 1,270,702 ft.
Station: ~
Offset: ~

Drilling Method: Mud Rotary
Drilling Company: Gregory
Drill Rig Equipment: CME 75 Truck
Other Comments: 9" HSA to 4 feet

Hole Diam.: 6 in.
Rod Diam.: NWJ 2-5/8"
Hammer Type: Automatic

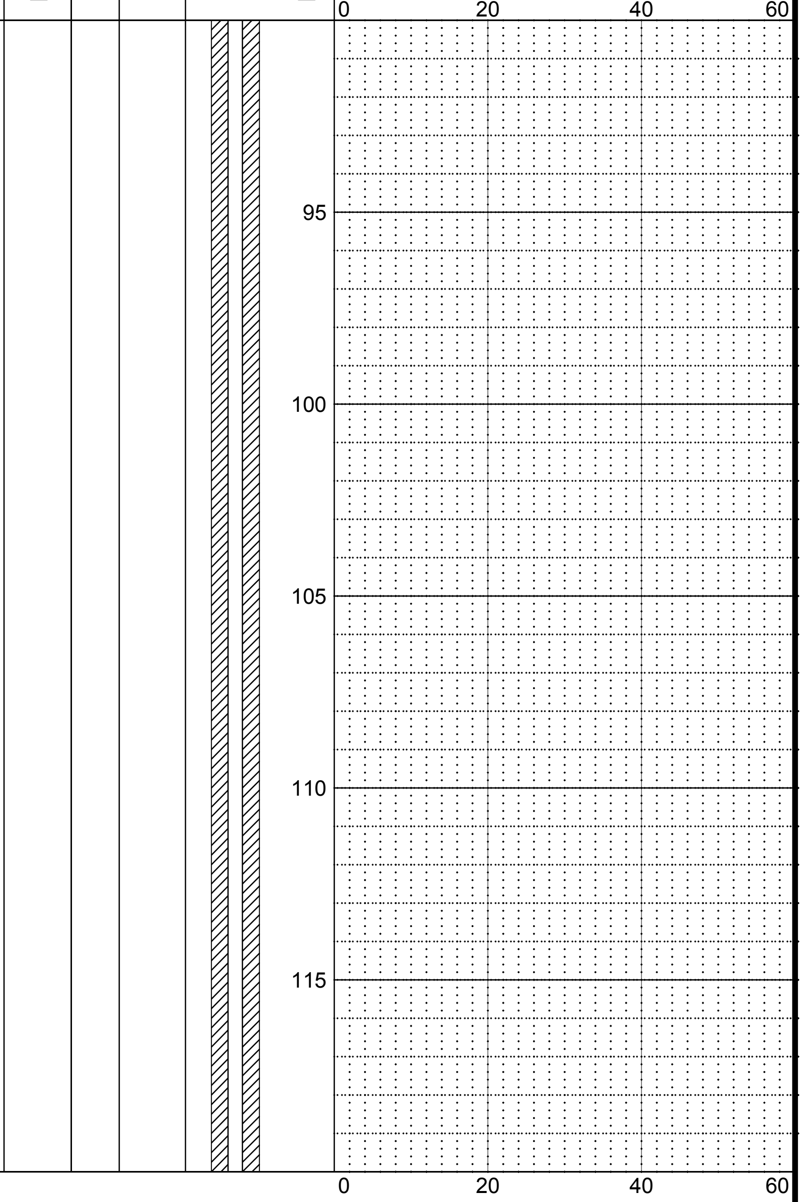
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Depth, ft. | Symbol | Samples | Ground Water | Depth, ft.

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: 140 lbs / 30 inches



CONTINUED NEXT SHEET

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
⌶ Standard Penetration Test

Piezometer Screen and Sand Filter
Bentonite-Cement Grout
Bentonite Chips/Pellets
Bentonite Grout
▼ Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

U.S. Geological Survey
John Stanford Center Liquefaction Array
Seattle, Washington

LOG OF BORING P-4

May 2018 21-1-21441-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-5
Sheet 4 of 6

REV 3

Log: PVH Rev: PHZ Typ: CLP

MASTER_LOG_E 21-21441.GPJ SHAN_WIL.GDT 5/3/18

Total Depth: 145.5 ft.
Top Elevation: ~ 18 ft.
Vert. Datum:
Horiz. Datum:
Northing: ~ 215,939 ft.
Easting: ~ 1,270,702 ft.
Station: ~
Offset: ~
Drilling Method: Mud Rotary
Drilling Company: Gregory
Drill Rig Equipment: CME 75 Truck
Other Comments: 9" HSA to 4 feet
Hole Diam.: 6 in.
Rod Diam.: NWJ 2-5/8"
Hammer Type: Automatic

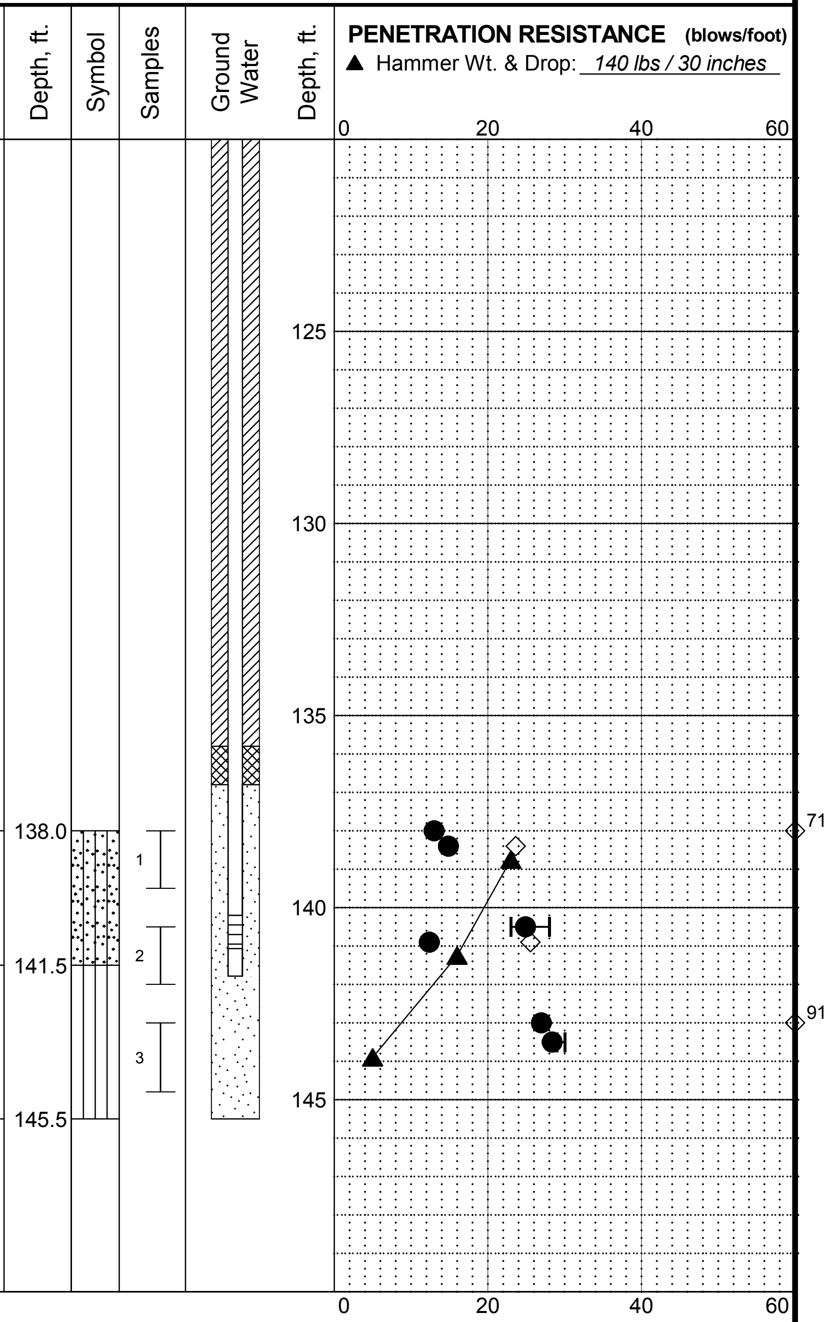
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Medium dense, interbedded black, silty, fine SAND and dark brown-gray, trace to slightly clayey, trace of fine sand to fine sandy SILT; wet; trace of organics and shells, locally trace of fine gravel; (He/Ha) SM/ML.
- Approximately 70-degree contact at about 141.
- Approximately horizontal contact at 141.5 feet.

Very soft to stiff, dark brown-gray, trace to slightly fine sandy, trace to slightly clayey SILT; wet; trace of shells, organic seams, and sand seams; (He/Ha) ML.

CONTINUED NEXT SHEET



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
⌶ Standard Penetration Test
Piezometer Screen and Sand Filter
▧ Bentonite-Cement Grout
☒ Bentonite Chips/Pellets
▨ Bentonite Grout
▼ Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

U.S. Geological Survey
John Stanford Center Liquefaction Array
Seattle, Washington

LOG OF BORING P-4

May 2018
21-1-21441-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-5
Sheet 5 of 6

REV 3

Total Depth:	145.5 ft.	Northing:	~ 215,939 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	6 in.
Top Elevation:	~ 18 ft.	Easting:	~ 1,270,702 ft.	Drilling Company:	Gregory	Rod Diam.:	NWJ 2-5/8"
Vert. Datum:		Station:	~	Drill Rig Equipment:	CME 75 Truck	Hammer Type:	Automatic
Horiz. Datum:		Offset:	~	Other Comments:	9" HSA to 4 feet		

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Depth, ft. | Symbol | Samples | Ground Water | Depth, ft.

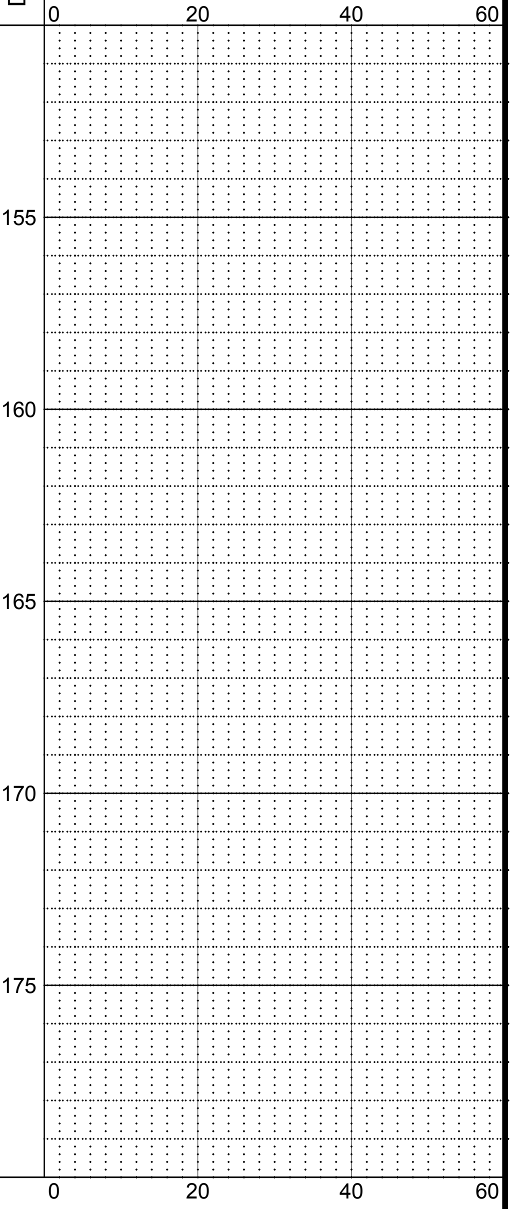
PENETRATION RESISTANCE **(blows/foot)**

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*

BOTTOM OF BORING
COMPLETED 12/15/2010

Note:

1. Contacts above the sampling zone were estimated based on adjacent borings, cuttings, and drill action.



◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ├──●──┤ Liquid Limit
Natural Water Content

LEGEND

- * Sample Not Recovered
- ⌶ Standard Penetration Test
- ▤ Piezometer Screen and Sand Filter
- ▧ Bentonite-Cement Grout
- ☒ Bentonite Chips/Pellets
- ▨ Bentonite Grout
- ▼ Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

U.S. Geological Survey
John Stanford Center Liquefaction Array
Seattle, Washington

LOG OF BORING P-4

May 2018 21-1-21441-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-5
Sheet 6 of 6

MASTER_LOG_E 21-21441.GPJ SHAN_WIL.GDT 5/3/18

Log: PVH Rev: PHZ Typ: CLP

REV 3

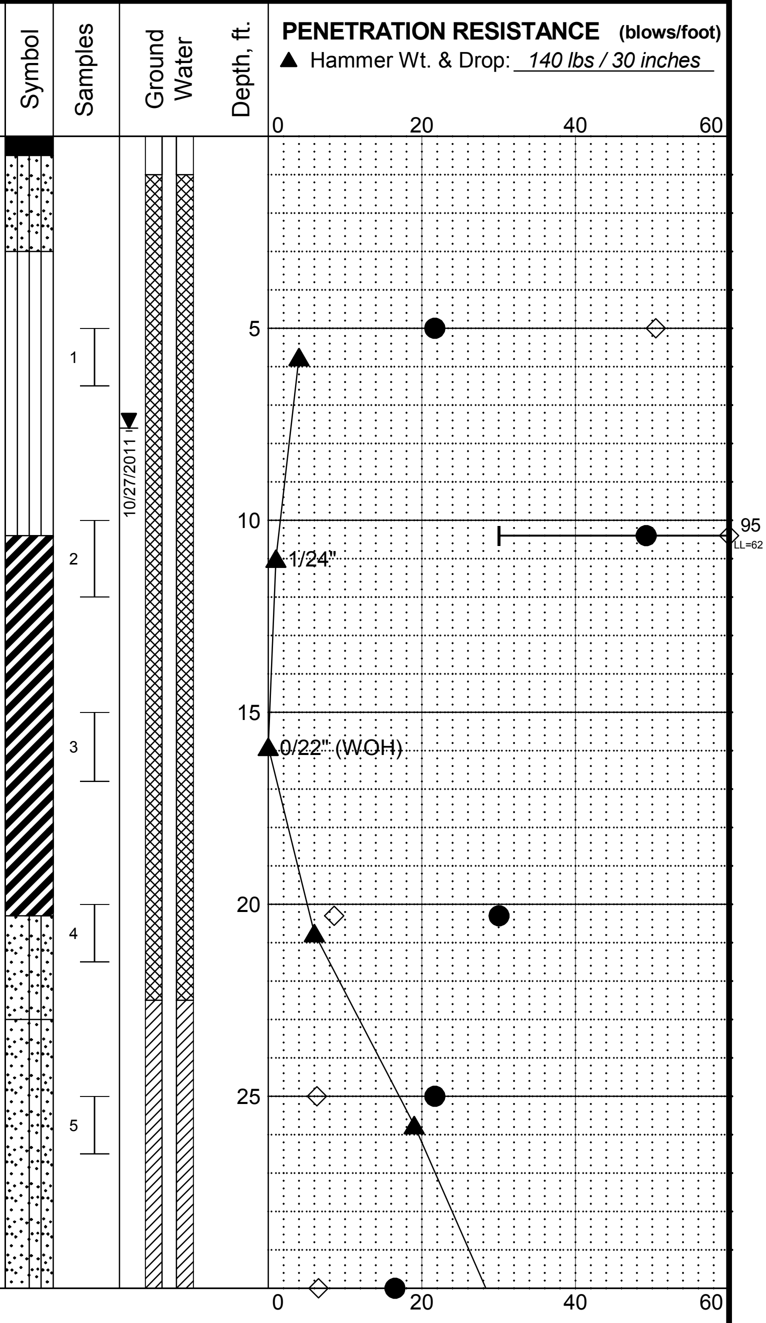
Total Depth:	156.8 ft.	Northing:	~ 215,949 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	6 in.
Top Elevation:	~ 18 ft.	Easting:	~ 1,270,704 ft.	Drilling Company:	Gregory	Rod Diam.:	NWJ 2-5/8"
Vert. Datum:		Station:	~	Drill Rig Equipment:	CME 75 Truck	Hammer Type:	Automatic
Horiz. Datum:		Offset:	~	Other Comments:	9" HSA to 4 feet		

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.
ASPHALT	0.5
Brown, silty, gravelly, fine to medium SAND; moist; (Hf) SM.	3.0
Very loose to loose, dark brown-gray, fine sandy SILT; wet; (Hf) ML.	10.4
Very soft, black and dark gray, silty CLAY; wet; locally trace of fine to medium sand (10.4 to 11 feet), locally trace of shell fragments, seam of shells at 11 feet; (Hf/He) CH. - With organic seam at base.	20.3
Loose to medium dense, black, slightly silty, slightly gravelly SAND; wet; scattered organics, cinders, coal, and clinker to at least 21 feet; (Hf/Ha) SP-SM.	23.0
Medium dense to dense, dark brown-gray to black, slightly silty, fine to medium and fine SAND; wet; trace of organics and shell fragments; (Ha) SP-SM. - Possible pumice at 25 to 25.5 feet and woody seams at 25.5 to 30 feet.	

CONTINUED NEXT SHEET



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

*	Sample Not Recovered
⌶	Standard Penetration Test
▦	Piezometer Screen and Sand Filter
▧	Bentonite-Cement Grout
▩	Bentonite Chips/Pellets
▨	Bentonite Grout
▼	Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

U.S. Geological Survey
John Stanford Center Liquefaction Array
Seattle, Washington

LOG OF BORING P-5

May 2018

21-1-21441-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-6
Sheet 1 of 6

REV 3

Log: PVH Rev: PHZ Typ: CLP

Total Depth: 156.8 ft.
Top Elevation: ~ 18 ft.
Vert. Datum:
Horiz. Datum:

Northing: ~ 215,949 ft.
Easting: ~ 1,270,704 ft.
Station: ~
Offset: ~

Drilling Method: Mud Rotary
Drilling Company: Gregory
Drill Rig Equipment: CME 75 Truck
Other Comments: 9" HSA to 4 feet

Hole Diam.: 6 in.
Rod Diam.: NWJ 2-5/8"
Hammer Type: Automatic

SOIL DESCRIPTION

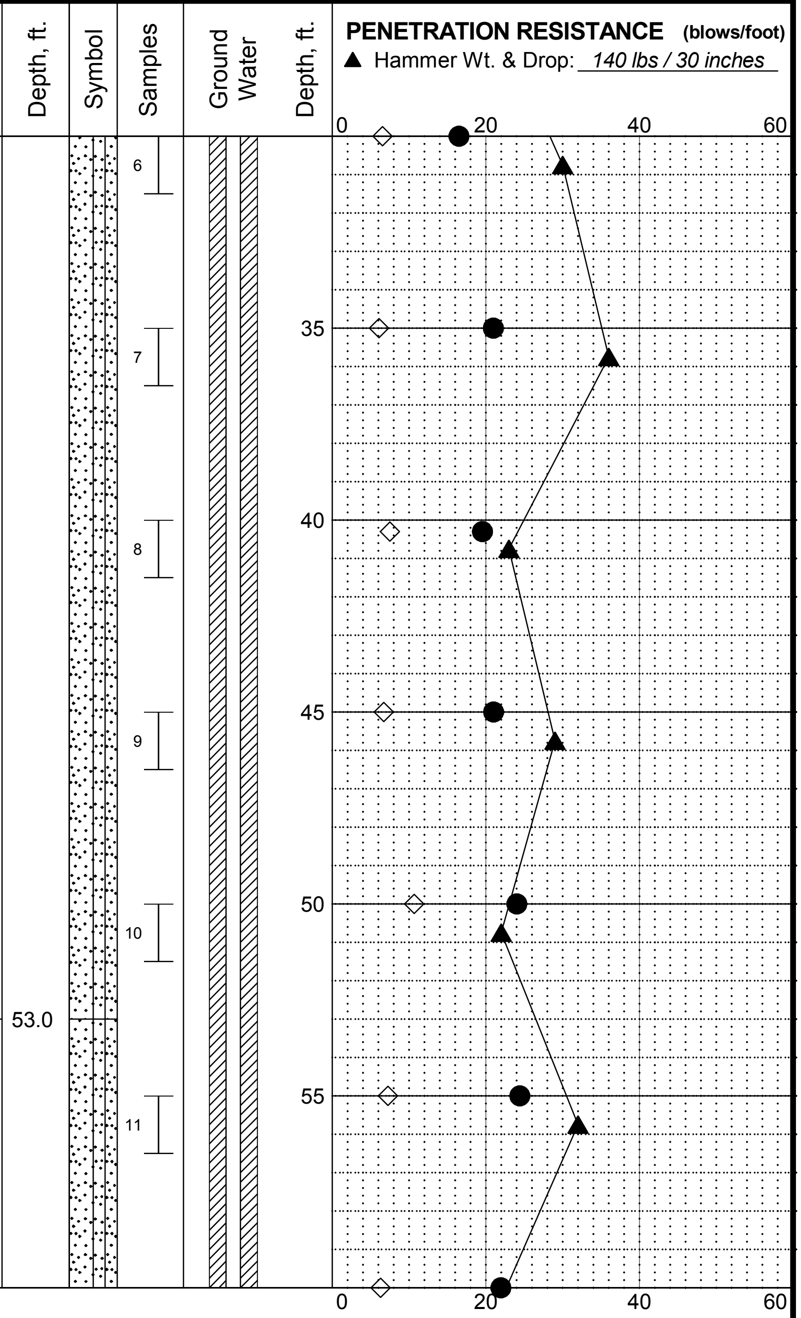
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

- Scattered silty organic seams below 35.5 feet.
- Sand is more fine-grained below 38 feet.
- Layer of wood fragments and twigs at 40.0 to 40.3 feet.
- Scattered silt seams below 50 feet.

53.0

Medium dense to dense, black, slightly silty, fine to medium SAND; wet; 1/2-inch organic layer at 55.1 feet; (Ha) SP-SM.

CONTINUED NEXT SHEET



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
⌶ Standard Penetration Test

▦ Piezometer Screen and Sand Filter
▧ Bentonite-Cement Grout
▩ Bentonite Chips/Pellets
▨ Bentonite Grout
▼ Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

U.S. Geological Survey
John Stanford Center Liquefaction Array
Seattle, Washington

LOG OF BORING P-5

May 2018 21-1-21441-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-6
Sheet 2 of 6

REV 3

Total Depth: 156.8 ft.
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Vert. Datum:
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Drilling Company: Gregory
Drill Rig Equipment: CME 75 Truck
Other Comments: 9" HSA to 4 feet
Hole Diam.: 6 in.
Rod Diam.: NWJ 2-5/8"
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Medium dense, dark brown-gray, silty, fine SAND to fine sandy SILT; wet; scattered organics; (Ha/He) SM/ML.

Medium dense, black and dark brown-gray, slightly silty to silty, fine SAND; wet; trace to scattered organics; (Ha) SP-SM/SM.

- Interbedded with layers of silt below 70 feet.

Interbedded dark gray-brown, very loose to loose, slightly fine sandy to fine sandy SILT, trace of clay, and loose to medium dense, dark brown-gray to black, slightly silty to silty, fine SAND; wet; scattered organic seams, scattered pumice, locally trace of clay, approximately 10-degree bedding; (He/Ha) ML/SM/SP-SM.

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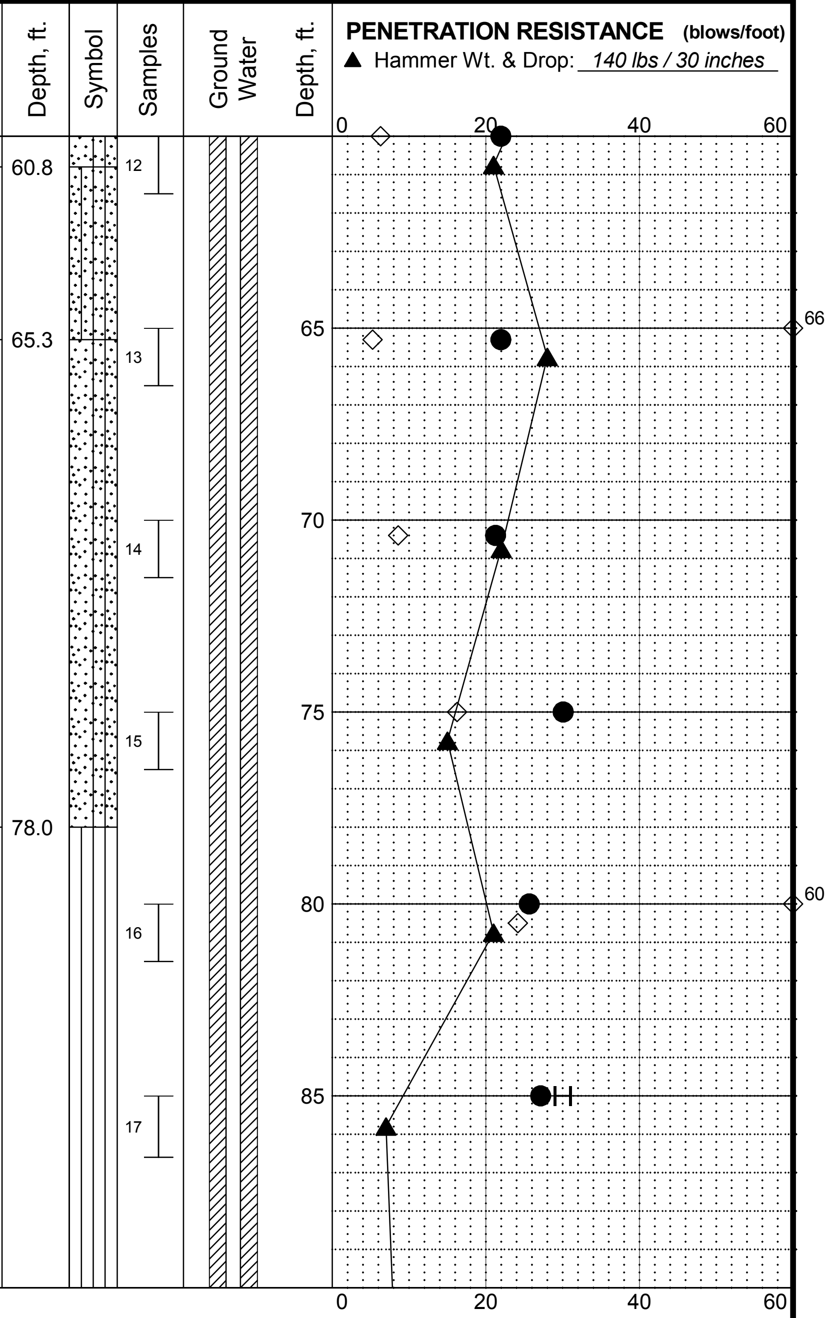

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
⌶ Standard Penetration Test
▦ Piezometer Screen and Sand Filter
▧ Bentonite-Cement Grout
▩ Bentonite Chips/Pellets
▨ Bentonite Grout
▼ Ground Water Level in Well

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SHANNON & WILSON, INC.
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FIG. A-6
Sheet 3 of 6

REV 3

Total Depth: 156.8 ft.
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Northing: ~ 215,949 ft.
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Drilling Company: Gregory
Drill Rig Equipment: CME 75 Truck
Other Comments: 9" HSA to 4 feet
Hole Diam.: 6 in.
Rod Diam.: NWJ 2-5/8"
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Depth, ft.	
90.6	Loose to medium dense, interbedded dark brown-gray, silty, and black, slightly silty, fine SAND; wet; trace to scattered organics, approximately 10-degree bedding; (Ha) SM/SP-SM.
98.0	Loose, dark brown-gray, interbedded slightly fine sandy SILT, trace of clay, and slightly silty to silty, fine SAND; wet; trace of shell fragments; (He/Ha) ML/SM/SP-SM.
101.0	Medium dense, black to dark brown-gray, interbedded trace of silt to silty, fine SAND; wet; trace to scattered organics; (Ha) SM/SP. - With scattered 1-inch layers of slightly sandy, clayey SILT at 105.2 to 110.8 feet (10-degree bedding).

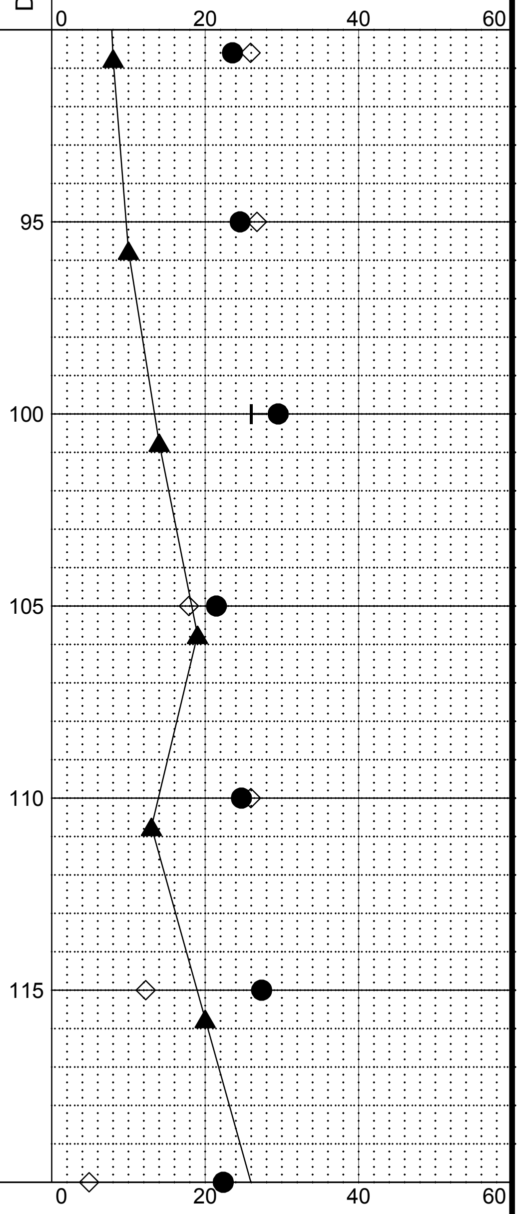
Symbol | Samples | Ground Water | Depth, ft.

18
19
20
21
22
23

CONTINUED NEXT SHEET

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: 140 lbs / 30 inches



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
⌶ Standard Penetration Test
⊡ Piezometer Screen and Sand Filter
▧ Bentonite-Cement Grout
⊠ Bentonite Chips/Pellets
▨ Bentonite Grout
▼ Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

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LOG OF BORING P-5

May 2018
21-1-21441-001

SHANNON & WILSON, INC.
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FIG. A-6
Sheet 4 of 6

REV 3

Log: PVH Rev: PHZ Typ: CLP

MASTER_LOG_E 21-21441.GPJ SHAN_WIL.GDT 5/3/18

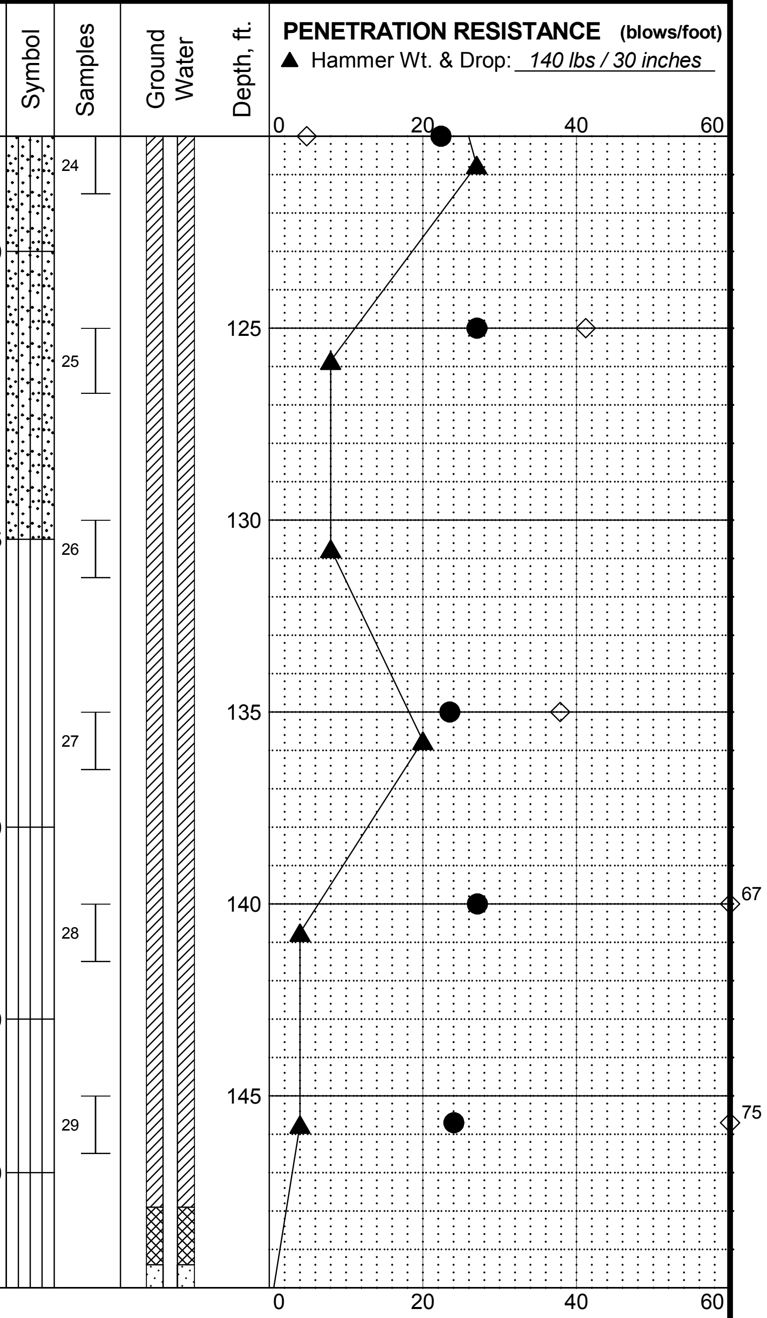
Total Depth: 156.8 ft.
Top Elevation: ~ 18 ft.
Vert. Datum:
Horiz. Datum:
Northing: ~ 215,949 ft.
Easting: ~ 1,270,704 ft.
Station: ~
Offset: ~
Drilling Method: Mud Rotary
Drilling Company: Gregory
Drill Rig Equipment: CME 75 Truck
Other Comments: 9" HSA to 4 feet
Hole Diam.: 6 in.
Rod Diam.: NWJ 2-5/8"
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Depth, ft.	Soil Description
123.0	Loose, black to dark brown-gray, silty, fine SAND; wet; scattered organics; (Ha) SM.
130.5	Loose to medium dense, dark brown-gray, interbedded fine sandy SILT, trace of clay, and silty, fine SAND; wet; scattered organics, scattered pumice within scattered 1/2-inch black sand layers; (He/Ha) ML.
138.0	Soft, dark brown-gray, clayey SILT; wet; scattered sand layers; (He) ML.
143.0	Very loose, dark brown-gray, interbedded sightly fine sandy SILT, trace of clay, and silty, fine SAND; wet; scattered organics and shell fragments; (He/Ha) ML/SM.
147.0	Very soft, dark brown-gray and black, clayey SILT, trace of fine sand; wet; trace of shell fragments and organics; (He) ML.

CONTINUED NEXT SHEET



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

*	Sample Not Recovered
⌶	Standard Penetration Test
⊡	Piezometer Screen and Sand Filter
▧	Bentonite-Cement Grout
⊠	Bentonite Chips/Pellets
▨	Bentonite Grout
▼	Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

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Seattle, Washington

LOG OF BORING P-5

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21-1-21441-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-6
Sheet 5 of 6

REV 3

Total Depth: 156.8 ft.
Top Elevation: ~ 18 ft.
Vert. Datum:
Horiz. Datum:

Northing: ~ 215,949 ft.
Easting: ~ 1,270,704 ft.
Station: ~
Offset: ~

Drilling Method: Mud Rotary
Drilling Company: Gregory
Drill Rig Equipment: CME 75 Truck
Other Comments: 9" HSA to 4 feet

Hole Diam.: 6 in.
Rod Diam.: NWJ 2-5/8"
Hammer Type: Automatic

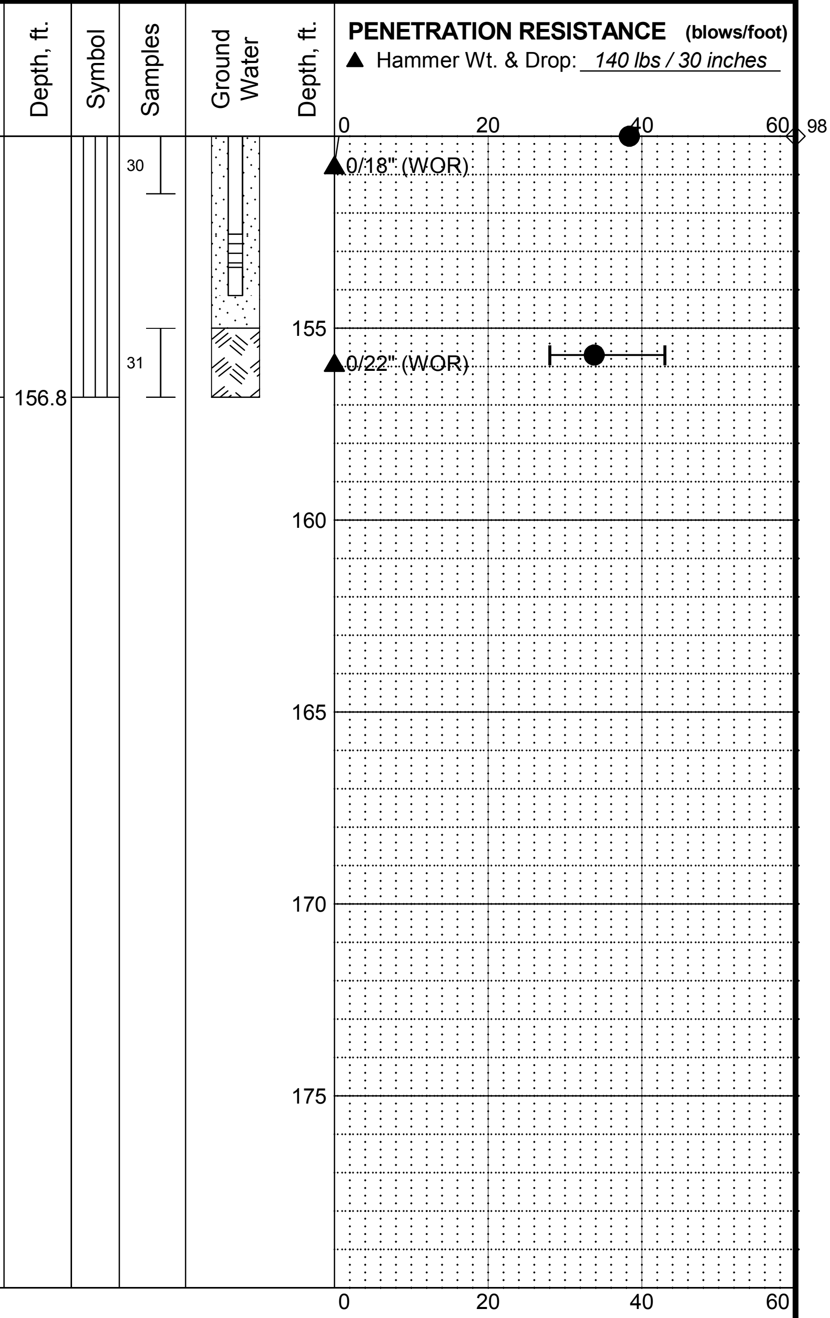
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

BOTTOM OF BORING
COMPLETED 12/16/2010

Note:

1. Topped off grout seal on 12/17/2010.



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit |—●—| Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
⌶ Standard Penetration Test

▨ Piezometer Screen and Sand Filter
▧ Bentonite-Cement Grout
⊠ Bentonite Chips/Pellets
▨ Bentonite Grout
▼ Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

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John Stanford Center Liquefaction Array
Seattle, Washington

LOG OF BORING P-5

May 2018 21-1-21441-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-6
Sheet 6 of 6

REV 3

Total Depth: 180.5 ft.
Top Elevation: ~ 18 ft.
Vert. Datum:
Horiz. Datum:

Northing: ~ 215,960 ft.
Easting: ~ 1,270,708 ft.
Station: ~
Offset: ~

Drilling Method: Mud Rotary
Drilling Company: Gregory
Drill Rig Equipment: CME 75 Truck
Other Comments: 9" HSA to 4 feet

Hole Diam.: 6 in.
Rod Diam.: NWJ 2-5/8"
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

ASPHALT

Brown, silty, sandy GRAVEL; moist; railroad ballast; (Hf) GM.

See logs of nearby borings P-4, P-5, S-2, and S-3 for soil descriptions above 169.5 feet.

- Top of sand at approximately 17 feet, based on drill action.

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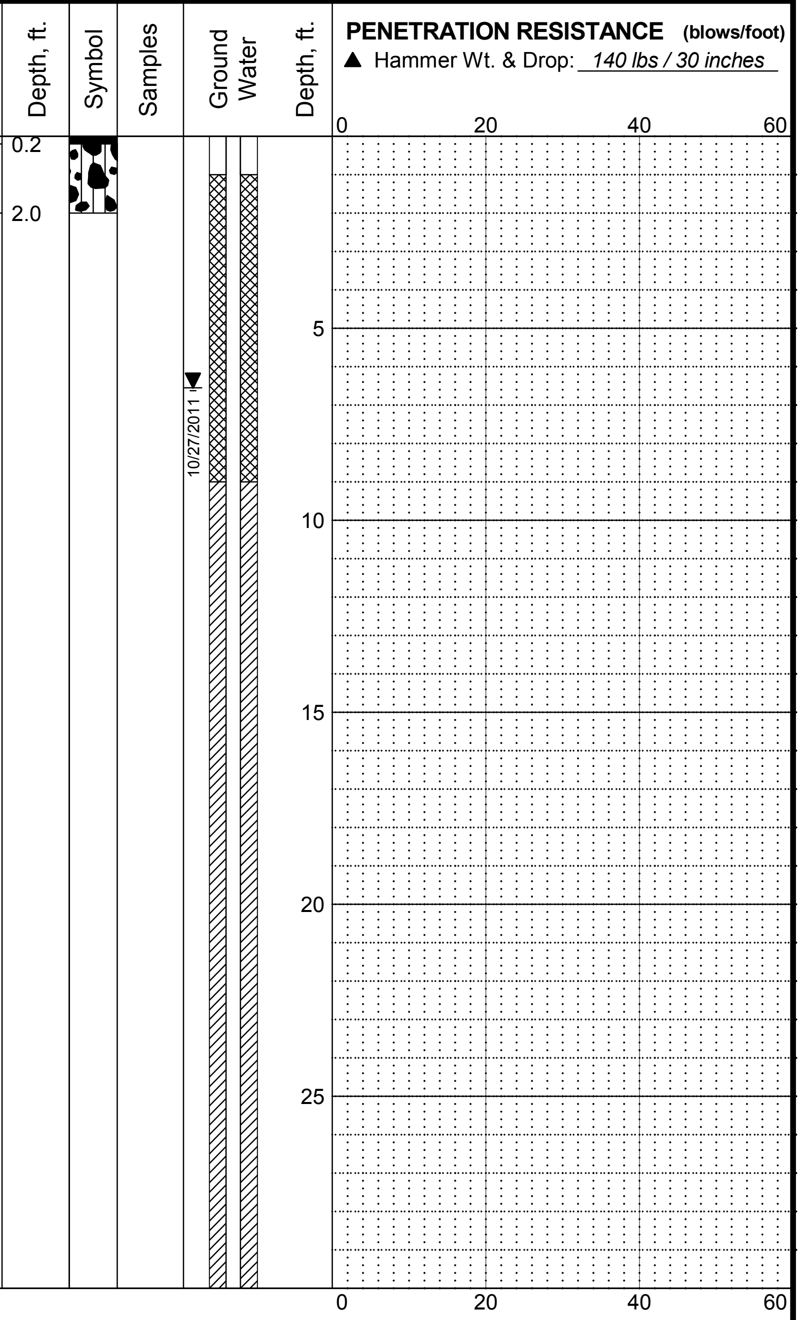

LEGEND

* Sample Not Recovered
⌶ Standard Penetration Test
⬚ Piezometer Screen and Sand Filter
▧ Bentonite-Cement Grout
⊠ Bentonite Chips/Pellets
▨ Bentonite Grout
▼ Ground Water Level in Well

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

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Seattle, Washington

LOG OF BORING P-6

May 2018 21-1-21441-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-7
Sheet 1 of 7

REV 3

Log: PVH Rev: PHZ Typ: CLP

MASTER_LOG_E 21-21441.GPJ SHAN_WIL.GDT 5/3/18

Total Depth: 180.5 ft.
Top Elevation: ~ 18 ft.
Vert. Datum:
Horiz. Datum:

Northing: ~ 215,960 ft.
Easting: ~ 1,270,708 ft.
Station: ~
Offset: ~

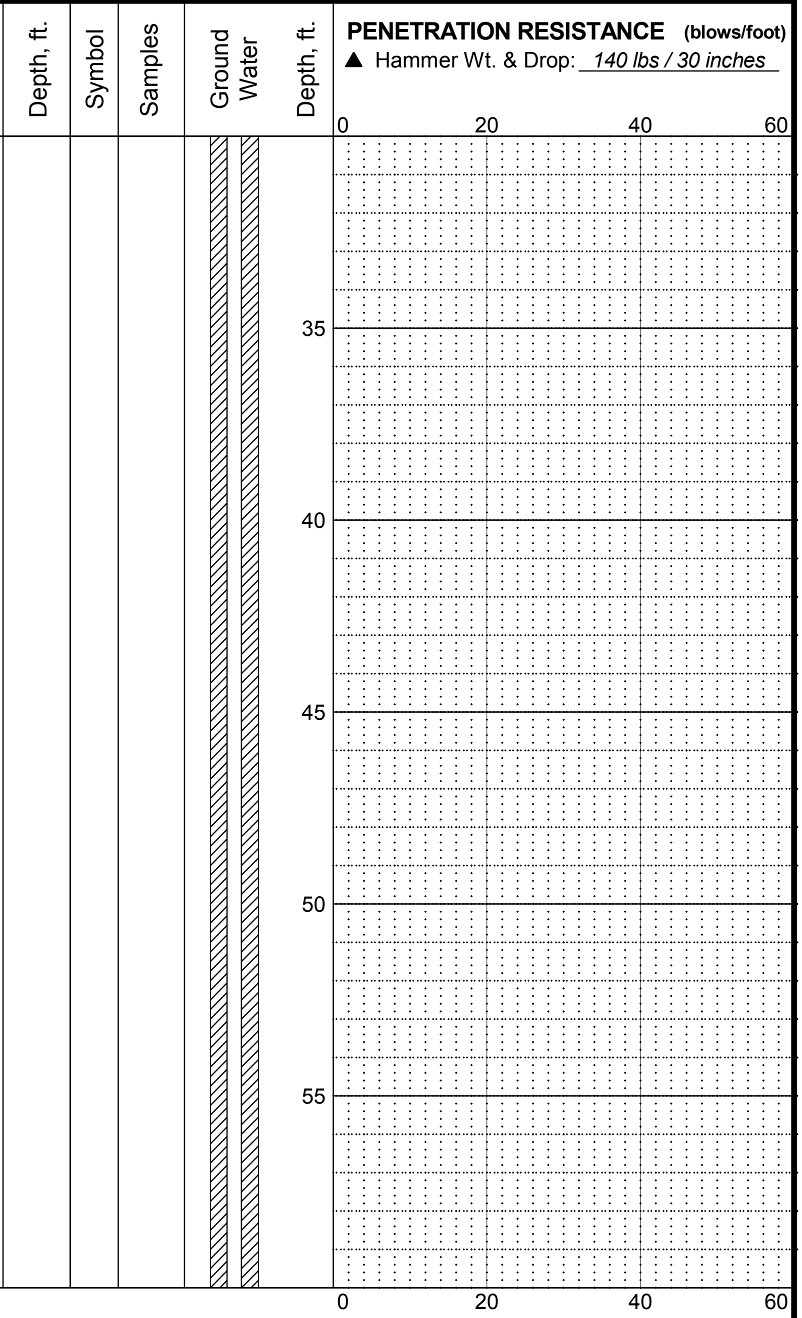
Drilling Method: Mud Rotary
Drilling Company: Gregory
Drill Rig Equipment: CME 75 Truck
Other Comments: 9" HSA to 4 feet

Hole Diam.: 6 in.
Rod Diam.: NWJ 2-5/8"
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

CONTINUED NEXT SHEET



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├──●──┤ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
⌶ Standard Penetration Test

▤ Piezometer Screen and Sand Filter
▧ Bentonite-Cement Grout
⊠ Bentonite Chips/Pellets
▨ Bentonite Grout
▼ Ground Water Level in Well

NOTES

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John Stanford Center Liquefaction Array
Seattle, Washington

LOG OF BORING P-6

May 2018 21-1-21441-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-7
Sheet 2 of 7

REV 3

Total Depth: 180.5 ft.
Top Elevation: ~ 18 ft.
Vert. Datum:
Horiz. Datum:
Northing: ~ 215,960 ft.
Easting: ~ 1,270,708 ft.
Station: ~
Offset: ~
Drilling Method: *Mud Rotary*
Drilling Company: *Gregory*
Drill Rig Equipment: *CME 75 Truck*
Other Comments: *9" HSA to 4 feet*
Hole Diam.: *6 in.*
Rod Diam.: *NWJ 2-5/8"*
Hammer Type: *Automatic*

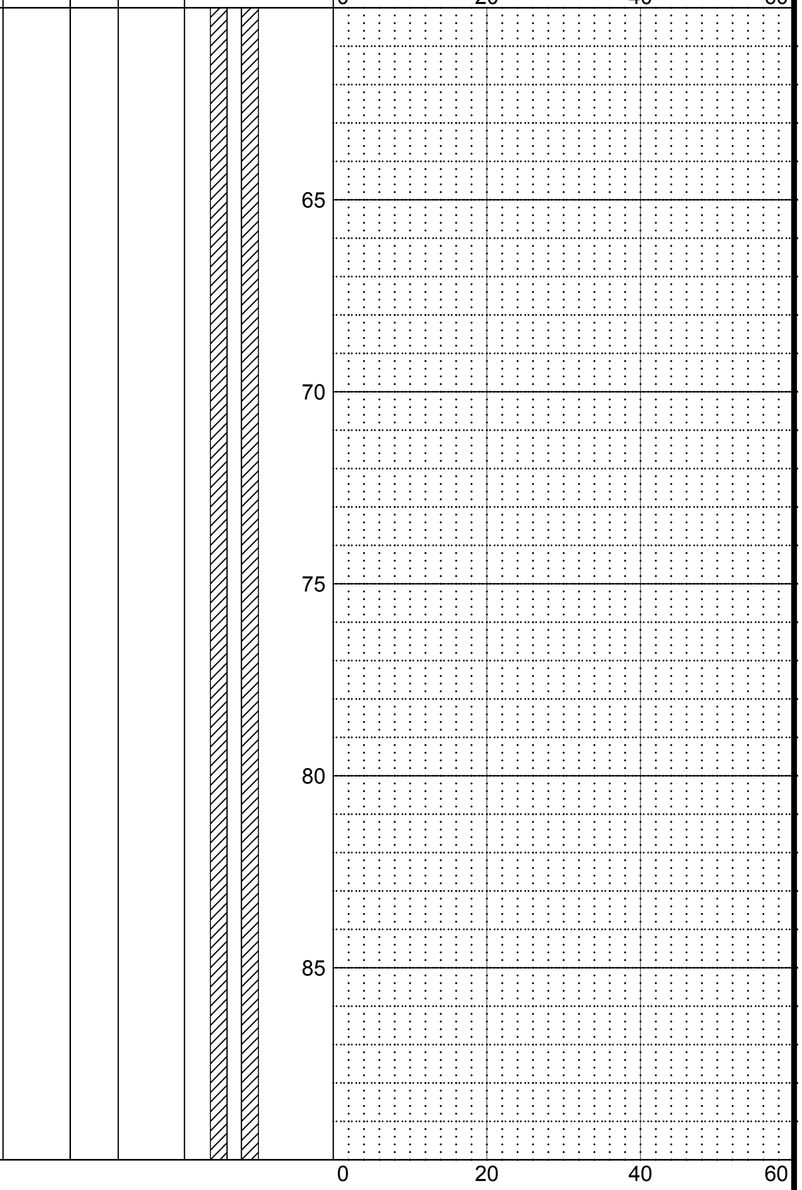
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Depth, ft. | Symbol | Samples | Ground Water | Depth, ft.

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
⌶ Standard Penetration Test
⊡ Piezometer Screen and Sand Filter
▧ Bentonite-Cement Grout
⊠ Bentonite Chips/Pellets
▨ Bentonite Grout
▼ Ground Water Level in Well

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit |—●—| Liquid Limit
Natural Water Content

NOTES

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LOG OF BORING P-6

May 2018
21-1-21441-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-7
Sheet 3 of 7

REV 3

MASTER_LOG_E 21-21441.GPJ SHAN_WIL.GDT 5/3/18

Log: PVH Rev: PHZ Typ: CLP

Total Depth: 180.5 ft.
Top Elevation: ~ 18 ft.
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Station: ~
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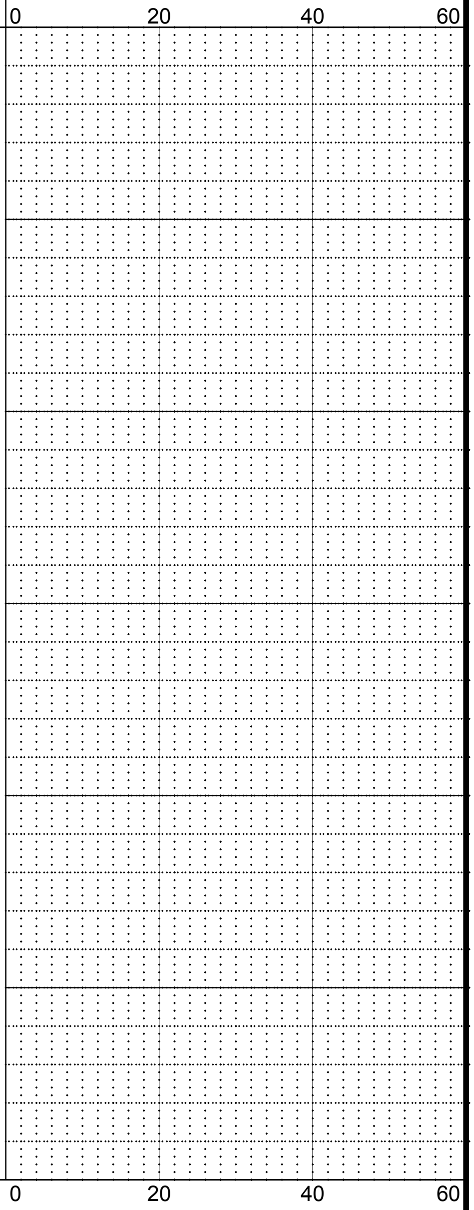
Drilling Method: *Mud Rotary*
Drilling Company: *Gregory*
Drill Rig Equipment: *CME 75 Truck*
Other Comments: *9" HSA to 4 feet*

Hole Diam.: *6 in.*
Rod Diam.: *NWJ 2-5/8"*
Hammer Type: *Automatic*

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.	Symbol	Samples	Ground Water	Depth, ft.	**PENETRATION RESISTANCE** (blows/foot) ▲ Hammer Wt. & Drop: *140 lbs / 30 inches*
				▨	95	
				▨	100	
				▨	105	
				▨	110	
				▨	115	
CONTINUED NEXT SHEET						



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
⌶ Standard Penetration Test

⊡ Piezometer Screen and Sand Filter
▧ Bentonite-Cement Grout
⊠ Bentonite Chips/Pellets
▨ Bentonite Grout
▼ Ground Water Level in Well

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LOG OF BORING P-6

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FIG. A-7
Sheet 4 of 7

REV 3

Total Depth: 180.5 ft.
Top Elevation: ~ 18 ft.
Vert. Datum:
Horiz. Datum:

Northing: ~ 215,960 ft.
Easting: ~ 1,270,708 ft.
Station: ~
Offset: ~

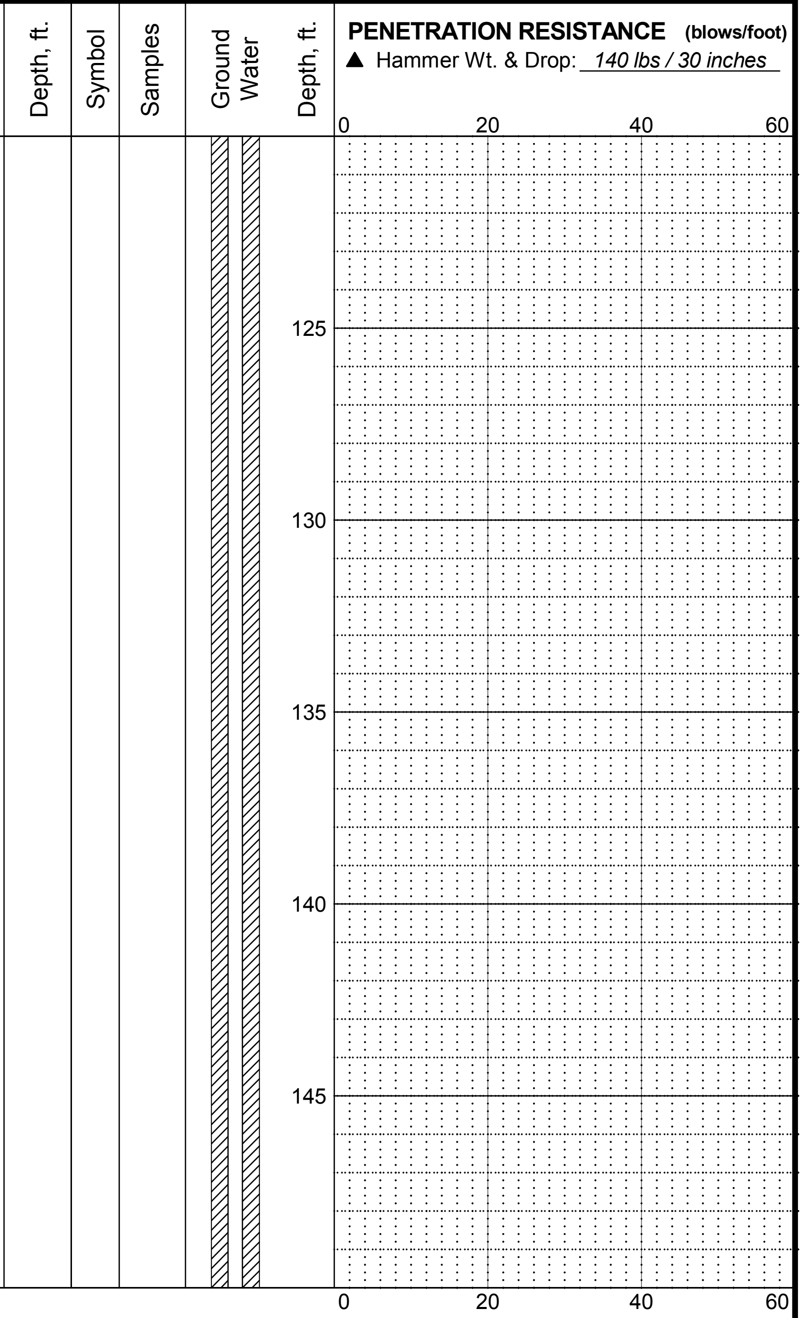
Drilling Method: Mud Rotary
Drilling Company: Gregory
Drill Rig Equipment: CME 75 Truck
Other Comments: 9" HSA to 4 feet

Hole Diam.: 6 in.
Rod Diam.: NWJ 2-5/8"
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

CONTINUED NEXT SHEET



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
⌶ Standard Penetration Test

⊡ Piezometer Screen and Sand Filter
▧ Bentonite-Cement Grout
⊠ Bentonite Chips/Pellets
▨ Bentonite Grout
▼ Ground Water Level in Well

NOTES

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LOG OF BORING P-6

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FIG. A-7
Sheet 5 of 7

REV 3

Total Depth:	180.5 ft.	Northing:	~ 215,960 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	6 in.
Top Elevation:	~ 18 ft.	Easting:	~ 1,270,708 ft.	Drilling Company:	Gregory	Rod Diam.:	NWJ 2-5/8"
Vert. Datum:		Station:	~	Drill Rig Equipment:	CME 75 Truck	Hammer Type:	Automatic
Horiz. Datum:		Offset:	~	Other Comments:	9" HSA to 4 feet		

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

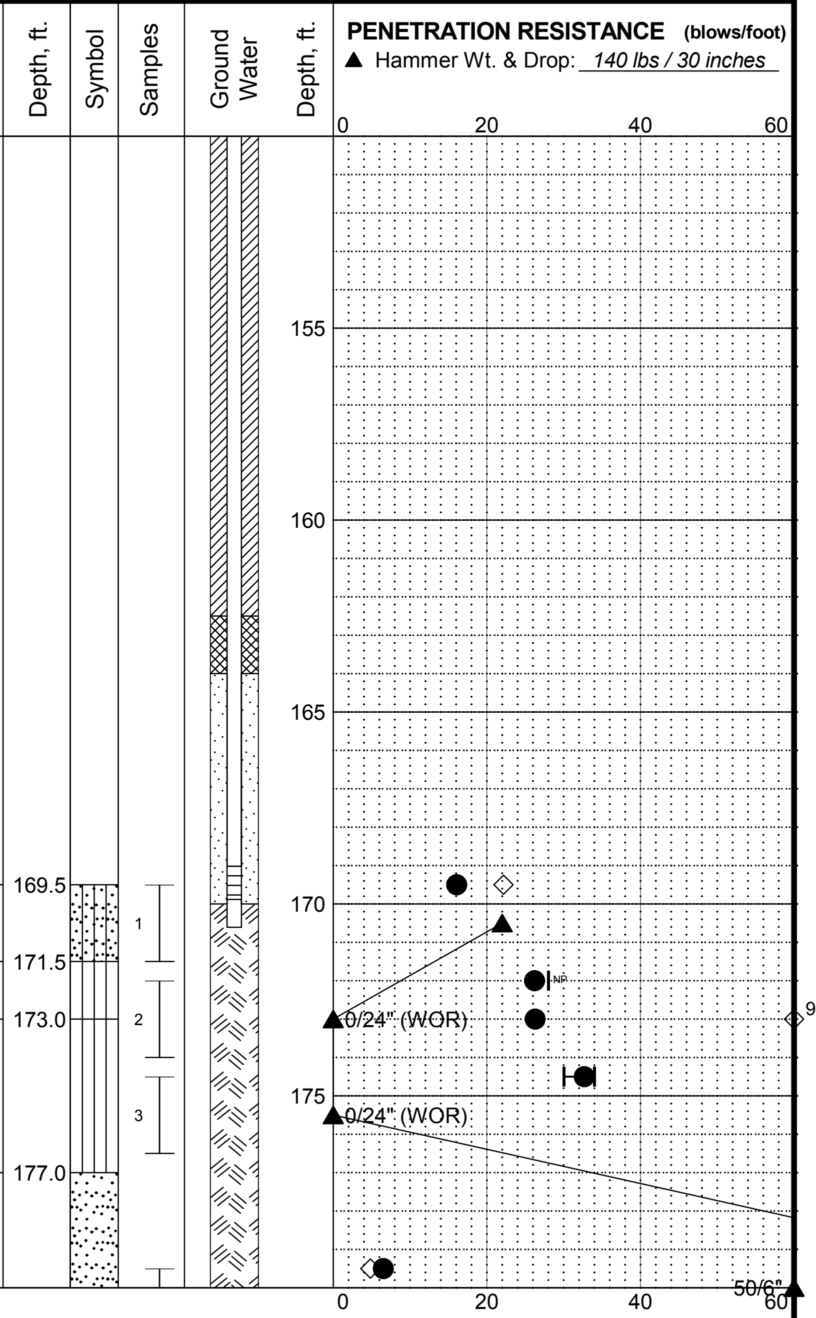
- Drill action very soft below about 156 feet.

- Stiffer drill action starting between about 165 and 168 feet, with clay chunks in cuttings by end of 169.5-foot run.

Medium dense(?), black, silty (169.5 to 170 feet) to slightly silty (170 to 171 feet), fine to medium SAND; wet; interbedded at 171 feet with dark brown-gray, sandy silt, trace of organic seams and shell fragments; (He/Ha) SM/SP-SM.
- Sampler collected at 169.5 feet was overfull and bulging; blow count may not be representative.

Very loose, black SILT, trace of fine sand and clay; wet; trace of shell fragments; (He/Ha) ML.

CONTINUED NEXT SHEET



LEGEND

*	Sample Not Recovered	⊡	Piezometer Screen and Sand Filter
⌶	Standard Penetration Test	▧	Bentonite-Cement Grout
		☒	Bentonite Chips/Pellets
		▨	Bentonite Grout
		▼	Ground Water Level in Well

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit

Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
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LOG OF BORING P-6

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SHANNON & WILSON, INC.
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FIG. A-7
Sheet 6 of 7

REV 3

Log: PVH Rev: PHZ Typ: CLP

MASTER_LOG_E 21-21441.GPJ SHAN WIL.GDT 5/3/18

Total Depth:	180.5 ft.	Northing:	~ 215,960 ft.	Drilling Method:	Mud Rotary
Top Elevation:	~ 18 ft.	Easting:	~ 1,270,708 ft.	Drilling Company:	Gregory
Vert. Datum:		Station:	~	Drill Rig Equipment:	CME 75 Truck
Horiz. Datum:		Offset:	~	Other Comments:	9" HSA to 4 feet

Hole Diam.: 6 in.
Rod Diam.: NWJ 2-5/8"
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

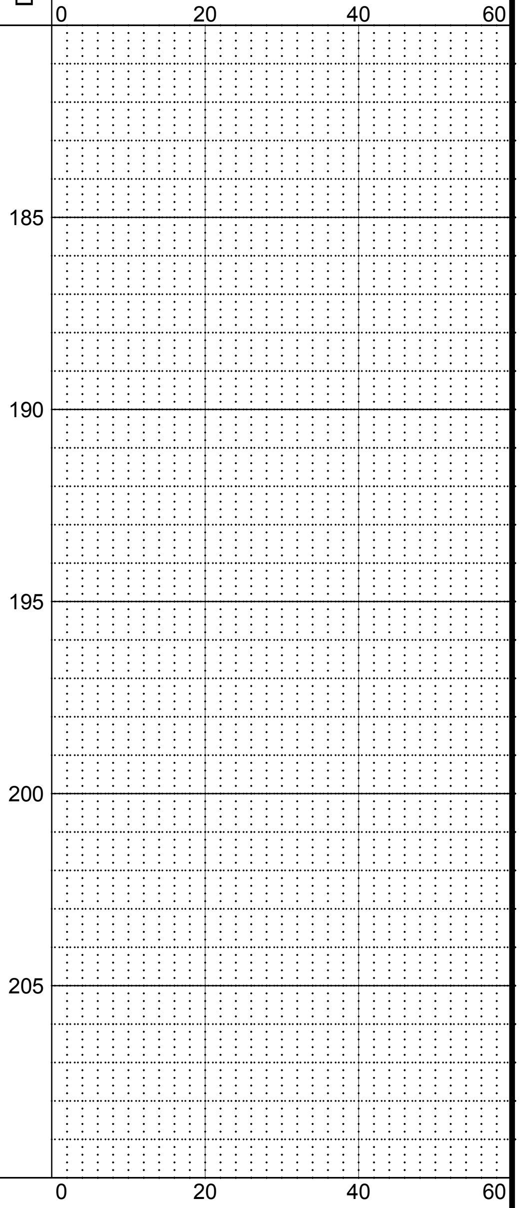
Depth, ft. | Symbol | Samples | Ground Water | Depth, ft.

PENETRATION RESISTANCE (blows/foot)
▲ Hammer Wt. & Drop: 140 lbs / 30 inches

Soil Description	Depth, ft.	Samples
Very soft, dark gray, slightly clayey SILT, trace of fine sand; wet; trace of shell fragments; (He) ML.	180.5	4 ⌶
Very dense, green-gray, gravelly SAND, trace of silt; wet; (Qpgo) SP.		

BOTTOM OF BORING
COMPLETED 12/20/2010

Note:
1. Contacts above the sampling zone were estimated based on adjacent borings, cuttings, and drill action.



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
⌶ Standard Penetration Test

▦ Piezometer Screen and Sand Filter
▧ Bentonite-Cement Grout
⊠ Bentonite Chips/Pellets
▨ Bentonite Grout
▼ Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

U.S. Geological Survey
John Stanford Center Liquefaction Array
Seattle, Washington

LOG OF BORING P-6

May 2018 21-1-21441-001

SHANNON & WILSON, INC.
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FIG. A-7
Sheet 7 of 7

REV 3

Log: PVH Rev: PHZ Typ: CLP

MASTER_LOG_E 21-21441.GPJ SHAN_WIL.GDT 5/3/18

Total Depth: 20.5 ft.
Top Elevation: ~ 18 ft.
Vert. Datum:
Horiz. Datum:

Northing: ~ 215,886 ft.
Easting: ~ 1,270,688 ft.
Station: ~
Offset: ~

Drilling Method: Mud Rotary
Drilling Company: Gregory
Drill Rig Equipment: CME 75 Truck
Other Comments: 9" HSA to 4 feet

Hole Diam.: 6.25 in.
Rod Diam.: NWJ 2-5/8"
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

ASPHALT

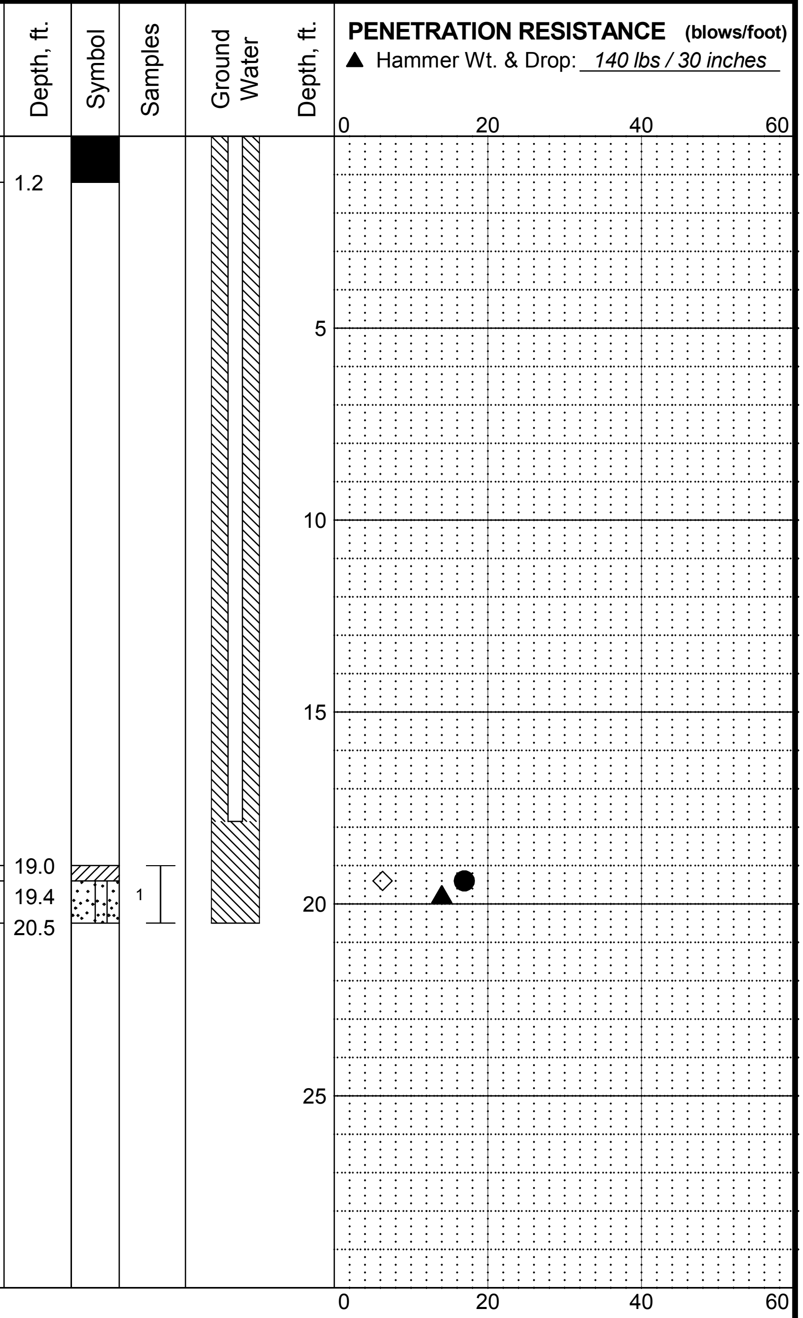
See logs of nearby borings P-1 and S-3 for soil descriptions above 19 feet.

Dark gray, silty CLAY; wet; (Hf/He) CL/CH.

Medium dense, black, slightly silty, fine to medium SAND; wet; (Ha/Hf) SP-SM.

BOTTOM OF BORING
COMPLETED 12/4/2010

Note:
1. Contacts above the sampling zone were estimated based on adjacent borings, cuttings, and drill action.



◇ % Fines (<0.075mm)
● % Water Content

LEGEND

* Sample Not Recovered
⌶ Standard Penetration Test

▦ Piezometer Screen and Sand Filter
▧ Bentonite-Cement Grout
▩ Bentonite Chips/Pellets
▨ Bentonite Grout
▼ Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

U.S. Geological Survey
John Stanford Center Liquefaction Array
Seattle, Washington

LOG OF BORING S-1

May 2018 21-1-21441-001

SHANNON & WILSON, INC.
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FIG. A-8

REV 3

Log: PVH Rev: PHZ Typ: CLP

Total Depth: 155 ft.
Top Elevation: ~ 18 ft.
Vert. Datum:
Horiz. Datum:
Northing: ~ 215,929 ft.
Easting: ~ 1,270,699 ft.
Station: ~
Offset: ~
Drilling Method: Mud Rotary
Drilling Company: Gregory
Drill Rig Equipment: CME 75 Truck
Other Comments: 9" HSA to 4 feet
Hole Diam.: 8 in.
Rod Diam.: NWJ 2-5/8"
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.
ASPHALT	0.5
Brown, silty, gravelly SAND; moist; (Hf) SM.	3.5
See logs of nearby borings P-4, P-5, and S-3 for soil descriptions above 140 feet. - SAND below approximately 18 feet, based on drill action.	

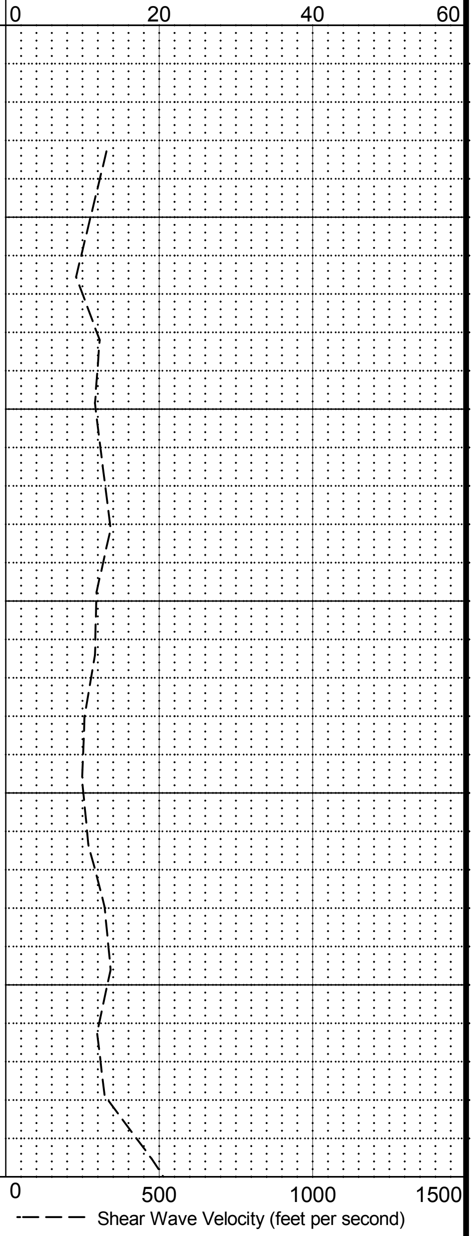
CONTINUED NEXT SHEET

Symbol | Samples | Ground Water | Depth, ft.

During Drilling ∇

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: 140 lbs / 30 inches



– – – Shear Wave Velocity (feet per second)

◇ % Fines (<0.075mm)
● % Water Content (use scale at top)
Plastic Limit ├──●──┤ Liquid Limit

LEGEND

* Sample Not Recovered
⌶ Standard Penetration Test
Piezometer Screen and Sand Filter
▧ Bentonite-Cement Grout
⊠ Bentonite Chips/Pellets
▨ Bentonite Grout
∇ Ground Water Level ATD
▼ Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

U.S. Geological Survey
John Stanford Center Liquefaction Array
Seattle, Washington

LOG OF BORING S-2

May 2018 21-1-21441-001

SHANNON & WILSON, INC.
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FIG. A-9
Sheet 1 of 6

REV 3

Log: PVH Rev: PHZ Typ: CLP

MASTER_LOG_E 21-21441.GPJ SHAN_WIL.GDT 5/3/18

Total Depth: 155 ft.
Top Elevation: ~ 18 ft.
Vert. Datum:
Horiz. Datum:

Northing: ~ 215,929 ft.
Easting: ~ 1,270,699 ft.
Station: ~
Offset: ~

Drilling Method: Mud Rotary
Drilling Company: Gregory
Drill Rig Equipment: CME 75 Truck
Other Comments: 9" HSA to 4 feet

Hole Diam.: 8 in.
Rod Diam.: NWJ 2-5/8"
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Depth, ft.

Symbol

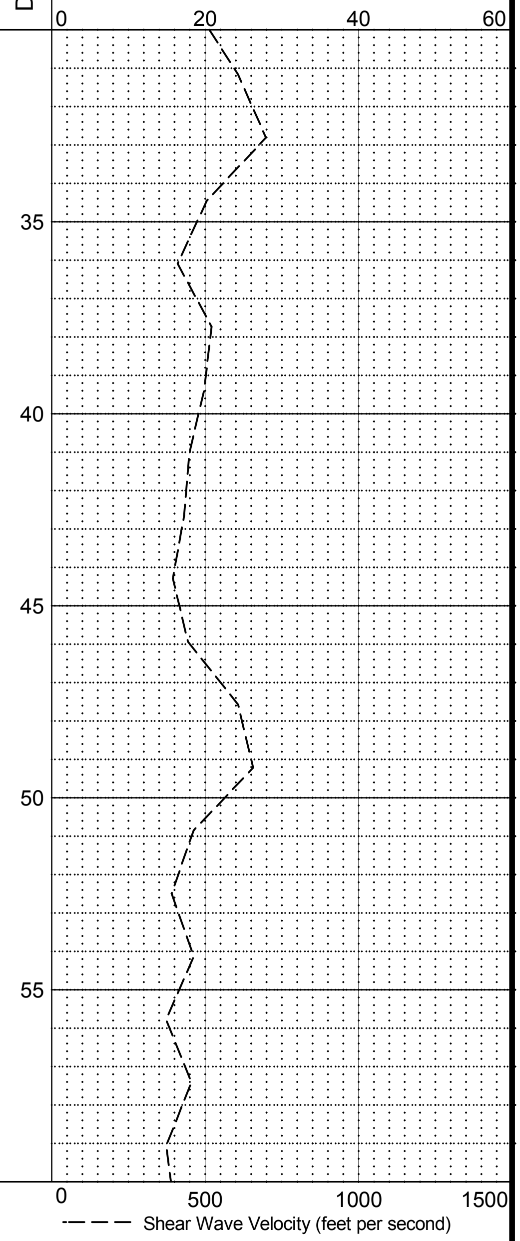
Samples

Ground Water

Depth, ft.

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: 140 lbs / 30 inches



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered

⌶ Standard Penetration Test

▦ Piezometer Screen and Sand Filter

▧ Bentonite-Cement Grout

⊠ Bentonite Chips/Pellets

▨ Bentonite Grout

▽ Ground Water Level ATD

▼ Ground Water Level in Well

◇ % Fines (<0.075mm)

● % Water Content ←(use scale at top)

Plastic Limit ├─●─┤ Liquid Limit

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

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Seattle, Washington

LOG OF BORING S-2

May 2018 21-1-21441-001

SHANNON & WILSON, INC.
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FIG. A-9
Sheet 2 of 6

REV 3

Log: PVH Rev: PHZ Typ: CLP

MASTER_LOG_E 21-21441.GPJ SHAN_WIL.GDT 5/3/18

Total Depth: 155 ft.
Top Elevation: ~ 18 ft.
Vert. Datum:
Horiz. Datum:

Northing: ~ 215,929 ft.
Easting: ~ 1,270,699 ft.
Station: ~
Offset: ~

Drilling Method: Mud Rotary
Drilling Company: Gregory
Drill Rig Equipment: CME 75 Truck
Other Comments: 9" HSA to 4 feet

Hole Diam.: 8 in.
Rod Diam.: NWJ 2-5/8"
Hammer Type: Automatic

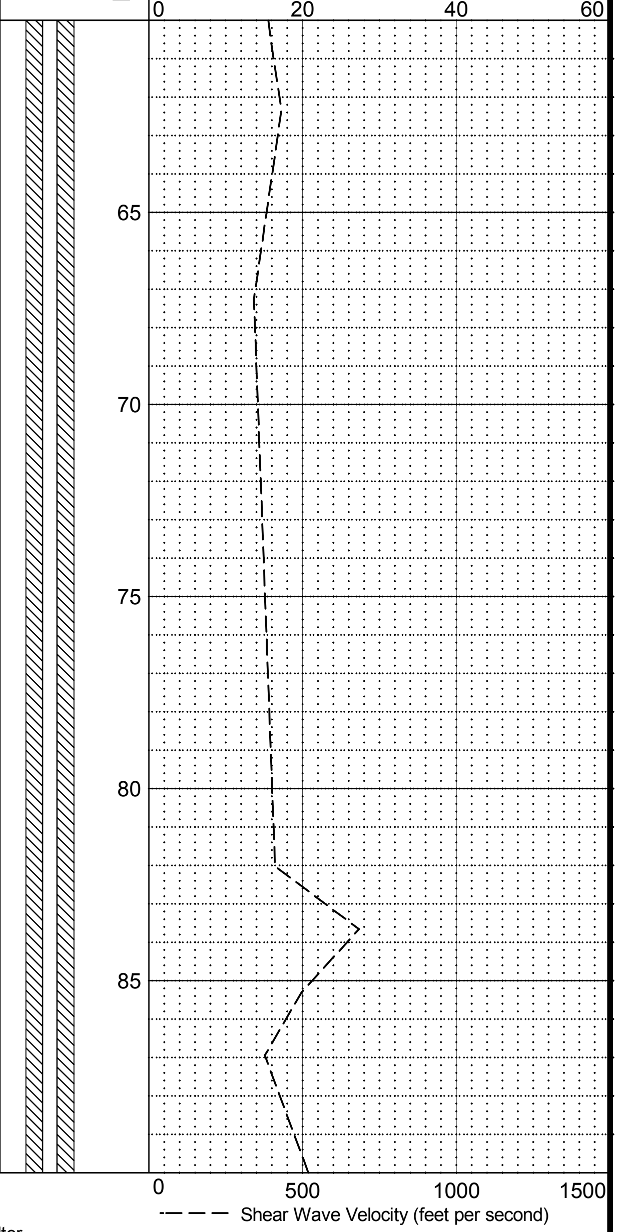
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Depth, ft. | Symbol | Samples | Ground Water | Depth, ft.

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: 140 lbs / 30 inches



CONTINUED NEXT SHEET

— — — Shear Wave Velocity (feet per second)

◇ % Fines (<0.075mm)

● % Water Content ←(use scale at top)

Plastic Limit ├──●──┤ Liquid Limit

LEGEND

* Sample Not Recovered

⌶ Standard Penetration Test

Piezometer Screen and Sand Filter

▧ Bentonite-Cement Grout

⊠ Bentonite Chips/Pellets

▨ Bentonite Grout

▽ Ground Water Level ATD

▼ Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

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Seattle, Washington

LOG OF BORING S-2

May 2018 21-1-21441-001

SHANNON & WILSON, INC.
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FIG. A-9
Sheet 3 of 6

REV 3

Total Depth:	155 ft.	Northing:	~ 215,929 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	8 in.
Top Elevation:	~ 18 ft.	Easting:	~ 1,270,699 ft.	Drilling Company:	Gregory	Rod Diam.:	NWJ 2-5/8"
Vert. Datum:		Station:	~	Drill Rig Equipment:	CME 75 Truck	Hammer Type:	Automatic
Horiz. Datum:		Offset:	~	Other Comments:	9" HSA to 4 feet		

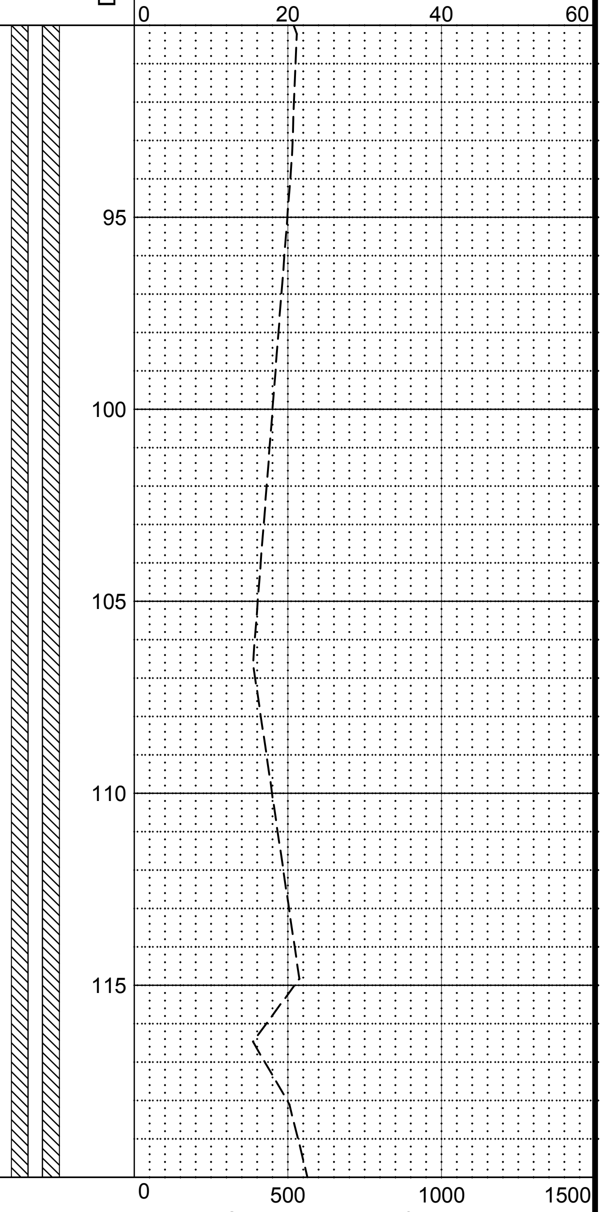
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Depth, ft. | Symbol | Samples | Ground Water | Depth, ft.

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



CONTINUED NEXT SHEET

— — — Shear Wave Velocity (feet per second)

◇ % Fines (<0.075mm)

● % Water Content *(use scale at top)*

Plastic Limit ├──●──┤ Liquid Limit

LEGEND

- * Sample Not Recovered
- ⌶ Standard Penetration Test
- ⊡ Piezometer Screen and Sand Filter
- ▧ Bentonite-Cement Grout
- ⊠ Bentonite Chips/Pellets
- ▨ Bentonite Grout
- ∇ Ground Water Level ATD
- ▼ Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

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Seattle, Washington

LOG OF BORING S-2

May 2018 21-1-21441-001

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FIG. A-9
Sheet 4 of 6

REV 3

Log: PVH Rev: PHZ Typ: CLP

MASTER_LOG_E 21-21441.GPJ SHAN_WIL.GDT 5/3/18

Total Depth: 155 ft.
Top Elevation: ~ 18 ft.
Vert. Datum:
Horiz. Datum:

Northing: ~ 215,929 ft.
Easting: ~ 1,270,699 ft.
Station: ~
Offset: ~

Drilling Method: Mud Rotary
Drilling Company: Gregory
Drill Rig Equipment: CME 75 Truck
Other Comments: 9" HSA to 4 feet

Hole Diam.: 8 in.
Rod Diam.: NWJ 2-5/8"
Hammer Type: Automatic

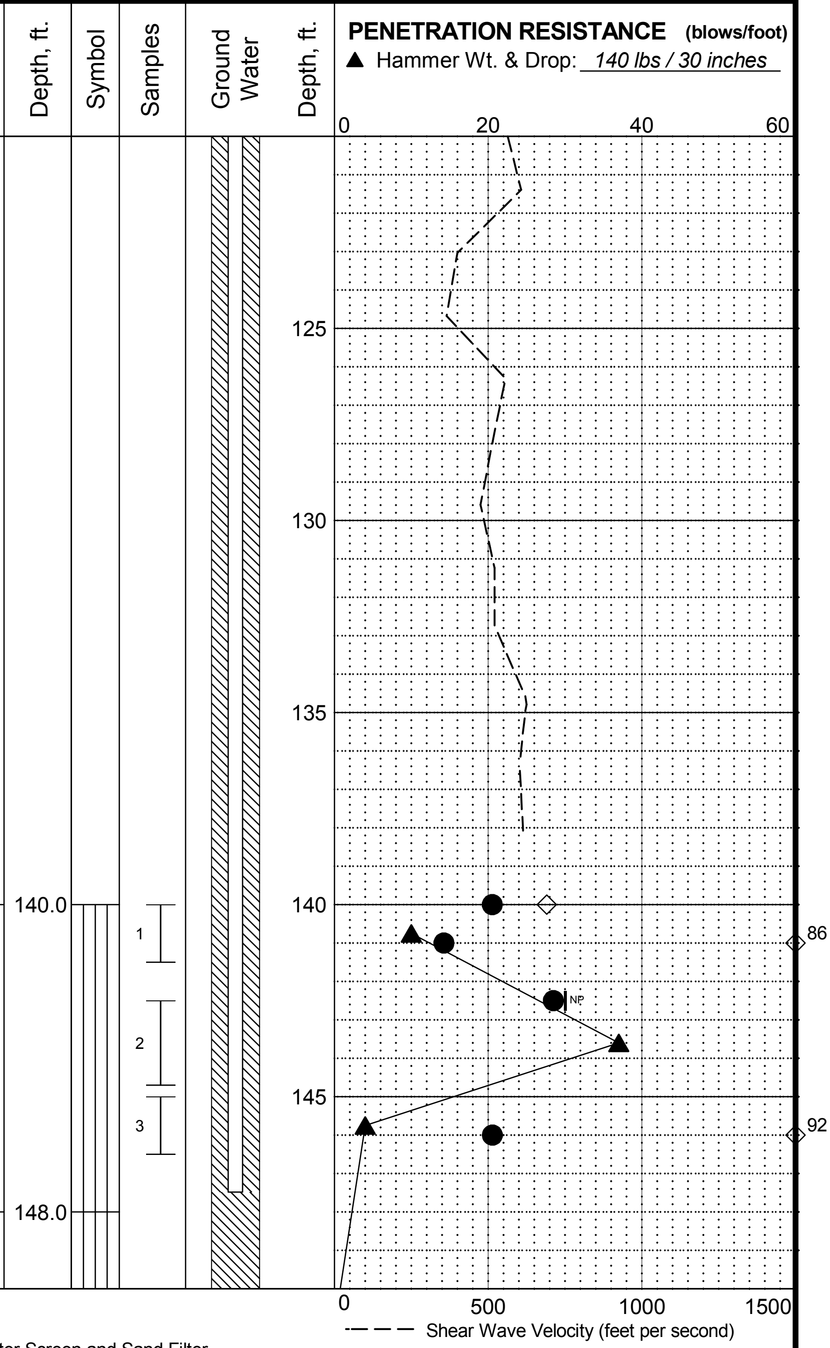
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Loose to dense(?), black to dark brown-gray to dark gray-brown, slightly fine sandy to fine sandy SILT; wet; locally trace of clay, scattered silty sand layers, trace of shell fragments and seams with organics; (He/Ha) ML.
- Sampler collected at 142.5 feet was overfull and bulging; blow count may not be representative.

Very soft, dark gray-brown, slightly fine sandy, clayey SILT; wet; trace of shells; (He) ML.

CONTINUED NEXT SHEET



— — — Shear Wave Velocity (feet per second)

◇ % Fines (<0.075mm)
● % Water Content ←(use scale at top)
Plastic Limit ├─●─┤ Liquid Limit

LEGEND

* Sample Not Recovered
⌶ Standard Penetration Test
Piezometer Screen and Sand Filter
▧ Bentonite-Cement Grout
⊠ Bentonite Chips/Pellets
▨ Bentonite Grout
▽ Ground Water Level ATD
▼ Ground Water Level in Well

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

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John Stanford Center Liquefaction Array
Seattle, Washington

LOG OF BORING S-2

May 2018 21-1-21441-001

SHANNON & WILSON, INC.
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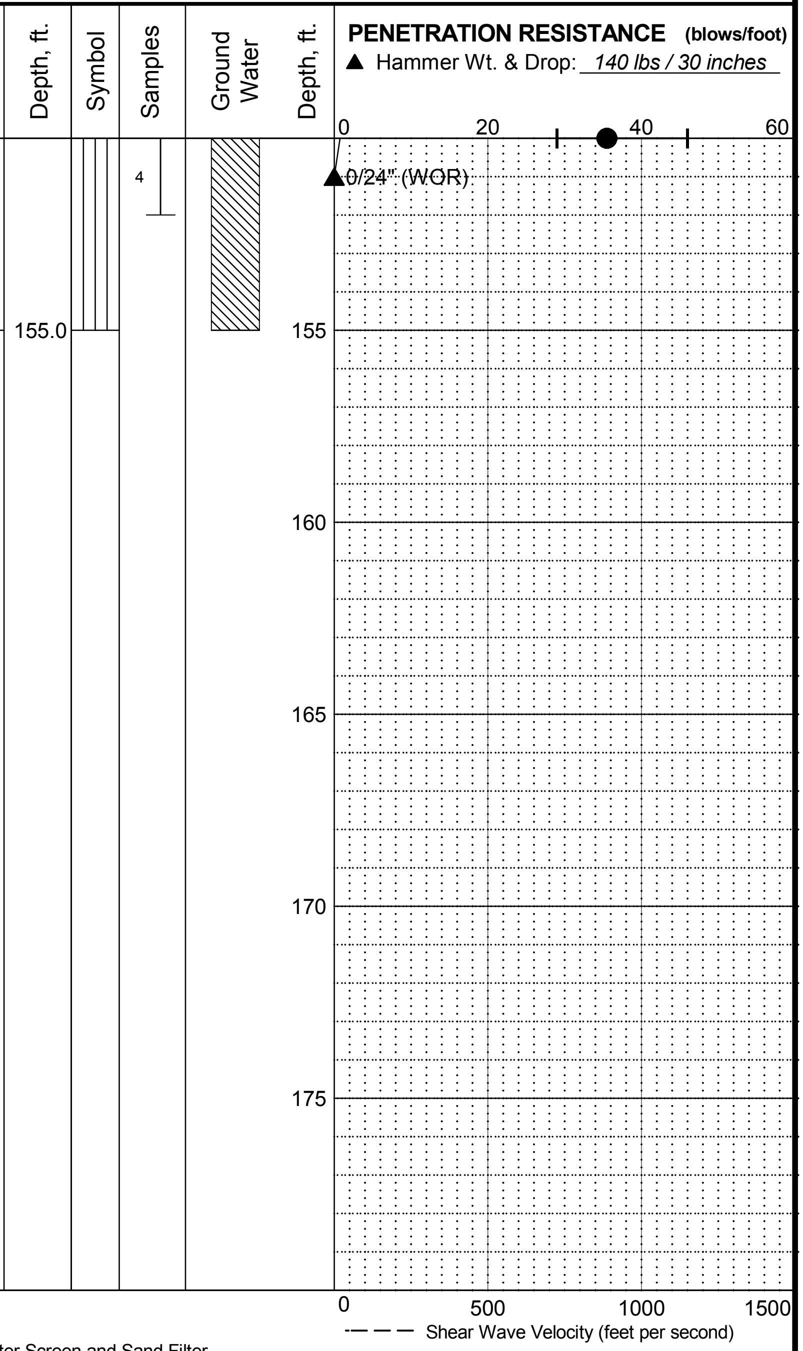
FIG. A-9
Sheet 5 of 6

REV 3

Total Depth:	*155 ft.*	Northing:	*~ 215,929 ft.*	Drilling Method:	*Mud Rotary*	Hole Diam.:	*8 in.*
Top Elevation:	*~ 18 ft.*	Easting:	*~ 1,270,699 ft.*	Drilling Company:	*Gregory*	Rod Diam.:	*NWJ 2-5/8"*
Vert. Datum:		Station:	*~*	Drill Rig Equipment:	*CME 75 Truck*	Hammer Type:	*Automatic*
Horiz. Datum:		Offset:	*~*	Other Comments:	*9" HSA to 4 feet*		

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.



BOTTOM OF BORING
COMPLETED 12/13/2010

Notes:

1. Contacts above the sampling zone were estimated based on adjacent borings, cuttings, and drill action.
2. Driller used a 6.25-inch tricone bit for initial drilling and sampling; first installation attempt failed on 12/10/2010 due to broken PVC casing. Boring was redrilled on 12/13/2010, using 7-7/8-inch tricone; second installation attempt failed due to broken PVC bottom cap. Third installation attempt succeeded after redrilling on 12/14/2010.
3. Driller topped off grout seal at about 15 feet on 12/21/2010.
4. Above a depth of 133 feet, velocities are the R1-R2 measurements. Below 133 feet, velocities are the S-R1 measurements.

LEGEND

* Sample Not Recovered

⌶ Standard Penetration Test

⊡ Piezometer Screen and Sand Filter

▧ Bentonite-Cement Grout

⊠ Bentonite Chips/Pellets

▨ Bentonite Grout

▽ Ground Water Level ATD

▼ Ground Water Level in Well

◇ % Fines (<0.075mm)

● % Water Content (use scale at top)

Plastic Limit ├─●─┤ Liquid Limit

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

U.S. Geological Survey
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Seattle, Washington

LOG OF BORING S-2

May 2018 21-1-21441-001

SHANNON & WILSON, INC.
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FIG. A-9
Sheet 6 of 6

Log: PVH Rev: PHZ Typ: CLP

MASTER_LOG_E 21-21441.GPJ SHAN_WIL.GDT 5/3/18

REV 3

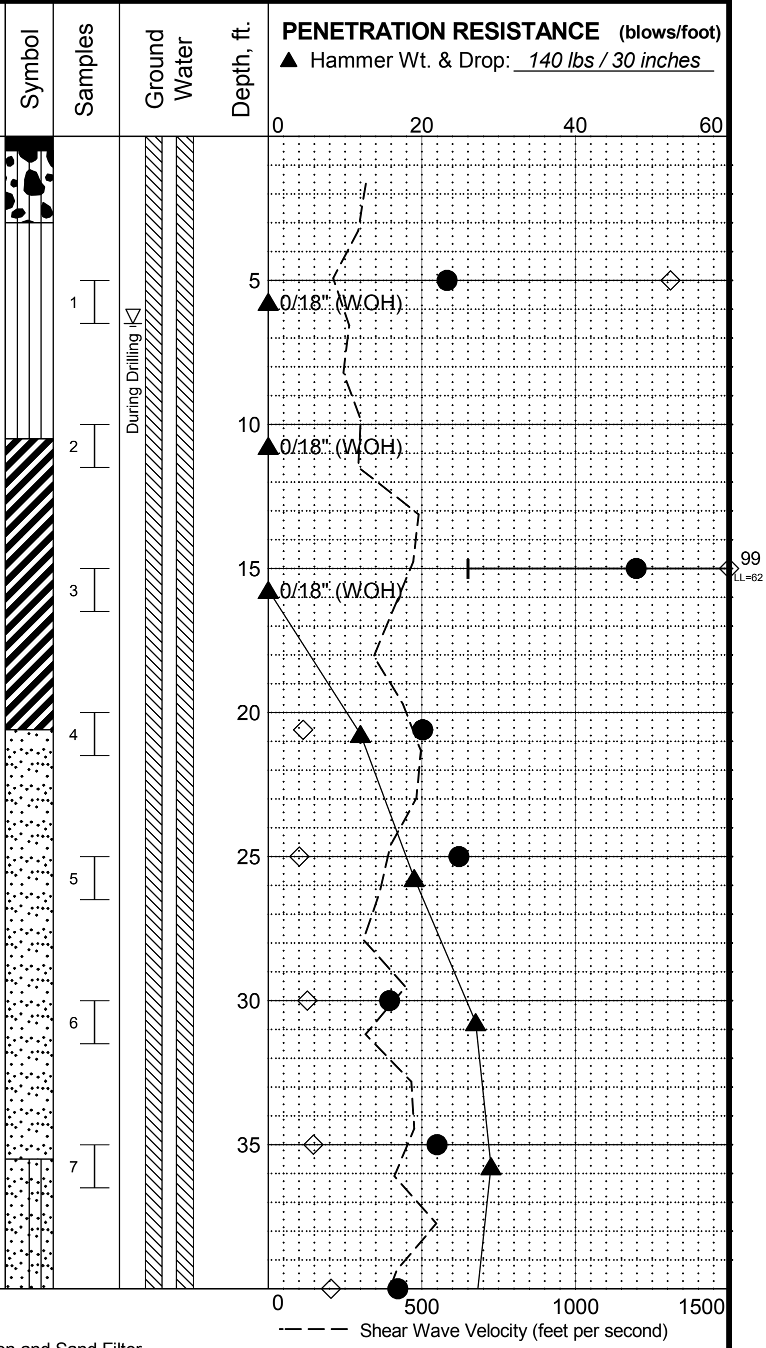
Total Depth:	201.4 ft.	Northing:	~ 215,919 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	6.25 in.
Top Elevation:	~ 18 ft.	Easting:	~ 1,270,696 ft.	Drilling Company:	Gregory	Rod Diam.:	NWJ 2-5/8"
Vert. Datum:		Station:	~	Drill Rig Equipment:	CME 75 Truck	Hammer Type:	Automatic
Horiz. Datum:		Offset:	~	Other Comments:	9" HSA to 4 feet		

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.
ASPHALT	0.5
Brown, silty, fine to medium sandy, fine to coarse GRAVEL; moist; (Hf) GM.	3.0
Very loose, dark brown-gray, fine sandy SILT, trace of clay; moist; trace of shell fragments; (Hf) ML. - Wet below approximately 6.5 feet.	10.5
Very soft, black and gray, silty CLAY, trace of sand; wet; trace to scattered wood and fine organics, trace of shells; (Hf/He) CH.	20.6
Medium dense, black, trace of silt to slightly silty, fine to medium SAND; wet; trace to scattered wood, fine organics, and shell fragments; (Ha) SP/SP-SM.	35.5
Medium dense, black, slightly silty to silty, fine to medium SAND; wet; trace of wood, fine organics, and shell fragments; (Ha) SP-SM/SM.	

CONTINUED NEXT SHEET



LEGEND

- * Sample Not Recovered
- Ⅰ Standard Penetration Test
- ▦ Piezometer Screen and Sand Filter
- ▧ Bentonite-Cement Grout
- ⊠ Bentonite Chips/Pellets
- ▨ Bentonite Grout
- ∇ Ground Water Level ATD
- ▼ Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

U.S. Geological Survey
John Stanford Center Liquefaction Array
Seattle, Washington

LOG OF BORING S-3

May 2018
21-1-21441-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-10
Sheet 1 of 6

REV 3

Log: PVH Rev: PHZ Typ: CLP

Total Depth: 201.4 ft.
Top Elevation: ~ 18 ft.
Vert. Datum:
Horiz. Datum:

Northing: ~ 215,919 ft.
Easting: ~ 1,270,696 ft.
Station: ~
Offset: ~

Drilling Method: Mud Rotary
Drilling Company: Gregory
Drill Rig Equipment: CME 75 Truck
Other Comments: 9" HSA to 4 feet

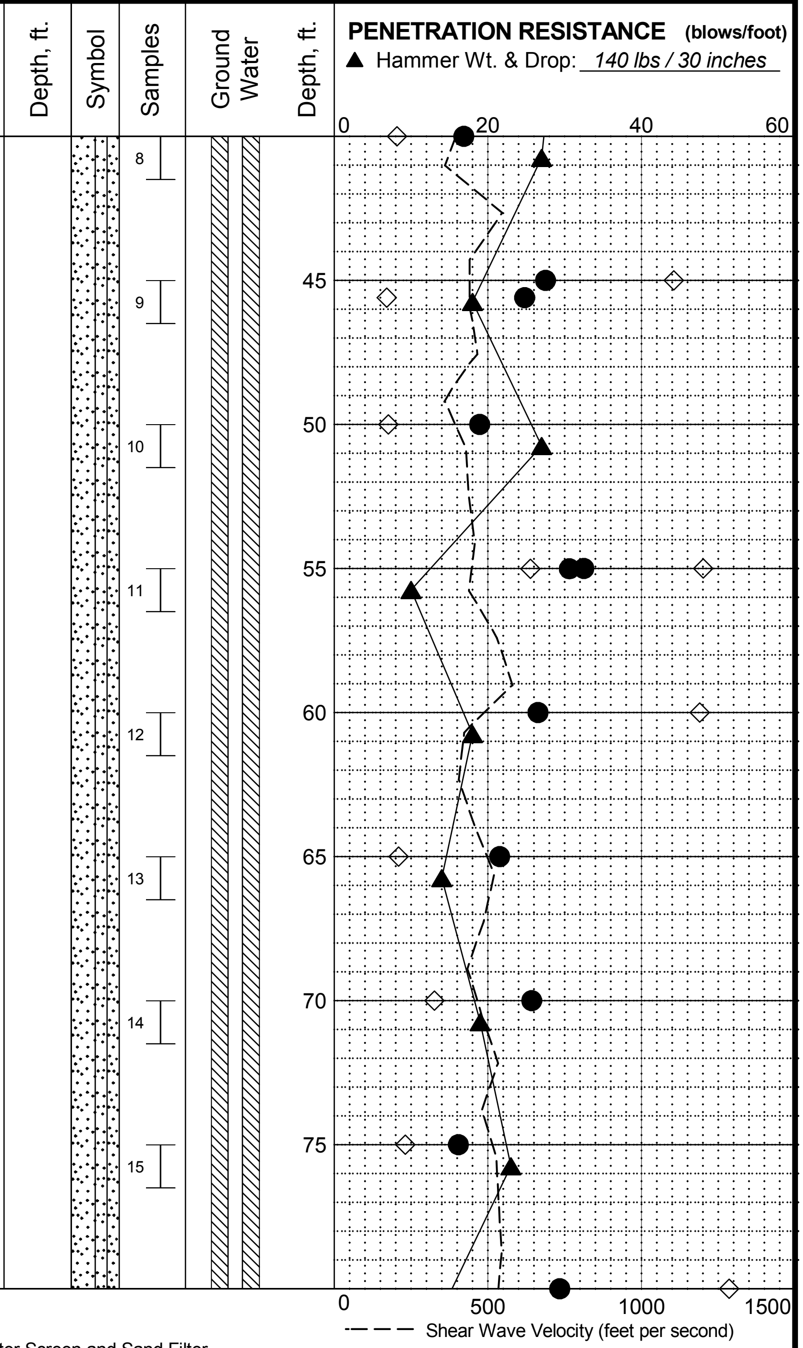
Hole Diam.: 6.25 in.
Rod Diam.: NWJ 2-5/8"
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

- Sand is more fine-grained below approximately 45 feet, with scattered layers of silt, trace of clay, and silty, fine sand, scattered to abundant organics; layers inclined at about 10-degrees.

CONTINUED NEXT SHEET



◇ % Fines (<0.075mm)
● % Water Content ← (use scale at top)
Plastic Limit ├─●─┤ Liquid Limit

LEGEND

*	Sample Not Recovered
⌶	Standard Penetration Test
▨	Piezometer Screen and Sand Filter
▨	Bentonite-Cement Grout
⊠	Bentonite Chips/Pellets
▨	Bentonite Grout
⊻	Ground Water Level ATD
▼	Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

U.S. Geological Survey
John Stanford Center Liquefaction Array
Seattle, Washington

LOG OF BORING S-3

May 2018 21-1-21441-001

SHANNON & WILSON, INC.
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FIG. A-10
Sheet 2 of 6

REV 3

Total Depth:	201.4 ft.	Northing:	~ 215,919 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	6.25 in.
Top Elevation:	~ 18 ft.	Easting:	~ 1,270,696 ft.	Drilling Company:	Gregory	Rod Diam.:	NWJ 2-5/8"
Vert. Datum:		Station:	~	Drill Rig Equipment:	CME 75 Truck	Hammer Type:	Automatic
Horiz. Datum:		Offset:	~	Other Comments:	9" HSA to 4 feet		

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

- With numerous pumice grains at approximately 80 feet.

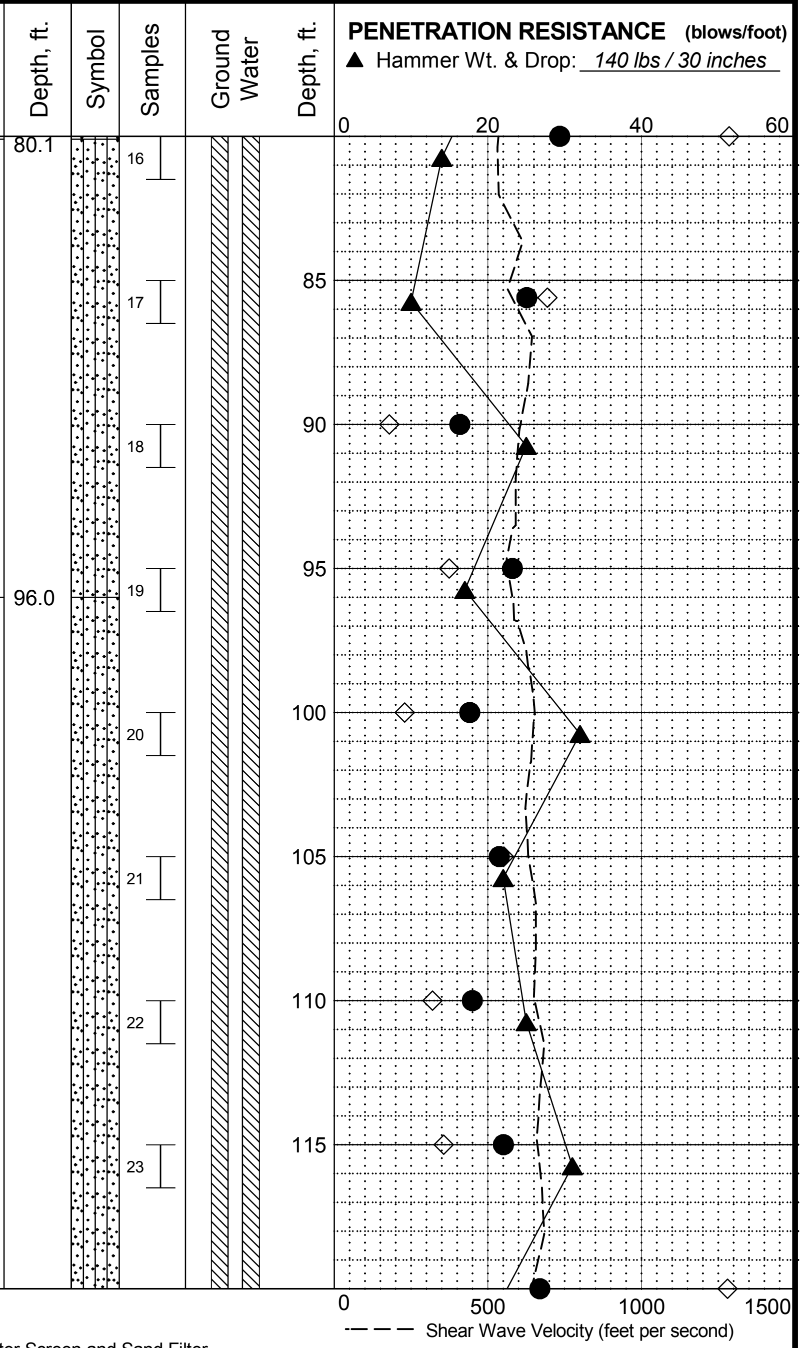
Loose to medium dense, interbedded black, slightly silty to silty, fine and fine to medium SAND and dark gray-brown, trace of fine sand to fine sandy SILT, trace of clay; wet; trace to abundant organics, approximately 10-degree bedding; (Ha/He) SM/SP-SM/ML.

Medium dense to dense, black, slightly silty to silty, fine SAND; wet; trace of shell fragments and organics; (Ha) SM/SP-SM.

- Possible pumice grains at approximately 100 and 116 feet.

- Interbedded with layers of fine sandy silt below 115.5 feet.

CONTINUED NEXT SHEET



◇ % Fines (<0.075mm)

● % Water Content ←(use scale at top)

Plastic Limit ├─●─┤ Liquid Limit

LEGEND

*	Sample Not Recovered
⌶	Standard Penetration Test
⬚	Piezometer Screen and Sand Filter
▧	Bentonite-Cement Grout
☒	Bentonite Chips/Pellets
▨	Bentonite Grout
▽	Ground Water Level ATD
▼	Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

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John Stanford Center Liquefaction Array
Seattle, Washington

LOG OF BORING S-3

May 2018 21-1-21441-001

SHANNON & WILSON, INC.
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FIG. A-10
Sheet 3 of 6

REV 3

Log: PVH Rev: PHZ Typ: CLP

MASTER_LOG_E 21-21441.GPJ SHAN_WIL.GDT 5/3/18

Total Depth: 201.4 ft.
Top Elevation: ~ 18 ft.
Vert. Datum:
Horiz. Datum:

Northing: ~ 215,919 ft.
Easting: ~ 1,270,696 ft.
Station: ~
Offset: ~

Drilling Method: Mud Rotary
Drilling Company: Gregory
Drill Rig Equipment: CME 75 Truck
Other Comments: 9" HSA to 4 feet

Hole Diam.: 6.25 in.
Rod Diam.: NWJ 2-5/8"
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Depth, ft.	SOIL DESCRIPTION
123.0	Dense, black, slightly silty, fine SAND; wet; trace of shell fragments; (Ha) SP-SM.
128.0	Dense, black, silty, fine SAND; wet; trace of organics; scattered seams of dark brown, fine sandy silt; (Ha) SM.
135.2	Interbedded loose to medium dense, black, silty, fine SAND to slightly fine sandy to fine sandy SILT, trace of clay; wet; scattered shell fragments, trace to scattered organics; (He/Ha) ML/SM.
148.0	Very soft, dark brown-gray, clayey SILT, trace of fine sand; wet; scattered shell fragments; (He) ML.
153.0	Very soft, dark brown-gray and gray, clayey SILT; wet; massive, scattered shell fragments, trace of organics; (He) ML.

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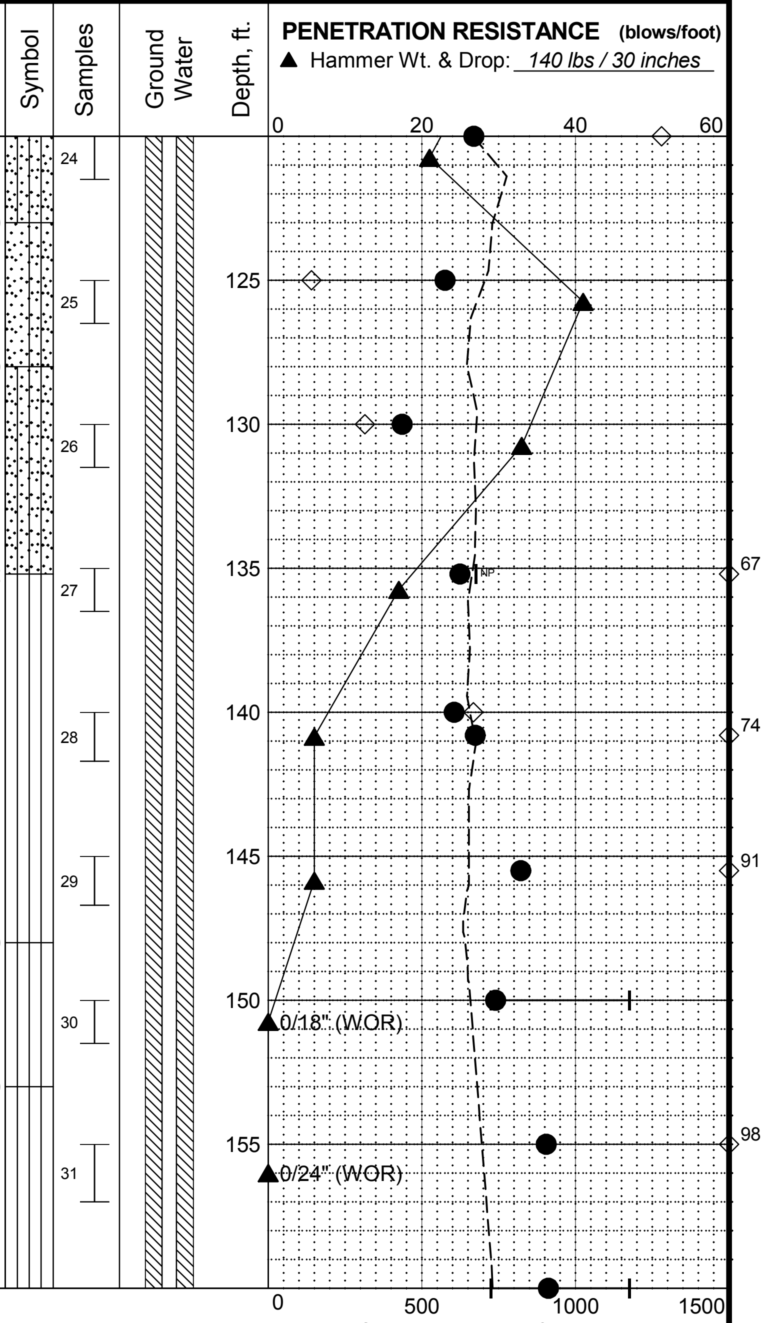

– – – Shear Wave Velocity (feet per second)

◇ % Fines (<0.075mm)

● % Water Content ← (use scale at top)

Plastic Limit |—●—| Liquid Limit

LEGEND

* Sample Not Recovered
⌶ Standard Penetration Test

⊞ Piezometer Screen and Sand Filter
▧ Bentonite-Cement Grout
⊠ Bentonite Chips/Pellets
▨ Bentonite Grout
⊻ Ground Water Level ATD
▼ Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

U.S. Geological Survey
John Stanford Center Liquefaction Array
Seattle, Washington

LOG OF BORING S-3

May 2018 21-1-21441-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-10
Sheet 4 of 6

REV 3

Log: PVH Rev: PHZ Typ: CLP

MASTER_LOG_E 21-21441.GPJ SHAN_WIL.GDT 5/3/18

Total Depth:	201.4 ft.	Northing:	~ 215,919 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	6.25 in.
Top Elevation:	~ 18 ft.	Easting:	~ 1,270,696 ft.	Drilling Company:	Gregory	Rod Diam.:	NWJ 2-5/8"
Vert. Datum:		Station:	~	Drill Rig Equipment:	CME 75 Truck	Hammer Type:	Automatic
Horiz. Datum:		Offset:	~	Other Comments:	9" HSA to 4 feet		

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

163.0

Medium dense(?), dark brown-gray, fine sandy SILT and slightly silty to silty, fine to medium SAND; wet; trace of shell fragments, scattered 10-degree laminations; (He/Ha) ML/SM/SP-SM.

165.6

- Approximately 60-degree contact with underlying clay.

Very soft to stiff, dark gray-brown, slightly clayey SILT, trace of fine sand; moist to wet; trace of shells and organics, scattered 60-degree bedding, 60-degree sand parting at approximately 166 feet; (He) ML.

- 0.3-foot layer of silty, fine SAND at 170.2 feet (approximately 60-degree contact).

173.0

Transition from sandy, gravelly, silty CLAY to dark gray-brown, silty, clayey, sandy GRAVEL; wet; trace of organics, scattered coarse shell fragments; (Hrw/Hb) GC/GM.

175.2

Very dense, green-gray, slightly silty to silty, sandy GRAVEL, trace of clay; wet; slightly weathered, diverse lithology (including intrusives); (Hrw/Hb) GM/GW-GM.

178.0

Very stiff, blue-gray, gravelly, silty CLAY, trace of sand; moist; scattered sand seams and organic or iron-oxide seams, scattered laminations; (Hrw/Qvrl) CH.

183.0

Very dense, green-gray, slightly silty, sandy GRAVEL to slightly silty, fine gravelly SAND; wet; slightly weathered, diverse lithology; (Qpgo) GP-SM/SP-SM.

194.5

Hard, gray, slightly sandy, slightly fine gravelly, clayey SILT; moist; massive, gravels form

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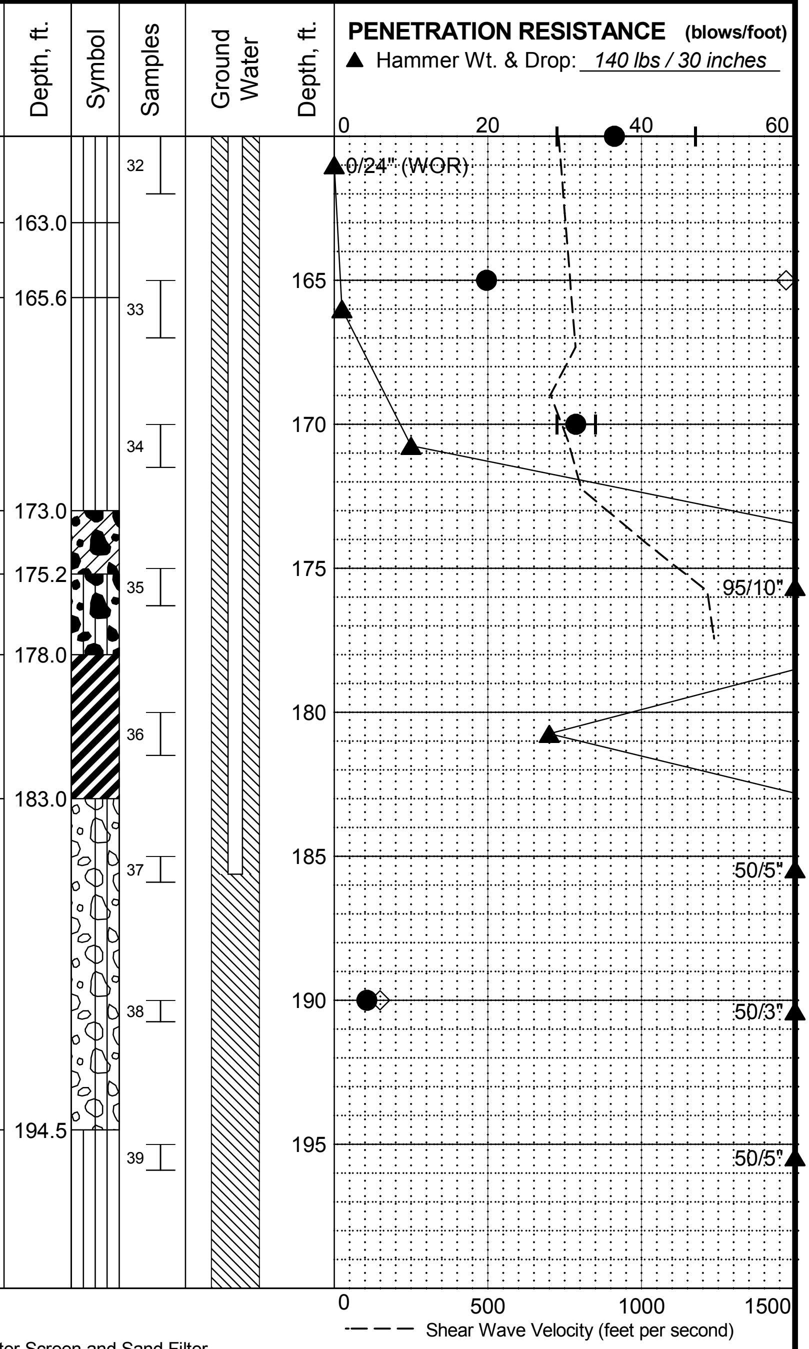

◇ % Fines (<0.075mm)

● % Water Content (use scale at top)

Plastic Limit ├─●─┤ Liquid Limit

LEGEND

* Sample Not Recovered

⌶ Standard Penetration Test

Piezometer Screen and Sand Filter

▧ Bentonite-Cement Grout

☒ Bentonite Chips/Pellets

▨ Bentonite Grout

▽ Ground Water Level ATD

▼ Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
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U.S. Geological Survey
John Stanford Center Liquefaction Array
Seattle, Washington

LOG OF BORING S-3

May 2018 21-1-21441-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-10
Sheet 5 of 6

REV 3

Total Depth: 201.4 ft.
Top Elevation: ~ 18 ft.
Vert. Datum:
Horiz. Datum:

Northing: ~ 215,919 ft.
Easting: ~ 1,270,696 ft.
Station: ~
Offset: ~

Drilling Method: Mud Rotary
Drilling Company: Gregory
Drill Rig Equipment: CME 75 Truck
Other Comments: 9" HSA to 4 feet

Hole Diam.: 6.25 in.
Rod Diam.: NWJ 2-5/8"
Hammer Type: Automatic

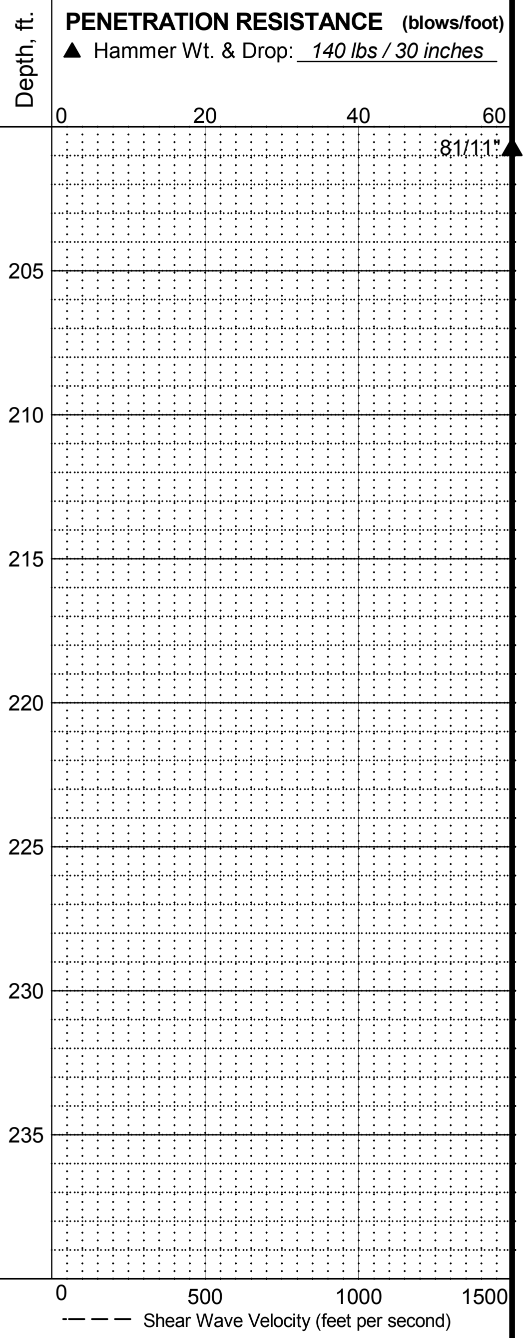
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

SOIL DESCRIPTION	Depth, ft.	Symbol	Samples	Ground Water
casts; (Qpgt) ML.	200.1	▨	40	▧
Hard, gray, silty CLAY, trace of gravel; moist; faintly bedded at approximately 60 degrees at 200.5 feet; (Qpgl) CL.	201.4			

BOTTOM OF BORING
COMPLETED 12/9/2010

Notes:
1. Driller topped off grout on 12/14/2010 at about 10 feet.
2. Above a depth of 173 feet, velocities are the R1-R2 measurements. Below 173 feet, velocities are the S-R1 measurements.



◇ % Fines (<0.075mm)
● % Water Content (use scale at top)
Plastic Limit ├─●─┤ Liquid Limit

LEGEND

* Sample Not Recovered
⌶ Standard Penetration Test

Piezometer Screen and Sand Filter
▧ Bentonite-Cement Grout
☒ Bentonite Chips/Pellets
▨ Bentonite Grout
▽ Ground Water Level ATD
▼ Ground Water Level in Well

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

U.S. Geological Survey
John Stanford Center Liquefaction Array
Seattle, Washington

LOG OF BORING S-3

May 2018
21-1-21441-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-10
Sheet 6 of 6

REV 3

Log: PVH Rev: PHZ Typ: CLP

MASTER_LOG_E 21-21441.GPJ SHAN_WIL.GDT 5/3/18

APPENDIX B

Downhole Geophysics

CONTENTS

- "Boring Geophysics in Borings S-2 and S-3, USGS John Stanford Center Liquefaction Array, Seattle, Washington," Fulcrum Report 12073 rev 1, October 8, 2012 (48 pages)

FULCRUM

BORING GEOPHYSICS
IN BORINGS S-2 AND S-3

USGS JOHN STANFORD CENTER
LIQUEFACTION ARRAY
SEATTLE, WASHINGTON

Report 12073 rev 1

October 8, 2012

BORING GEOPHYSICS
IN BORINGS S-2 AND S-3

USGS JOHN STANFORD CENTER
LIQUEFACTION ARRAY
SEATTLE, WASHINGTON

Report 12073 rev 1

October 8, 2012

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APPENDICES

INTRODUCTION

Boring geophysical measurements were collected in two PVC cased borings as a component of the installation of the John Stanford Center Liquefaction Array, in Seattle, Washington. Geophysical data acquisition was performed on January 17, 2012 by Robert Steller of Fulcrum Consulting. Data analysis and report preparation was performed by Robert Steller of Fulcrum Consulting. The work was performed under subcontract with the United States geologic Survey (USGS), with Tom Yelin as the point of contact for USGS.

This report describes the field measurements, data analysis, and results of this work.

SCOPE OF WORK

This report presents the results of boring geophysical measurements collected in two 4-inch diameter PVC cased borings, as detailed below. The purpose of these studies were to supplement stratigraphic information obtained during USGS's soil sampling program and to acquire shear wave velocities and compressional wave velocities as a function of depth.

BORING DESIGNATION	DATES LOGGED	LOCATION (FEET)		ELEVATION (FEET MSL)
		NORTHING	EASTING	
S-2	1/17/2012	~215,929	~1,270,699	~18
S-3	1/17/2012	~215,919	~1,270,696	~18

Location information provided by Shannon & Wilson.

Table 1. Boring logging dates and locations

The OYO Suspension Logging System was used to obtain in-situ horizontal shear and compressional wave velocity measurements at 1.6-foot intervals. The acquired data were analyzed and a profile of velocity versus depth was produced for both compressional and horizontally polarized shear waves.

A detailed reference for the velocity measurement techniques used in this study is:

> Guidelines for Determining Design Basis Ground Motions, Report TR-102293, Electric Power Research Institute, Palo Alto, California, November 1993, Sections 7 and 8.

A Robertson Geologging 3ACS caliper probe was used to collect natural gamma data at 0.05 foot intervals. Measurement procedures followed these ASTM standards:

- ASTM D5753-05 (Re-approved 2010), “Planning and Conducting Borehole Geophysical Logging”
- ASTM D6274-10, “Conducting Borehole Geophysical Logging – Gamma”

INSTRUMENTATION

Suspension Instrumentation

Suspension soil velocity measurements were performed using the suspension PS logging system, manufactured by OYO Corporation, and their subsidiary, Robertson Geologging. This system directly determines the average velocity of a 3.3 feet high segment of the soil column surrounding the boring of interest by measuring the elapsed time between arrivals of a wave propagating upward through the soil column. The receivers that detect the wave, and the source that generates the wave, are moved as a unit in the boring producing relatively constant amplitude signals at all depths.

The suspension system probe consists of a combined reversible polarity solenoid horizontal shear-wave source (S_H) and compressional-wave source (P), joined to two biaxial receivers by a flexible isolation cylinder, as shown in Figure 1. The separation of the two receivers is 3.3 feet, allowing average wave velocity in the region between the receivers to be determined by inversion of the wave travel time between the two receivers. The total length of the probe as used in these surveys is approximately 25 feet, with the center point of the receiver pair 12.5 feet above the bottom end of the probe.

The probe receives control signals from, and sends the receiver signals to, instrumentation on the surface via an armored 4-conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured to provide probe depth data, using a 1.3-foot circumference sheave fitted with a digital rotary encoder.

The entire probe is suspended in the boring by the cable, therefore, source motion is not coupled directly to the boring walls; rather, the source motion creates a horizontally propagating impulsive pressure wave in the fluid filling the boring and surrounding the source. This pressure wave is converted to P and S_H-waves in the surrounding soil as it passes through the casing and grout annulus and impinges upon the wall of the boring. These waves propagate through the soil and rock surrounding the boring, in turn causing a pressure wave to be generated in the fluid surrounding the receivers as the soil waves pass their location. Separation of the P and S_H-waves at the receivers is performed using the following steps:

1. Orientation of the horizontal receivers is maintained parallel to the axis of the source, maximizing the amplitude of the recorded S_H -wave signals.
2. At each depth, S_H-wave signals are recorded with the source actuated in opposite directions, producing S_H-wave signals of opposite polarity, providing a characteristic S_H-wave signature distinct from the P-wave signal.
3. The 7.1-foot separation of source and receiver 1 permits the P-wave signal to pass and damp significantly before the slower S_H-wave signal arrives at the receiver. In faster soils or rock, the isolation cylinder is extended to allow greater separation of the P- and S_H-wave signals.
4. In saturated soils, the received P-wave signal is typically of much higher frequency than the received S_H-wave signal, permitting additional separation of the two signals by low pass filtering.
5. Direct arrival of the original pressure pulse in the fluid is not detected at the receivers because the wavelength of the pressure pulse in fluid is significantly greater than the dimension of the fluid annulus surrounding the probe, preventing significant energy transmission through the fluid medium.

In operation, a distinct, repeatable pattern of impulses is generated at each depth as follows:

1. The source is fired in one direction producing dominantly horizontal shear with some vertical compression, and the signals from the horizontal receivers situated parallel to the axis of motion of the source are recorded.
2. The source is fired again in the opposite direction and the horizontal receiver signals are recorded.
3. The source is fired again and the vertical receiver signals are recorded. The repeated source pattern facilitates the picking of the P and S_H-wave arrivals; reversal of the source changes the polarity of the S_H-wave pattern but not the P-wave pattern.

The data from each receiver during each source activation is recorded as a different channel on the recording system. The suspension PS system has six channels (two simultaneous recording channels), each with a 1024 sample record. The recorded data are displayed as six channels with a common time scale. Data are stored on disk for further processing.

Review of the displayed data on the recorder or computer screen allows the operator to set the gains, filters, delay time, pulse length (energy), sample rate, and summing number to optimize the quality of the data before recording. Verification of the calibration of the suspension PS digital recorder is generally performed every twelve months using a NIST traceable frequency source and counter, as outlined in Appendix C.

Natural Gamma Instrumentation

Formation natural gamma data were collected using a 3ACS model caliper probe, S/N 5368, manufactured by Robertson Geologging, Ltd. The probe is 6.8 feet long, and 1.5 inches in diameter.

This probe may be useful in the following studies:

- Bed boundary identification
- Strata correlation between borings
- Strata geometry and type (shale indication)

The probe receives control signals from, and sends the digitized measurement values to, a Robertson Micrologger II on the surface via an armored 4 conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured to provide probe depth data, using a 1.3 foot circumference sheave fitted with a digital rotary encoder. The probe and depth data are transmitted by USB link from the Micrologger unit to a laptop computer where it is displayed and stored on hard disk.

Natural gamma measurements rely upon small quantities of radioactive material contained in soil and rocks to emit gamma radiation as they decay. Trace amounts of uranium and thorium are present in a few minerals, where potassium-bearing minerals such as feldspar, mica and clays will include traces of a radioactive isotope of potassium. These emit gamma radiation as they decay with an extremely long half-life. This radiation is detected by scintillation - the production of a tiny flash of light when gamma rays strike a crystal of sodium iodide. The light is converted into an electrical pulse by a photomultiplier tube. Pulses above a threshold value of 60 KeV are counted by the probe's microprocessor. The measurement is useful because the radioactive elements are concentrated in certain soil and rock types e.g. clay or shale, and depleted in others e.g. sandstone or coal.

MEASUREMENT PROCEDURES

Suspension Measurement Procedures

Each boring was logged while filled with clear water. All measurement depths were referenced to ground level. The probe was positioned with the top of the probe at ground level, and the electronic depth counter was set to 8.2 feet, the distance between the mid-point of the receivers and the top of the probe. The probe was then lowered to the bottom of the boring, stopping at 1.6-foot intervals to collect data, as summarized in Table 2.

At each measurement depth the measurement sequence of two opposite horizontal records and one vertical record was performed, and the gains were adjusted as required. The data from each depth were viewed on the computer display, checked, and recorded on disk before moving to the next depth.

Upon completion of the measurements, the probe zero depth indication at the depth reference point was verified prior to removal from the boring.

Natural Gamma Measurement Procedures

Boring S-3 was logged while filled with clear water. The probe was positioned with the top of the probe at ground surface, and the electronic depth counter was set to the specified length of the probe. The probe was lowered to the bottom of the boring where data acquisition was begun, and the probe was returned to the surface at 10 feet/sec, collecting data continuously at 0.05-foot spacing, as summarized in Table 2. Measurements followed ASTM D6274-10, “Conducting Borehole Geophysical Logging – Gamma”. This probe was not calibrated in the field, as it is used to provide qualitative measurements, not quantitative values, and is used only to assist in picking transitions between stratigraphic units, as described in the ASTM standard.

Upon completion of the measurements, the probe zero depth indication at the depth reference point was verified prior to removal from the boring.

BORING NUMBER	TOOL AND RUN NUMBER	DEPTH RANGE (FEET)	OPEN HOLE (FEET)	DEPTH TO BOTTOM OF CASING (FEET)	SAMPLE INTERVAL (FEET)	DATE LOGGED
S-2	SUSPENSION 1	3.3 – 132.9	145.4	PVC CASED	1.6	1/17/2012
S-3	SUSPENSION 1	1.6 – 172.2	184.8	PVC CASED	1.6	1/17/2012
S-3	NATURAL GAMMA 1	184.8 - 0	184.8	PVC CASED	0.05	1/17/2012

Table 2. Logging dates and depth ranges

DATA ANALYSIS

Suspension Analysis

Using the proprietary OYO program PSLOG.EXE version 1.0, the recorded digital waveforms were analyzed to locate the most prominent first minima, first maxima, or first break on the vertical axis records, indicating the arrival of P-wave energy. The difference in travel time between receiver 1 and receiver 2 (R1-R2) arrivals was used to calculate the P-wave velocity for that 3.3-foot segment of the soil column. When observable, P-wave arrivals on the horizontal axis records were used to verify the velocities determined from the vertical axis data. The time picks were then transferred into a Microsoft Excel® template (Excel® version 2003 SP2) to complete the velocity calculations based upon the arrival time picks made in PSLOG.

The P-wave velocity over the 7.1-foot interval from source to receiver 1 (S-R1) was also picked using PSLOG, and calculated and plotted in Microsoft Excel®, for quality assurance of the velocity derived from the travel time between receivers. In this analysis, the depth values as recorded were increased by 5.1 feet to correspond to the mid-point of the 7.1-foot S-R1 interval. Travel times were obtained by picking the first break of the P-wave signal at receiver 1 and subtracting 0.3 milliseconds, the calculated and experimentally verified delay from source trigger pulse (beginning of record) to source impact. This delay corresponds to the duration of acceleration of the solenoid before impact.

As with the P-wave records, using PSLOG, the recorded digital waveforms were analyzed to locate the presence of clear S_H-wave pulses, as indicated by the presence of opposite polarity pulses on each pair of horizontal records. Ideally, the S_H-wave signals from the 'normal' and 'reverse' source pulses are very nearly inverted images of each other. Digital FFT - IFFT lowpass filtering was used to remove the higher frequency P-wave signal from the S_H-wave signal. Different filter cutoffs were used to separate P- and S_H-waves at different depths, ranging from 300 Hz in the slowest zones to 2000 Hz in the regions of highest velocity. At each depth, the filter frequency was selected to be at least twice the fundamental frequency of the S_H-wave signal being filtered.

Generally, the first maxima were picked for the 'normal' signals and the first minima for the 'reverse' signals, although other points on the waveform were used if the first pulse was distorted. The absolute arrival time of the 'normal' and 'reverse' signals may vary by +/- 0.2 milliseconds, due to differences in the actuation time of the solenoid source caused by constant mechanical bias in the source or by boring inclination. This variation does not affect the R1-R2 velocity determinations, as the differential time is measured between arrivals of waves created by the same source actuation. The final velocity value is the average of the values obtained from the 'normal' and 'reverse' source actuations.

As with the P-wave data, S_H-wave velocity calculated from the travel time over the 7.1-foot interval from source to receiver 1 was calculated and plotted for verification of the velocity derived from the travel time between receivers. In this analysis, the depth values were increased by 5.1 feet to correspond to the mid-point of the 7.1-foot S-R1 interval. Travel times were obtained by picking the first break of the S_H-wave signal at the near receiver and subtracting 0.3 milliseconds, the calculated and experimentally verified delay from the beginning of the record at the source trigger pulse to source impact.

Figure 2 shows an example of R1 - R2 measurements on a sample filtered suspension record. In Figure 2, the time difference over the 3.3-foot interval of 1.88 milliseconds for the horizontal signals is equivalent to an S_H-wave velocity of 1745 feet/second. Whenever possible, time differences were determined from several phase points on the S_H-waveform records to verify the data obtained from the first arrival of the S_H-wave pulse. Figure 3 displays the same record before filtering of the S_H-waveform record with a 1400 Hz FFT - IFFT digital lowpass filter, illustrating the presence of higher frequency P-wave energy at the beginning of the record, and distortion of the lower frequency S_H-wave by residual P-wave signal.

Poisson's ratio is calculated and tabulated using the following relationship.

Poisson's Ratio,

$$\nu \quad = \quad \frac{\left(\dfrac{v_s}{v_p}\right)^2 - 0.5}{\left(\dfrac{v_s}{v_p}\right)^2 - 1.0}$$

Where v_s is the S_H-wave velocity, and v_p is the P-wave velocity.

Natural Gamma Analysis

No analysis is required with the natural gamma data. Using Robertson WinLogger software version 1.5, these data were converted to LAS and PDF formats for transmittal to the client.

RESULTS

Suspension Results

Suspension R1-R2 P- and S_H-wave velocities are plotted in Figures 4 and 5. The suspension velocity data presented in these figures are presented in Tables 3 and 4. These plots and data are included in the Microsoft Excel® analysis file on the disk (CD-R) that accompanies this report.

P- and S_H-wave velocity data from R1-R2 analysis and quality assurance analysis of S-R1 data are plotted together in Appendix A as Figures A-1 and a-2 to aid in visual comparison. It should be noted that R1-R2 data are an average velocity over a 3.3 feet segment of the soil column; S-R1 data are an average over 7.1 feet, creating a significant smoothing relative to the R1-R2 plots. S-R1 data are presented in Appendix A as Tables A-1 and A-2 and included in the Microsoft Excel® analysis files.

Calibration procedures and records for the suspension PS measurement system are presented in Appendix C.

Natural Gamma Results

Natural gamma data are presented as single page logs in Figure 6. A multi-page log with 1in: 10ft scale is presented in Appendix B as Figure B-1 and as a .pdf file on the disk (CD-R) that accompanies this report. The raw data is available as a .LAS file on the disk as well.

SUMMARY

Discussion of Suspension Results

Suspension PS velocity data are ideally collected in an uncased or well grouted PVC cased, fluid filled boring drilled with rotary mud (rotary wash) methods. These borings presented poor suspension PS velocity data. The cause for this is unknown, as the equipment was subsequently used in an uncased boring with no difficulty. The usual explanations are poor grout coupling of the casing, though this is unlikely considering the experience of the drilling crew that placed the casing, and an enlarged or irregular walled boring. In Boring S-2, the first placement of casing was unsuccessful, and the boring was re-drilled to a larger diameter (nominal 7 – 7/8”). This larger diameter and the boring disruption caused by re-drilling may account for the particularly poor data quality in this boring.

Suspension PS velocity data quality is judged based upon 5 criteria:

1. Consistent data between receiver to receiver (R1 – R2) and source to receiver (S – R1) data.
2. Consistent relationship between P-wave and S_H -wave (excluding transition to saturated soils)
3. Consistency between data from adjacent depth intervals.
4. Clarity of P-wave and S_H-wave onset, as well as damping of later oscillations.
5. Consistency of profile between adjacent boring, if available.

Boring S-3 data show good correlation between R1 – R2 and S – R1 S_H-wave data, though P-wave R1 – R2 and S – R1 do not correlate well with each other, or with the S_H-wave data. It is common in this area to not see correlation between S_H-wave and P-wave data due to changes in saturation from organic decomposition. Adjacent depth intervals provide similar velocities, indicating fairly consistent velocities at most depth intervals. P-wave and S_H-wave onsets were not generally clear, and arrivals were difficult to pick.

Borings S-2 and S-3 do show similar trends in the velocity profiles, though data from S-2 is sparse and poor enough to be suspect. It is not recommended that the S-2 data be used for further analysis. Boring S-3 had several data points that could not be picked as R1-R2 data, but are covered by the S-R1 data, as presented in Appendix A. Boring S-3 data is an almost exact match to Boring SD-110 data, located approximately 250 feet south-west of S-3, and Boring SD-108, located approximately 1200 feet south-west of S-3. These data were collected for Shannon & Wilson on October 10, 2003 and August 28, 2003, as part of the Seattle Monorail Project. The good correlation between R1 – R2 and S – R1 S_H-wave data and close match to SB-110 and SB-108 provide confidence in the Boring S-3 S_H-wave data.

Discussion of Natural Gamma Results

The natural gamma profile from S-3 suggests thin interbedding of slightly varying materials. A relative increase in natural gamma response is observed at approximately 20 feet, corresponding to a transition into sands. A decrease in natural gamma response is observed at approximately 173 feet, corresponding to a transition into glacially over-consolidated till.

Quality Assurance

These boring geophysical measurements were performed using industry-standard or better methods for measurements and analyses. All work was performed under Fulcrum Consulting quality assurance procedures, which include:

- Use of NIST-traceable calibrations, where applicable, for field and laboratory instrumentation
- Use of standard field data logs
- Use of independent verification of velocity data by comparison of receiver-to-receiver and source-to-receiver velocities

Suspension Data Reliability

P- and S_H-wave velocity measurement using the Suspension Method gives average velocities over a 3.3 feet interval of depth. This high resolution results in the scatter of values shown in the graphs. Individual measurements are very reliable with estimated precision of +/- 5%. In cased borings, with uncertain grout bond, estimated precision is +/- 15%.

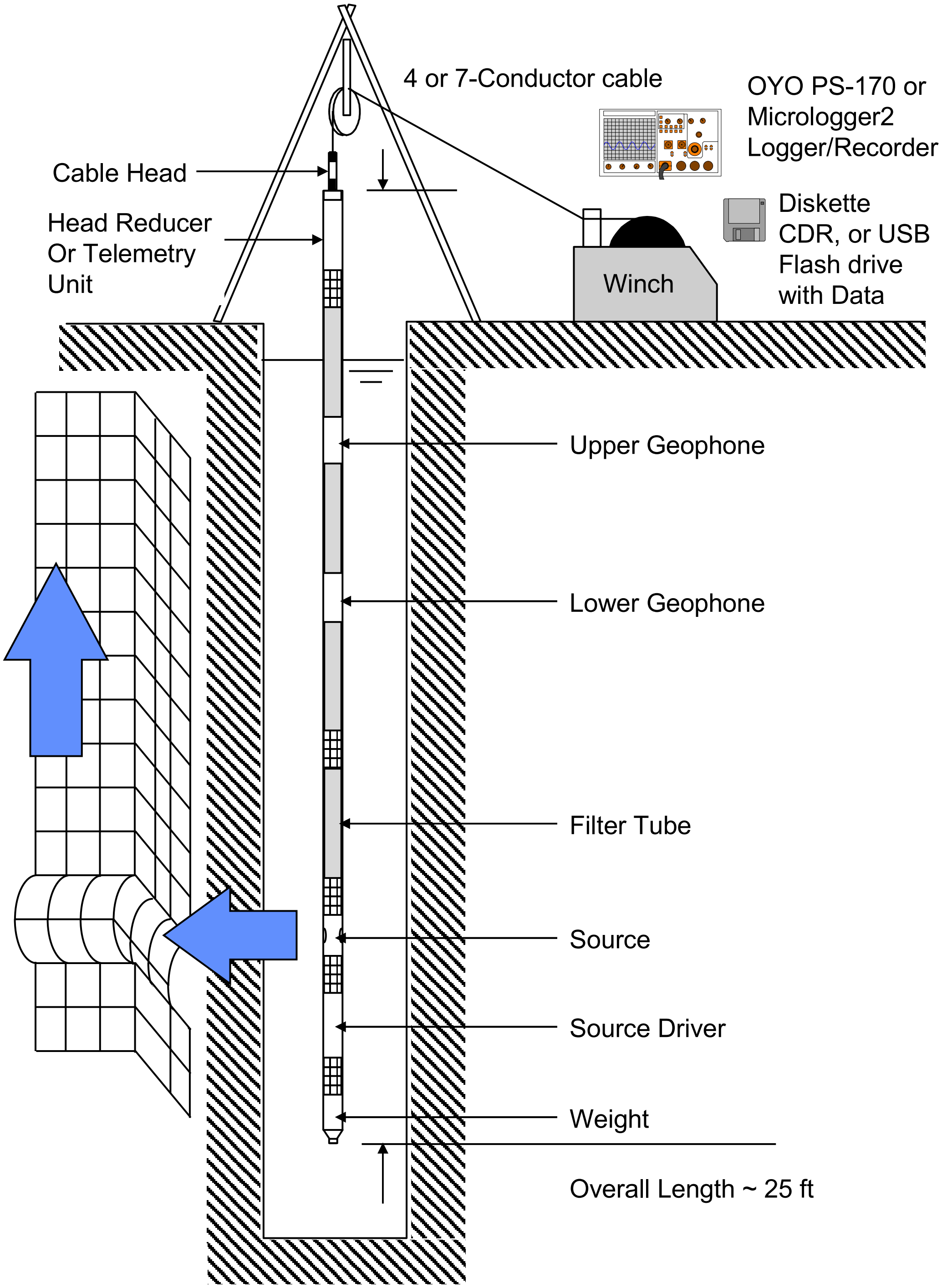


Figure 1: Concept illustration of P-S logging system

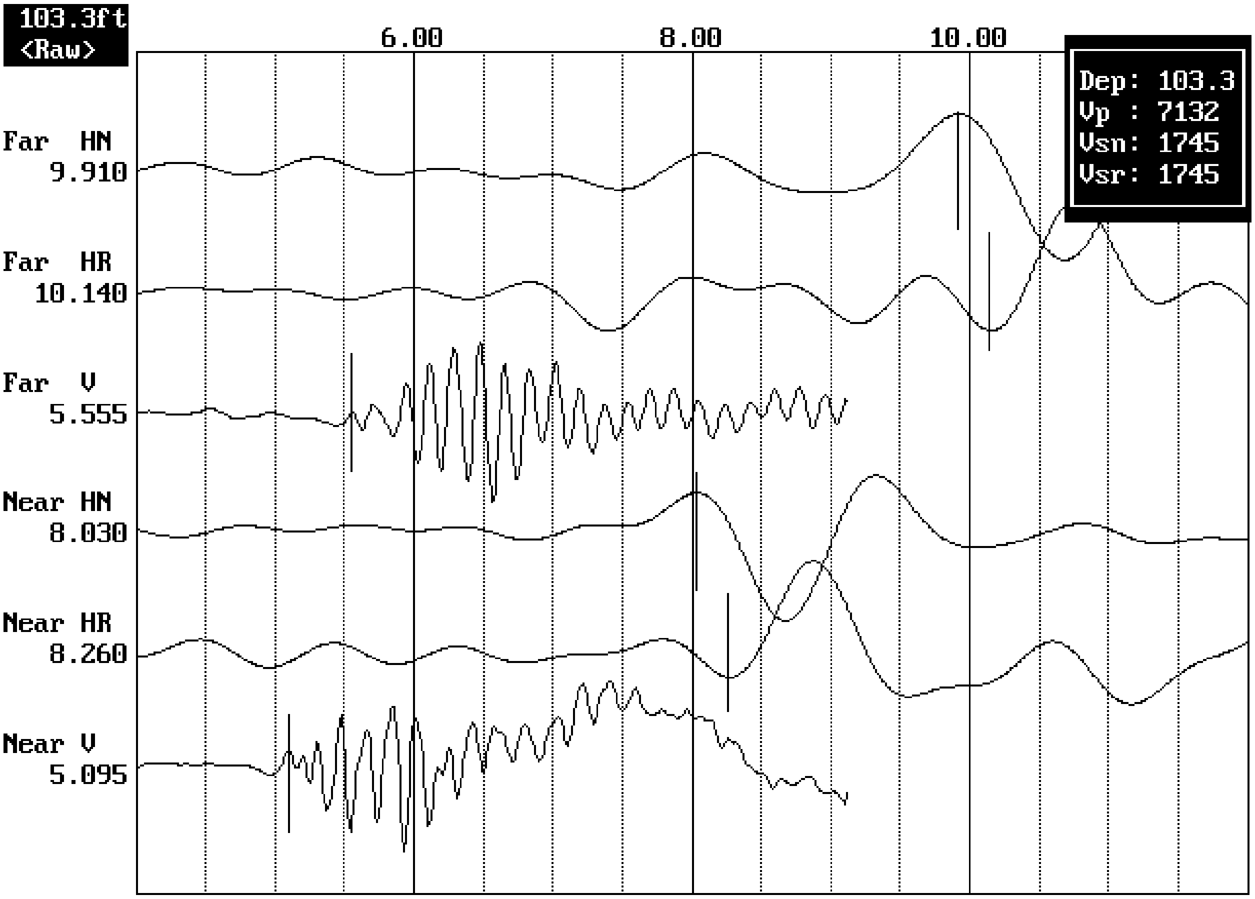


Figure 2. Example of filtered (1400 Hz lowpass) record

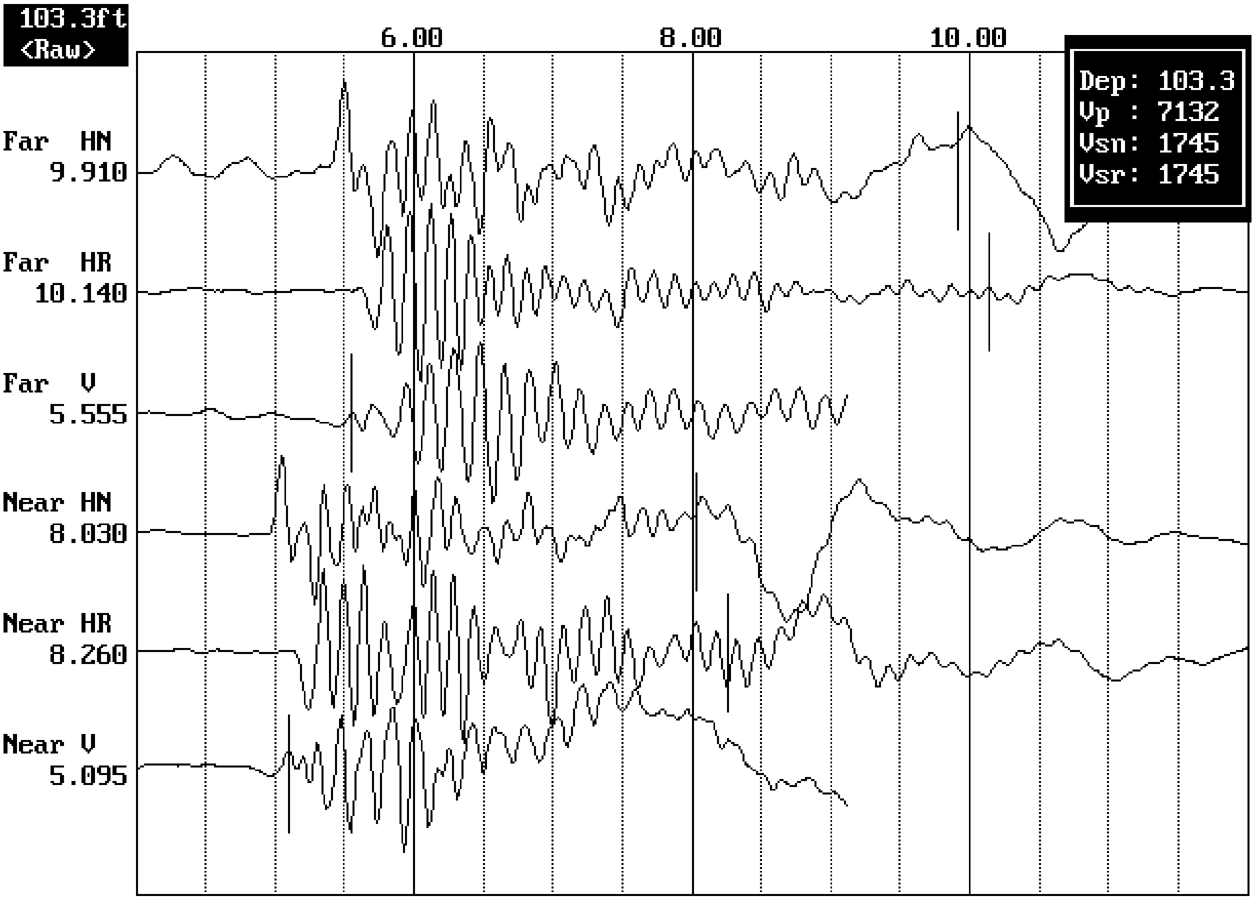


Figure 3. Example of unfiltered record

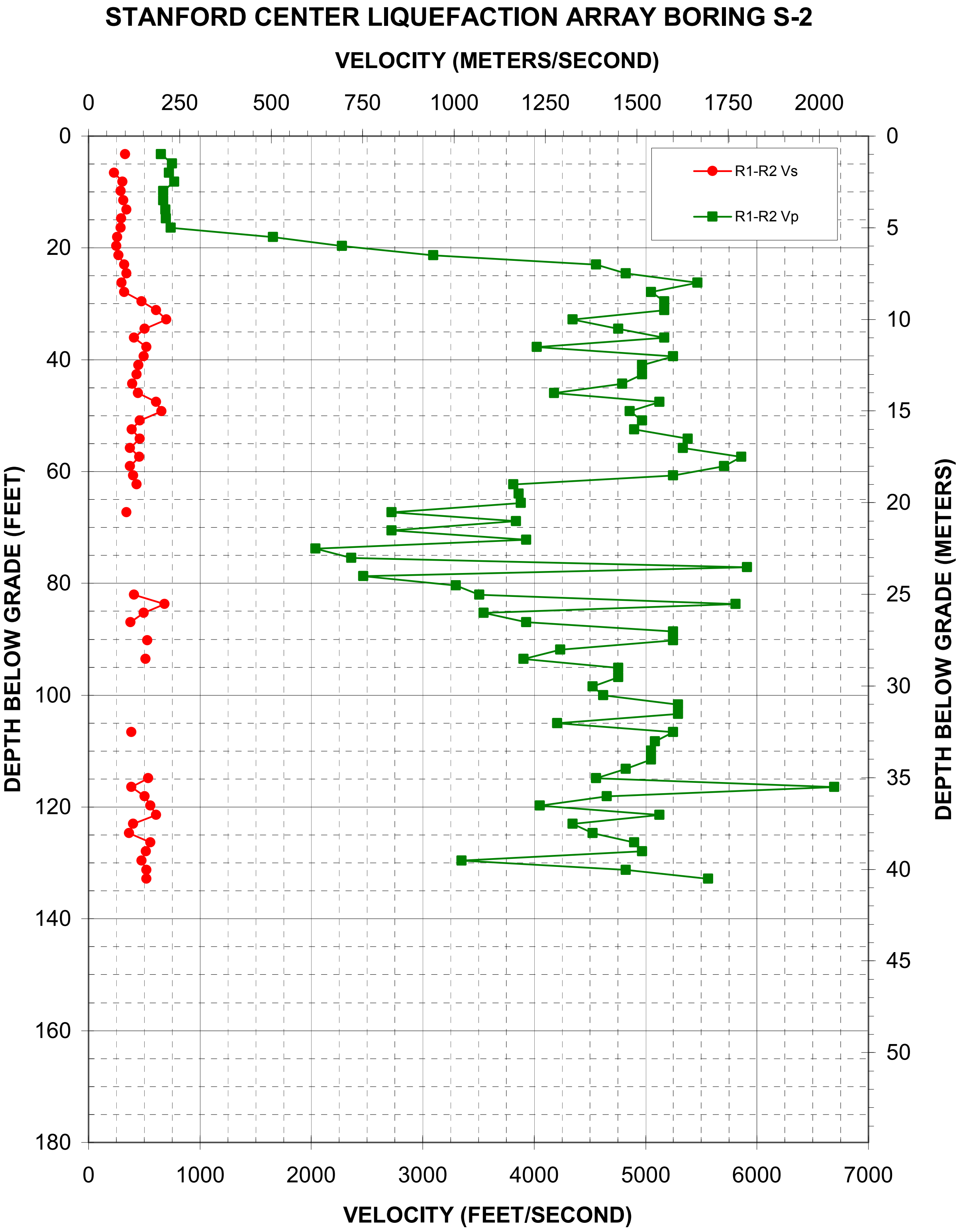


Figure 4. Boring S-2, Suspension R1-R2 P- and S_H-wave velocities

Table 3. Boring S-2, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio
Based on Receiver-to-Receiver Travel Time Data - Borehole S-2

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
3.28	328	651	0.33
4.92		749	
6.56	229	723	0.44
8.20	307	770	0.41
9.84	290	672	0.39
11.48	315	672	0.36
13.12	342	692	0.34
14.76	296	695	0.39
16.40	290	739	0.41
18.04	256	1657	0.49
19.69	249	2278	0.49
21.33	269	3095	0.50
22.97	322	4557	0.50
24.61	342	4825	0.50
26.25	298	5468	0.50
27.89	322	5047	0.50
29.53	475	5167	0.50
31.17	608	5167	0.49
32.81	698	4345	0.49
34.45	505	4755	0.49
36.09	410	5167	0.50
37.73	521	4026	0.49
39.37	497	5249	0.50
41.01	449	4971	0.50
42.65	432	4971	0.50
44.29	395	4790	0.50
45.93	443	4179	0.49
47.57	608	5126	0.49
49.21	656	4861	0.49
50.85	462	4971	0.50
52.49	391	4897	0.50
54.13	462	5378	0.50
55.77	373	5335	0.50
57.41	456	5859	0.50
59.06	373	5706	0.50
60.70	400	5249	0.50

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.0	300	1080	0.46
2.5	230	1200	0.48
3.0	260	1270	0.48
3.5	430	730	0.23
4.0	390	1130	0.43
4.5	350	980	0.43
5.0	330	1540	0.48
5.5	350	1240	0.46
6.0	360	1150	0.45
6.5	420	1950	0.48
7.0	400	1340	0.45
7.5	410	1690	0.47
8.0	370	1410	0.46
8.5	400	1450	0.46
9.0	420	1360	0.45
9.5	390	1330	0.45
10.0	350	1040	0.44
10.5	310	880	0.43
11.0	300	1080	0.46
11.5	300	1160	0.46
12.0	270	1360	0.48
12.5	270	1490	0.48
13.0	260	1550	0.49
13.5	360	1750	0.48
14.0	850	1600	0.31
14.5	720	1590	0.37
15.0	930	2120	0.38
15.5	1270	2820	0.37
16.0	1350	2990	0.37
16.5	1310	3080	0.39
17.0	1330	2570	0.32
17.5	1400	2670	0.31
18.0	1510	2990	0.33
18.5	900	2820	0.44

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole S-2

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
62.34	432	3815	0.49
63.98		3860	
65.62		3883	
67.26	342	2723	0.49
68.90		3837	
70.54		2723	
72.18		3929	
73.82		2038	
75.46		2360	
77.10		5911	
78.74		2467	
80.38		3297	
82.02	410	3509	0.49
83.66	684	5807	0.49
85.30	497	3547	0.49
86.94	377	3929	0.50
88.58		5249	
90.22	529	5249	0.49
91.86		4233	
93.50	513	3906	0.49
95.14		4755	
96.78		4755	
98.43		4525	
100.07		4621	
101.71		5292	
103.35		5292	
104.99		4206	
106.63	386	5249	0.50
108.27		5087	
109.91		5047	
111.55		5047	
113.19		4825	
114.83	538	4557	0.49
116.47	386	6696	0.50
118.11	505	4654	0.49
119.75	556	4050	0.49
121.39	608	5126	0.49
123.03	400	4345	0.50
124.67	365	4525	0.50

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
1.0	100	198	0.49
1.5		228	
2.0	70	220	
2.5	93	235	0.49
3.0	88	205	
3.5	96	205	
4.0	104	211	
4.5	90	212	
5.0	88	225	
5.5	78	505	
6.0	76	694	
6.5	82	943	
7.0	98	1389	0.49
7.5	104	1471	0.49
8.0	91	1667	0.49
8.5	98	1538	0.50
9.0	145	1575	
9.5	185	1575	0.49
10.0	213	1325	
10.5	154	1449	0.49
11.0	125	1575	
11.5	159	1227	
12.0	152	1600	
12.5	137	1515	
13.0	132	1515	
13.5	120	1460	
14.0	135	1274	
14.5	185	1563	0.50
15.0	200	1481	
15.5	141	1515	
16.0	119	1493	
16.5	141	1639	
17.0	114	1626	0.49
17.5	139	1786	0.50
18.0	114	1739	0.49
18.5	122	1600	0.49
19.0	132	1163	0.49
19.5		1176	0.50
20.0		1183	0.50

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole S-2

American Units			
Depth at Midpoint Between Receivers	**Velocity**		**Poisson's Ratio**
	V_s	**V_p**	
(ft)	(ft/s)	(ft/s)	
126.31	556	4897	0.49
127.95	515	4971	0.49
129.59	475	3348	0.49
131.23	521	4825	0.49
132.87	521	5561	0.50

Metric Units			
Depth at Midpoint Between Receivers	**Velocity**		**Poisson's Ratio**
	V_s	**V_p**	
(m)	(m/s)	(m/s)	
20.5	104	830	0.49
21.0		1170	0.49
21.5		830	0.49
22.0		1198	0.49
22.5		621	0.50

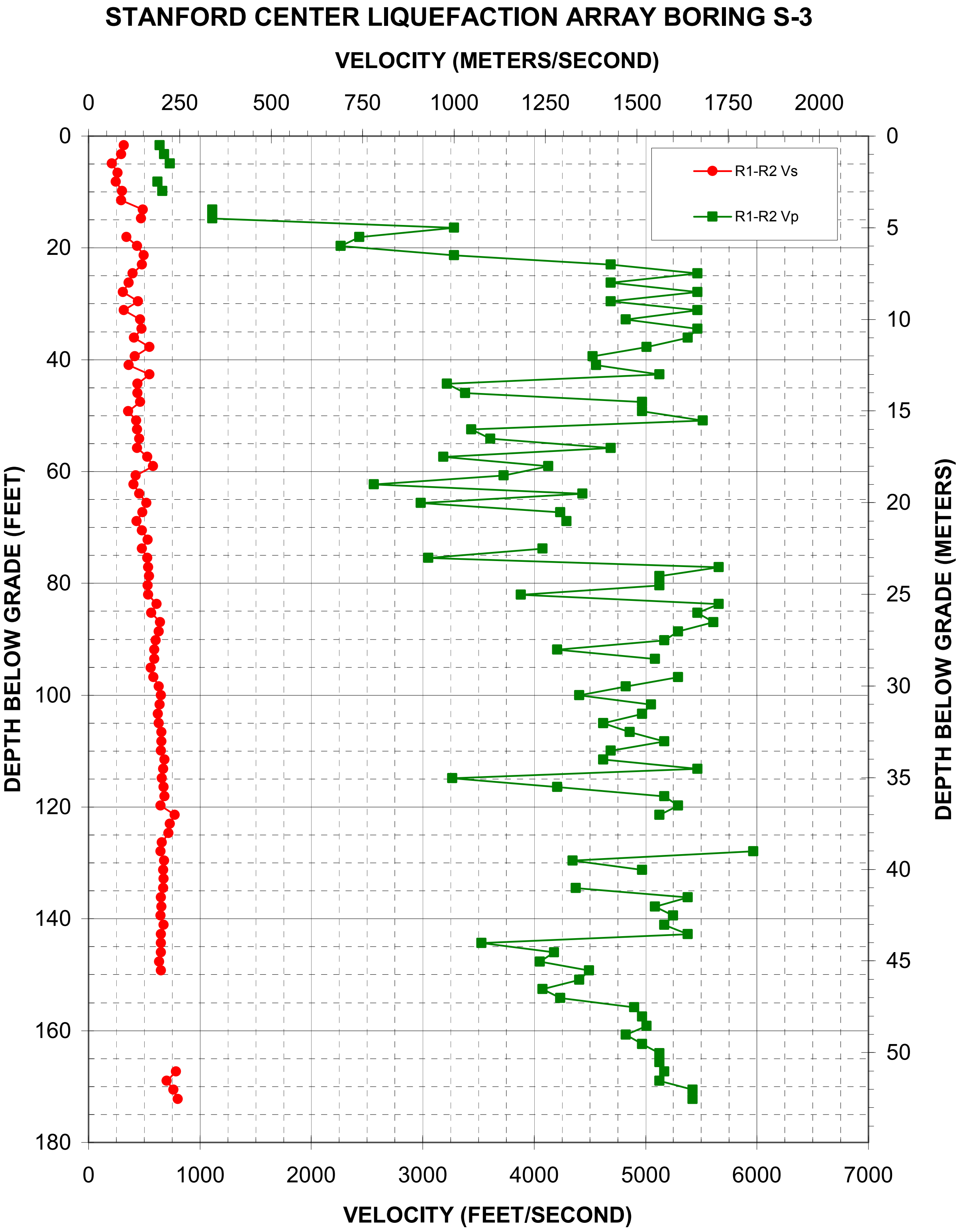


Figure 5. Boring S-3, Suspension R1-R2 P- and S_H-wave velocities

Table 4. Boring S-3, Suspension R1-R2 depths and P- and S_H-wave velocities

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio
Based on Receiver-to-Receiver Travel Time Data - Borehole S-3

American Units			
Depth at Midpoint Between Receivers	**Velocity**		**Poisson's Ratio**
	V_s	**V_p**	
(ft)	(ft/s)	(ft/s)	
1.64	318	641	0.34
3.28	293	681	0.39
4.92	211	729	0.45
6.56	264		
8.20	245	619	0.41
9.84	301	663	0.37
11.48	293		
13.12	490	1112	0.38
14.76	472	1112	0.39
16.40		3281	
18.04	344	2430	0.49
19.69	437	2263	0.48
21.33	497	3281	0.49
22.97	482	4687	0.49
24.61	398	5468	0.50
26.25	363	4687	0.50
27.89	310	5468	0.50
29.53	446	4687	0.50
31.17	317	5468	0.50
32.81	465	4825	0.50
34.45	475	5468	0.50
36.09	410	5378	0.50
37.73	547	5009	0.49
39.37	418	4525	0.50
41.01	361	4557	0.50
42.65	547	5126	0.49
44.29	440	3217	0.49
45.93	440	3382	0.49
47.57	465	4971	0.50
49.21	359	4971	0.50
50.85	428	5514	0.50
52.49	437	3435	0.49
54.13	457	3605	0.49
55.77	439	4687	0.50
57.41	529	3185	0.49
59.06	581	4127	0.49
60.70	423	3728	0.49

Metric Units			
Depth at Midpoint Between Receivers	**Velocity**		**Poisson's Ratio**
	V_s	**V_p**	
(m)	(m/s)	(m/s)	
0.5	97	195	0.34
1.0	89	207	0.39
1.5	64	222	0.45
2.0	80		
2.5	75	189	0.41
3.0	92	202	0.37
3.5	89		
4.0	149	339	0.38
4.5	144	339	0.39
5.0		1000	
5.5	105	741	0.49
6.0	133	690	0.48
6.5	152	1000	0.49
7.0	147	1429	0.49
7.5	121	1667	0.50
8.0	110	1429	0.50
8.5	94	1667	0.50
9.0	136	1429	0.50
9.5	97	1667	0.50
10.0	142	1471	0.50
10.5	145	1667	0.50
11.0	125	1639	0.50
11.5	167	1527	0.49
12.0	127	1379	0.50
12.5	110	1389	0.50
13.0	167	1563	0.49
13.5	134	980	0.49
14.0	134	1031	0.49
14.5	142	1515	0.50
15.0	109	1515	0.50
15.5	131	1681	0.50
16.0	133	1047	0.49
16.5	139	1099	0.49
17.0	134	1429	0.50
17.5	161	971	0.49
18.0	177	1258	0.49
18.5	129	1136	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole S-3

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
62.34	405	2563	0.49
63.98	457	4434	0.49
65.62	521	2983	0.48
67.26	486	4233	0.49
68.90	433	4289	0.49
70.54	481		
72.18	533		
73.82	481	4076	0.49
75.46	527	3052	0.48
77.10	536	5657	0.50
78.74	545	5126	0.49
80.38	531	5126	0.49
82.02	536	3883	0.49
83.66	613	5657	0.49
85.30	563	5468	0.49
86.94	643	5608	0.49
88.58	631	5292	0.49
90.22	602	5167	0.49
91.86	591	4206	0.49
93.50	591	5087	0.49
95.14	561		
96.78	586	5292	0.49
98.43	631	4825	0.49
100.07	653	4404	0.49
101.71	640	5047	0.49
103.35	622	4971	0.49
104.99	631	4621	0.49
106.63	656	4861	0.49
108.27	656	5167	0.49
109.91	650	4687	0.49
111.55	684	4621	0.49
113.19	670	5468	0.49
114.83	659	3265	0.48
116.47	676	4206	0.49
118.11	684	5167	0.49
119.75	646	5292	0.49
121.39	777	5126	0.49
123.03	729		
124.67	717		

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
19.0	123	781	0.49
19.5	139	1351	0.49
20.0	159	909	0.48
20.5	148	1290	0.49
21.0	132	1307	0.49
21.5	147		
22.0	163		
22.5	147	1242	0.49
23.0	161	930	0.48
23.5	163	1724	0.50
24.0	166	1563	0.49
24.5	162	1563	0.49
25.0	163	1183	0.49
25.5	187	1724	0.49
26.0	172	1667	0.49
26.5	196	1709	0.49
27.0	192	1613	0.49
27.5	183	1575	0.49
28.0	180	1282	0.49
28.5	180	1550	0.49
29.0	171		
29.5	179	1613	0.49
30.0	192	1471	0.49
30.5	199	1342	0.49
31.0	195	1538	0.49
31.5	190	1515	0.49
32.0	192	1408	0.49
32.5	200	1481	0.49
33.0	200	1575	0.49
33.5	198	1429	0.49
34.0	208	1408	0.49
34.5	204	1667	0.49
35.0	201	995	0.48
35.5	206	1282	0.49
36.0	208	1575	0.49
36.5	197	1613	0.49
37.0	237	1563	0.49
37.5	222		
38.0	219		

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole S-3

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
126.31	659		
127.95	646	5965	0.49
129.59	680	4345	0.49
131.23	670	4971	0.49
132.87	676		
134.51	673	4374	0.49
136.15	650	5378	0.49
137.80	656	5087	0.49
139.44	646	5249	0.49
141.08	676	5167	0.49
142.72	653	5378	0.49
144.36	653	3528	0.48
146.00	653	4179	0.49
147.64	634	4050	0.49
149.28	650	4494	0.49
150.92		4404	
152.56		4076	
154.20		4233	
155.84		4897	
157.48		4971	
159.12		5009	
160.76		4825	
162.40		4971	
164.04		5126	
165.68		5126	
167.32	786	5167	0.49
168.96	704	5126	0.49
170.60	761	5423	0.49
172.24	804	5423	0.49

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
38.5	201		
39.0	197	1818	0.49
39.5	207	1325	0.49
40.0	204	1515	0.49
40.5	206		
41.0	205	1333	0.49
41.5	198	1639	0.49
42.0	200	1550	0.49
42.5	197	1600	0.49
43.0	206	1575	0.49
43.5	199	1639	0.49
44.0	199	1075	0.48
44.5	199	1274	0.49
45.0	193	1235	0.49
45.5	198	1370	0.49
46.0		1342	
46.5		1242	
47.0		1290	
47.5		1493	
48.0		1515	
48.5		1527	
49.0		1471	
49.5		1515	
50.0		1563	
50.5		1563	
51.0	240	1575	0.49
51.5	215	1563	0.49
52.0	232	1653	0.49
52.5	245	1653	0.49

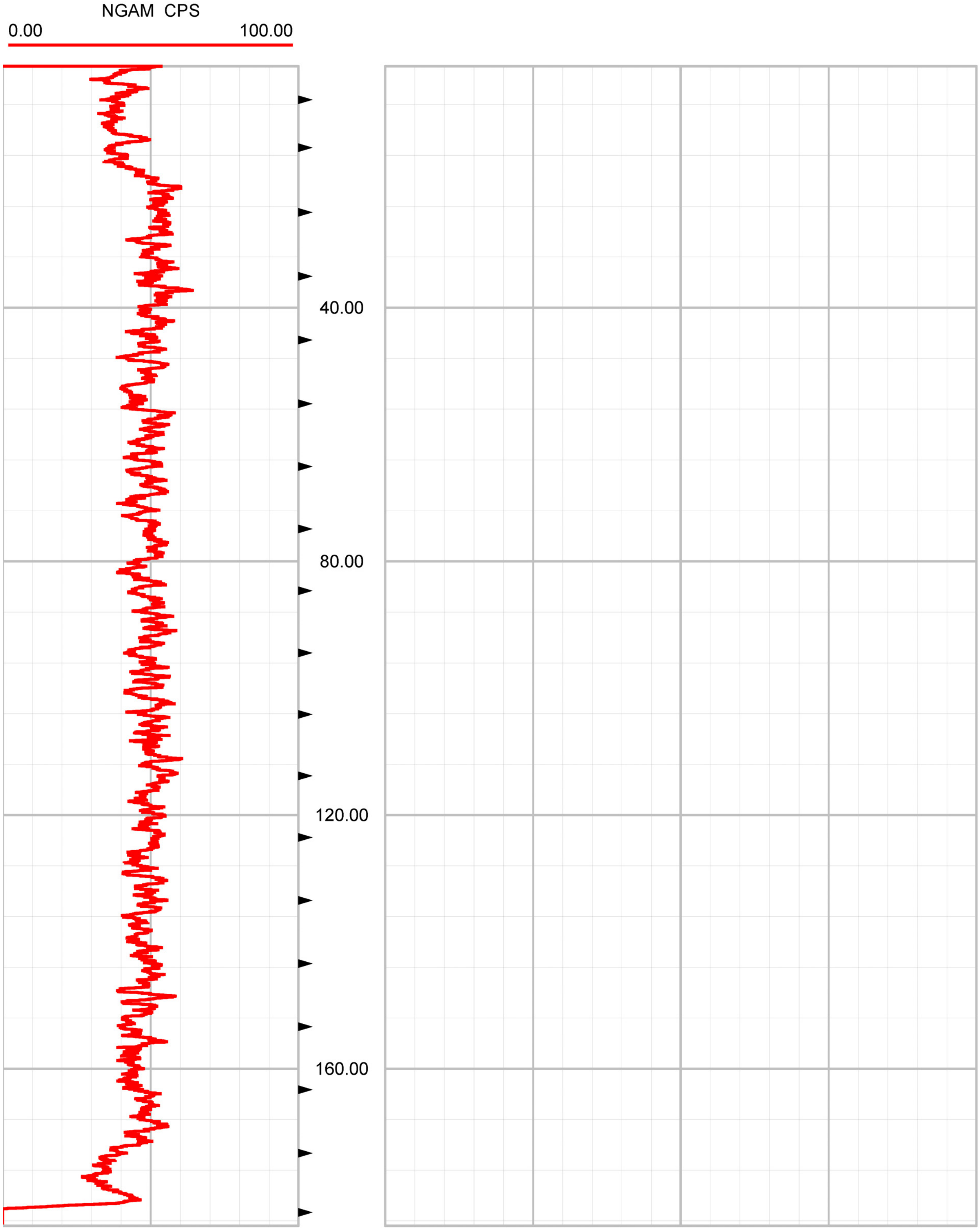


Figure 6. Boring S-3, Natural gamma log

APPENDIX A

SUSPENSION VELOCITY MEASUREMENT QUALITY ASSURANCE SUSPENSION SOURCE TO RECEIVER ANALYSIS RESULTS

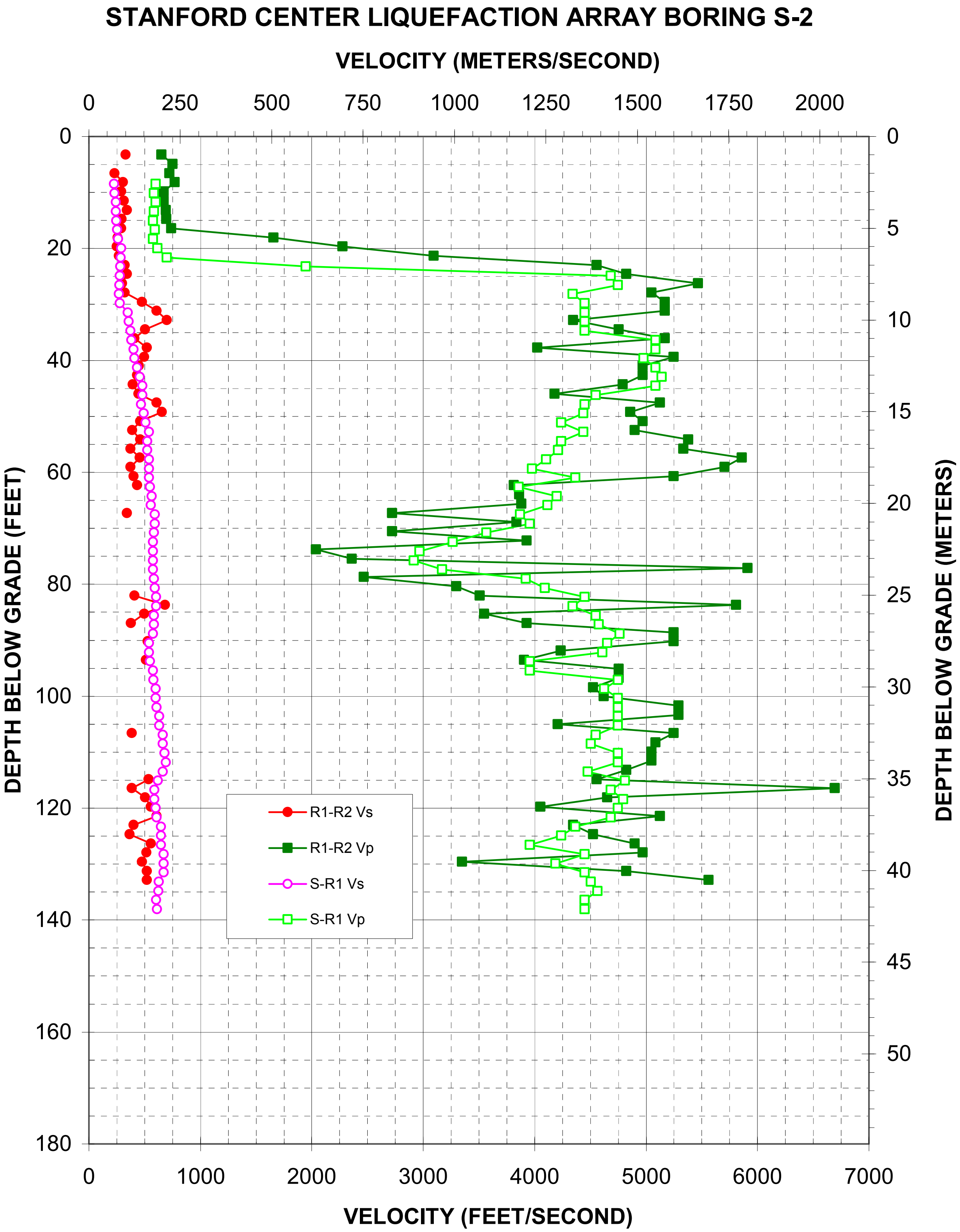


Figure A-1. Boring S-2, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-1. Boring S-2, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio
Based on Source-to-Receiver Travel Time Data - Borehole S-2

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
8.48	225	598	0.42
10.12	232	583	0.41
11.76	242	600	0.40
13.40	242	585	0.40
15.04	247	575	0.39
16.68	254	593	0.39
18.32	264	577	0.37
19.96	289	615	0.36
21.60	285	698	0.40
23.24	280	1945	0.49
24.89	278	4684	0.50
26.53	276	4746	0.50
28.17	272	4341	0.50
29.81	278	4450	0.50
31.45	349	4450	0.50
33.09	356	4450	0.50
34.73	375	4450	0.50
36.37	383	5085	0.50
38.01	400	5085	0.50
39.65	409	4979	0.50
41.29	434	5085	0.50
42.93	456	5140	0.50
44.57	481	5085	0.50
46.21	481	4549	0.49
47.85	468	4450	0.49
49.49	494	4436	0.49
51.13	509	4238	0.49
52.77	539	4436	0.49
54.41	523	4238	0.49
56.05	526	4213	0.49
57.69	539	4103	0.49
59.33	539	3977	0.49
60.97	539	4368	0.49
62.61	548	3859	0.49
64.26	565	4200	0.49
65.90	556	4115	0.49
67.54	593	3869	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.6	69	182	0.42
3.1	71	178	0.41
3.6	74	183	0.40
4.1	74	178	0.40
4.6	75	175	0.39
5.1	78	181	0.39
5.6	80	176	0.37
6.1	88	187	0.36
6.6	87	213	0.40
7.1	85	593	0.49
7.6	85	1428	0.50
8.1	84	1447	0.50
8.6	83	1323	0.50
9.1	85	1356	0.50
9.6	106	1356	0.50
10.1	109	1356	0.50
10.6	114	1356	0.50
11.1	117	1550	0.50
11.6	122	1550	0.50
12.1	125	1517	0.50
12.6	132	1550	0.50
13.1	139	1567	0.50
13.6	147	1550	0.50
14.1	147	1387	0.49
14.6	143	1356	0.49
15.1	151	1352	0.49
15.6	155	1292	0.49
16.1	164	1352	0.49
16.6	160	1292	0.49
17.1	160	1284	0.49
17.6	164	1251	0.49
18.1	164	1212	0.49
18.6	164	1331	0.49
19.1	167	1176	0.49
19.6	172	1280	0.49
20.1	170	1254	0.49
20.6	181	1179	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio
Based on Source-to-Receiver Travel Time Data - Borehole S-2

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
69.18	593	3955	0.49
70.82	584	3569	0.49
72.46	574	3266	0.48
74.10	574	2966	0.48
75.74	574	2918	0.48
77.38	574	3171	0.48
79.02	584	3923	0.49
80.66	593	4092	0.49
82.30	603	4450	0.49
83.94	603	4341	0.49
85.58	585	4549	0.49
87.22	585	4578	0.49
88.86	574	4762	0.49
90.50	539	4653	0.49
92.14	539	4608	0.49
93.78	548	3955	0.49
95.42	574	3955	0.49
97.06	579	4746	0.49
98.70	598	4623	0.49
100.34	598	4746	0.49
101.98	608	4746	0.49
103.63	630	4746	0.49
105.27	630	4746	0.49
106.91	665	4549	0.49
108.55	665	4506	0.49
110.19	678	4746	0.49
111.83	691	4746	0.49
113.47	665	4478	0.49
115.11	619	4810	0.49
116.75	588	4684	0.49
118.39	588	4794	0.49
120.03	598	4746	0.49
121.67	608	4684	0.49
123.31	647	4368	0.49
124.95	647	4238	0.49
126.59	647	3955	0.49
128.23	672	4450	0.49
129.87	672	4188	0.49
131.51	672	4450	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
21.1	181	1206	0.49
21.6	178	1088	0.49
22.1	175	995	0.48
22.6	175	904	0.48
23.1	175	889	0.48
23.6	175	967	0.48
24.1	178	1196	0.49
24.6	181	1247	0.49
25.1	184	1356	0.49
25.6	184	1323	0.49
26.1	178	1387	0.49
26.6	178	1395	0.49
27.1	175	1452	0.49
27.6	164	1418	0.49
28.1	164	1405	0.49
28.6	167	1206	0.49
29.1	175	1206	0.49
29.6	176	1447	0.49
30.1	182	1409	0.49
30.6	182	1447	0.49
31.1	185	1447	0.49
31.6	192	1447	0.49
32.1	192	1447	0.49
32.6	203	1387	0.49
33.1	203	1373	0.49
33.6	207	1447	0.49
34.1	211	1447	0.49
34.6	203	1365	0.49
35.1	189	1466	0.49
35.6	179	1428	0.49
36.1	179	1461	0.49
36.6	182	1447	0.49
37.1	185	1428	0.49
37.6	197	1331	0.49
38.1	197	1292	0.49
38.6	197	1206	0.49
39.1	205	1356	0.49
39.6	205	1276	0.49
40.1	205	1356	0.49

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole S-2

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
133.15	628	4506	0.49
134.79	625	4564	0.49
136.43	603	4450	0.49
138.07	614	4450	0.49

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
40.6	191	1373	0.49
41.1	190	1391	0.49
41.6	184	1356	0.49
42.1	187	1356	0.49

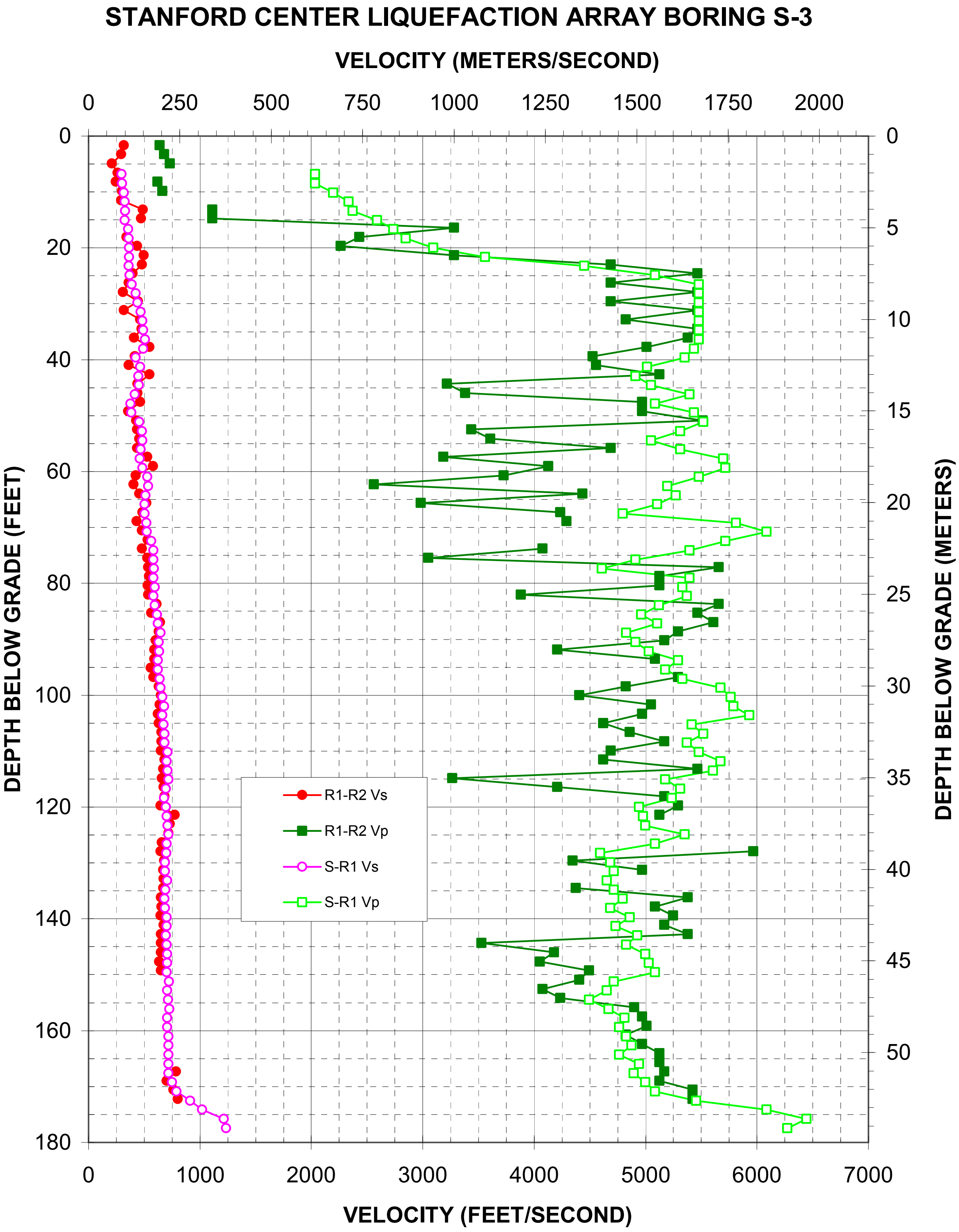


Figure A-2. Boring S-3, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-2. Boring S-3, S - R1 quality assurance analysis P- and S_H-wave data

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio
Based on Source-to-Receiver Travel Time Data - Borehole S-3

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
6.84	296	2034	0.49
8.48	300	2034	0.49
10.12	317	2197	0.49
11.76	327	2334	0.49
13.40	330	2373	0.49
15.04	327	2589	0.49
16.68	356	2738	0.49
18.32	363	2848	0.49
19.96	365	3095	0.49
21.60	365	3560	0.49
23.24	360	4450	0.50
24.89	371	5085	0.50
26.53	389	5476	0.50
28.17	424	5476	0.50
29.81	442	5476	0.50
31.45	468	5476	0.50
33.09	484	5476	0.50
34.73	494	5476	0.50
36.37	509	5476	0.50
38.01	492	5435	0.50
39.65	427	5353	0.50
41.29	465	5014	0.50
42.93	448	4910	0.50
44.57	451	5049	0.50
46.21	416	5394	0.50
47.85	379	5085	0.50
49.49	387	5435	0.50
51.13	456	5519	0.50
52.77	481	5313	0.50
54.41	486	5049	0.50
56.05	468	5313	0.50
57.69	459	5696	0.50
59.33	486	5718	0.50
60.97	529	5476	0.50
62.61	535	5197	0.49
64.26	512	5274	0.50
65.90	505	5104	0.50

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
2.1	90	620	0.49
2.6	92	620	0.49
3.1	97	670	0.49
3.6	100	711	0.49
4.1	100	723	0.49
4.6	100	789	0.49
5.1	109	835	0.49
5.6	111	868	0.49
6.1	111	943	0.49
6.6	111	1085	0.49
7.1	110	1356	0.50
7.6	113	1550	0.50
8.1	119	1669	0.50
8.6	129	1669	0.50
9.1	135	1669	0.50
9.6	143	1669	0.50
10.1	148	1669	0.50
10.6	151	1669	0.50
11.1	155	1669	0.50
11.6	150	1656	0.50
12.1	130	1632	0.50
12.6	142	1528	0.50
13.1	136	1497	0.50
13.6	138	1539	0.50
14.1	127	1644	0.50
14.6	115	1550	0.50
15.1	118	1656	0.50
15.6	139	1682	0.50
16.1	147	1619	0.50
16.6	148	1539	0.50
17.1	143	1619	0.50
17.6	140	1736	0.50
18.1	148	1743	0.50
18.6	161	1669	0.50
19.1	163	1584	0.49
19.6	156	1607	0.50
20.1	154	1556	0.50

67.54	505	4794	0.49
69.18	522	5812	0.50
70.82	525	6085	0.50
72.46	565	5718	0.50
74.10	584	5394	0.49
75.74	586	4910	0.49
77.38	587	4608	0.49
79.02	586	5394	0.49
80.66	596	5333	0.49
82.30	586	5373	0.49
83.94	596	5122	0.49
85.58	616	4961	0.49
87.22	622	5104	0.49
88.86	647	4827	0.49
90.50	630	4910	0.49
92.14	636	5031	0.49
93.78	625	5293	0.49
95.42	622	5178	0.49
97.06	641	5333	0.49
98.70	647	5673	0.49
100.34	665	5765	0.49
101.98	678	5788	0.49
103.63	665	5933	0.49
105.27	675	5414	0.49
106.91	685	5519	0.49
108.55	685	5373	0.49
110.19	712	5476	0.49
111.83	704	5673	0.49
113.47	711	5606	0.49
115.11	719	5178	0.49
116.75	697	5313	0.49
118.39	681	5235	0.49
120.03	695	4944	0.49
121.67	705	4979	0.49
123.31	712	4996	0.49
124.95	719	5353	0.49
126.59	705	5085	0.49
128.23	698	4593	0.49
129.87	688	4684	0.49
131.51	688	4715	0.49
133.15	708	4653	0.49
134.79	691	4715	0.49
136.43	683	4794	0.49
138.07	688	4684	0.49
139.71	705	4860	0.49
141.35	701	4731	0.49
143.00	695	4927	0.49
144.64	705	4827	0.49

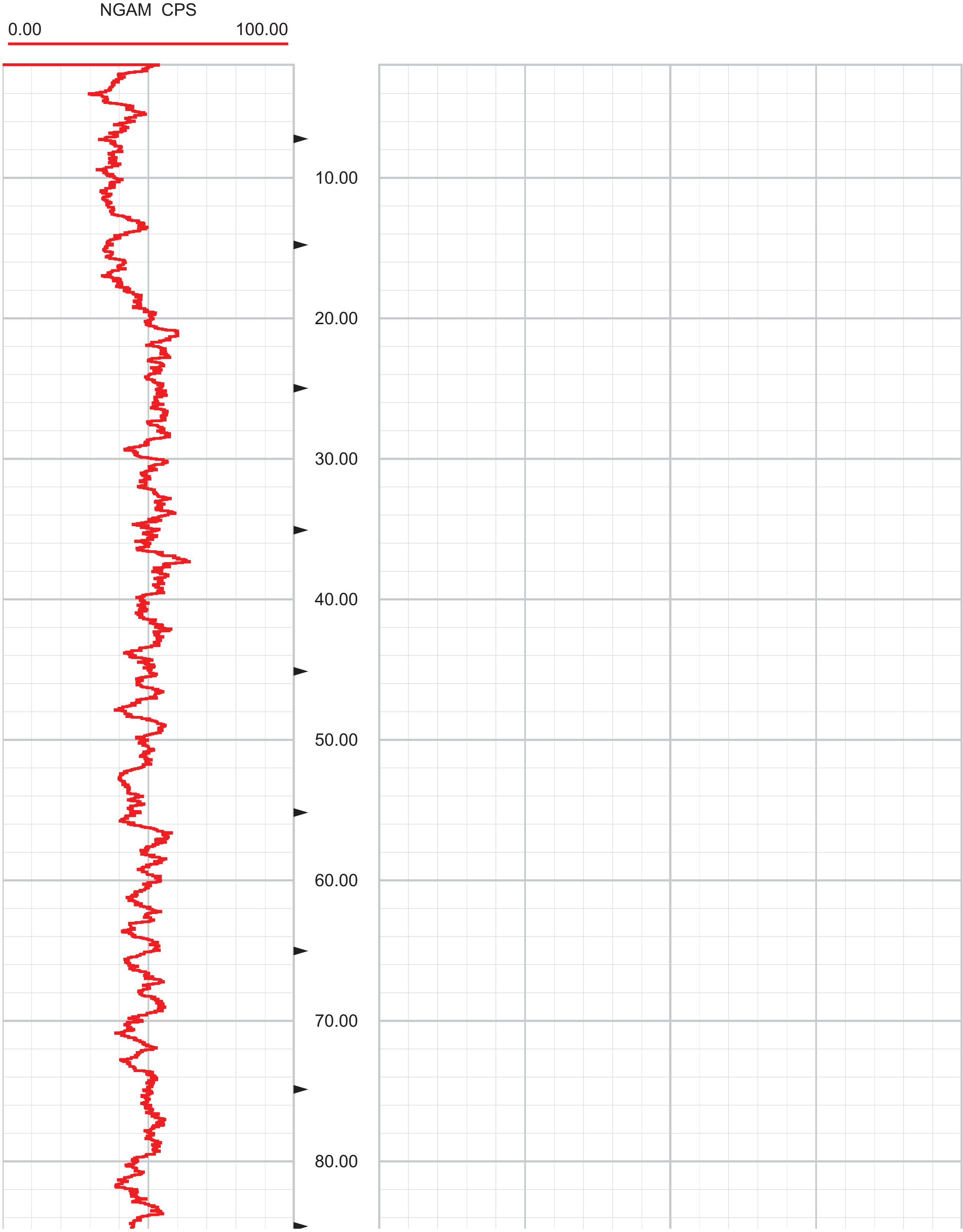
20.6	154	1461	0.49
21.1	159	1771	0.50
21.6	160	1855	0.50
22.1	172	1743	0.50
22.6	178	1644	0.49
23.1	179	1497	0.49
23.6	179	1405	0.49
24.1	179	1644	0.49
24.6	182	1625	0.49
25.1	179	1638	0.49
25.6	182	1561	0.49
26.1	188	1512	0.49
26.6	190	1556	0.49
27.1	197	1471	0.49
27.6	192	1497	0.49
28.1	194	1534	0.49
28.6	190	1613	0.49
29.1	190	1578	0.49
29.6	195	1625	0.49
30.1	197	1729	0.49
30.6	203	1757	0.49
31.1	207	1764	0.49
31.6	203	1808	0.49
32.1	206	1650	0.49
32.6	209	1682	0.49
33.1	209	1638	0.49
33.6	217	1669	0.49
34.1	215	1729	0.49
34.6	217	1709	0.49
35.1	219	1578	0.49
35.6	212	1619	0.49
36.1	208	1596	0.49
36.6	212	1507	0.49
37.1	215	1517	0.49
37.6	217	1523	0.49
38.1	219	1632	0.49
38.6	215	1550	0.49
39.1	213	1400	0.49
39.6	210	1428	0.49
40.1	210	1437	0.49
40.6	216	1418	0.49
41.1	211	1437	0.49
41.6	208	1461	0.49
42.1	210	1428	0.49
42.6	215	1481	0.49
43.1	214	1442	0.49
43.6	212	1502	0.49
44.1	215	1471	0.49

146.28	708	4996	0.49
147.92	708	5031	0.49
149.56	701	5085	0.49
151.20	723	4715	0.49
152.84	708	4653	0.49
154.48	716	4492	0.49
156.12	728	4668	0.49
157.76	709	4810	0.49
159.40	709	4762	0.49
161.04	718	4827	0.49
162.68	718	4876	0.49
164.32	718	4762	0.49
165.96	718	4944	0.49
167.60	718	4893	0.49
169.24	749	4996	0.49
170.88	791	5085	0.49
172.52	914	5455	0.49
174.16	1020	6085	0.49
175.80	1215	6443	0.48
177.44	1236	6273	0.48

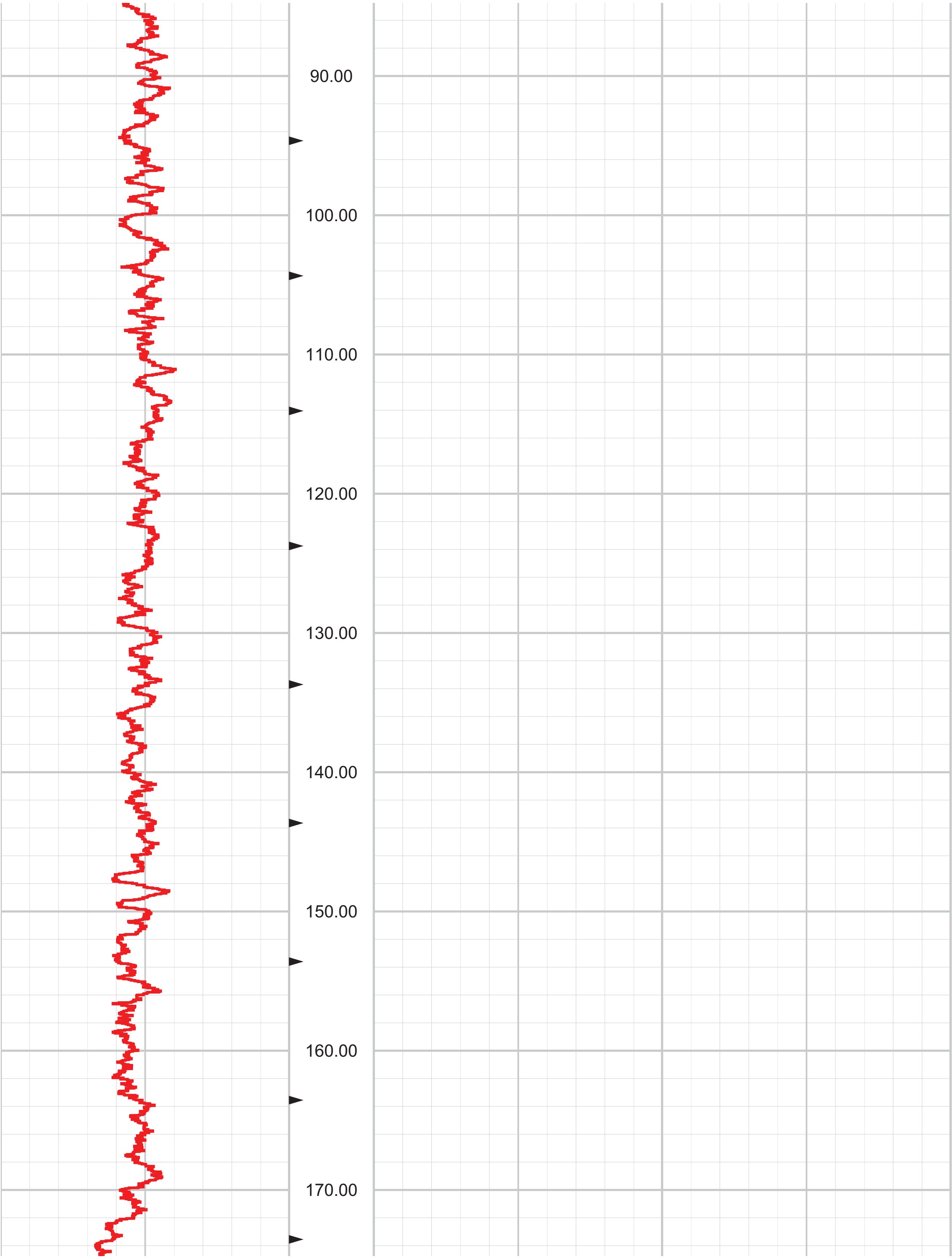
44.6	216	1523	0.49
45.1	216	1534	0.49
45.6	214	1550	0.49
46.1	220	1437	0.49
46.6	216	1418	0.49
47.1	218	1369	0.49
47.6	222	1423	0.49
48.1	216	1466	0.49
48.6	216	1452	0.49
49.1	219	1471	0.49
49.6	219	1486	0.49
50.1	219	1452	0.49
50.6	219	1507	0.49
51.1	219	1491	0.49
51.6	228	1523	0.49
52.1	241	1550	0.49
52.6	279	1663	0.49
53.1	311	1855	0.49
53.6	370	1964	0.48
54.1	377	1912	0.48

APPENDIX B

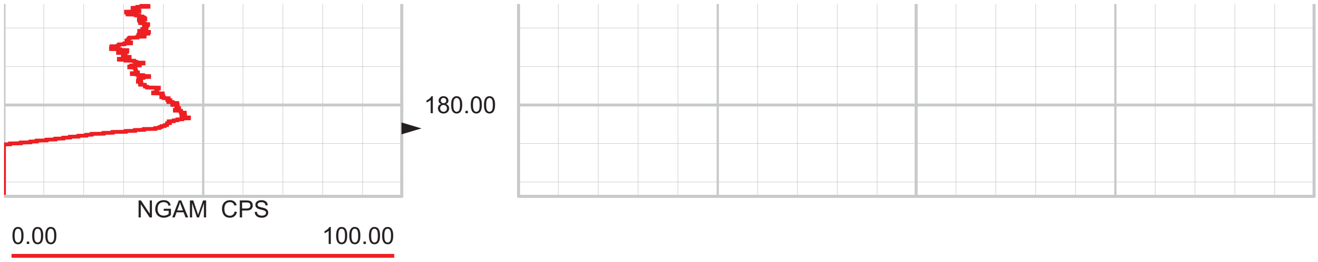
NATURAL GAMMA LOGS



Seattle Stanford School Center Boring S-3 natural gamma log rev 1 sheet 1 of 3



Seattle Stanford School Center Boring S-3 natural gamma log rev 1 sheet 2 of 3



Seattle Stanford School Center Boring S-3 natural gamma log rev 1 sheet 3 of 3

APPENDIX C

BORING GEOPHYSICAL LOGGING SYSTEMS
NIST TRACEABLE CALIBRATION RECORDS

MICRO PRECISION CALIBRATION, INC.
12686 HOOVER STREET
GARDEN GROVE, CA, 92841
(714) 901-5659

Certificate of Calibration

Date: 8/8/2011

Lab # 935.11

Certificate #: 1462589

Customer:
GEOVISION
1124 OLYMPIC DRIVE
CORONA, CA, 92881

Purchase Order: BCHMPC2001001
Work Order: N/A

MPC Control #: AM6767
Asset ID: 160023
Gage Type: LOGGER
Manufacturer: OYO
Model Number: 3403
Size: N/A
Temp./RH: 70 °F / 35 %

Serial Number: 160023
Department: N/A
Performed By: JIM WILLIAMS
Received Condition: IN TOLERANCE
Returned Condition: IN TOLERANCE
Cal Date: July 29, 2011
Cal. Interval: 12 MONTHS
Cal. Due Date: July 29, 2012

Found conditions meet or exceed manufacturer specifications.

***Calibration Notes:**
This certificate superceeds 1452653.

See attached data sheet for calculations.
Calibrated IAW customer supplied calibration data form Rev 2.0

Test Points

Description	Standard	Tolerance -	Tolerance +	As Found	As Left	UOM	Result
Test Frequency	50.000	49.500	50.500	50.000	50.000	Hz	Pass
Test Frequency	100.000	99.000	101.000	100.000	100.000	Hz	Pass
Test Frequency	200.000	198.000	202.000	200.000	200.000	Hz	Pass
Test Frequency	500.000	495.000	505.000	500.000	500.000	Hz	Pass
Test Frequency	1000.000	990.000	1010.000	1000.000	1000.000	Hz	Pass
Test Frequency	2000.000	1980.000	2020.000	2000.000	2000.000	Hz	Pass

Standards Used To Calibrate Equipment

I.D.	Description	Model	Serial	Manufacturer	Cal. Due Date	Traceability #
AM4000	WAVEFORM GENERATOR	33250A	MY40000703	AGILENT	8/17/2011	1063979
CC8501	GPS TIME & FREQUENCY RECEIVER	58503A	3710A08295	HEWLETT PACKARD	1/31/2013	1269299

Calibrating Technician: JIM WILLIAMS

QC Approval: Tammy Webster

MICRO PRECISION CALIBRATION, INC.
12686 HOOVER STREET
GARDEN GROVE, CA, 92841
(714) 901-5659

Certificate of Calibration

Date: 8/8/2011 **Lab #** 935.11 **Certificate #: 1462589**

T1100	COUNTER	53131A	3546A09912	HEWLETT PACKARD	1/27/2012	1233372

Procedures Used In This Event:

Procedure Name	Description
CALIBRATION GENERAL	GENERAL CALIBRATION INSTRUCTION

Calibrating Technician: JWilli

JIM WILLIAMS

QC Approval: Tammy Webster

Tammy Webster

Unless Otherwise Noted, Uncertainty Estimated at >= 4 to 1. Uncertainties have been estimated at a 95 percent confidence level (k=2). Services rendered comply with ISO 17025:2005, ISO 9001:2008, ANSI/NCSL Z540-3, MPC Quality Manual, MPC CSD and with customer purchase order instructions.

Calibration cycles and resulting due dates were submitted/approved by the customer. Any number of factors may cause an instrument to drift out of tolerance before the next scheduled calibration. Recalibration cycles should be based on frequency of use, environmental conditions and customer's established systematic accuracy. The information on this report, pertains only to the instrument identified.

All standards are traceable to the National Institute of Standards and Technology (NIST). Services rendered include proper manufacturer's service instructions and are warranted for no less than thirty (30) days This report may not be reproduced in part or in whole without the prior written approval of the issuing MPC lab.

AM 6767

geophysical services

SUSPENSION PS SEISMIC LOGGER/RECORDER CALIBRATION DATA FORM

INSTRUMENT DATA

System mfg.:	OYO	Model no.:	3403
Serial no.:	160023	Calibration date:	7/29/2011
By:	Jim Williams	Due date:	7/29/2012
Counter mfg.:	Hewlett Packard	Model no.:	53131A
Serial no.:	3546A09912	Calibration date:	1/27/2011
By:	Micro Precision Calibration	Due date:	1/27/2012
Signal generator mfg.:	Hewlett Packard	Model no.:	33250A
Serial no.:	MY40000703	Calibration date:	8/17/2010
By:	Micro Precision Calibration	Due date:	8/17/2011

SYSTEM SETTINGS:

Gain:	2
Filter	Analog:10kHz; Digital: Off
Range:	See sample period in table below
Delay:	0ms
Stack (1 std)	1
System date = correct date and time	7/29/2011 14:30

PROCEDURE:

Set sine wave frequency to target frequency with amplitude of approximately 0.25 volt peak
Note actual frequency on data form.
Set sample period and record data file to disk. Note file name on data form.
Pick duration of 9 cycles using PSLOG.EXE program, note duration on data form, and save as .sps file. Calculate average frequency for each channel pair and note on data form.

Average frequency must be within +/- 1% of actual frequency at all data points.

Maximum error ((AVG-ACT)/ACT*100)% As found 0.10% As left 0.10%

Target Frequency (Hz)	Actual Frequency (Hz)	Sample Period (microS)	File Name	Time for 9 cycles Hn (msec)	Average Frequency Hn (Hz)	Time for 9 cycles Hr (msec)	Average Frequency Hr (Hz)	Time for 9 cycles V (msec)	Average Frequency V (Hz)
50.00	50.000	200	501	180.0	50.00	180.0	50.00	180.0	50.00
100.0	100.00	100	502	90.00	100.0	90.00	100.0	90.00	100.0
200.0	200.00	50	503	45.00	200.0	44.95	200.2	44.95	200.2
500.0	500.00	20	504	18.00	500.0	18.00	500.0	18.00	500.0
1000	1000.0	10	505	9.000	1000	9.000	1000	9.000	1000
2000	2000.0	5	506	4.500	2000	4.500	2000	4.500	2000

Calibrated by:	Jim Williams	7/29/2011	
	Name	Date	Signature
Witnessed by:	Robert Steller	7/29/2011	
	Name	Date	Signature

Suspension PS Seismic Recorder/Logger Calibration Data Form Rev 2.0 July 21, 2008

APPENDIX C: GEOTECHNICAL LABORATORY TESTING

APPENDIX C

Geotechnical Laboratory Testing

CONTENTS

TABLE C-1
SUMMARY OF GEOTECHNICAL LABORATORY TESTS

Boring No.	Top Depth (feet)	Sample No.	Sample Type[a]	Blow Count (blows/foot)	USCS[b]	Geologic Unit[c]	Water Content (%)	Grain Size Analyses[d]				Plasticity[e]			ASTM Standard	Soil Description
								Gravel (%)	Sand (%)	Fines (%)	<2 microns (%)	Liquid Limit	Plastic Limit	Nonplastic		
P-1	18	1	SPT	0	CL	HF	36.2					36	22		D4318	Gray, silty CLAY
P-1	19.5	1	SPT	0	SP	HA	21.8	0.0	98.9	1.1					D422	Black, fine to medium SAND, trace of silt
P-2	70.5	1	SPT	12	SM	HA	19.6	0.0	67.1	32.9					D422	Dark gray, silty, fine SAND
P-2	71	1	SPT	12	ML	HA	31.4					26	28	NP	D4318	Dark gray, fine sandy SILT
P-2	75.5	2	SPT	12	ML	HA	30.8	0.0	10.8	89.2	5.8				D422	Dark gray, slightly fine sandy SILT, trace of clay; trace of shell fragments
P-2	76.5	2	SPT	12	SM	HA	20.4			28.1					D1140	Dark gray, silty, fine SAND
P-3	92	1	SPT	25	SM	HA	14.1	0.0	87.7	12.3					D422	Black, silty, fine to medium SAND
P-3	97.2	2	SPT	27	SP-SM	HA	17.7			8.0					D1140	Black, slightly silty, fine to medium SAND
P-4	138	1	SPT	23	ML	HE	13.0			71.4					D1140	Dark brown-gray, fine sandy SILT, trace of clay
P-4	138.4	1	SPT	23	SM	HE	14.9	0.0	76.4	23.6					D422	Black, silty, fine SAND
P-4	140.5	2	SPT	16	ML	HE	24.9					28	23		D4318	Dark brown-gray, slightly clayey SILT, trace of fine sand and fine gravel; trace of shell fragments
P-4	140.9	2	SPT	16	SM	HE	12.4			25.5					D1140	Dark brown-gray, silty, fine SAND
P-4	143	3	SPT	5	ML	HE	27.0	0.0	8.8	91.2	11.5				D422	Dark brown-gray, slightly fine sandy SILT, trace of clay; trace of shell fragments
P-4	143.5	3	SPT	5	ML	HE	28.4					30	29		D4318	Dark brown-gray SILT, trace of fine sand and clay
P-5	5	1	SPT	4	ML	HF	21.7	0.0	49.5	50.5					D422	Dark brown-gray, fine sandy SILT
P-5	10.4	2	SPT	1	CH	HF	49.2	0.0	4.7	95.3	23.2	62	30		D422/D4318	Dark gray, silty CLAY, trace of fine to medium sand
P-5	20.3	4	SPT	6	SP-SM	HF	30.0	7.9	83.5	8.6					D422	Black, slightly gravelly, slightly silty SAND
P-5	25	5	SPT	19	SP-SM	HA	21.7			6.3					D1140	Dark gray-brown, slightly silty, fine to medium SAND; trace of organics
P-5	30	6	SPT	30	SP-SM	HA	16.5	0.1	93.4	6.5					D422	Black, slightly silty, fine to medium SAND
P-5	35	7	SPT	36	SP-SM	HA	21.0			6.1					D1140	Dark gray-brown, slightly silty, fine to medium SAND
P-5	40.3	8	SPT	23	SP-SM	HA	19.6	0.0	92.5	7.5					D422	Dark gray-brown, slightly silty, fine to medium SAND
P-5	45	9	SPT	29	SP-SM	HA	21.0			6.7					D1140	Dark gray-brown, slightly silty, fine to medium SAND

TABLE C-1
SUMMARY OF GEOTECHNICAL LABORATORY TESTS

								Grain Size Analyses[d]				Plasticity[e]				
Boring No.	Top Depth (feet)	Sample No.	Sample Type[a]	Blow Count (blows/foot)	USCS[b]	Geologic Unit[c]	Water Content (%)	Gravel (%)	Sand (%)	Fines (%)	<2 microns (%)	Liquid Limit	Plastic Limit	Nonplastic	ASTM Standard	Soil Description
P-5	50	10	SPT	22	SP-SM	HA	24.0			10.7					D1140	Dark gray-brown, slightly silty, fine to medium SAND; trace of organics
P-5	55	11	SPT	32	SP-SM	HA	24.4	0.0	92.7	7.3					D422	Black, slightly silty, fine to medium SAND; trace of organics
P-5	60	12	SPT	21	SP-SM	HA	21.9			6.3					D1140	Black, slightly silty, fine to medium SAND
P-5	65	13	SPT	28	ML	HA				65.8					D1140	Dark brown-gray, fine sandy SILT
P-5	65.3	13	SPT	28	SP-SM	HA	22.0	0.0	94.7	5.3					D422	Dark gray-brown, slightly silty, fine SAND; trace of organics
P-5	70.4	14	SPT	22	SP-SM	HA	21.3			8.6					D1140	Dark gray-brown, slightly silty, fine SAND; trace of organics
P-5	75	15	SPT	15	SM	HA	30.1			16.2					D1140	Dark gray-brown, silty, fine SAND; trace of organics
P-5	80	16	SPT	21	ML	HE	25.6			60.1					D1140	Dark gray-brown, fine sandy SILT
P-5	80.5	16	SPT	21	SM	HE				24.1					D1140	Dark gray-brown, silty, fine SAND; scattered fine sandy silt layers, trace of organics
P-5	85	17	SPT	7	ML	HE	27.1					31	29		D4318	Dark gray-brown, slightly fine sandy SILT, trace of clay
P-5	90.6	18	SPT	8	SM	HA	23.6			25.9					D1140	Black, silty, fine SAND; trace of organics
P-5	95	19	SPT	10	SM	HA	24.5	0.0	73.2	26.8					D422	Black, silty, fine SAND; trace of organics
P-5	100	20	SPT	14	ML	HE	29.5					26	28	NP	D4318	Dark gray-brown, slightly fine sandy SILT, trace of clay
P-5	105	21	SPT	19	SM	HA	21.5	0.0	82.1	17.9					D422	Dark gray-brown, silty, fine SAND; trace of organics
P-5	110	22	SPT	13	SM	HA	24.7			25.9					D1140	Dark gray-brown, silty, fine SAND
P-5	115	23	SPT	20	SM	HA	27.4			12.3					D1140	Dark gray-brown, silty, fine SAND; trace of organics
P-5	120	24	SPT	27	SP	HA	22.4			4.9					D1140	Black, fine SAND, trace of silt
P-5	125	25	SPT	8	SM	HA	27.0	0.0	58.8	41.2	3.7				D422	Black, silty, fine SAND
P-5	135	27	SPT	20	SM	HE	23.5			37.9					D1140	Dark gray-brown, silty, fine SAND; trace of silt layers
P-5	140	28	SPT	4	ML	HE	27.1			66.7					D1140	Dark gray-brown, fine sandy SILT
P-5	145.7	29	SPT	4	ML	HE	24.0	0.0	25.4	74.6	6.1				D422	Dark gray-brown, fine sandy SILT
P-5	150	30	SPT	0	ML	HE	38.4	0.0	1.6	98.4	16.4				D422	Dark gray-brown, clayey SILT, trace of fine sand; trace of organics

TABLE C-1
SUMMARY OF GEOTECHNICAL LABORATORY TESTS

								Grain Size Analyses[d]				Plasticity[e]				
Boring No.	Top Depth (feet)	Sample No.	Sample Type[a]	Blow Count (blows/foot)	USCS[b]	Geologic Unit[c]	Water Content (%)	Gravel (%)	Sand (%)	Fines (%)	<2 microns (%)	Liquid Limit	Plastic Limit	Nonplastic	ASTM Standard	Soil Description
P-5	155.7	31	SPT	0	ML	HE	33.8					43	28		D4318	Dark gray-brown, clayey SILT
P-6	169.5	1	SPT	22	SM	HE	16.1	0.0	77.8	22.2	4.3				D422	Black, silty, fine to medium SAND; trace of organics and shell fragments
P-6	172	2	SPT	0	ML	HE	26.2					28	28	NP	D4318	Black SILT, trace of fine sand and clay
P-6	173	2	SPT	0	ML	HE	26.3	0.0	4.7	95.3	11.9				D422	Dark gray, slightly clayey SILT, trace of fine sand
P-6	174.5	3	SPT	0	ML	HE	32.7					34	30		D4318	Dark gray, slightly clayey SILT, trace of fine sand; trace of shell fragments
P-6	179.5	4	SPT	50/6"	SP	QPGO	6.5	32.6	62.5	4.8					D422	Dark green-gray, gravelly SAND, trace of silt
S-1	19.4	1	SPT	14	SP-SM	HA	16.9	0.0	93.7	6.3					D422	Black, slightly silty, fine to medium SAND
S-2	140	1	SPT	10	SM	HE	20.5			27.6					D1140	Black, silty, fine SAND; trace of shell fragments
S-2	141	1	SPT	10	ML	HE	14.2			85.5					D1140	Dark brown-gray, fine sandy SILT, trace of clay; trace of shell fragments
S-2	142.5	2	SPT	37	ML	HE	28.5					30	30	NP	D4318	Dark brown-gray, fine sandy SILT
S-2	146	3	SPT	4	ML	HE	20.6	0.0	8.5	91.5	12.4				D422	Gray, slightly fine sandy SILT, trace of clay; trace of shell fragments
S-2	150	4	SPT	0	ML	HE	35.5					46	29		D4318	Dark gray-brown, slightly fine sandy, clayey SILT
S-3	5	1	SPT	0	ML	HF	23.3			52.4					D1140	Dark brown-gray, fine sandy SILT, trace of clay; trace of organics and shell fragments
S-3	15	3	SPT	0	CH	HF	47.9	0.0	0.9	99.1	47.8	62	26		D422/D4318	Gray, silty CLAY, trace of sand; trace of shell fragments
S-3	20.6	4	SPT	12	SP	HA	20.1			4.5					D1140	Black, fine to medium SAND, trace of silt; trace of organics
S-3	25	5	SPT	19	SP	HA	24.8	0.2	95.8	4.0					D422	Black, fine to medium SAND, trace of silt; trace of organics
S-3	30	6	SPT	27	SP-SM	HA	15.8			5.1					D1140	Black, slightly silty, fine to medium SAND; trace of organics
S-3	35	7	SPT	29	SP-SM	HA	22.0			5.9					D1140	Black, slightly silty, fine to medium SAND; trace of organics
S-3	40	8	SPT	27	SP-SM	HA	16.9	0.0	91.9	8.1					D422	Black, slightly silty, fine to medium SAND
S-3	45	9	SPT	18	SM	HA	27.5			44.2					D1140	Black, silty, fine SAND; trace of organics
S-3	45.6	9	SPT	18	SP-SM	HA	24.8			6.8					D1140	Black, slightly silty, fine to medium SAND; trace of organics
S-3	50	10	SPT	27	SP-SM	HA	18.9			7.1					D1140	Black, slightly silty, fine to medium SAND; trace of organics
S-3	55	11	SPT	10	SM	HA	32.5			48.1					D1140	Black, silty, fine SAND; trace of organics (siltier portion of sample)

TABLE C-1
SUMMARY OF GEOTECHNICAL LABORATORY TESTS

								Grain Size Analyses[d]				Plasticity[e]				
Boring No.	Top Depth (feet)	Sample No.	Sample Type[a]	Blow Count (blows/foot)	USCS[b]	Geologic Unit[c]	Water Content (%)	Gravel (%)	Sand (%)	Fines (%)	<2 microns (%)	Liquid Limit	Plastic Limit	Nonplastic	ASTM Standard	Soil Description
S-3	55.01	11	SPT	10	SM	HA	30.6			25.5					D1140	Black, silty, fine to medium SAND; trace of organics (sandier portion of sample)
S-3	60	12	SPT	18	SM	HA	26.5			47.6					D1140	Black, silty, fine SAND; trace of organics
S-3	65	13	SPT	14	SP-SM	HA	21.5			8.4					D1140	Black, slightly silty, fine to medium SAND; trace of organics
S-3	70	14	SPT	19	SM	HA	25.7	0.0	86.9	13.1					D422	Black, silty, fine to medium SAND
S-3	75	15	SPT	23	SP-SM	HA	16.2			9.3					D1140	Black, slightly silty, fine to medium SAND; trace of organics
S-3	80	16	SPT	14	ML	HA	29.4			51.4					D1140	Dark gray-brown, fine sandy SILT; trace of organics
S-3	85.6	17	SPT	10	SM	HA	25.1	0.0	72.3	27.7	2.0				D422	Black, silty, fine to medium SAND
S-3	90	18	SPT	25	SP-SM	HA	16.3			7.1					D1140	Black, slightly silty, fine to medium SAND; trace of organics
S-3	95	19	SPT	17	SM	HA	23.2			14.9					D1140	Black, silty, fine to medium SAND; trace of organics
S-3	100	20	SPT	32	SP-SM	HA	17.6			9.2					D1140	Black, slightly silty, fine SAND; trace of organics
S-3	105	21	SPT	22	SM	HA	21.5			22.1					D1140	Black, silty, fine SAND; trace of organics
S-3	110	22	SPT	25	SM	HA	18.0	0.0	87.2	12.8					D422	Black, silty, fine SAND
S-3	115	23	SPT	31	SM	HA	22.0			14.3					D1140	Black, silty, fine SAND; trace of organics
S-3	120	24	SPT	21	ML	HA	26.8	0.0	48.8	51.2	4.5				D422	Black, fine sandy SILT
S-3	125	25	SPT	41	SP-SM	HA	23.0			5.6					D1140	Black, slightly silty, fine SAND
S-3	130	26	SPT	33	SM	HA	17.4			12.6					D1140	Black, silty, fine SAND; trace of organics
S-3	135.2	27	SPT	17	ML	HE	25.0	0.0	33.5	66.5	4.0	27	27	NP	D422/D4318	Black, fine sandy SILT, trace of clay; trace of organics
S-3	140	28	SPT	6	SM	HE	24.2			26.7					D1140	Black, silty, fine SAND; scattered organics
S-3	140.8	28	SPT	6	ML	HE	26.9			74.4					D1140	Black, fine sandy SILT; trace of organics
S-3	145.5	29	SPT	6	ML	HE	32.9	0.0	9.3	90.7	10.2				D422	Black, slightly fine sandy SILT, trace of clay
S-3	150	30	SPT	0	ML	HE	29.6					47	29		D4318	Dark gray-brown, clayey SILT, trace of fine sand; scattered shell fragments
S-3	155	31	SPT	0	ML	HE	36.2	0.0	2.3	97.7	17.2				D422	Dark gray-brown, clayey SILT, trace of fine sand
S-3	160	32	SPT	0	ML	HE	36.5					47	29		D4318	Dark gray-brown, clayey SILT; trace of organics

TABLE C-1
SUMMARY OF GEOTECHNICAL LABORATORY TESTS

Boring No.	Top Depth (feet)	Sample No.	Sample Type[a]	Blow Count (blows/foot)	USCS[b]	Geologic Unit[c]	Water Content (%)	Grain Size Analyses[d]				Plasticity[e]			ASTM Standard	Soil Description
								Gravel (%)	Sand (%)	Fines (%)	<2 microns (%)	Liquid Limit	Plastic Limit	Nonplastic		
S-3	165	33	SPT	1	ML	HE	19.8	0.0	41.2	58.8	4.3				D422	Dark gray-brown, fine sandy SILT; interbedded with silty, fine to medium sand
S-3	170	34	SPT	10	ML	HE	31.4					34	29		D4318	Dark gray-brown, slightly clayey SILT, trace of fine sand
S-3	190	38	SPT	50/3"	SP-SM	QPGO	4.2	24.2	69.9	6.0					D422	Green-gray, slightly silty, fine gravelly SAND

Notes:

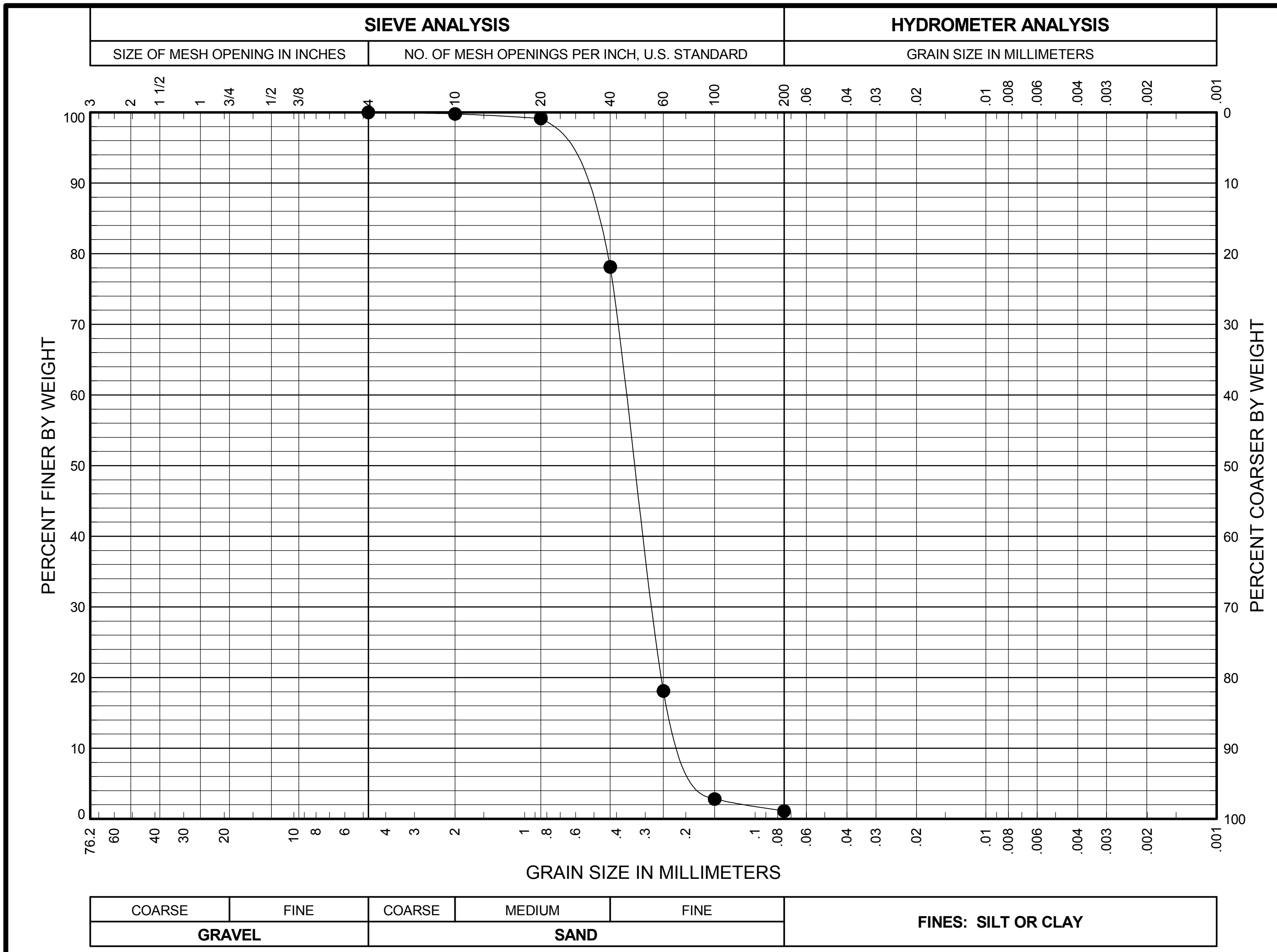
[a] SPT = Standard Penetration Test (split-spoon) sample.

[b] USCS = Unified Soil Classification System. See Figure A-1 in Appendix A for explanation of classifications.

[c] See Figure 3 for descriptions of geologic units.

[d] See Appendix C for plots of the grain size curves.

[e] NP = Nonplastic. See Appendix C for plasticity plots.



LEGEND

USCS: Unified Soil Classification System

COBBLE REM %: Percentage of cobbles removed from specimen; based on pre-removal total dry mass

SG: Specific gravity of soil solids < No. 4 sieve per ASTM D854

NAT WC %: Natural water content

Cu: Coefficient of uniformity

Cc: Coefficient of curvature

ASTM DES: ASTM International test standard designation

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BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	GRAVEL %	SAND %	FINES %	COBBLE REM %	SG	NAT WC %	Cu	Cc	TEST BY	REVIEW BY	ASTM DES
● P-1, S-1	19.5	SP	Black, fine to medium SAND, trace of silt		99	1.1			21.8	1.9	1.1	AFW	JFL	D422

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FIG. C-1
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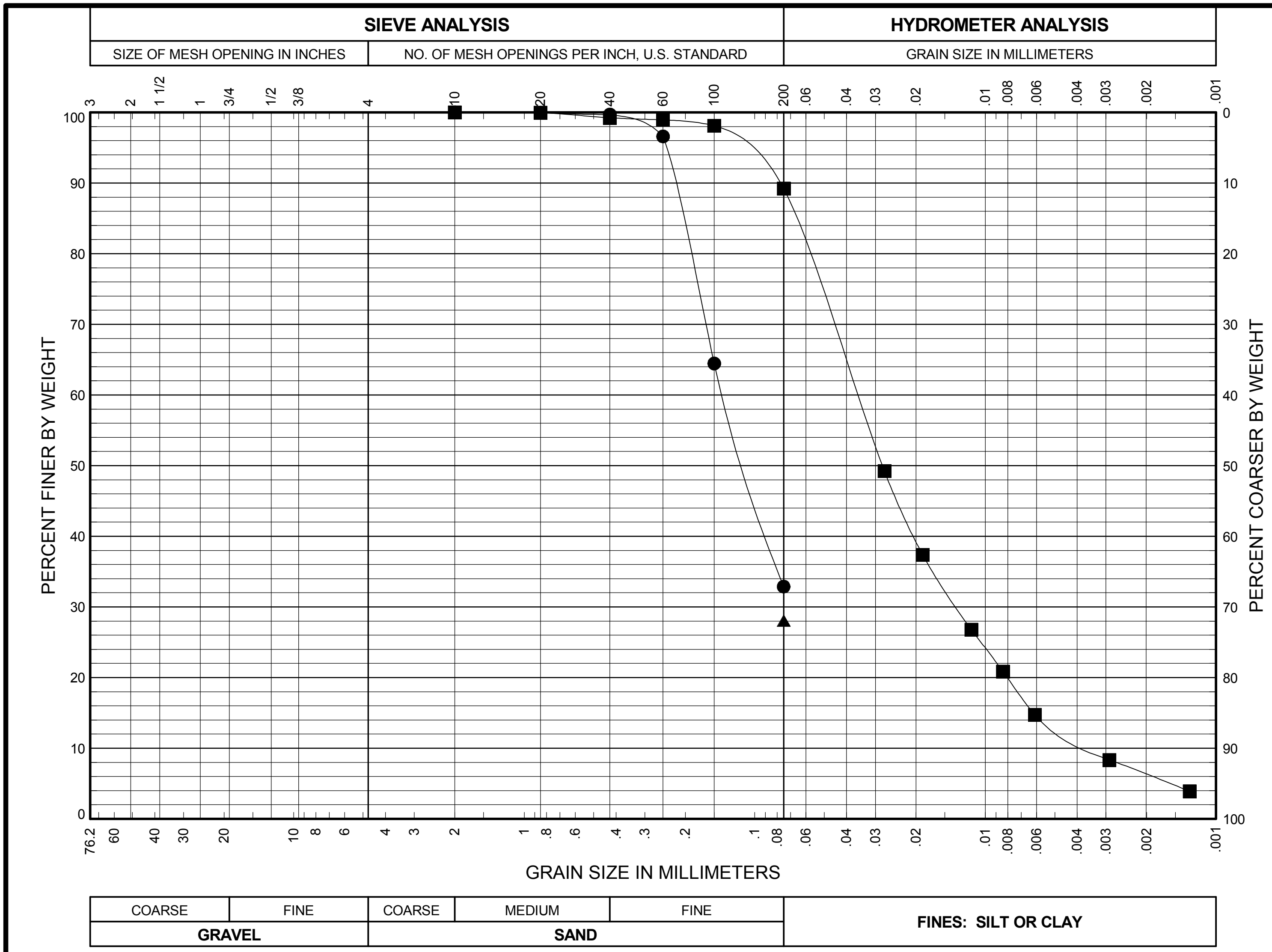
FIG. C-1



LEGEND

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BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	GRAVEL %	SAND %	FINES %	COBBLE REM %	SG	NAT WC %	Cu	Cc	TEST BY	REVIEW BY	ASTM DES
● P-2, S-1	70.5	SM	Dark gray, silty, fine SAND		67	32.9			19.6			AFW	JFL	D422
■ P-2, S-2	75.5	ML	Dark gray, slightly fine sandy SILT, trace of clay; trace of shell fragments		11	89.2			30.8			JFL	JFL	D422
▲ P-2, S-2	76.5	SM	Dark gray, silty, fine SAND			28.1			20.4			AFW	JFL	D1140

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FIG. C-2
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FIG. C-2

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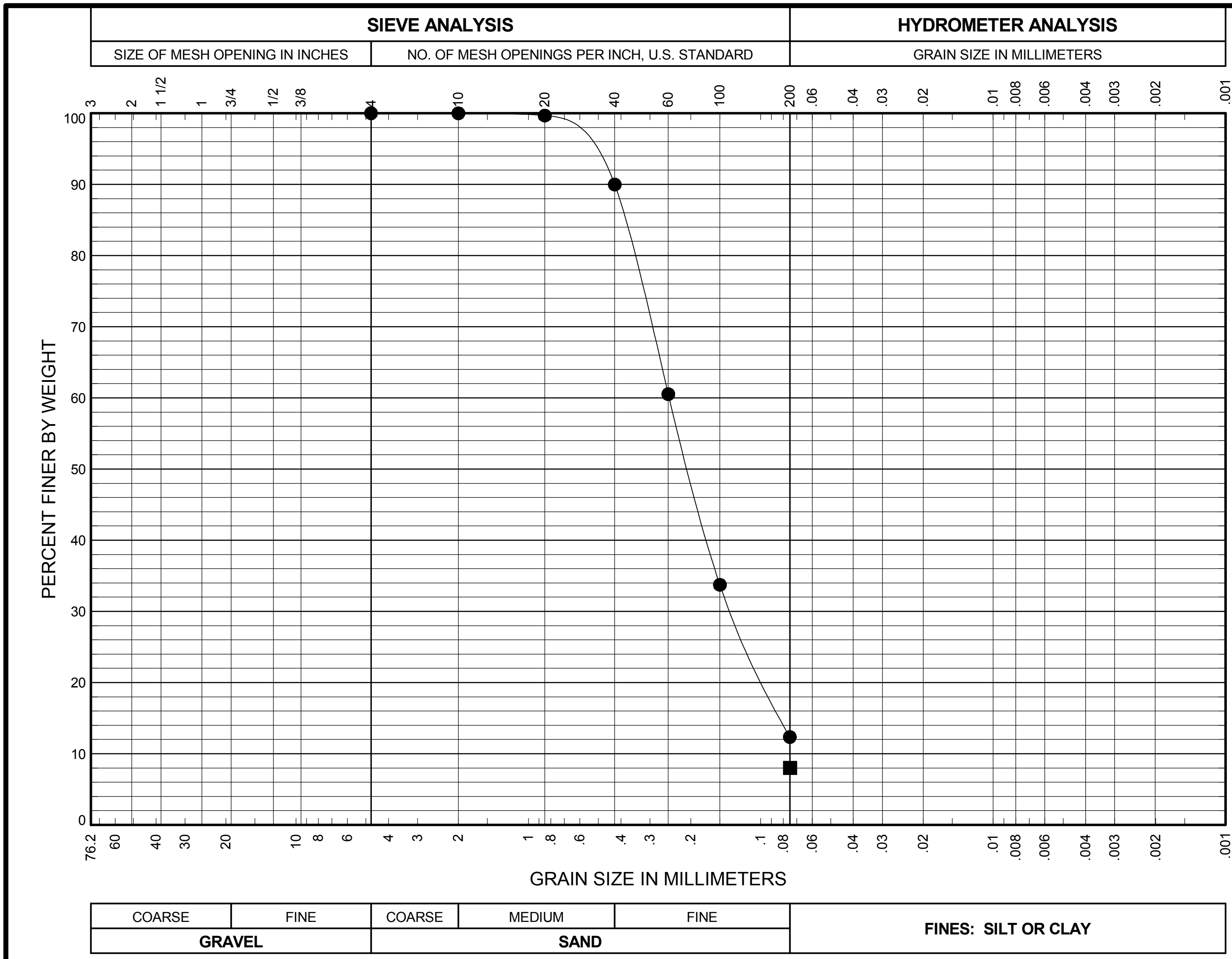

LEGEND

USCS: Unified Soil Classification System

COBBLE REM %: Percentage of cobbles removed from specimen; based on pre-removal total dry mass

SG: Specific gravity of soil solids < No. 4 sieve per ASTM D854

NAT WC %: Natural water content

Cu: Coefficient of uniformity

Cc: Coefficient of curvature

ASTM DES: ASTM International test standard designation

BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	GRAVEL %	SAND %	FINES %	COBBLE REM %	SG	NAT WC %	Cu	Cc	TEST BY	REVIEW BY	ASTM DES
● P-3, S-1	92.0	SM	Black, silty, fine to medium SAND		88	12.3			14.1	3.6	1.0	AFW	JFL	D422
■ P-3, S-2	97.2	SP-SM	Black, slightly silty, fine to medium SAND			8.0			17.7			AFW	JFL	D1140

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BORING P-3

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FIG. C-3
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FIG. C-3

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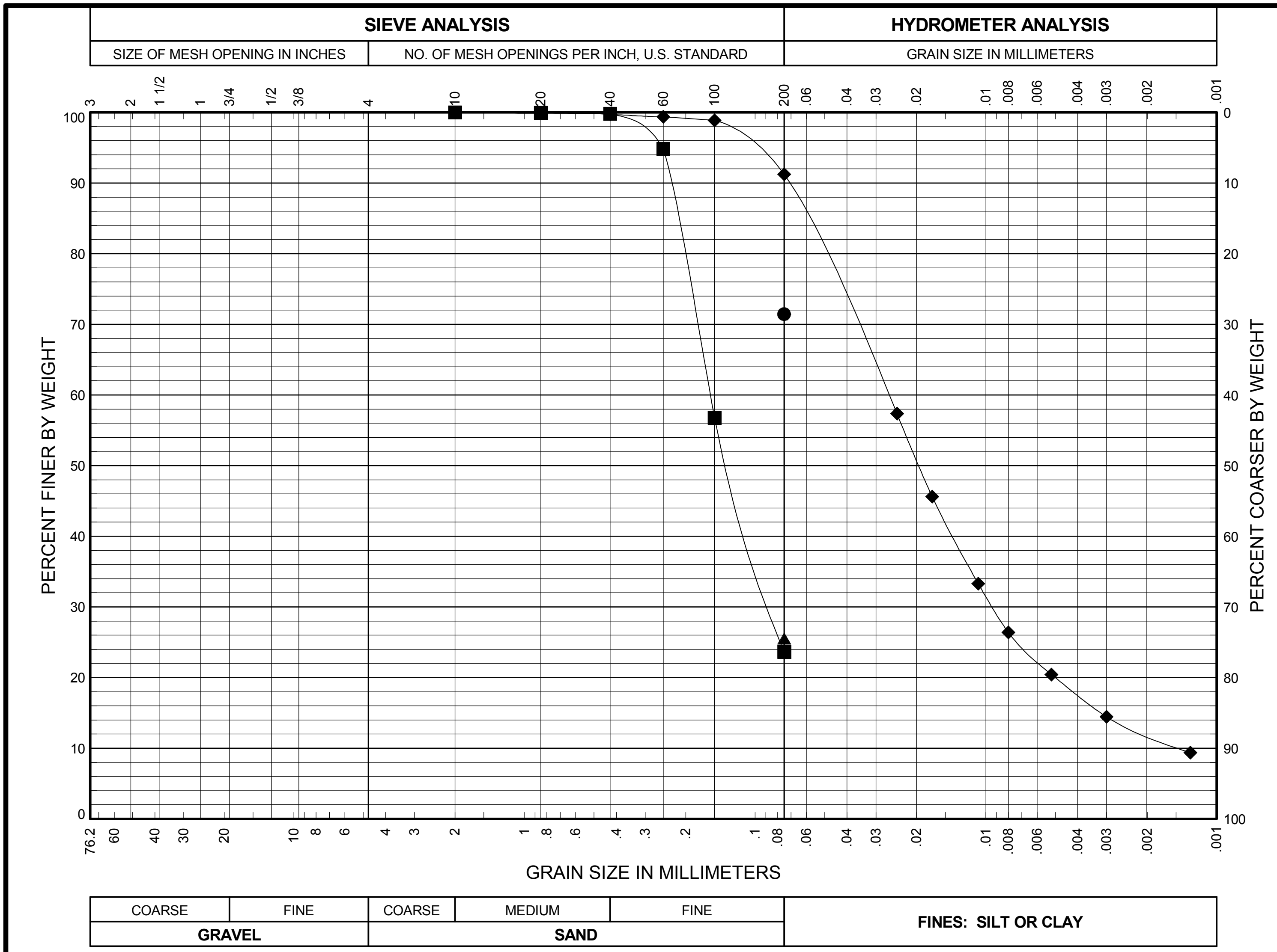

LEGEND

USCS: Unified Soil Classification System

COBBLE REM %: Percentage of cobbles removed from specimen; based on pre-removal total dry mass

SG: Specific gravity of soil solids < No. 4 sieve per ASTM D854

NAT WC %: Natural water content

Cu: Coefficient of uniformity

Cc: Coefficient of curvature

ASTM DES: ASTM International test standard designation

BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	GRAVEL %	SAND %	FINES %	COBBLE REM %	SG	NAT WC %	Cu	Cc	TEST BY	REVIEW BY	ASTM DES
● P-4, S-1	138.0	ML	Dark brown-gray, fine sandy SILT, trace of clay			71.4			13.0			AFW	JFL	D1140
■ P-4, S-1*	138.4	SM	Black, silty, fine SAND		76	23.6			14.9			AFW	JFL	D422
▲ P-4, S-2	140.9	SM	Dark brown-gray, silty, fine SAND			25.5			12.4			AFW	JFL	D1140
◆ P-4, S-3	143.0	ML	Dark brown-gray, slightly fine sandy SILT, trace of clay; trace of shell fragments		9	91.2			27.0			JFL	JFL	D422

** Sample specimen weight did not meet required minimum mass for ASTM test method.*

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FIG. C-4
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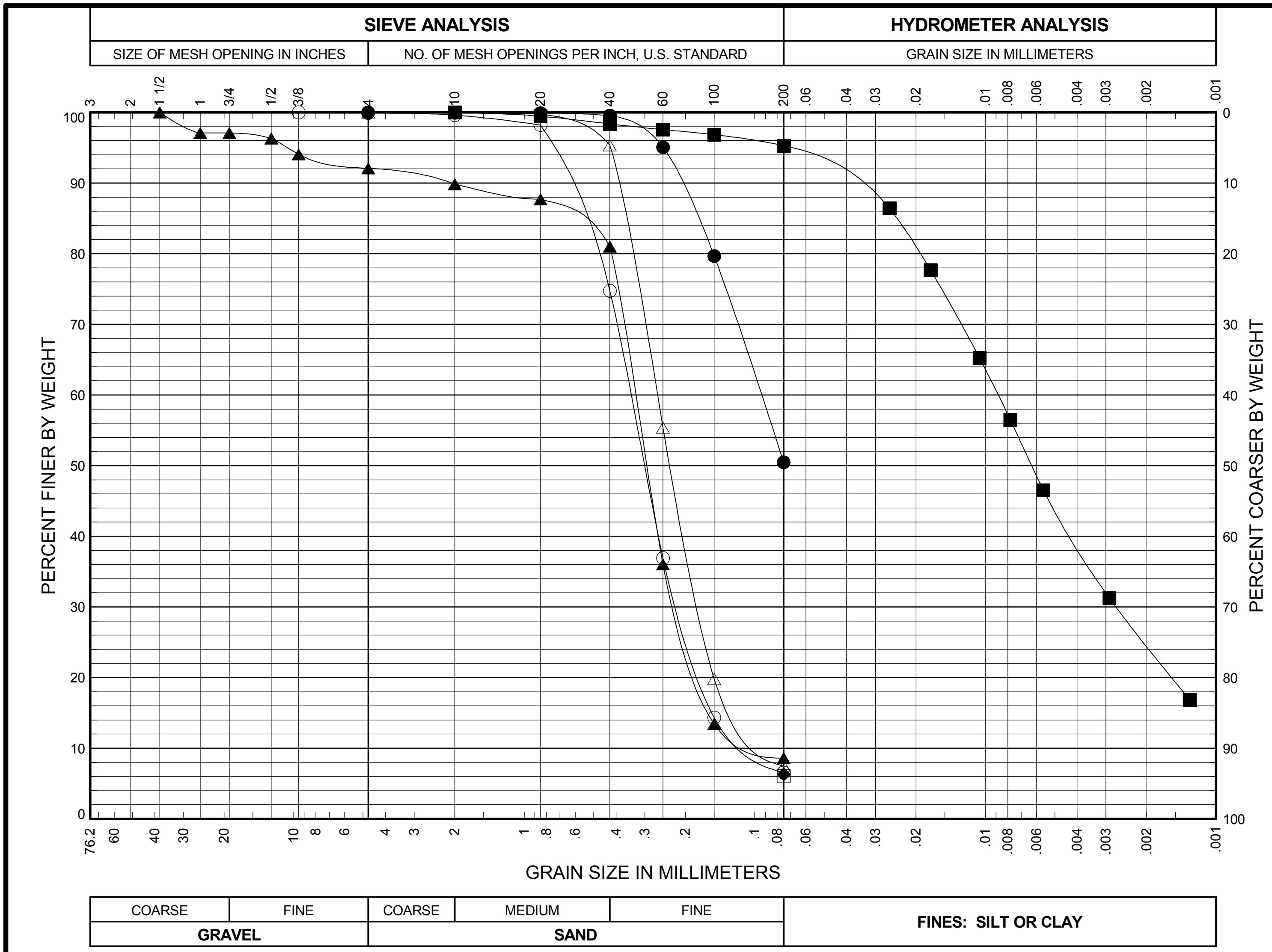
FIG. C-4



LEGEND

USCS: Unified Soil Classification System

COBBLE REM %: Percentage of cobbles removed from specimen; based on pre-removal total dry mass

SG: Specific gravity of soil solids < No. 4 sieve per ASTM D854

NAT WC %: Natural water content

Cu: Coefficient of uniformity

Cc: Coefficient of curvature

ASTM DES: ASTM International test standard designation

BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	GRAVEL %	SAND %	FINES %	COBBLE REM %	SG	NAT WC %	Cu	Cc	TEST BY	REVIEW BY	ASTM DES
● P-5, S-1	5.0	ML	Dark brown-gray, fine sandy SILT		50	50.5			21.7			AFW	JFL	D422
■ P-5, S-2	10.4	CH	Dark gray, silty CLAY, trace of fine to medium sand		5	95.3			49.2			AKV	JFL	D422
▲ P-5, S-4*	20.3	SP-SM	Black, slightly gravelly, slightly silty SAND	8	83	8.6			30.0	3.6	1.6	AFW	JFL	D422
◆ P-5, S-5	25.0	SP-SM	Dark gray-brown, slightly silty, fine to medium SAND; trace of organics			6.3			21.7			AKV	JFL	D1140
○ P-5, S-6	30.0	SP-SM	Black, slightly silty, fine to medium SAND	0	93	6.5			16.5	3.4	1.3	AFW	JFL	D422
□ P-5, S-7	35.0	SP-SM	Dark gray-brown, slightly silty, fine to medium SAND			6.1			21.0			AKV	JFL	D1140
△ P-5, S-8	40.3	SP-SM	Dark gray-brown, slightly silty, fine to medium SAND		93	7.5			19.6	3.1	1.3	AFW	JFL	D422

** Sample specimen weight did not meet required minimum mass for ASTM test method.*

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GRAIN SIZE DISTRIBUTION BORING P-5

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FIG. C-5
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FIG. C-5

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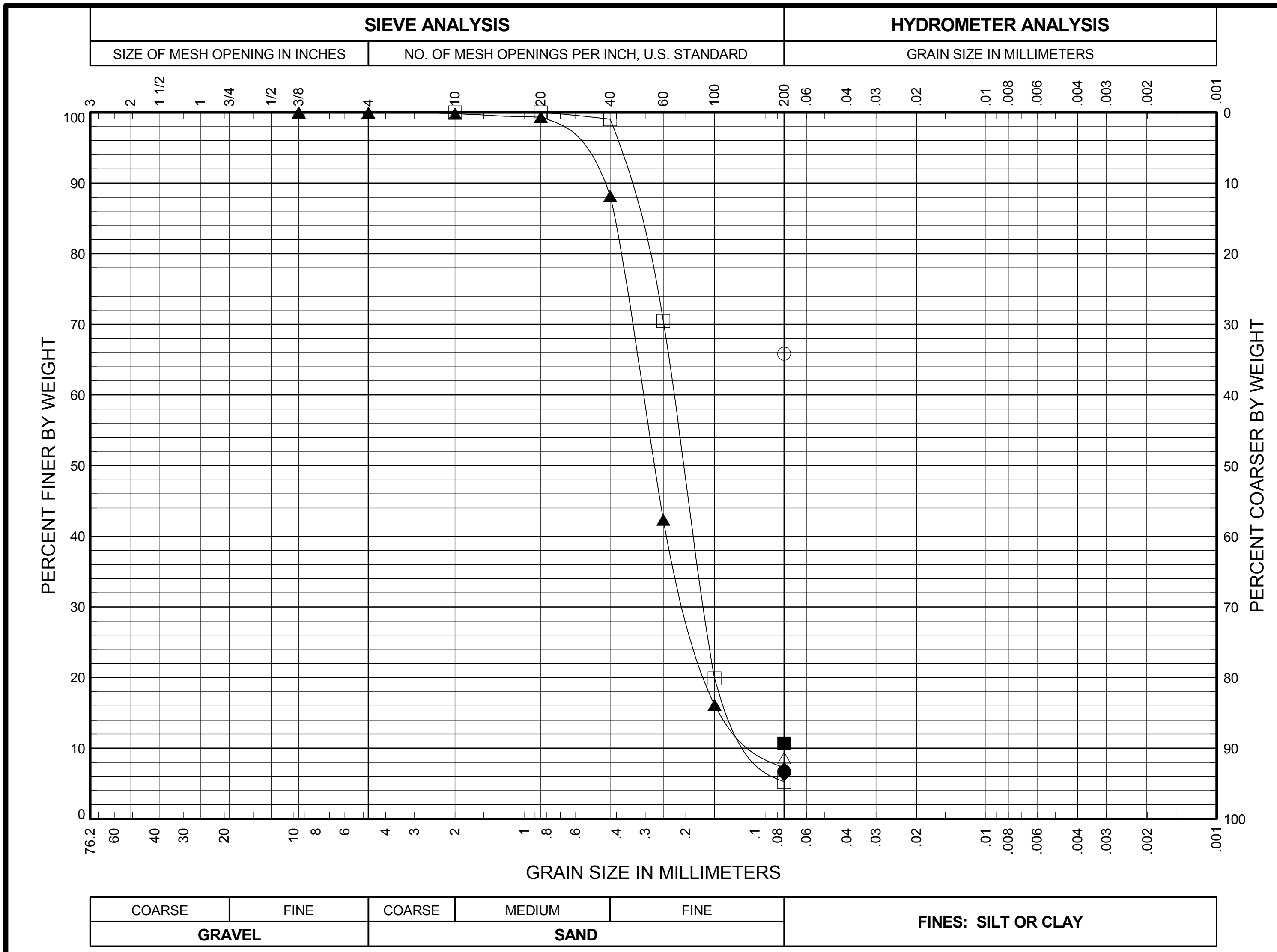

LEGEND

USCS: Unified Soil Classification System

COBBLE REM %: Percentage of cobbles removed from specimen; based on pre-removal total dry mass

SG: Specific gravity of soil solids < No. 4 sieve per ASTM D854

NAT WC %: Natural water content

Cu: Coefficient of uniformity

Cc: Coefficient of curvature

ASTM DES: ASTM International test standard designation

BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	GRAVEL %	SAND %	FINES %	COBBLE REM %	SG	NAT WC %	Cu	Cc	TEST BY	REVIEW BY	ASTM DES
● P-5, S-9	45.0	SP-SM	Dark gray-brown, slightly silty, fine to medium SAND			6.7			21.0			AKV	JFL	D1140
■ P-5, S-10	50.0	SP-SM	Dark gray-brown, slightly silty, fine to medium SAND; trace of organics			10.7			24.0			AKV	JFL	D1140
▲ P-5, S-11	55.0	SP-SM	Black, slightly silty, fine to medium SAND; trace of organics	0	93	7.3			24.4	3.3	1.4	AFW	JFL	D422
◆ P-5, S-12	60.0	SP-SM	Black, slightly silty, fine to medium SAND			6.3			21.9			AKV	JFL	D1140
○ P-5, S-13	65.0	ML	Dark brown-gray, fine sandy SILT			65.8						AKV	JFL	D1140
☐ P-5, S-13	65.3	SP-SM	Dark gray-brown, slightly silty, fine SAND; trace of organics		95	5.3			22.0	2.4	1.3	AFW	JFL	D422
△ P-5, S-14	70.4	SP-SM	Dark gray-brown, slightly silty, fine SAND; trace of organics			8.6			21.3			AKV	JFL	D1140

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BORING P-5

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FIG. C-5
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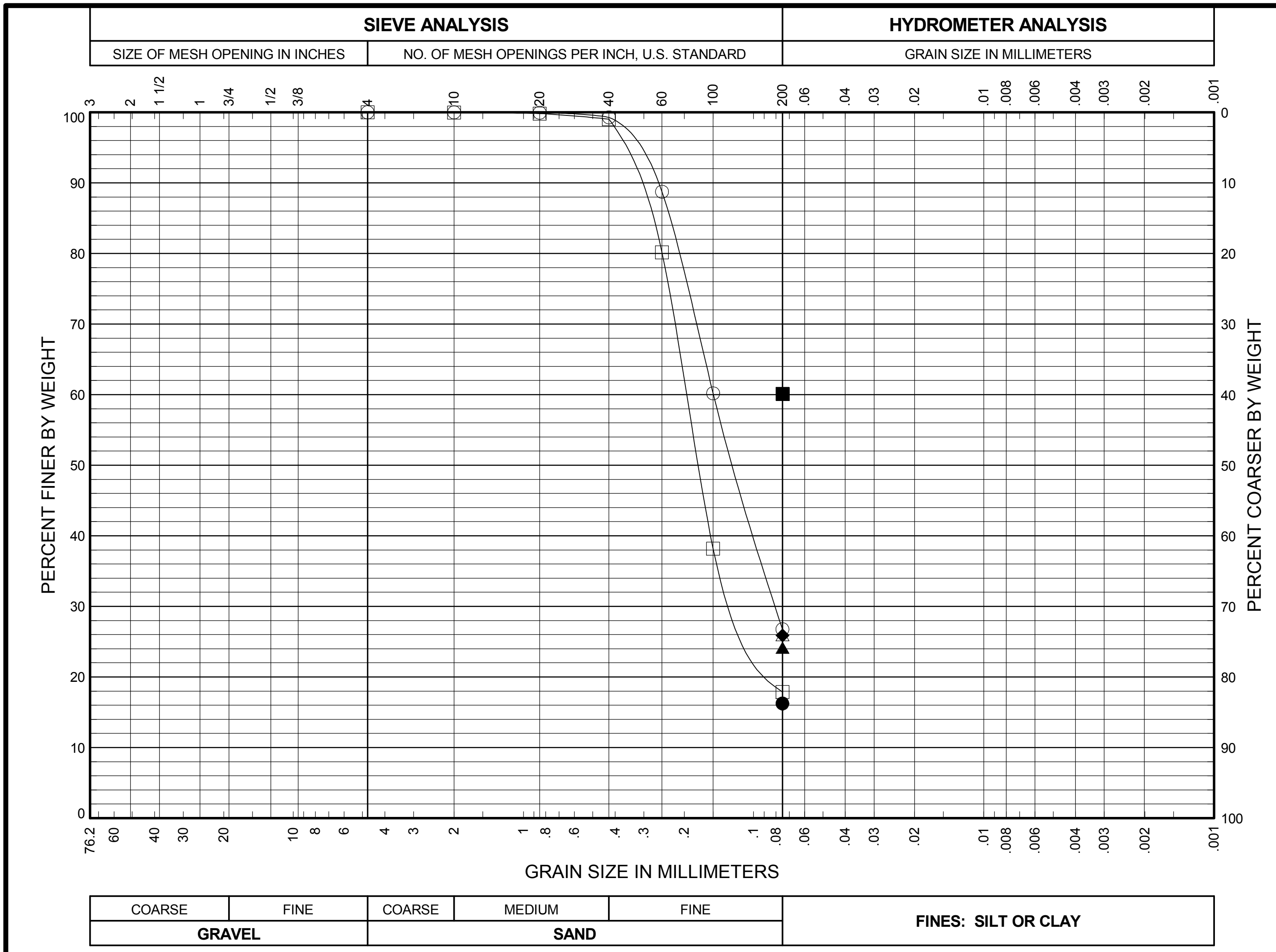
FIG. C-5



LEGEND

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COBBLE REM %: Percentage of cobbles removed from specimen; based on pre-removal total dry mass

SG: Specific gravity of soil solids < No. 4 sieve per ASTM D854

NAT WC %: Natural water content

Cu: Coefficient of uniformity

Cc: Coefficient of curvature

ASTM DES: ASTM International test standard designation

BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	GRAVEL %	SAND %	FINES %	COBBLE REM %	SG	NAT WC %	Cu	Cc	TEST BY	REVIEW BY	ASTM DES
● P-5, S-15	75.0	SM	Dark gray-brown, silty, fine SAND; trace of organics			16.2			30.1			AKV	JFL	D1140
■ P-5, S-16	80.0	ML	Dark gray-brown, fine sandy SILT			60.1			25.6			AKV	JFL	D1140
▲ P-5, S-16	80.5	SM	Dark gray-brown, silty, fine SAND; scattered fine sandy silt layers, trace of organics			24.1						AKV	JFL	D1140
◆ P-5, S-18	90.6	SM	Black, silty, fine SAND; trace of organics			25.9			23.6			AKV	JFL	D1140
○ P-5, S-19	95.0	SM	Black, silty, fine SAND; trace of organics		73	26.8			24.5			AFW	JFL	D422
□ P-5, S-21	105.0	SM	Dark gray-brown, silty, fine SAND; trace of organics		82	17.9			21.5			AFW	JFL	D422
△ P-5, S-22	110.0	SM	Dark gray-brown, silty, fine SAND			25.9			24.7			AKV	JFL	D1140

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GRAIN SIZE DISTRIBUTION
BORING P-5

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FIG. C-5
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FIG. C-5

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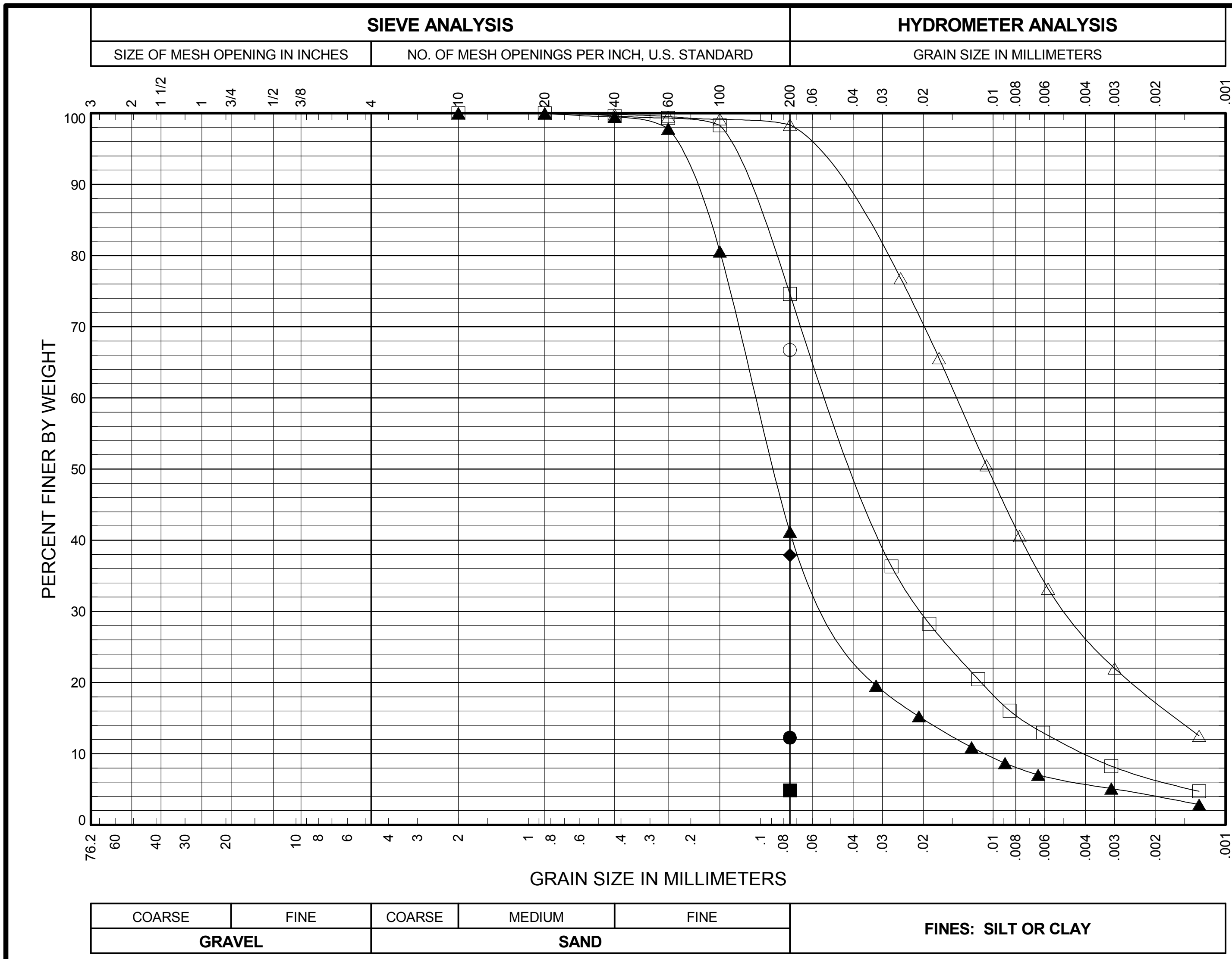

LEGEND

USCS: Unified Soil Classification System

COBBLE REM %: Percentage of cobbles removed from specimen; based on pre-removal total dry mass

SG: Specific gravity of soil solids < No. 4 sieve per ASTM D854

NAT WC %: Natural water content

Cu: Coefficient of uniformity

Cc: Coefficient of curvature

ASTM DES: ASTM International test standard designation

BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	GRAVEL %	SAND %	FINES %	COBBLE REM %	SG	NAT WC %	Cu	Cc	TEST BY	REVIEW BY	ASTM DES
● P-5, S-23	115.0	SM	Dark gray-brown, silty, fine SAND; trace of organics			12.3			27.4			AKV	JFL	D1140
■ P-5, S-24	120.0	SP	Black, fine SAND, trace of silt			4.9			22.4			AKV	JFL	D1140
▲ P-5, S-25	125.0	SM	Black, silty, fine SAND		59	41.2			27.0			AKV	JFL	D422
◆ P-5, S-27	135.0	SM	Dark gray-brown, silty, fine SAND; trace of silt layers			37.9			23.5			AKV	JFL	D1140
○ P-5, S-28	140.0	ML	Dark gray-brown, fine sandy SILT			66.7			27.1			AKV	JFL	D1140
□ P-5, S-29	145.7	ML	Dark gray-brown, fine sandy SILT		25	74.6			24.0			AKV	JFL	D422
△ P-5, S-30	150.0	ML	Dark gray-brown, clayey SILT, trace of fine sand; trace of organics		2	98.4			38.4			AKV	JFL	D422

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GRAIN SIZE DISTRIBUTION BORING P-5

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FIG. C-5
Sheet 4 of 4

FIG. C-5

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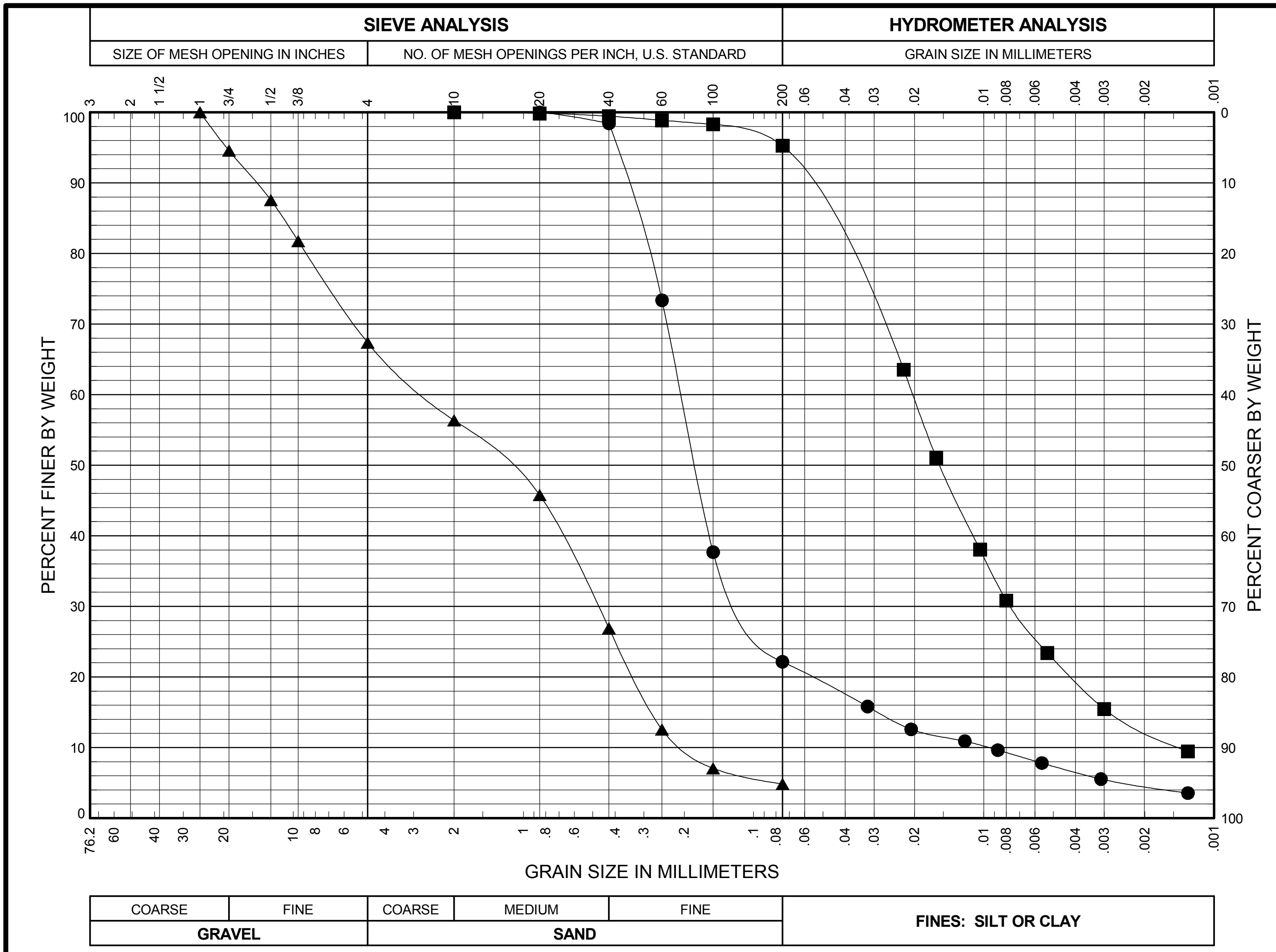

LEGEND

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COBBLE REM %:	Percentage of cobbles removed from specimen; based on pre-removal total dry mass
SG:	Specific gravity of soil solids < No. 4 sieve per ASTM D854
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Cc:	Coefficient of curvature
ASTM DES:	ASTM International test standard designation

AASHTO GSA MAIN 3INCHMINUS 21-21441.GPJ SHAN_WIL.GDT 1/10/13

BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	GRAVEL %	SAND %	FINES %	COBBLE REM %	SG	NAT WC %	Cu	Cc	TEST BY	REVIEW BY	ASTM DES
● P-6, S-1	169.5	SM	Black, silty, fine to medium SAND; trace of organics and shell fragments		78	22.2			16.1			JFL	JFL	D422
■ P-6, S-2	173.0	ML	Dark gray, slightly clayey SILT, trace of fine sand		5	95.3			26.3			JFL	JFL	D422
▲ P-6, S-4*	179.5	SP	Dark green-gray, gravelly SAND, trace of silt	33	63	4.8			6.5	13.5	0.4	AFW	JFL	D422

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BORING P-6

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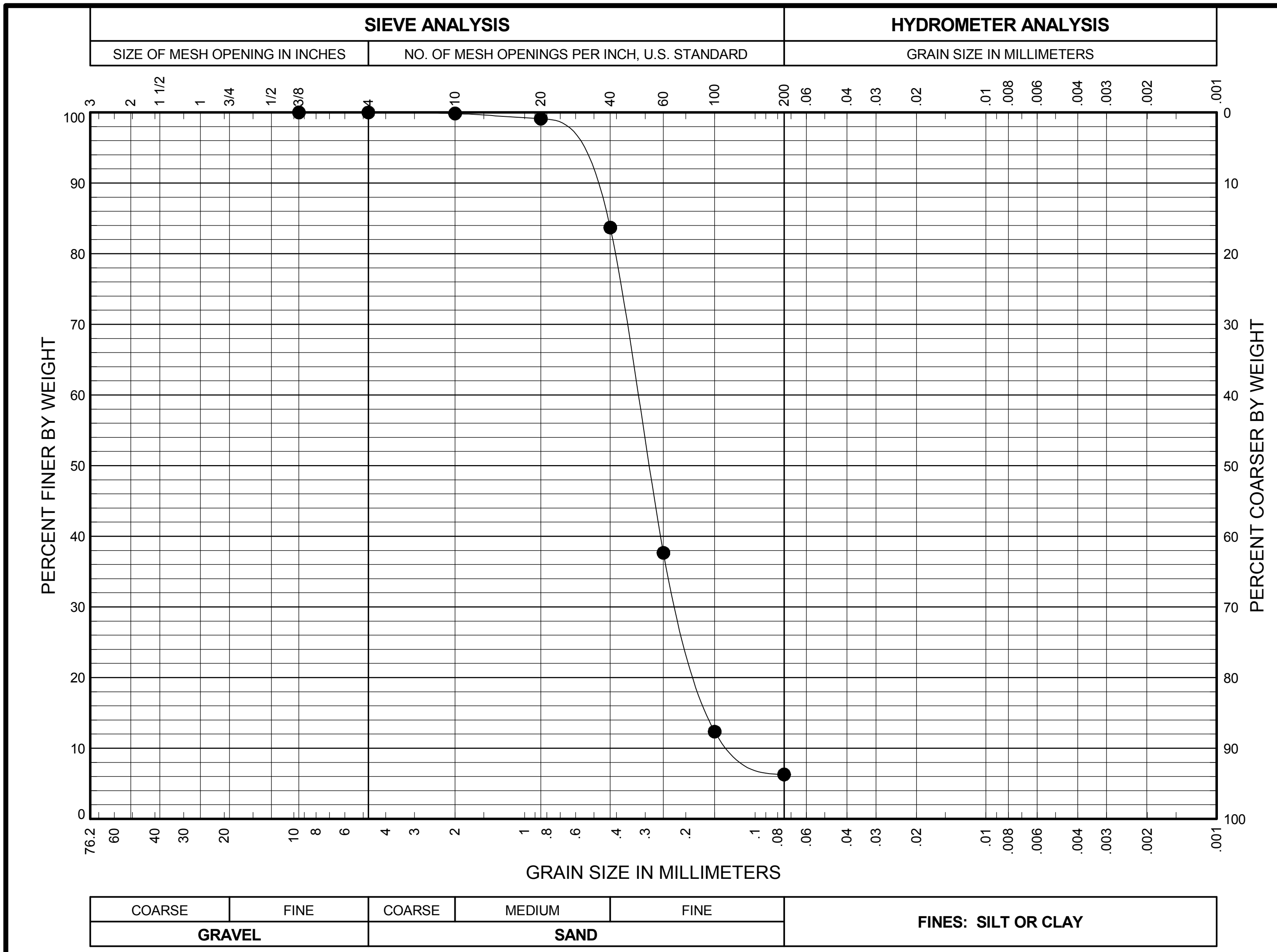
FIG. C-6
Sheet 1 of 1

FIG. C-6

** Sample specimen weight did not meet required minimum mass for ASTM test method.*



LEGEND

USCS: Unified Soil Classification System

COBBLE REM %: Percentage of cobbles removed from specimen; based on pre-removal total dry mass

SG: Specific gravity of soil solids < No. 4 sieve per ASTM D854

NAT WC %: Natural water content

Cu: Coefficient of uniformity

Cc: Coefficient of curvature

ASTM DES: ASTM International test standard designation

BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	GRAVEL %	SAND %	FINES %	COBBLE REM %	SG	NAT WC %	Cu	Cc	TEST BY	REVIEW BY	ASTM DES
● S-1, S-1*	19.4	SP-SM	Black, slightly silty, fine to medium SAND	0	94	6.3			16.9	2.8	1.2	AFW	JFL	D422

* *Sample specimen weight did not meet required minimum mass for ASTM test method.*

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GRAIN SIZE DISTRIBUTION
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FIG. C-7
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FIG. C-7

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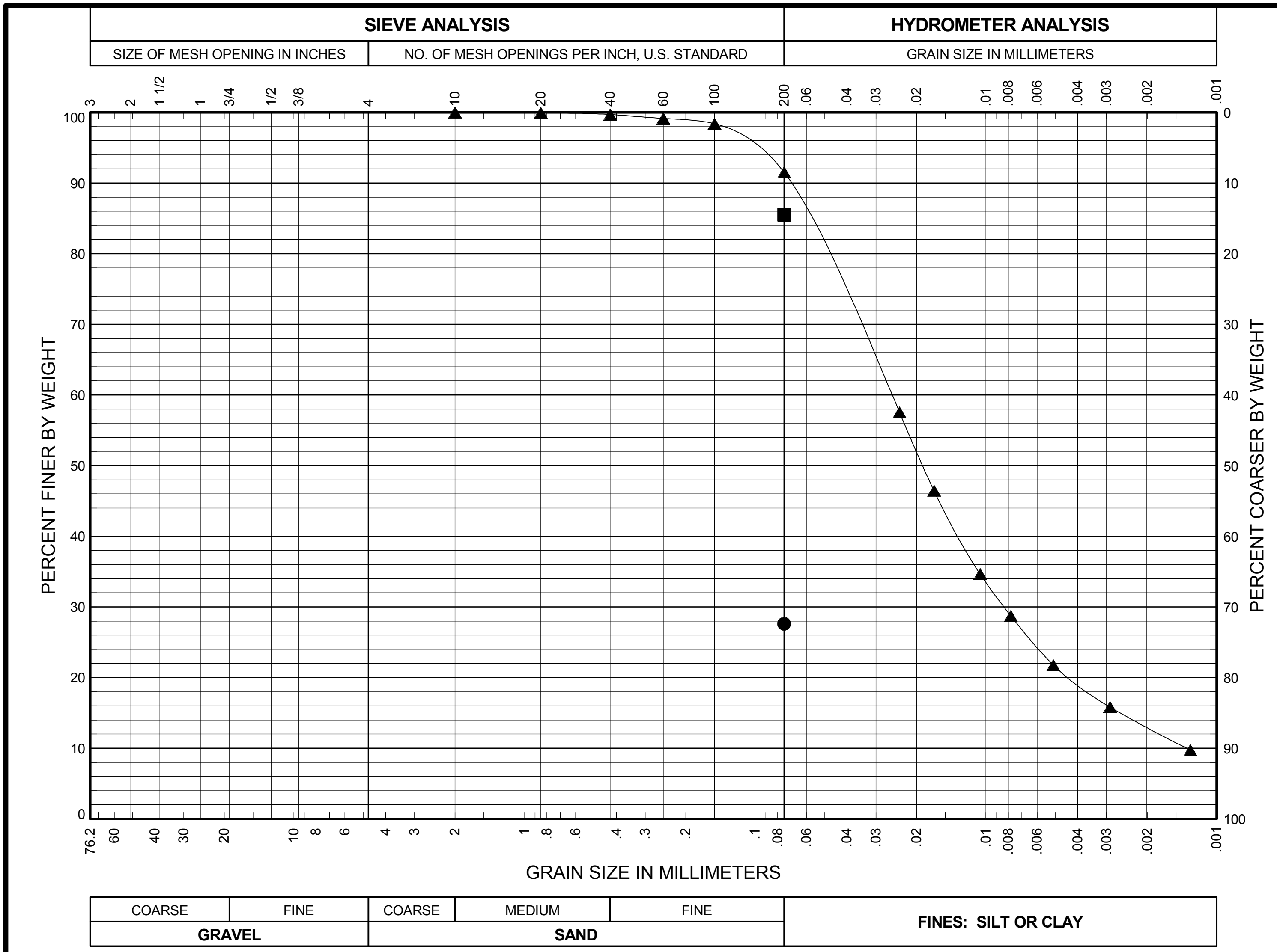

LEGEND

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AASHTO GSA MAIN 3INCHMINUS 21-21441.GPJ SHAN WIL.GDT 1/10/13

BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	GRAVEL %	SAND %	FINES %	COBBLE REM %	SG	NAT WC %	Cu	Cc	TEST BY	REVIEW BY	ASTM DES
● S-2, S-1	140.0	SM	Black, silty, fine SAND; trace of shell fragments			27.6			20.5			AFW	JFL	D1140
■ S-2, S-1	141.0	ML	Dark brown-gray, fine sandy SILT, trace of clay; trace of shell fragments			85.5			14.2			AFW	JFL	D1140
▲ S-2, S-3	146.0	ML	Gray, slightly fine sandy SILT, trace of clay; trace of shell fragments		8	91.5			20.6			JFL	JFL	D422

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GRAIN SIZE DISTRIBUTION BORING S-2

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FIG. C-8
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FIG. C-8

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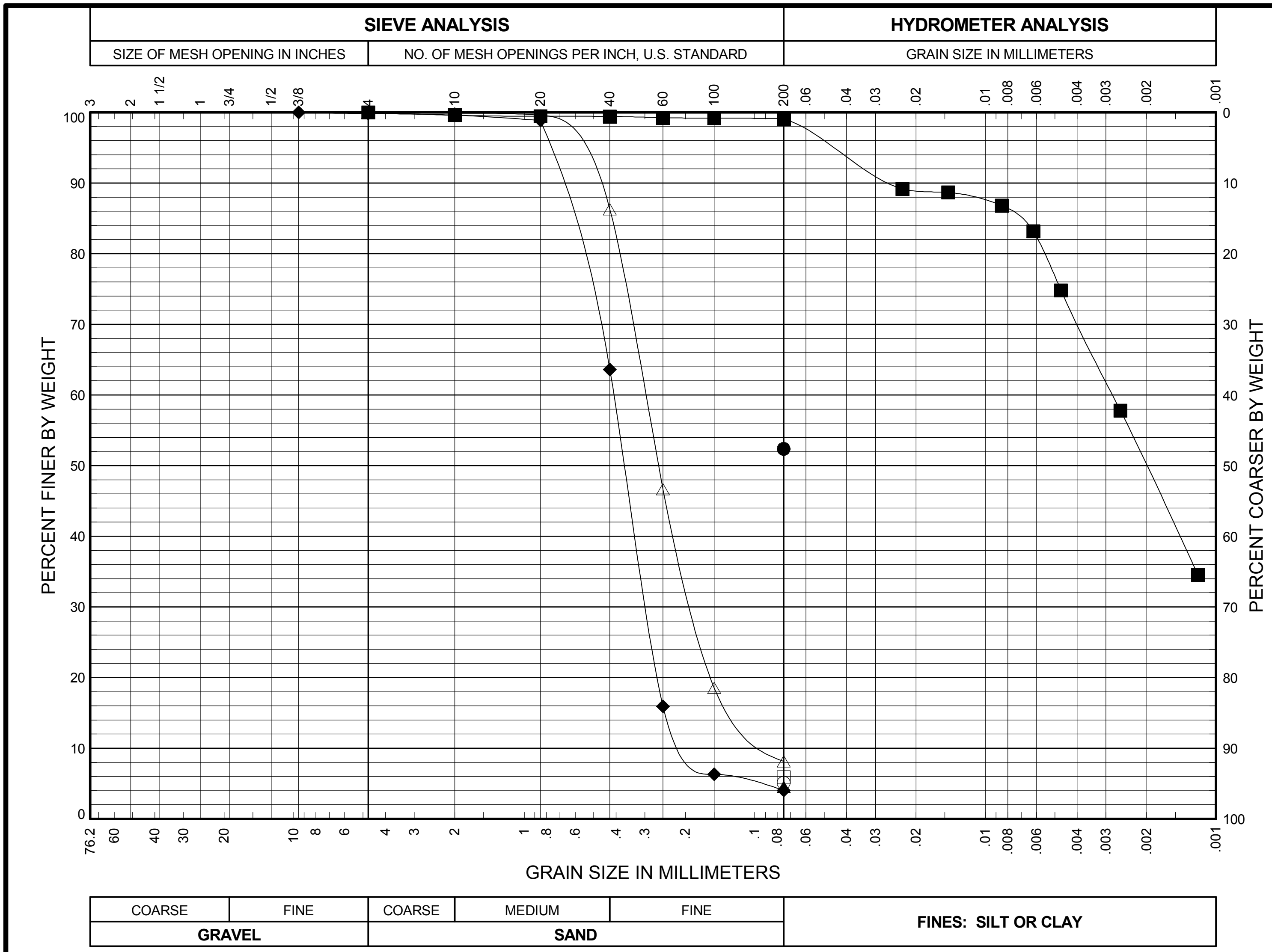

LEGEND

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SG: Specific gravity of soil solids < No. 4 sieve per ASTM D854

NAT WC %: Natural water content

Cu: Coefficient of uniformity

Cc: Coefficient of curvature

ASTM DES: ASTM International test standard designation

BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	GRAVEL %	SAND %	FINES %	COBBLE REM %	SG	NAT WC %	Cu	Cc	TEST BY	REVIEW BY	ASTM DES
● S-3, S-1	5.0	ML	Dark brown-gray, fine sandy SILT, trace of clay; trace of organics and shell fragments			52.4			23.3			AFW	JFL	D1140
■ S-3, S-3	15.0	CH	Gray, silty CLAY, trace of sand; trace of shell fragments		1	99.1			47.9			AFW	JFL	D422
▲ S-3, S-4	20.6	SP	Black, fine to medium SAND, trace of silt; trace of organics			4.5			20.1			AFW	JFL	D1140
◆ S-3, S-5	25.0	SP	Black, fine to medium SAND, trace of silt; trace of organics	0	96	4.0			24.8	2.2	1.1	AFW	JFL	D422
○ S-3, S-6	30.0	SP-SM	Black, slightly silty, fine to medium SAND; trace of organics			5.1			15.8			AFW	JFL	D1140
☐ S-3, S-7	35.0	SP-SM	Black, slightly silty, fine to medium SAND; trace of organics			5.9			22.0			AFW	JFL	D1140
△ S-3, S-8*	40.0	SP-SM	Black, slightly silty, fine to medium SAND		92	8.1			16.9	3.5	1.3	AFW	JFL	D422

** Sample specimen weight did not meet required minimum mass for ASTM test method.*

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GRAIN SIZE DISTRIBUTION
BORING S-3

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FIG. C-9
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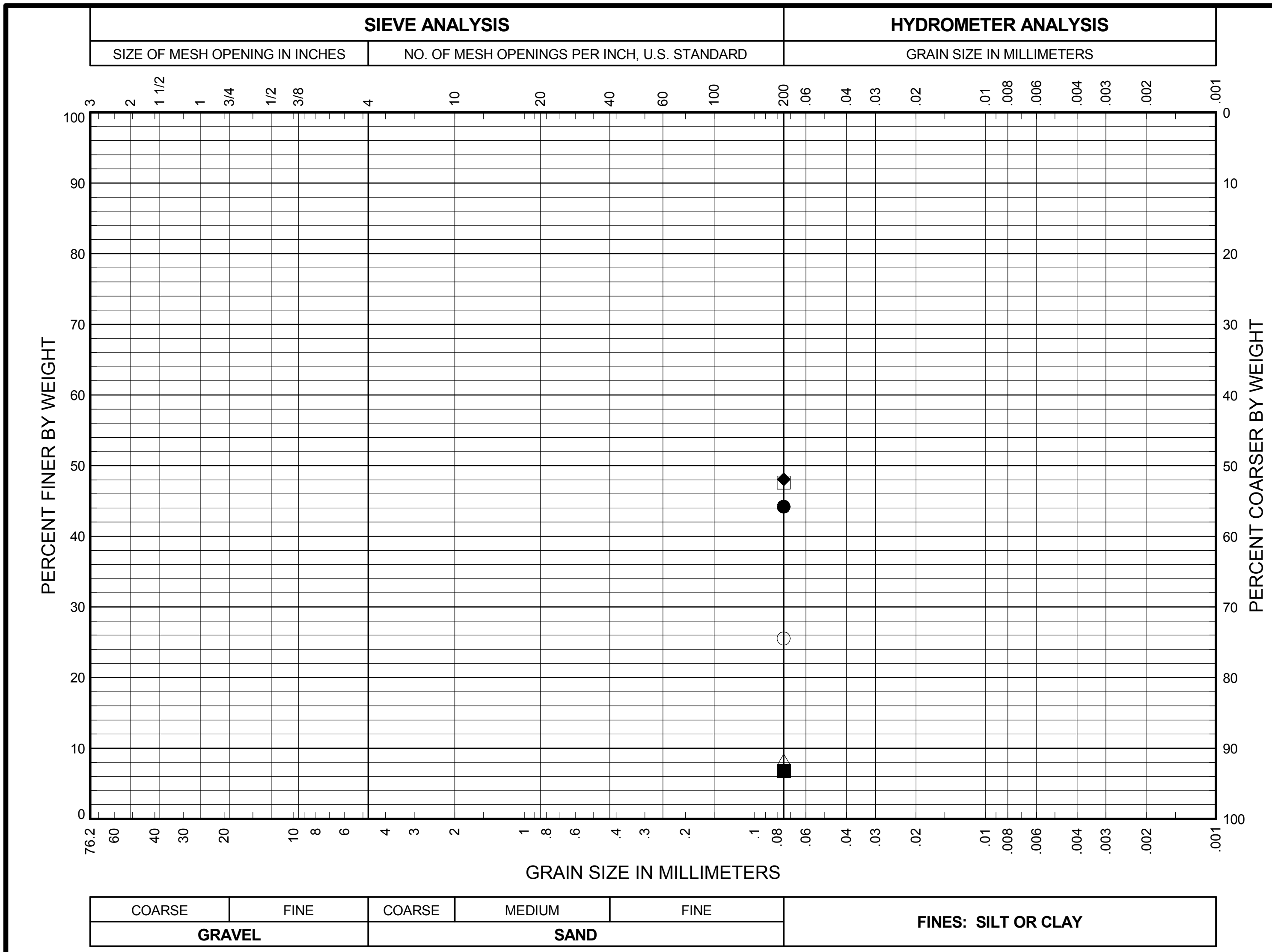
FIG. C-9



LEGEND

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ASTM DES: ASTM International test standard designation

BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	GRAVEL %	SAND %	FINES %	COBBLE REM %	SG	NAT WC %	Cu	Cc	TEST BY	REVIEW BY	ASTM DES
● S-3, S-9	45.0	SM	Black, silty, fine SAND; trace of organics			44.2			27.5			AFW	JFL	D1140
■ S-3, S-9	45.6	SP-SM	Black, slightly silty, fine to medium SAND; trace of organics			6.8			24.8			AFW	JFL	D1140
▲ S-3, S-10	50.0	SP-SM	Black, slightly silty, fine to medium SAND; trace of organics			7.1			18.9			AFW	JFL	D1140
◆ S-3, S-11	55.0	SM	Black, silty, fine SAND; trace of organics (siltier portion of sample)			48.1			32.5			AFW	JFL	D1140
○ S-3, S-11	55.0	SM	Black, silty, fine to medium SAND; trace of organics (sandier portion of sample)			25.5			30.6			AFW	JFL	D1140
□ S-3, S-12	60.0	SM	Black, silty, fine SAND; trace of organics			47.6			26.5			AFW	JFL	D1140
△ S-3, S-13	65.0	SP-SM	Black, slightly silty, fine to medium SAND; trace of organics			8.4			21.5			AFW	JFL	D1140

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FIG. C-9
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FIG. C-9

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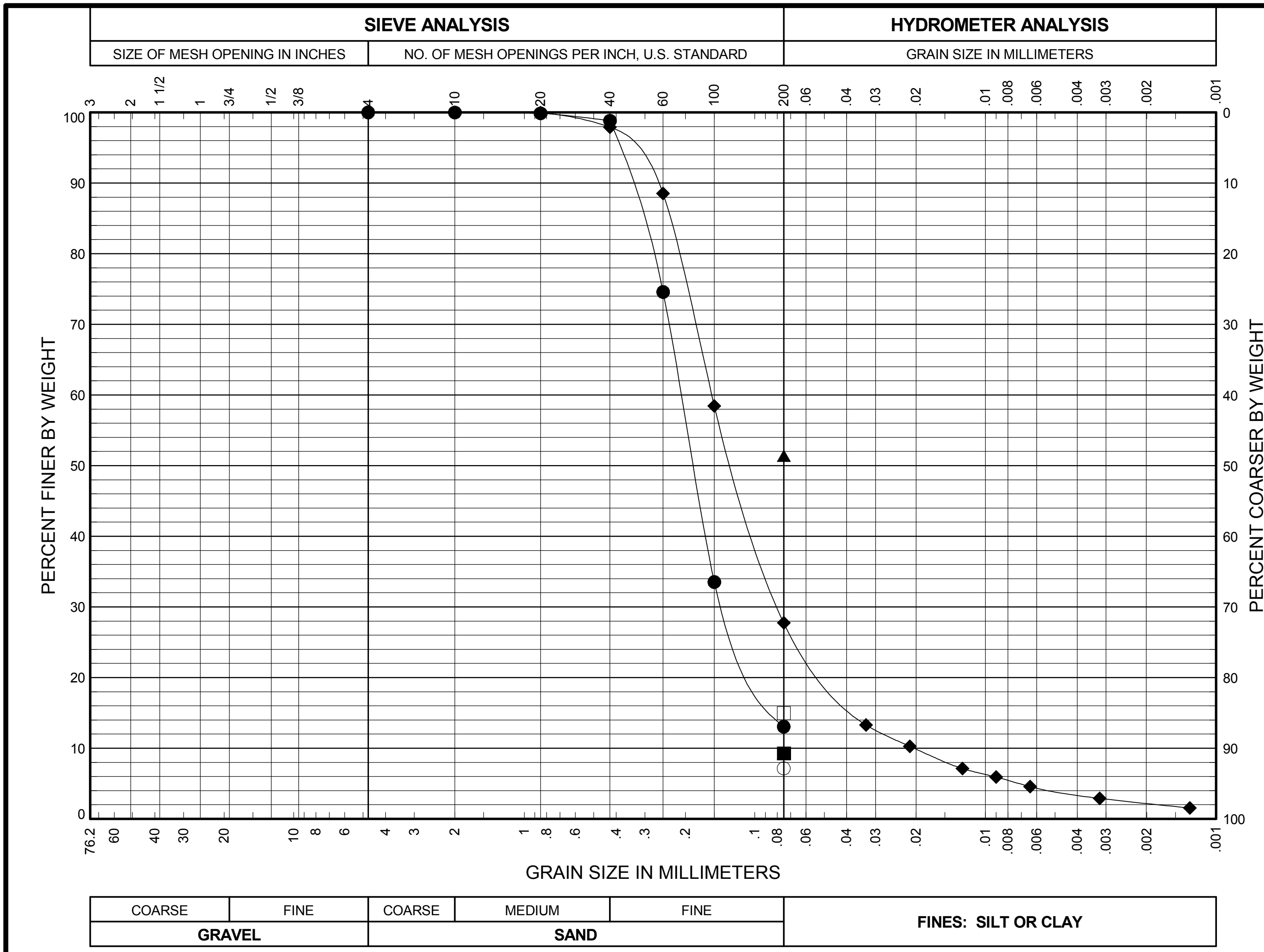

LEGEND

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BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	GRAVEL %	SAND %	FINES %	COBBLE REM %	SG	NAT WC %	Cu	Cc	TEST BY	REVIEW BY	ASTM DES
● S-3, S-14	70.0	SM	Black, silty, fine to medium SAND		87	13.1			25.7			AFW	JFL	D422
■ S-3, S-15	75.0	SP-SM	Black, slightly silty, fine to medium SAND; trace of organics			9.3			16.2			AFW	JFL	D1140
▲ S-3, S-16	80.0	ML	Dark gray-brown, fine sandy SILT; trace of organics			51.4			29.4			AFW	JFL	D1140
◆ S-3, S-17	85.6	SM	Black, silty, fine to medium SAND		72	27.7			25.1			AFW	JFL	D422
○ S-3, S-18	90.0	SP-SM	Black, slightly silty, fine to medium SAND; trace of organics			7.1			16.3			AFW	JFL	D1140
□ S-3, S-19	95.0	SM	Black, silty, fine to medium SAND; trace of organics			14.9			23.2			AFW	JFL	D1140
△ S-3, S-20	100.0	SP-SM	Black, slightly silty, fine SAND; trace of organics			9.2			17.6			AFW	JFL	D1140

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GRAIN SIZE DISTRIBUTION
BORING S-3

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FIG. C-9
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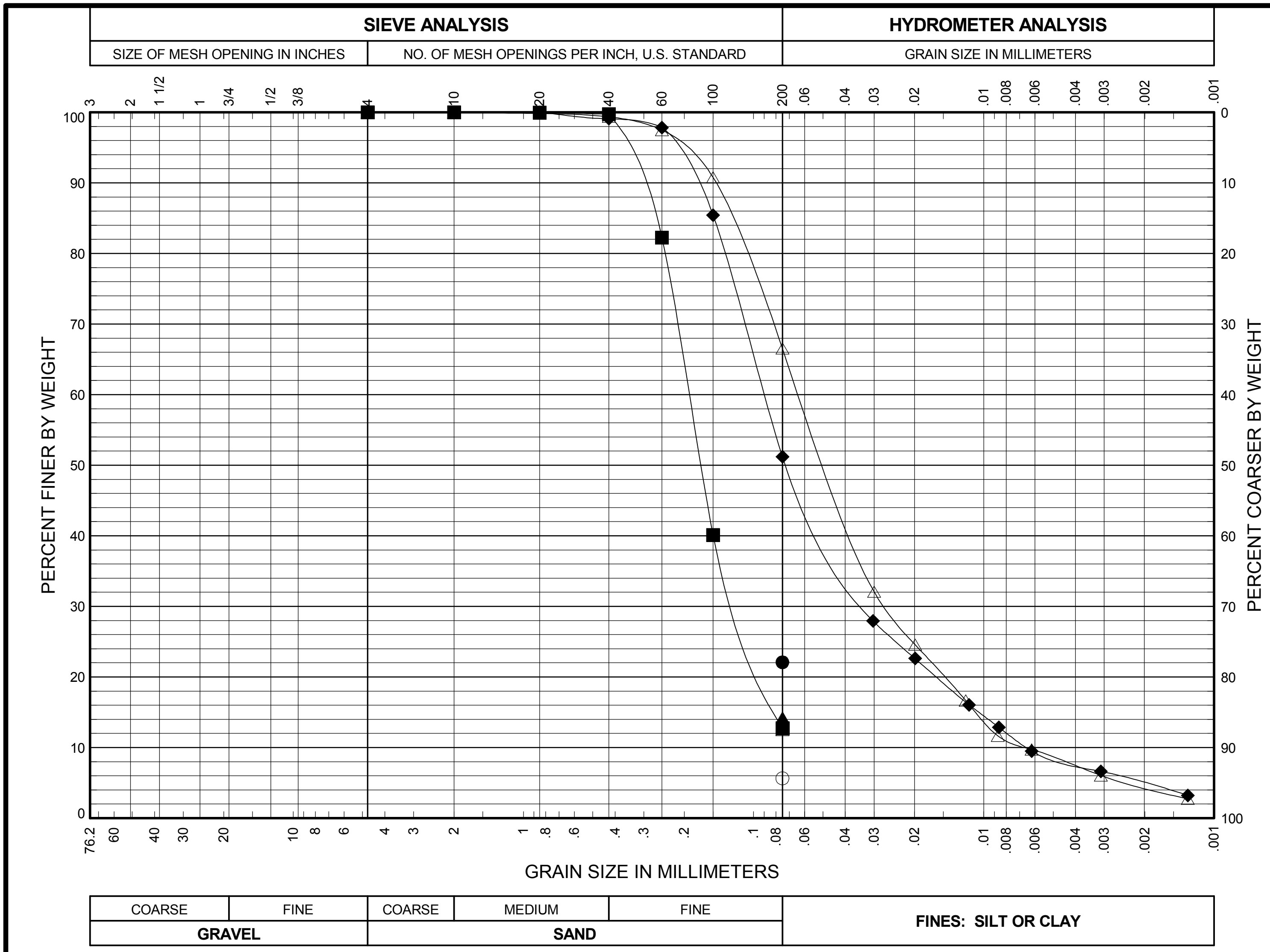
FIG. C-9



LEGEND

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ASTM DES: ASTM International test standard designation

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BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	GRAVEL %	SAND %	FINES %	COBBLE REM %	SG	NAT WC %	Cu	Cc	TEST BY	REVIEW BY	ASTM DES
● S-3, S-21	105.0	SM	Black, silty, fine SAND; trace of organics			22.1			21.5			AFW	JFL	D1140
■ S-3, S-22*	110.0	SM	Black, silty, fine SAND		87	12.8			18.0			AFW	JFL	D422
▲ S-3, S-23	115.0	SM	Black, silty, fine SAND; trace of organics			14.3			22.0			AFW	JFL	D1140
◆ S-3, S-24	120.0	ML	Black, fine sandy SILT		49	51.2			26.8			AFW	JFL	D422
○ S-3, S-25	125.0	SP-SM	Black, slightly silty, fine SAND			5.6			23.0			AFW	JFL	D1140
□ S-3, S-26	130.0	SM	Black, silty, fine SAND; trace of organics			12.6			17.4			AFW	JFL	D1140
△ S-3, S-27	135.2	ML	Black, fine sandy SILT, trace of clay; trace of organics		33	66.5			25.0			AKV	JFL	D422

Sample specimen weight did not meet required minimum mass for ASTM test method.

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GRAIN SIZE DISTRIBUTION
BORING S-3

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FIG. C-9
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FIG. C-9

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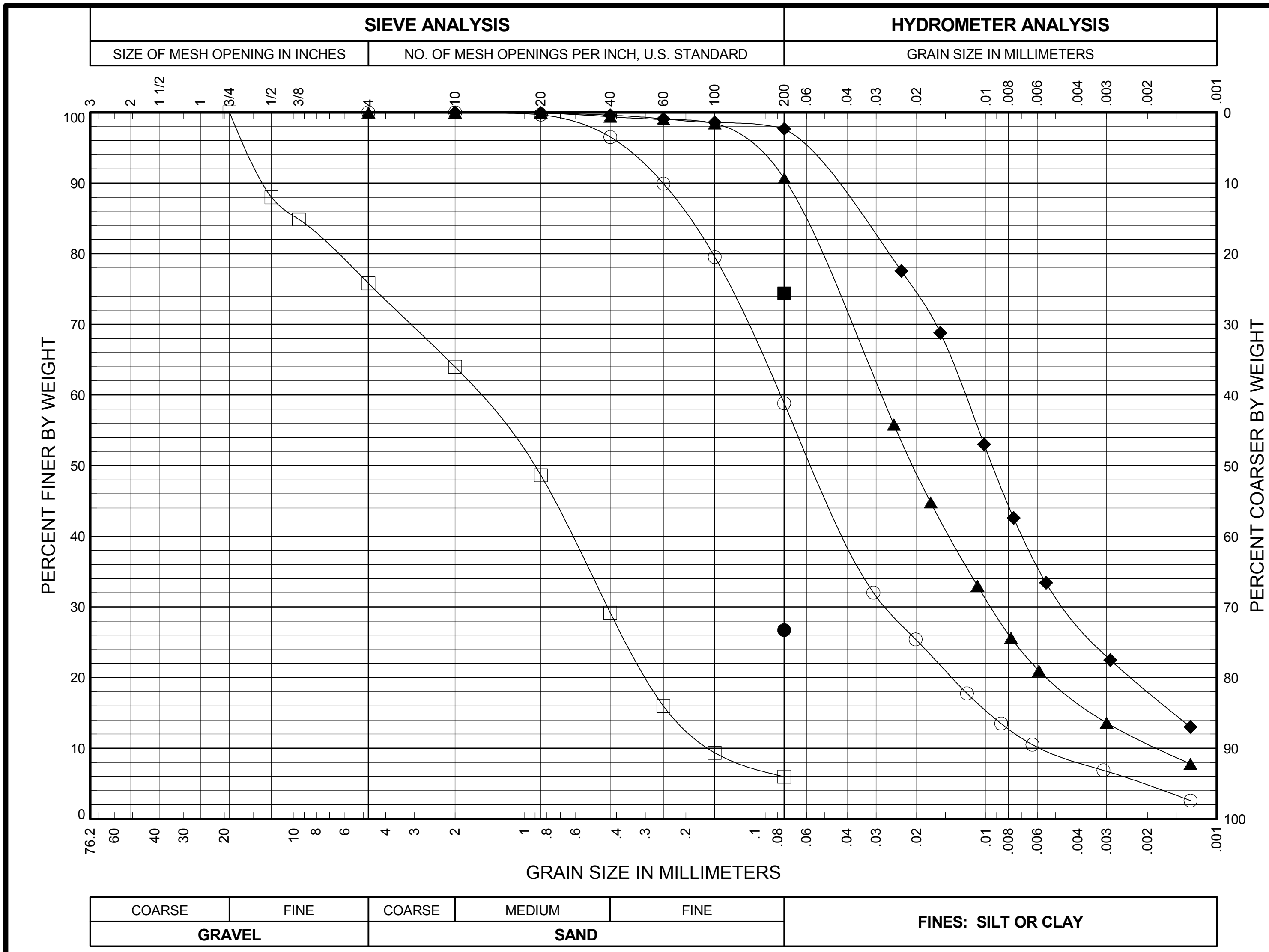

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BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	GRAVEL %	SAND %	FINES %	COBBLE REM %	SG	NAT WC %	Cu	Cc	TEST BY	REVIEW BY	ASTM DES
● S-3, S-28	140.0	SM	Black, silty, fine SAND; scattered organics			26.7			24.2			AKV	JFL	D1140
■ S-3, S-28	140.8	ML	Black, fine sandy SILT; trace of organics			74.4			26.9			AKV	JFL	D1140
▲ S-3, S-29	145.5	ML	Black, slightly fine sandy SILT, trace of clay		9	90.7			32.9			AKV	JFL	D422
◆ S-3, S-31	155.0	ML	Dark gray-brown, clayey SILT, trace of fine sand		2	97.7			36.2			AKV	JFL	D422
○ S-3, S-33	165.0	ML	Dark gray-brown, fine sandy SILT; interbedded with silty, fine to medium sand		41	58.8			19.8			AKV	JFL	D422
□ S-3, S-38*	190.0	SP-SM	Green-gray, slightly silty, fine gravelly SAND	24	70	6.0			4.2	10.2	0.8	AKV	JFL	D422

** Sample specimen weight did not meet required minimum mass for ASTM test method.*

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BORING S-3

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FIG. C-9
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FIG. C-9

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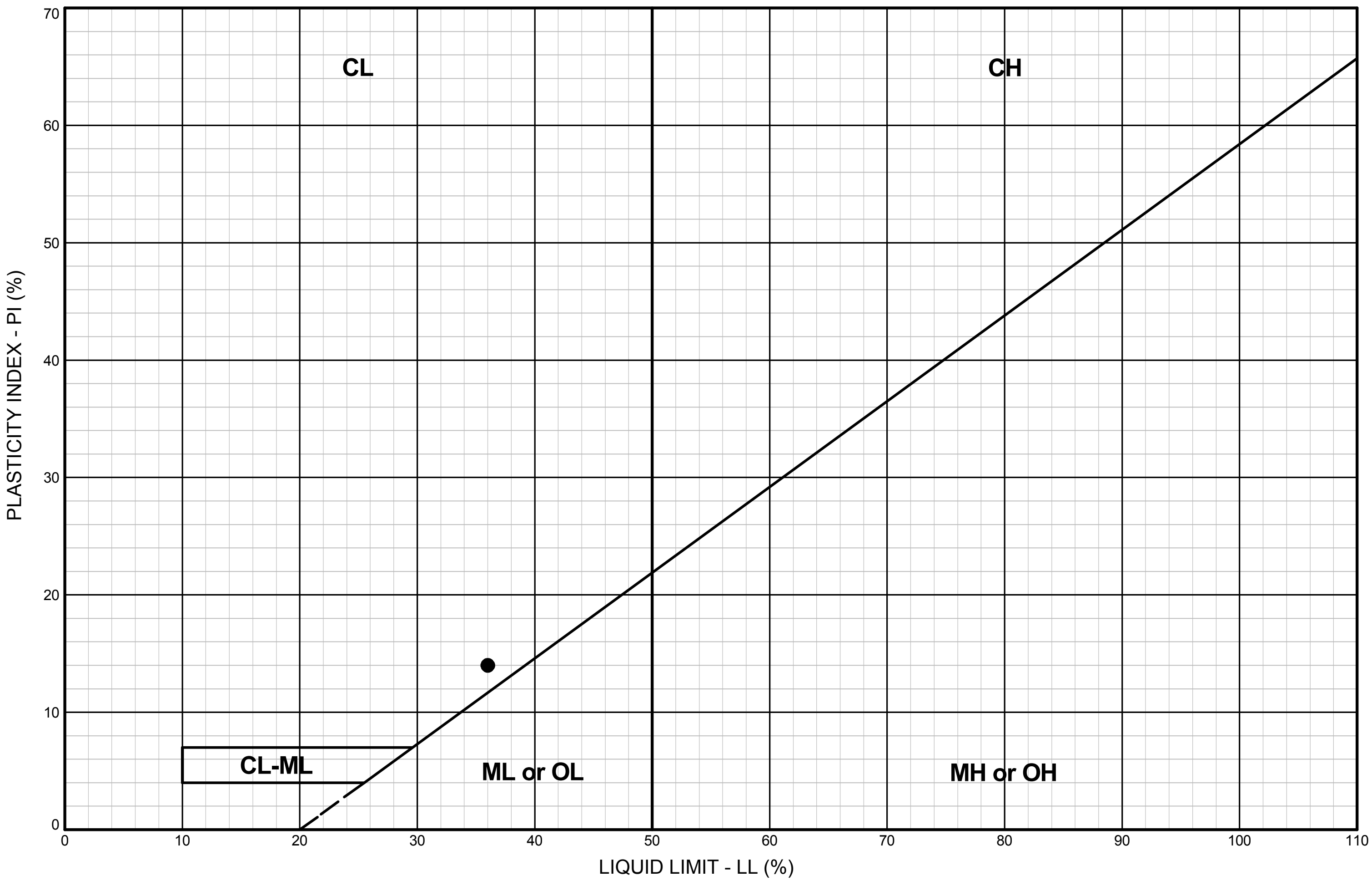
AASHTO ATT MAIN 21-21441.GPJ SHAN WIL.GDT 1/10/13



LEGEND

CL: Low plasticity inorganic clays; sandy and silty clays

CH: High plasticity inorganic clays

ML: Inorganic silts and clayey silts of low plasticity

MH: Inorganic silts and clayey silts of high plasticity

CL-ML: Silty clays and clayey silts

OL: Organic silts and clays of low plasticity

OH: Organic silts and clays of high plasticity

LL: Liquid limit

PL: Plastic limit

PI: Plasticity index; PI=LL-PL

NP: Nonplastic

ˇˇ : Nonplastic

^,>> : Test value exceeds limit of graph

BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	LL %	PL %	PI %	NAT. W.C. %	PASS. #200,%	TEST BY	CKD BY	ASTM STD
● P-1, S-1	18.0	CL	Gray, silty CLAY	36	22	14	36.2		AKV	JFL	D4318

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PLASTICITY CHART
BORING P-1

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FIG. C-10
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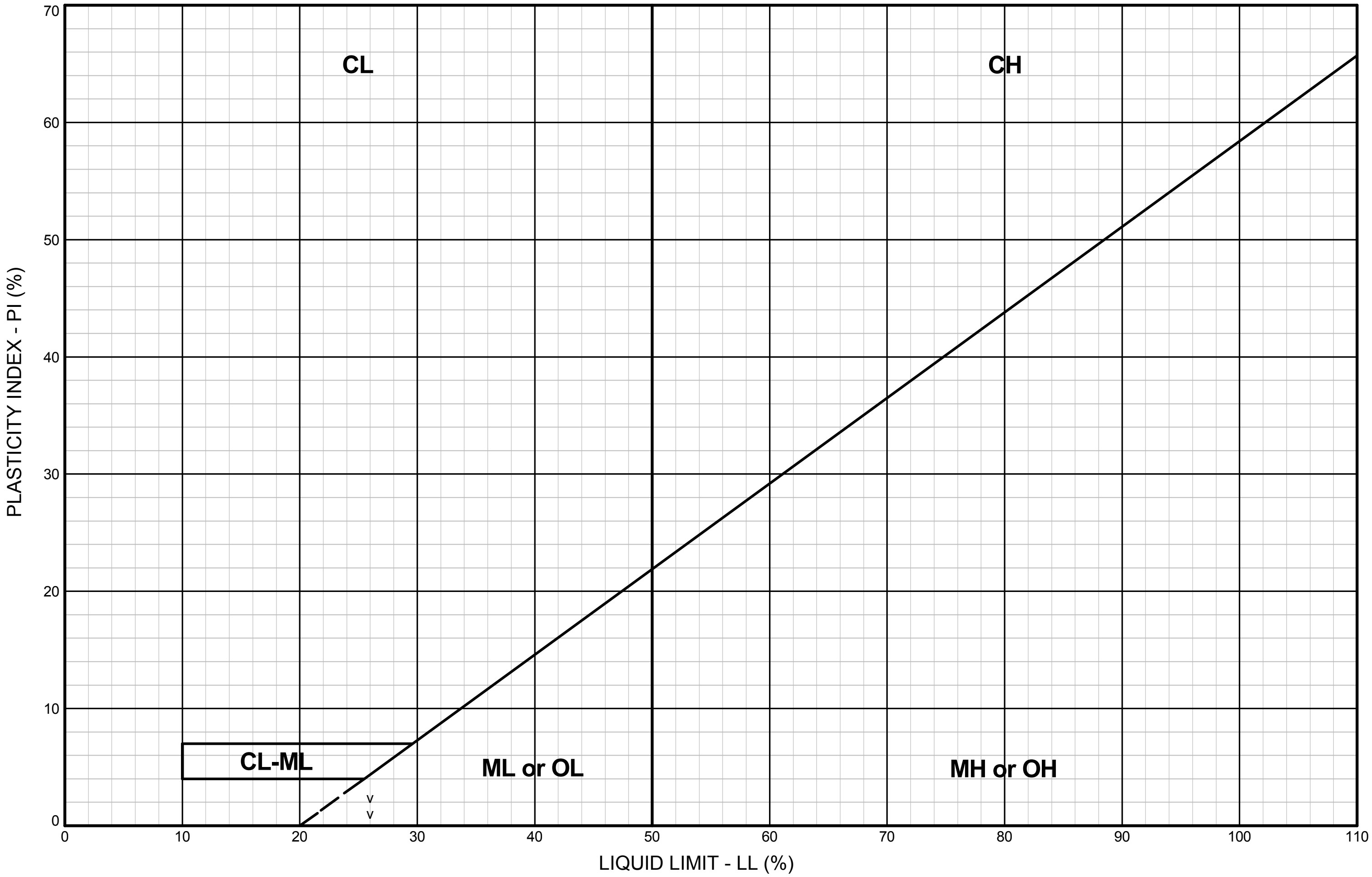
FIG. C-10



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PL: Plastic limit

PI: Plasticity index; PI=LL-PL

NP: Nonplastic

ˇ : Nonplastic

^,>>: Test value exceeds limit of graph

BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	LL %	PL %	PI %	NAT. W.C. %	PASS. #200,%	TEST BY	CKD BY	ASTM STD
P-2, S-1	71.0	ML	Dark gray, fine sandy SILT	26	28	NP	31.4		AKV	JFL	D4318

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PLASTICITY CHART
BORING P-2

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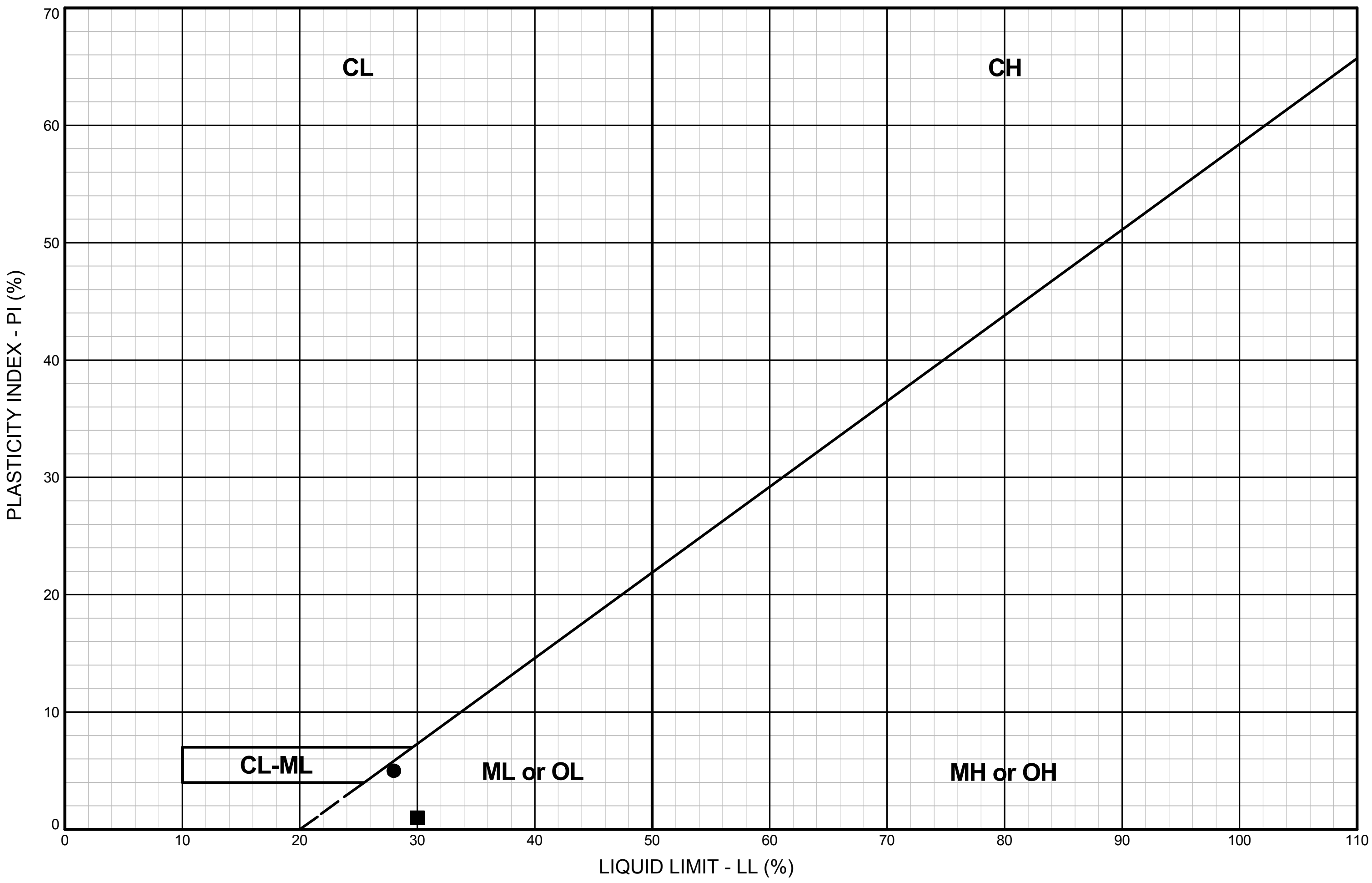
FIG. C-11
Sheet 1 of 1



LEGEND

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LL: Liquid limit

PL: Plastic limit

PI: Plasticity index; PI=LL-PL

NP: Nonplastic

ˇ : Nonplastic

^,>>: Test value exceeds limit of graph

AASHTO_ATT_MAIN 21-21441.GPJ SHAN_WIL.GDT 1/10/13

BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	LL %	PL %	PI %	NAT. W.C. %	PASS. #200,%	TEST BY	CKD BY	ASTM STD
● P-4, S-2	140.5	ML	Dark brown-gray, slightly clayey SILT, trace of fine sand and fine gravel; trace of shell fragments	28	23	5	24.9		AKV	JFL	D4318
■ P-4, S-3	143.5	ML	Dark brown-gray SILT, trace of fine sand and clay	30	29	1	28.4		AKV	JFL	D4318

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Seattle, Washington

PLASTICITY CHART
BORING P-4

May 2018
21-1-21441-001

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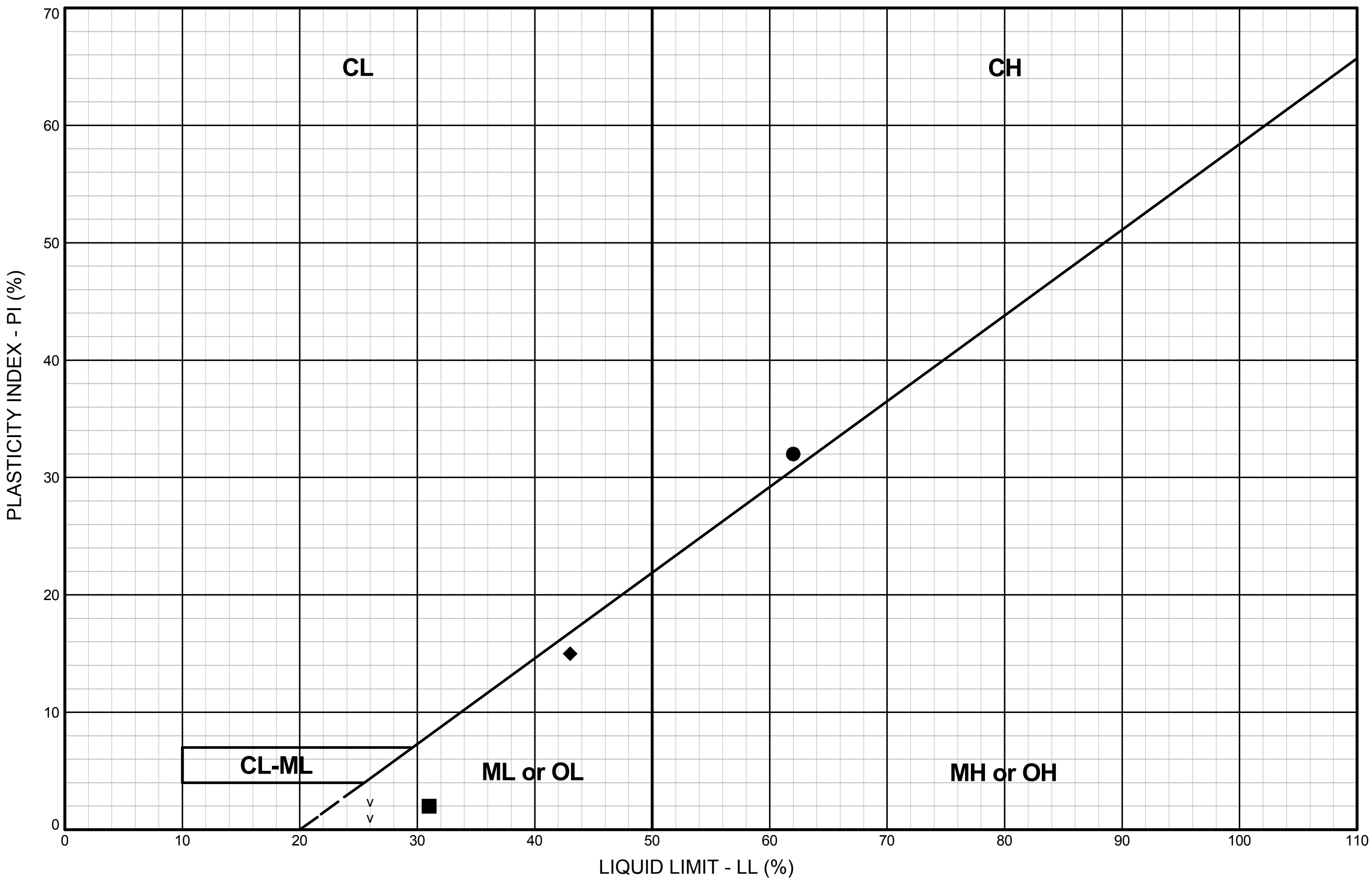
FIG. C-12
Sheet 1 of 1

FIG. C-12

AASHTO_ATT_MAIN 21-21441.GPJ SHAN_WIL.GDT 1/10/13



LEGEND

CL: Low plasticity inorganic clays; sandy and silty clays

CH: High plasticity inorganic clays

ML: Inorganic silts and clayey silts of low plasticity

MH: Inorganic silts and clayey silts of high plasticity

CL-ML: Silty clays and clayey silts

OL: Organic silts and clays of low plasticity

OH: Organic silts and clays of high plasticity

LL: Liquid limit

PL: Plastic limit

PI: Plasticity index; PI=LL-PL

NP: Nonplastic

ˇˇ : Nonplastic

^,>>: Test value exceeds limit of graph

BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	LL %	PL %	PI %	NAT. W.C. %	PASS. #200,%	TEST BY	CKD BY	ASTM STD
● P-5, S-2	10.4	CH	Dark gray, silty CLAY, trace of fine to medium sand	62	30	32	49.2	95.3	AKV	JFL	D4318
■ P-5, S-17	85.0	ML	Dark gray-brown, slightly fine sandy SILT, trace of clay	31	29	2	27.1		AKV	JFL	D4318
P-5, S-20	100.0	ML	Dark gray-brown, slightly fine sandy SILT, trace of clay	26	28	NP	29.5		AKV	JFL	D4318
◆ P-5, S-31	155.7	ML	Dark gray-brown, clayey SILT	43	28	15	33.8		AKV	JFL	D4318

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PLASTICITY CHART
BORING P-5

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21-1-21441-001

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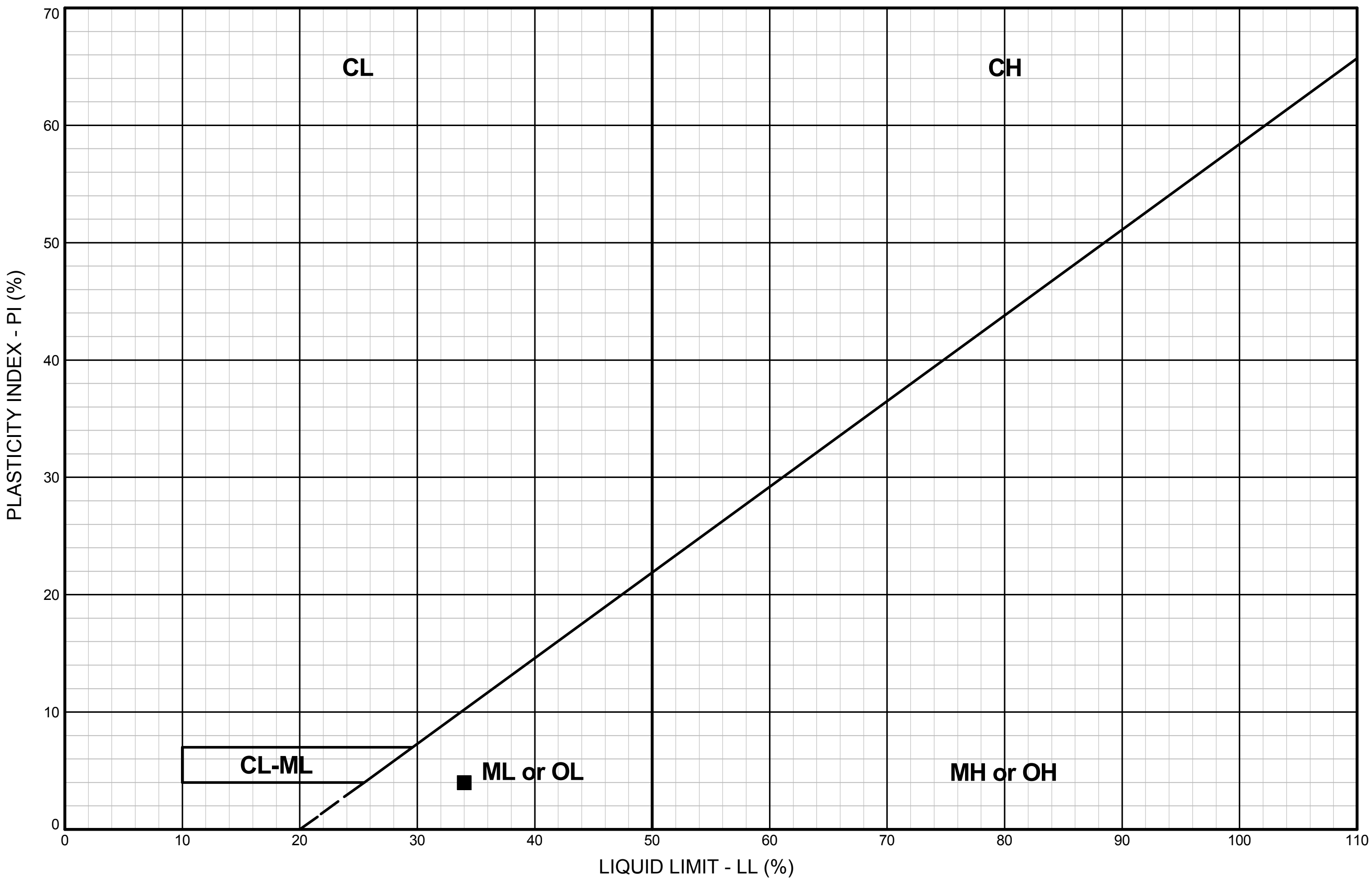
FIG. C-13
Sheet 1 of 1

FIG. C-13

AASHTO ATT MAIN 21-21441.GPJ SHAN WIL.GDT 1/10/13



LEGEND

CL: Low plasticity inorganic clays; sandy and silty clays

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ML: Inorganic silts and clayey silts of low plasticity

MH: Inorganic silts and clayey silts of high plasticity

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OH: Organic silts and clays of high plasticity

LL: Liquid limit

PL: Plastic limit

PI: Plasticity index; PI=LL-PL

NP: Nonplastic

ˇ : Nonplastic

^,>> : Test value exceeds limit of graph

BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	LL %	PL %	PI %	NAT. W.C. %	PASS. #200,%	TEST BY	CKD BY	ASTM STD
P-6, S-2	172.0	ML	Black SILT, trace of fine sand and clay	28	28	NP	26.2		AKV	JFL	D4318
■ P-6, S-3	174.5	ML	Dark gray, slightly clayey SILT, trace of fine sand; trace of shell fragments	34	30	4	32.7		AKV	JFL	D4318

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PLASTICITY CHART
BORING P-6

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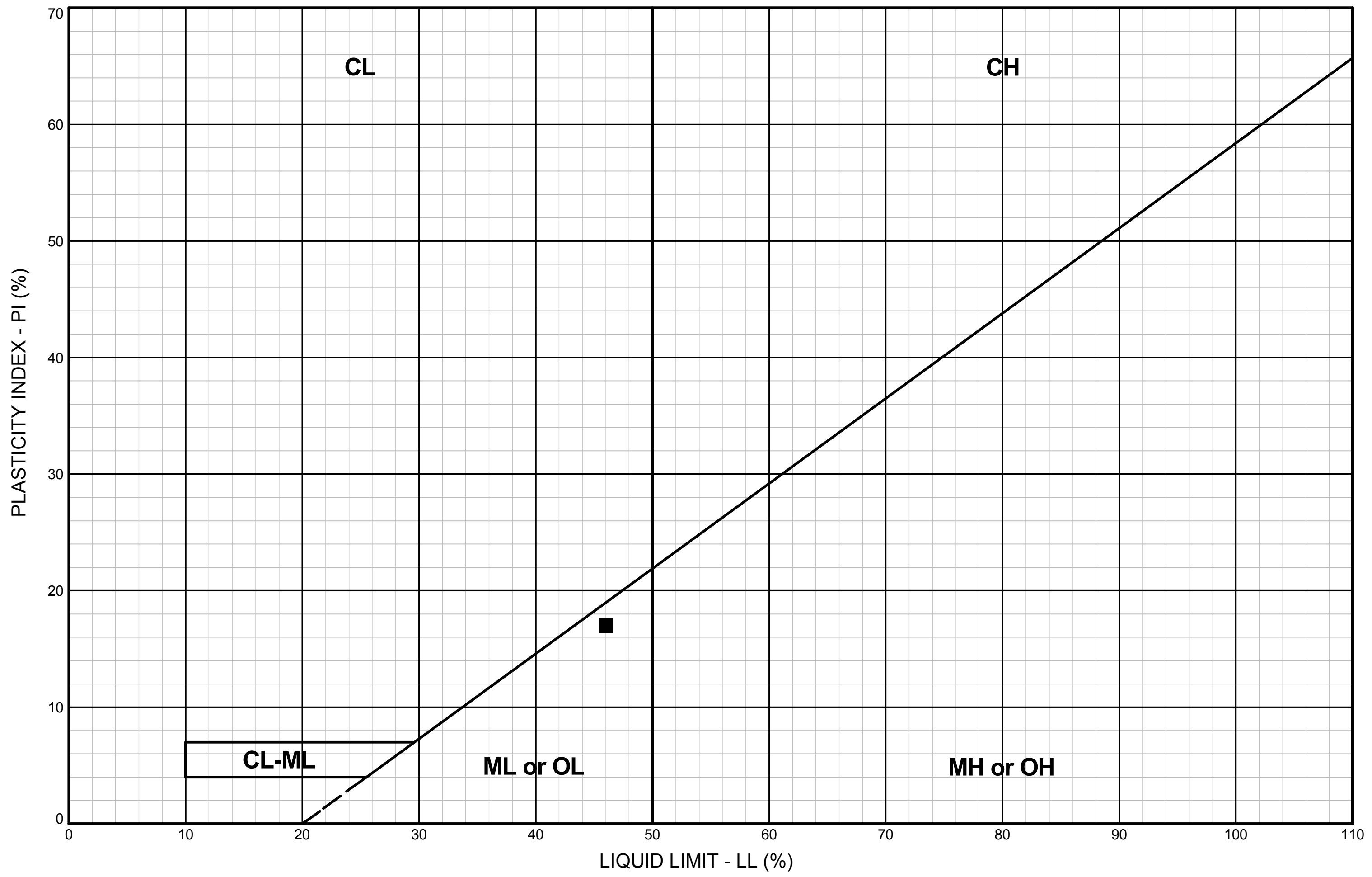
FIG. C-14
Sheet 1 of 1

FIG. C-14



LEGEND

CL: Low plasticity inorganic clays; sandy and silty clays

CH: High plasticity inorganic clays

ML: Inorganic silts and clayey silts of low plasticity

MH: Inorganic silts and clayey silts of high plasticity

CL-ML: Silty clays and clayey silts

OL: Organic silts and clays of low plasticity

OH: Organic silts and clays of high plasticity

LL: Liquid limit

PL: Plastic limit

PI: Plasticity index; PI=LL-PL

NP: Nonplastic

ˇˇ : Nonplastic

^,>>: Test value exceeds limit of graph

BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	LL %	PL %	PI %	NAT. W.C. %	PASS. #200,%	TEST BY	CKD BY	ASTM STD
S-2, S-2	142.5	ML	Dark brown-gray, fine sandy SILT	30	30	NP	28.5		AKV	JFL	D4318
■ S-2, S-4	150.0	ML	Dark gray-brown, slightly fine sandy, clayey SILT	46	29	17	35.5		AKV	JFL	D4318

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PLASTICITY CHART
BORING S-2

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21-1-21441-001

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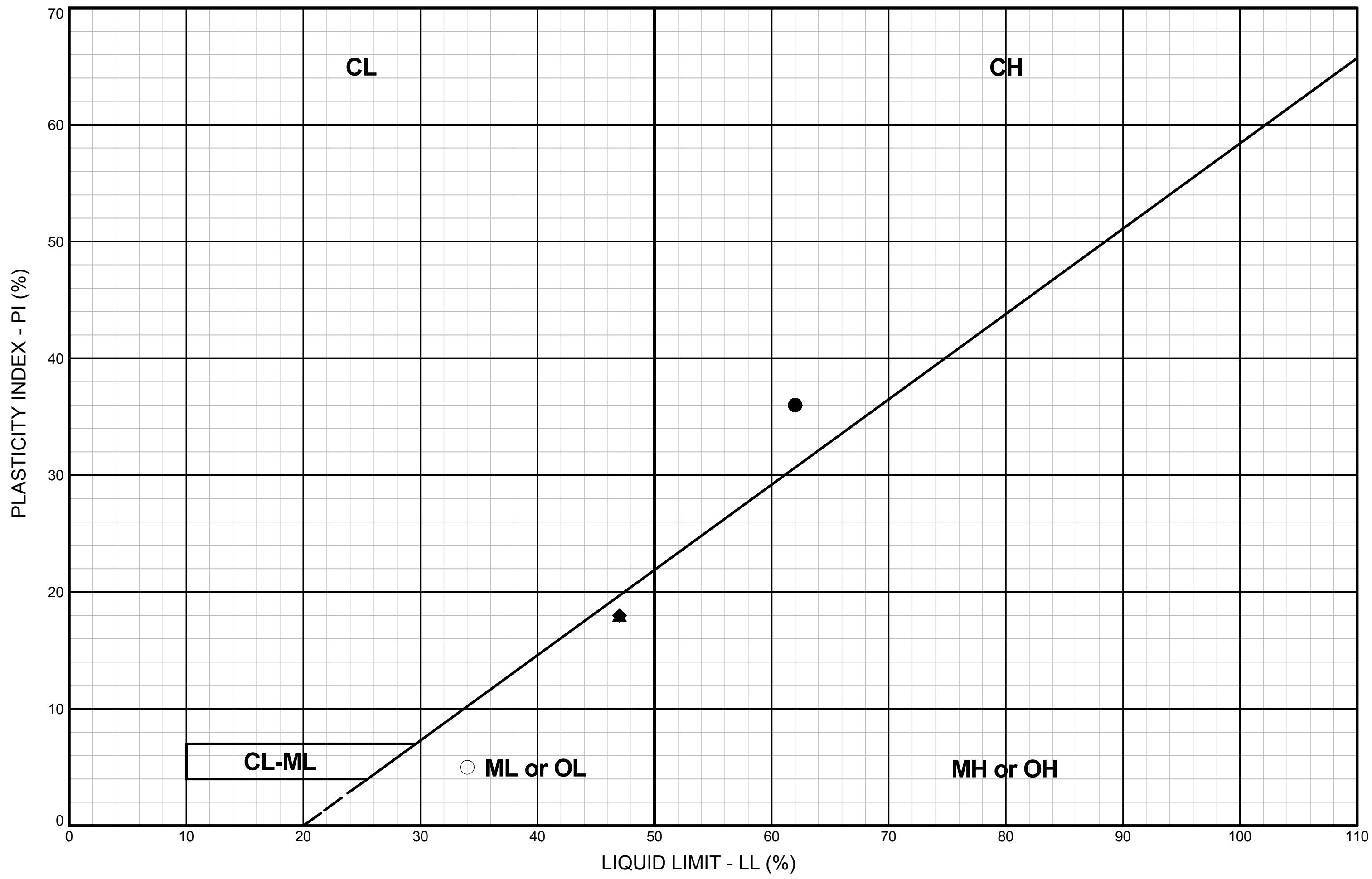
FIG. C-15
Sheet 1 of 1

AASHTO_ATT_MAIN 21-21441.GPJ SHAN_WIL.GDT 1/10/13

FIG. C-15



LEGEND

CL: Low plasticity inorganic clays; sandy and silty clays

CH: High plasticity inorganic clays

ML: Inorganic silts and clayey silts of low plasticity

MH: Inorganic silts and clayey silts of high plasticity

CL-ML: Silty clays and clayey silts

OL: Organic silts and clays of low plasticity

OH: Organic silts and clays of high plasticity

LL: Liquid limit

PL: Plastic limit

PI: Plasticity index; PI=LL-PL

NP: Nonplastic

ˇˇ : Nonplastic

^,>>: Test value exceeds limit of graph

BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	LL %	PL %	PI %	NAT. W.C. %	PASS. #200,%	TEST BY	CKD BY	ASTM STD
● S-3, S-3	15.0	CH	Gray, silty CLAY, trace of sand; trace of shell fragments	62	26	36	47.9	99.1	AFW	JFL	D4318
S-3, S-27	135.2	ML	Black, fine sandy SILT, trace of clay; trace of organics	27	27	NP	25.0	66.5	AKV	JFL	D4318
▲ S-3, S-30	150.0	ML	Dark gray-brown, clayey SILT, trace of fine sand; scattered shell fragments	47	29	18	29.6		AKV	JFL	D4318
◆ S-3, S-32	160.0	ML	Dark gray-brown, clayey SILT; trace of organics	47	29	18	36.5		AKV	JFL	D4318
○ S-3, S-34	170.0	ML	Dark gray-brown, slightly clayey SILT, trace of fine sand	34	29	5	31.4		AKV	JFL	D4318

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PLASTICITY CHART
BORING S-3

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FIG. C-16
Sheet 1 of 1

APPENDIX D

Non-Project Information

CONTENTS

D.1 SEATTLE MONORAIL PROJECT DRAFT GEOTECHNICAL DATA REPORT EXCERPTS

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APPENDIX A

SUBSURFACE EXPLORATION PROGRAM

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Figure No.

LIST OF SUBAPPENDICES

TABLE A-1
GEOLOGIC UNITS AND DESCRIPTIONS

Unit Name[1]	Abbrev.	General Unit Description	Soil Description
HOLOCENE UNITS			
Fill	Hf	Fill placed by humans, both engineered and nonengineered	Various materials, including debris; cobbles and boulders common; commonly dense or stiff if engineered, but very loose to dense or very soft to stiff if non-engineered
Landslide Deposits	Hls	Deposits of landslides, normally at and adjacent to the toe of slopes	Disturbed, heterogeneous mixture of one or more soil types; may contain wood and other organics; loose or soft, with random dense or hard pockets
Alluvium	Ha	River or creek deposits, normally associated with historical streams, including deltaic and overbank deposits	Sand, silty Sand, gravelly Sand; very loose to very dense
Peat Deposits	Hp	Depression fillings of organic materials	Peat, peaty Silt, organic Silt; very soft to medium stiff
Estuarine Deposits	He	Fine-grained sediments deposited in brackish water associated with rivers and streams located along the present and former Puget Sound shoreline	Clayey Silt, silty Clay; commonly with scattered organics; very soft to stiff or very loose to medium dense
Lake Deposits	Hl	Depression fillings of fine-grained soils	Sandy Silt, Clayey silt, silty clay; commonly with scattered organics; very soft to stiff or very loose to medium dense.
Beach Deposits	Hb	Deposits along present and former shorelines of Puget Sound and tributary river mouths	Silty Sand, sandy Gravel, gravelly Sand, wood and shell debris common; loose to dense
Reworked Glacial Deposits	Hrw	Glacially deposited soils that have been reworked by fluvial or wave action	Sand, silty Sand, gravelly Sand; lies on top of glacially overridden soils; loose to dense

TABLE A-1
GEOLOGIC UNITS AND DESCRIPTIONS

Unit Name[1]	Abbrev.	General Unit Description	Soil Description
QUATERNARY VASHON UNITS			
Recessional Outwash	Qvro	Glaciofluvial sediment deposited as glacial ice retreated	Clean to silty Sand, gravelly Sand, sandy Gravel; cobbles and boulders common; loose to very dense
Recessional Lacustrine Deposits	Qvrl	Glaciolacustrine sediment deposited as glacial ice retreated	Fine Sand, Silt, and Clay; medium dense to dense, soft to hard
Ice-Contact Deposits	Qvri	Heterogeneous soils deposited against or adjacent to ice during the wasting of glacial ice; commonly reworked	Stratified to irregular bodies of Gravel, Sand, Silt, and Clay; loose to dense
Ablation Till	Qvat	Heterogeneous soils deposited during the wasting of glacial ice; generally not reworked	Gravelly silty Sand, silty gravelly Sand, with some clay; cobbles and boulders common; loose to very dense or soft to hard
Till	Qvt	Lodgement till laid down along the base of the glacial ice	Gravelly silty Sand, silty gravelly Sand ("hardpan"); cobbles and boulders common; very dense
Till-like Deposits (diamict)	Qvd	Glacial deposit intermediate between till and outwash, subglacially reworked	Silty gravelly Sand, silty Sand, sandy Gravel; highly variable over short distances; cobbles and boulders common; dense to very dense
Advance Outwash	Qva	Glaciofluvial sediment deposited as the glacial ice advanced through the Puget Lowland	Clean to silty Sand, gravelly Sand, sandy Gravel; dense to very dens
Glaciolacustrine Deposits	Qvgl	Fine-grained glacial flour deposited in proglacial lake in Puget Lowland	Silty Clay, clayey Silt, with interbeds of Silt and fine Sand; locally laminated; scattered organic fragments locally; hard or dense to very dense

(see Page 3 for notes)

TABLE A-1
GEOLOGIC UNITS AND DESCRIPTIONS

Unit Name[1]	Abbrev.	General Unit Description	Soil Description
QUATERNARY PRE-VASHON UNITS			
Fluvial Deposits	Qpnf	Alluvial deposits of rivers and creeks	Clean to silty Sand, gravelly Sand, sandy Gravel; very dense
Lacustrine Deposits	Qpnl	Fine-grained lake deposits in depressions, large and small	Fine sandy Silt, silty fine Sand, clayey Silt; scattered to abundant fine organics; dense to very dense or very stiff to hard
Peat Deposits	Qpnp	Depression fillings of organic materials	Peat, peaty Silt, organic Silt; hard
Landslide Deposits	Qpls	Heterogeneous deposits of landslide debris	Chaotic mixture of silt, sand, clay and gravel; may contain wood and other organics; hard or very dense
Outwash	Qpgo	Glaciofluvial sediment deposited as the glacial ice advanced or retreated through the Puget Lowland	Clean to silty Sand, gravelly Sand, sandy Gravel; very dense
Glaciolacustrine Deposits	Qpgl	Fine-grained glacial flour deposited in proglacial lake in Puget Lowland	Silty Clay, clayey Silt, with interbeds of Silt and fine Sand; very stiff to hard or very dense
Till	Qpgt	Lodgement till laid down along the base of the glacial ice	Gravelly silty Sand, silty gravelly Sand ("hardpan"); cobbles and boulders common; very dense
Till-like Deposits (diamict)	Qpgd	Glacial deposits intermediate between till and outwash, subglacially reworked	Silty gravelly Sand, silty Sand, sandy Gravel; highly variable over short distances; cobbles and boulders common; very dense
Glaciomarine Deposits	Qpgm	Till-like deposits with clayey matrix deposited in proglacial lake by icebergs, floating ice, and gravity currents	Variable mixture of Clay, Silt, Sand and Gravel; scattered shells locally; cobbles and boulders common; very dense or hard

NOTE:

1. The geologic units are interpretive and based on our opinion of the grouping of complex sediments and soil types into units appropriate for the project. The description of each geologic unit includes only general information regarding the environment of deposition and basic soil characteristics. For example, cobbles and boulders are only included in the description of those units where they are most prominent.

Shannon & Wilson, Inc. (S&W), uses a soil classification system modified from the Unified Soil Classification System (USCS). Elements of the USCS and other definitions are provided on this and the following page. Soil descriptions are based on visual-manual procedures (ASTM D 2488-93) unless otherwise noted.

S&W CLASSIFICATION OF SOIL CONSTITUENTS

- MAJOR constituents compose more than 50 percent, by weight, of the soil. Major consituents are capitalized (i.e., SAND).
- Minor constituents compose 12 to 50 percent of the soil and precede the major constituents (i.e., silty SAND). Minor constituents preceded by "slightly" compose 5 to 12 percent of the soil (i.e., slightly silty SAND).
- Trace constituents compose 0 to 5 percent of the soil (i.e., slightly silty SAND, trace of gravel).

MOISTURE CONTENT DEFINITIONS

Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, from below water table

ABBREVIATIONS

ATD	At Time of Drilling
Elev.	Elevation
ft	feet
FeO	Iron Oxide
MgO	Magnesium Oxide
HSA	Hollow Stem Auger
ID	Inside Diameter
in	inches
lbs	pounds
Mon.	Monument cover
N	Blows for last two 6-inch increments
NA	Not applicable or not available
NP	Non plastic
OD	Outside diameter
OVA	Organic vapor analyzer
PID	Photo-ionization detector
ppm	parts per million
PVC	Polyvinyl Chloride
SS	Split spoon sampler
SPT	Standard penetration test
USC	Unified soil classification
WLI	Water level indicator

GRAIN SIZE DEFINITION

DESCRIPTION	SIEVE NUMBER AND/OR SIZE
FINES	< #200 (0.08 mm)
SAND*	
- Fine	#200 to #40 (0.08 to 0.4 mm)
- Medium	#40 to #10 (0.4 to 2 mm)
- Coarse	#10 to #4 (2 to 5 mm)
GRAVEL*	
- Fine	#4 to 3/4 inch (5 to 19 mm)
- Coarse	3/4 to 3 inches (19 to 76 mm)
COBBLES	3 to 12 inches (76 to 305 mm)
BOULDERS	> 12 inches (305 mm)

* Unless otherwise noted, sand and gravel, when present, range from fine to coarse in grain size.

RELATIVE DENSITY / CONSISTENCY

COARSE-GRAINED SOILS		FINE-GRAINED SOILS	
N, SPT, BLOWS/FT.	RELATIVE DENSITY	N, SPT, BLOWS/FT.	RELATIVE CONSISTENCY
0 - 4	Very loose	Under 2	Very soft
4 - 10	Loose	2 - 4	Soft
10 - 30	Medium dense	4 - 8	Medium stiff
30 - 50	Dense	8 - 15	Stiff
Over 50	Very dense	15 - 30	Very stiff
		Over 30	Hard

WELL AND OTHER SYMBOLS

▧	Bent. Cement Grout	▦	Surface Cement Seal
▨	Bentonite Grout	■	Asphalt or Cap
▩	Bentonite Chips	▨	Slough
☐	Silica Sand	▩	Bedrock
▤	PVC Screen		
◨	Vibrating Wire		

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Seattle, Washington

SOIL CLASSIFICATION AND LOG KEY

December 2003 21-1-09910-091

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FIG. A-1
Sheet 1 of 2

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)
(From ASTM D 2487-98 & 2488-93)

MAJOR DIVISIONS			GROUP/GRAPHIC SYMBOL		TYPICAL DESCRIPTION
COARSE-GRAINED SOILS *(more than 50% retained on No. 200 sieve)*	Gravels *(more than 50% of coarse fraction retained on No. 4 sieve)*	Clean Gravels *(less than 5% fines)*	GW	●	Well-graded gravels, gravels, gravel/sand mixtures, little or no fines
			GP	○	Poorly graded gravels, gravel-sand mixtures, little or no fines
		Gravels with Fines *(more than 12% fines)*	GM	●	Silty gravels, gravel-sand-silt mixtures
			GC	▨	Clayey gravels, gravel-sand-clay mixtures
	Sands *(50% or more of coarse fraction passes the No. 4 sieve)*	Clean Sands *(less than 5% fines)*	SW	░	Well-graded sands, gravelly sands, little or no fines
			SP	░	Poorly graded sand, gravelly sands, little or no fines
		Sands with Fines *(more than 12% fines)*	SM	▥	Silty sands, sand-silt mixtures
			SC	▨	Clayey sands, sand-clay mixtures
FINE-GRAINED SOILS *(50% or more passes the No. 200 sieve)*	Silts and Clays *(liquid limit less than 50)*	Inorganic	ML	▥	Inorganic silts of low to medium plasticity, rock flour, sandy silts, gravelly silts, or clayey silts with slight plasticity
			CL	▨	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
		Organic	OL	▤	Organic silts and organic silty clays of low plasticity
	Silts and Clays *(liquid limit 50 or more)*	Inorganic	MH	▥	Inorganic silts, micaceous or diatomaceous fine sands or silty soils, elastic silt
			CH	▨	Inorganic clays or medium to high plasticity, sandy fat clay, or gravelly fat clay
		Organic	OH	▨	Organic clays of medium to high plasticity, organic silts
HIGHLY-ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor		PT	▤	Peat, humus, swamp soils with high organic content (see ASTM D 4427)

NOTES

1. Dual symbols *(symbols separated by a hyphen, i.e., SP-SM, slightly silty fine SAND)* are used for soils with between 5% and 12% fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.
2. Borderline symbols *(symbols separated by a slash, i.e., CL/ML, silty CLAY/clayey SILT; GW/SW, sandy GRAVEL/gravelly SAND)* indicate that the soil may fall into one of two possible basic groups.

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SOIL CLASSIFICATION AND LOG KEY

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FIG. A-1
Sheet 2 of 2

TABLE A.2-1
SUMMARY OF FIELD EXPLORATIONS
SODO SEGMENT

Exploration No.[1]	Total Hole Depth (feet)	Northing[2] (feet)	Easting[2] (feet)	Surface Elevation[3] (feet)	Date of Drilling		Drilling Company[4]	Special Testing						Comments
					Start	End		Monitoring Well Installed	Vibrating Wire Piezometer Installed	Energy Tests Performed	Downhole Seismic Tests Performed	Pressuremeter Tests Performed	Tube Samples Obtained	
SD-101	210.2	212,566	1,268,446	14.8	22-Aug-03	27-Aug-03	GE			X	X		X	
SD-102	225.5	213,100	1,268,620	15.3	5-Aug-03	7-Aug-03	GE	X						
SD-103	269.0	213,128	1,269,210	14.8	25-Aug-03	28-Aug-03	HD						X	
SD-104	227.0	213,122	1,269,605	15.0	29-Aug-03	4-Sep-03	PR						X	Hole moved and redrilled due to hole obstruction (see SD-104A)
SD-104A	280.8	213,122	1,269,595	15.0	5-Sep-03	10-Sep-03	PR						X	
SD-105	244.0	213,682	1,269,738	15.5	19-Aug-03	22-Aug-03	HD							
SD-106	241.0	214,078	1,269,739	16.1	20-Aug-03	22-Aug-03	PR						X	
SD-107	226.0	214,612	1,269,759	16.3	26-Aug-03	28-Aug-03	PR						X	
SD-108	246.5	215,044	1,269,773	15.0	25-Aug-03	27-Aug-03	GE	X		X	X			
SD-109	234.0	215,456	1,270,232	16.3	16-Sep-03	19-Sep-03	PR	X					X	
SD-110	249.0	215,769	1,270,515	17.2	8-Oct-03	10-Oct-03	HD				X		X	
SD-111	141.5	215,398	1,271,042	17.5	18-Aug-03	22-Aug-03	GE							Hole moved and redrilled due to excessive mud loss (see SD-111A)
SD-111A	216.5	215,392	1,271,039	17.5	18-Aug-03	22-Aug-03	GE						X	
SD-112	206.4	215,943	1,271,076	18.9	15-Aug-03	20-Aug-03	GE						X	
SD-113	176.5	216,468	1,271,098	18.9	11-Aug-03	13-Aug-03	GE	X	X					
SD-114	161.5	216,998	1,271,108	20.3	18-Aug-03	19-Aug-03	PR						X	
SD-115	136.5	217,481	1,271,114	20.1	14-Aug-03	15-Aug-03	GE							
SD-116	121.5	218,011	1,271,125	17.4	28-Aug-03	29-Aug-03	GE				X			
SD-117	110.3	220,606	1,271,285	18.9	4-Sep-03	5-Sep-03	GE							
SD-118	106.5	221,038	1,271,148	17.0	8-Sep-03	10-Sep-03	PR	X					X	
SD-119	118.0	221,518	1,271,062	17.2	29-Aug-03	10-Sep-03	HD							
SD-120	121.3	221,866	1,270,999	17.7	3-Sep-03	5-Sep-03	GE		X					

(see page 2 for notes)

TABLE A.2-1
SUMMARY OF FIELD EXPLORATIONS
SODO SEGMENT

Exploration No[1]	Total Hole Depth (feet)	Northing[2] (feet)	Easting[2] (feet)	Surface Elevation[3] (feet)	Date of Drilling		Drilling Company[4]	Special Testing						Comments
					Start	End		Monitoring Well Installed	Vibrating Wire Piezometer Installed	Energy Tests Performed	Downhole Seismic Tests Performed	Pressuremeter Tests Performed	Tube Samples Obtained	
SD-121	108.5	222,539	1,270,999	30.3	11-Sep-03	15-Sep-03	HD							
SD-122	234.0	215,931	1,270,655	18.0	16-Sep-03	22-Sep-03	HD					X	X	
SD-201	211.5	213,137	1,268,847	14.5	30-Oct-03	30-Oct-03	NCE							CPT Testing Only
SD-202	242.2	213,383	1,269,725	15.6	30-Oct-03	30-Oct-03	NCE							CPT Testing Only
SD-203	98.8	216,138	1,270,874	16.9	28-Oct-03	28-Oct-03	NCE							CPT Testing Only - Hole moved due to obstruction (see SD-203A)
SD-203A	169.7	216,138	1,270,874	16.9	31-Oct-03	31-Oct-03	NCE							CPT Testing Only
SD-205	130.3	221,156	1,271,139	16.5	21-Oct-03	22-Oct-03	GE						X	
SD-206	106.0	222,256	1,271,127	33.9	4-Nov-03	12-Nov-03	PR							Hole moved due to difficulty drilling (see SD-206A)
SD-206A	135.5	222,255	1,271,127	33.9	20-Nov-03	20-Nov-03	GE							
31	5,706	< TOTALS					TOTALS >	5	2	2	4	1	14	

NOTES:

1. Borings not surveyed are indicated by an asterisk. Locations and elevations were estimated from topographic maps based on approximate field measures.
2. Northings and Eastings were surveyed by Duane Hartman & Associates and are referenced to the NAD83 horizontal datum except as noted by asterisk next to exploration number.
3. Surface elevations were surveyed by Duane Hartman & Associates and are referenced to the NAVD88 vertical datum, except as noted by asterisk next to exploration number.
4. GE=Geotech Explorations, Inc.; PR=PacRim Geotechnical; HD=Holocene Drilling, Inc. NCE= Northwest Cone exploration
GE used a rope and cathead hammer. PR and HD used an Automatic Trip Hammer. NCE used a cone penetration test method to perform the probe.

SOIL DESCRIPTION

Coordinates: N: 215,456 E: 1,270,232
Surface Elevation: 16.3 Ft. (NAVD-88)

CONCRETE

Dense, brown, silty SAND, trace of gravel; moist; scattered asphalt and concrete, scattered sandy silt clasts; (Hf) SM.

Loose to medium dense, brown, slightly silty to silty, gravelly SAND; moist; scattered to abundant cinders; scattered iron-oxide staining below 6 feet; (Hf) SM/SP-SM.

Very loose, dark gray-brown, silty, fine SAND; wet; abundant organics, scattered cinders; (Hf) SM.

Very loose to loose, dark gray-brown, slightly silty to silty, fine to medium SAND; wet; abundant seams of fine sandy silt, scattered shell fragments; (Hf/Ha) SM/SP-SM.

Medium dense, dark gray, slightly silty, fine to medium SAND; wet; scattered shell fragments, trace of gravel locally; (Ha) SP-SM/SP.

Loose, dark gray-brown, clean to slightly silty, fine to medium SAND; wet; scattered shell fragments and wood debris; (Ha) SP-SM/SP.

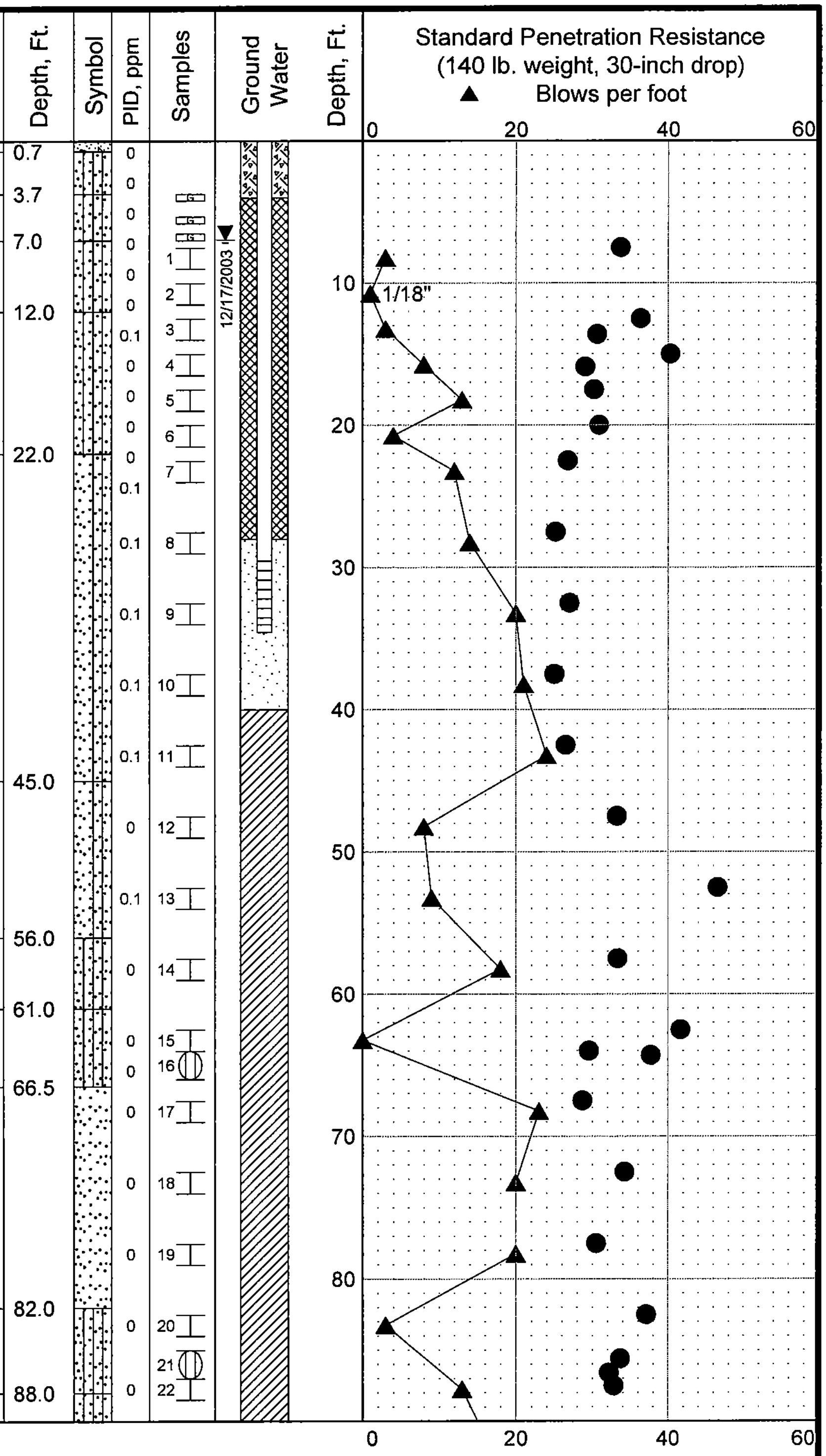
Medium dense, dark gray, silty, fine to medium SAND; wet; scattered to abundant clayey seams; (Ha) SM.

Interbedded, very loose, gray, silty, fine SAND to very soft, slightly clayey, fine sandy SILT; wet; (He/Ha) SM/ML.

Medium dense, dark gray, fine to medium SAND, trace of silt; wet; scattered to abundant shell fragments, locally abundant wood debris; (Ha) SP.

Interbedded, very loose, dark gray-brown, slightly clayey, silty, fine SAND and silty, fine SAND; wet; scattered layers of sandy,

CONTINUED NEXT SHEET



● % Water Content

Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
🄶 Grab Sample
⌶ Standard Penetration Test
⏀ 3.0" O.D. Osterberg Sample

⬚ Piezometer Screen and Sand Filter
▧ Bentonite-Cement Grout
▩ Bentonite Chips/Pellets
▨ Bentonite Grout
▼ Ground Water Level in Well

NOTES

1. The boring was performed using drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Seattle Monorail Project
Seattle, Washington

LOG OF BORING SD-109

December 2003 21-1-09910-091

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A.2-10
Sheet 1 of 3

REV 3

MASTER LOG2 21-09910.GPJ SHAN WIL.GDT 12/19/03

Log: FA Rev: WDN Typ: EET

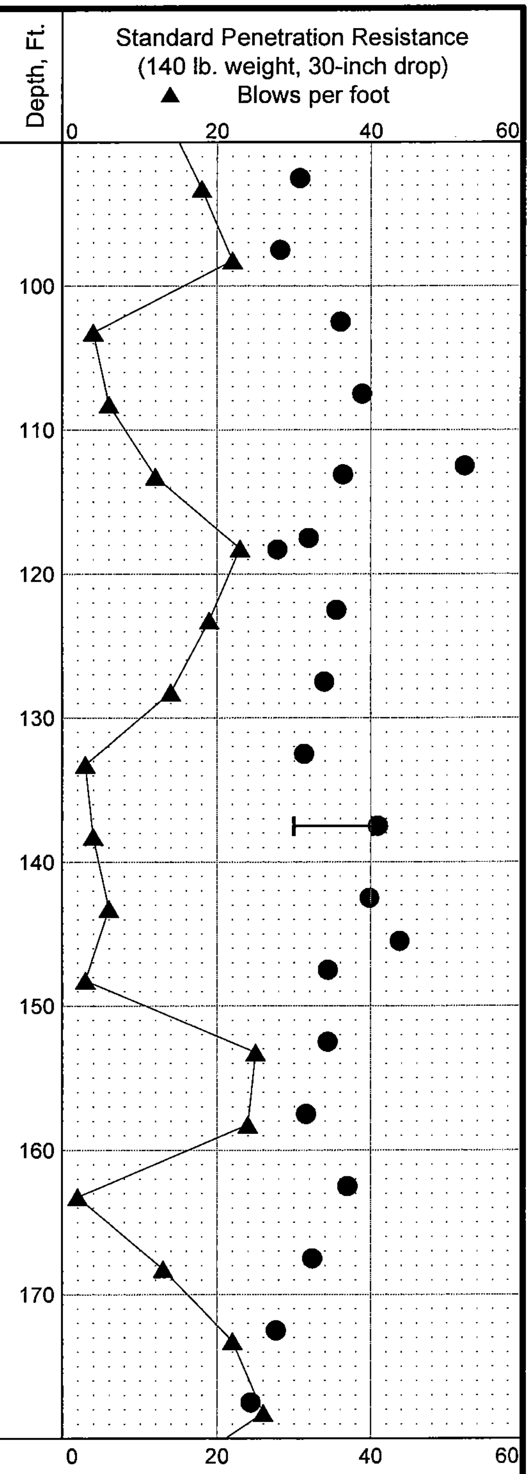
SOIL DESCRIPTION

Coordinates: N: 215,456 E: 1,270,232
Surface Elevation: 16.3 Ft. (NAVD-88)

SOIL DESCRIPTION	Depth, Ft.
clayey silt; (Ha/He) SM/ML.	
Medium dense, dark gray-brown, slightly silty to silty, fine to medium SAND; wet; abundant wood debris; (Ha) SM/SP-SM.	96.0
Medium dense, dark gray-brown, slightly silty, fine to medium SAND; wet; (Ha/He) SP-SM.	101.0
Loose, gray-brown, silty, fine SAND, trace of clay to fine sandy SILT; wet; scattered organics; (Ha/He) SM/ML.	111.0
Medium dense, dark gray-brown, silty, fine SAND; wet; scattered seams with abundant wood debris, locally slightly silty, slightly clayey at bottom; (Ha) SM.	130.0
Soft, dark gray-brown, fine sandy, clayey SILT; wet; scattered shell fragments; (He) ML.	136.0
Soft, dark gray, clayey SILT, trace of fine sand; wet; scattered seams of silty clay, scattered to abundant shell fragments; (He) CL.	151.0
Medium dense, dark gray-brown, silty, fine SAND to slightly clayey, silty, fine SAND; wet; abundant seams of fine sandy, clayey silt; (Ha/He) SM/ML.	162.0
Soft to stiff, gray-brown, fine sandy, clayey SILT; wet; (He) ML.	170.0
Medium dense, dark gray-brown, silty, fine to medium SAND; wet; scattered shells, scattered clayey seams; (Ha) SP-SM.	

CONTINUED NEXT SHEET

PID, ppm	Samples
0	23 I
0	24 I
0	25 I
0	26 I
0	27 I
0	28 I
0	29 I
0	30 I
0.2	31 I
0.2	32 I
0	33 I
0	34 ◫
0	35 I
0	36 I
0	37 I
0	38 I
0	39 I
0	40 I
0	41 I



LEGEND

- * Sample Not Recovered
- Ⓖ Grab Sample
- I Standard Penetration Test
- ◫ 3.0" O.D. Osterberg Sample
- ⌸ Piezometer Screen and Sand Filter
- ▧ Bentonite-Cement Grout
- ▩ Bentonite Chips/Pellets
- ▨ Bentonite Grout
- ▼ Ground Water Level in Well

● % Water Content

Plastic Limit ├──●──┤ Liquid Limit
Natural Water Content

NOTES

1. The boring was performed using drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Seattle Monorail Project
Seattle, Washington

LOG OF BORING SD-109

December 2003 21-1-09910-091

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A.2-10
Sheet 2 of 3

REV 3

MASTER LOG2 21-09910.GPJ SHAN WIL.GDT 12/19/03

Log: FA Rev: WDN Typ: EET

SOIL DESCRIPTION

Coordinates: N: 215,456 E: 1,270,232
Surface Elevation: 16.3 Ft. (NAVD-88)

180.0

Stiff to soft, dark gray, silty CLAY; wet; scattered shell fragments; (He) CL.

200.0

Loose, green-gray, slightly clayey, silty, fine to medium SAND, trace of gravel; wet; abundant shells; (Hrw) SM.

206.0

Soft, gray, silty CLAY; moist; bedded; (Qvrl) CH/CL.

211.0

Very dense, gray, silty, fine SAND; wet; (Qpgo/Qva) SM.

215.0

Very dense, gray, slightly silty, fine to medium SAND to slightly silty, gravelly SAND; wet; (Qpgo/Qva) SP-SM.

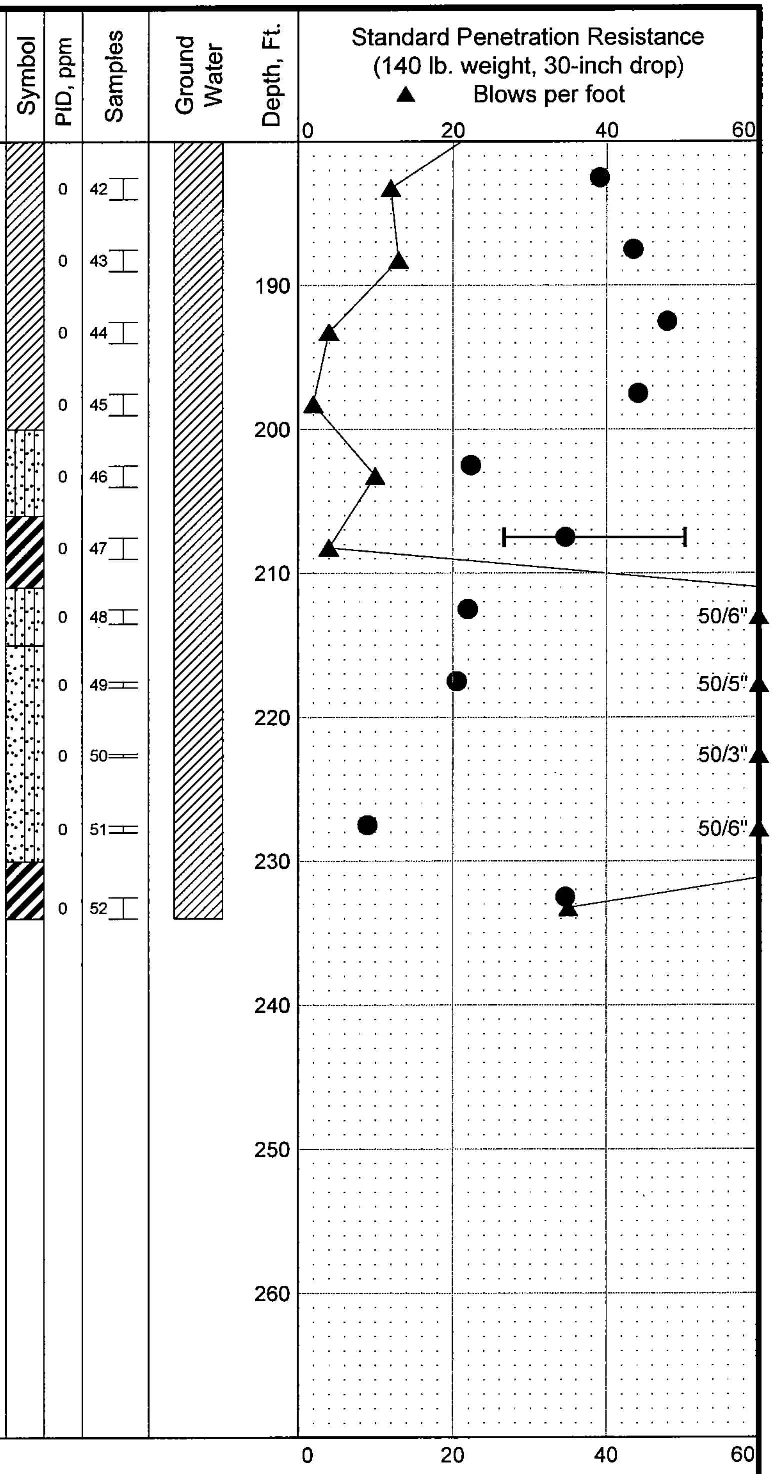
230.0

Hard, gray, silty CLAY, trace of gravel; wet; (Qpgl/Qvgl) CH/CL.

234.0

BOTTOM OF BORING
COMPLETED 9/19/2003

Note: Soil descriptions and PID readings above 7.0 feet are based on observations made during vacuum excavation.



● % Water Content

Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered	⬚ Piezometer Screen and Sand Filter
Ⓖ Grab Sample	▧ Bentonite-Cement Grout
⌶ Standard Penetration Test	⊠ Bentonite Chips/Pellets
⌶ 3.0" O.D. Osterberg Sample	▨ Bentonite Grout
	▼ Ground Water Level in Well

NOTES

1. The boring was performed using drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Seattle Monorail Project
Seattle, Washington

LOG OF BORING SD-109

December 2003 21-1-09910-091

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A.2-10
Sheet 3 of 3

MASTER LOG2 21-09910.GPJ SHAN WIL.GDT 12/19/03 Log: FA Rev: WDN Typ: EET

REV 3

SOIL DESCRIPTION

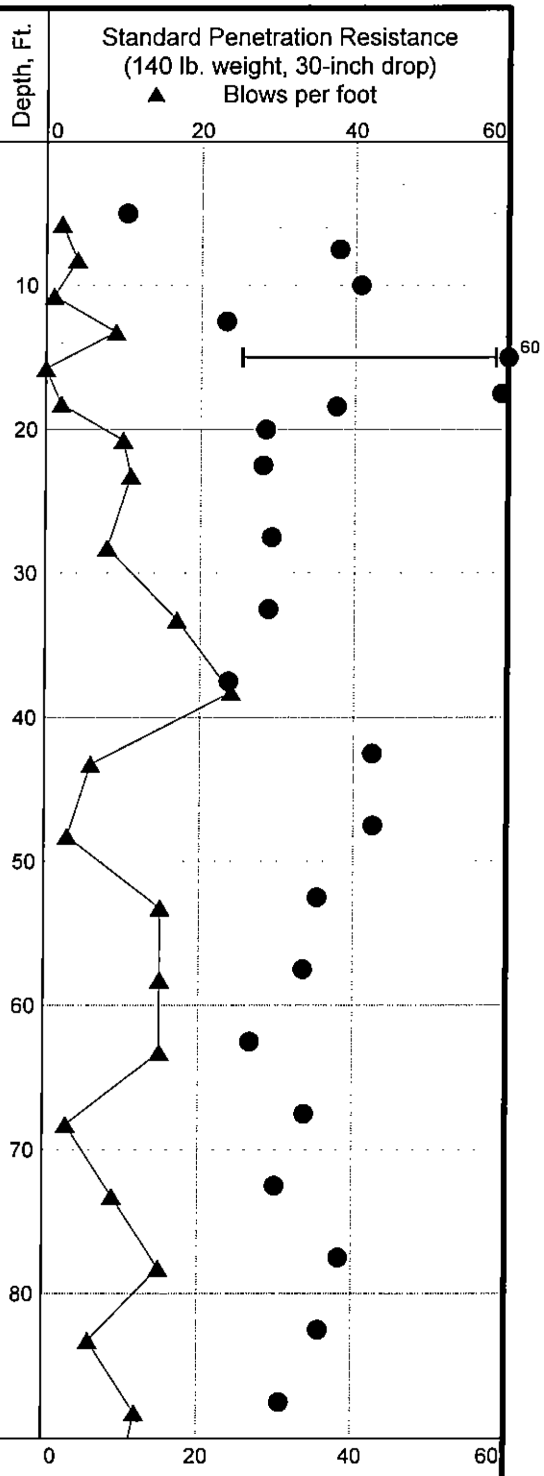
Coordinates: N: 215,769 E: 1,270,515
Surface Elevation: 17.2 Ft. (NAVD-88)

SOIL DESCRIPTION	Depth, Ft.
Very loose, silty, sandy GRAVEL to sandy, clayey SILT; moist; abundant brick and concrete debris; (Hf) GM/ML.	7.0
Soft, dark brown, slightly clayey, sandy SILT; wet; layers of silty, sand; (Hf) ML/SM.	10.0
Very soft, gray, clayey SILT to loose, dark gray, silty, fine to medium SAND; wet; scattered gravel and wood fragments; (Hf) SM.	15.0 18.0
Very soft, gray, silty CLAY; wet; (He) CH.	20.0
Loose, dark gray-brown, silty, fine SAND; wet; seams of sandy, clayey silt; (He) ML.	
Loose to medium dense, dark gray-brown, slightly silty, fine to medium SAND; wet; (Ha) SP-SM.	40.0
Loose to very loose, dark gray-brown, silty, fine to medium SAND; wet; abundant wood fragments and fine organics; fine sandy silt at bottom; (Ha/He) SM.	51.0
Medium dense, dark gray-brown, slightly silty, fine to medium SAND; wet; scattered to abundant wood decreasing with depth; (Ha) SP-SM.	66.0
Loose to medium dense, dark gray-brown, interbedded, slightly silty, fine to medium SAND and silty, fine SAND; wet; scattered seams of fine sandy silt, scattered to abundant wood fragments; (Ha) SM/SP-SM.	

CONTINUED NEXT SHEET

PID, ppm	Samples
0	
0	
0	1
0	2
0	3
0	4
0	5
0	6
0	7
9	8
0	9
0	10
0.5	11
8	12
14	13
10	14
0	15
1.4	16
1.3	17
1	18
0.8	19
1	20
1	21

Ground Water: During Drilling ∇



● % Water Content

Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

- * Sample Not Recovered
- ⌶ Standard Penetration Test
- ⌶ 3.0" O.D. Osterberg Sample
- ∇ Ground Water Level ATD

NOTES

1. The boring was performed using Mud Rotary drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Seattle Monorail Project
Seattle, Washington

LOG OF BORING SD-110

March 2004 21-1-09910-091

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A.2-11
Sheet 1 of 3

REVISED FOR ADDENDUM NO. 095-1

REV 3

MASTER LOG2 21-09910.GPJ TEMP.GDT 4/1/04

Log: AM Rev: WDN Typ: EET

SOIL DESCRIPTION

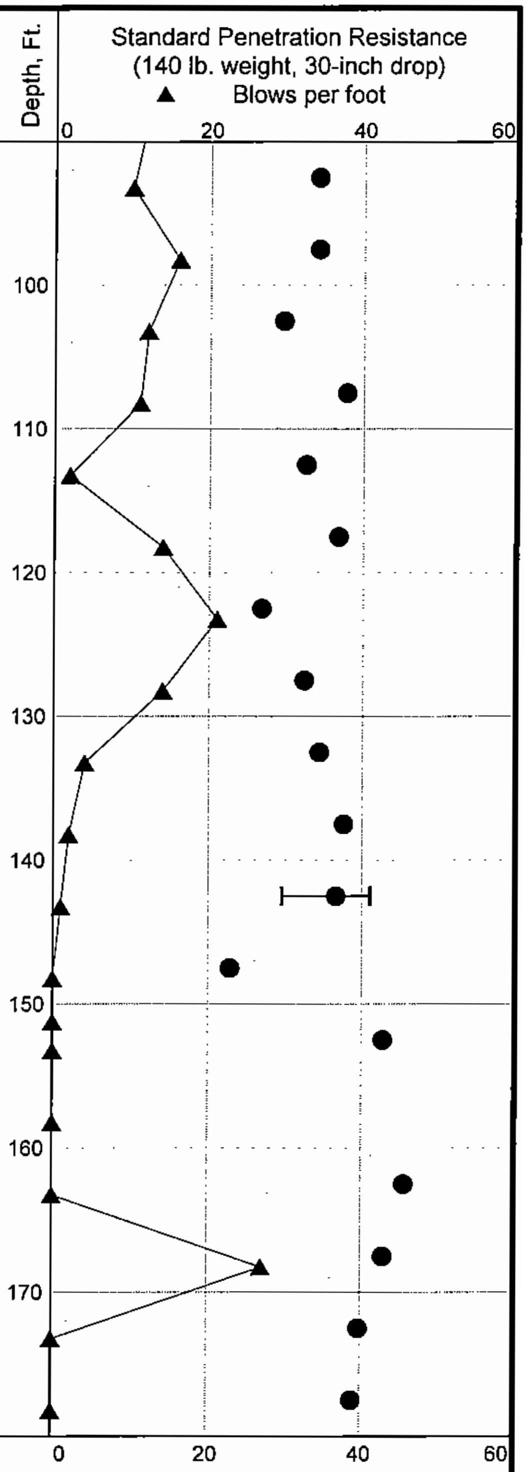
Coordinates: N: 215,769 E: 1,270,515

Surface Elevation: 17.2 Ft. (NAVD-88)

SOIL DESCRIPTION	Depth, Ft.
Loose, interbedded slightly silty SAND and silty SAND; (Ha) SM/SP-SM (cont.)	110.0
Soft, gray-brown, slightly clayey, fine sandy SILT; wet; abundant organic fragments; (He) ML.	115.0
Medium dense, dark gray-brown, slightly silty, fine to medium SAND; wet; (Ha) SP-SM.	131.0
Loose, gray-brown, silty, fine SAND; wet; abundant organics and wood debris; (Ha/He) SM.	135.0
Very soft, dark gray, clayey SILT to silty CLAY; wet; scattered to abundant shell fragments; (He) ML/CL.	166.0
Medium dense, dark gray-brown, silty, fine to medium SAND; wet; abundant wood debris; (Ha) SM.	171.0
Very soft, gray-brown, clayey SILT, trace of sand; wet; (He) ML.	

PID, ppm	Samples
	22 ⌶
	23 ⌶
	24 ⌶
	25 ⌶
	26 ⌶
	27 ⌶
	28 ⌶
	29 ⌶
0.2	30 ⌶
0.2	31 ⌶
12	32 ⌶
12	33 ⌶
	34 ⓘ
12	35 ⌶
	36 ⌶ *
3.1	37 ⌶
1	38 ⌶
2	39 ⌶
0.9	40 ⌶

CONTINUED NEXT SHEET



LEGEND

- * Sample Not Recovered
- ⌶ Standard Penetration Test
- ⓘ 3.0" O.D. Osterberg Sample
- ∇ Ground Water Level ATD

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit

Natural Water Content

NOTES

1. The boring was performed using Mud Rotary drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Seattle Monorail Project
Seattle, Washington

LOG OF BORING SD-110

March 2004 21-1-09910-091

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

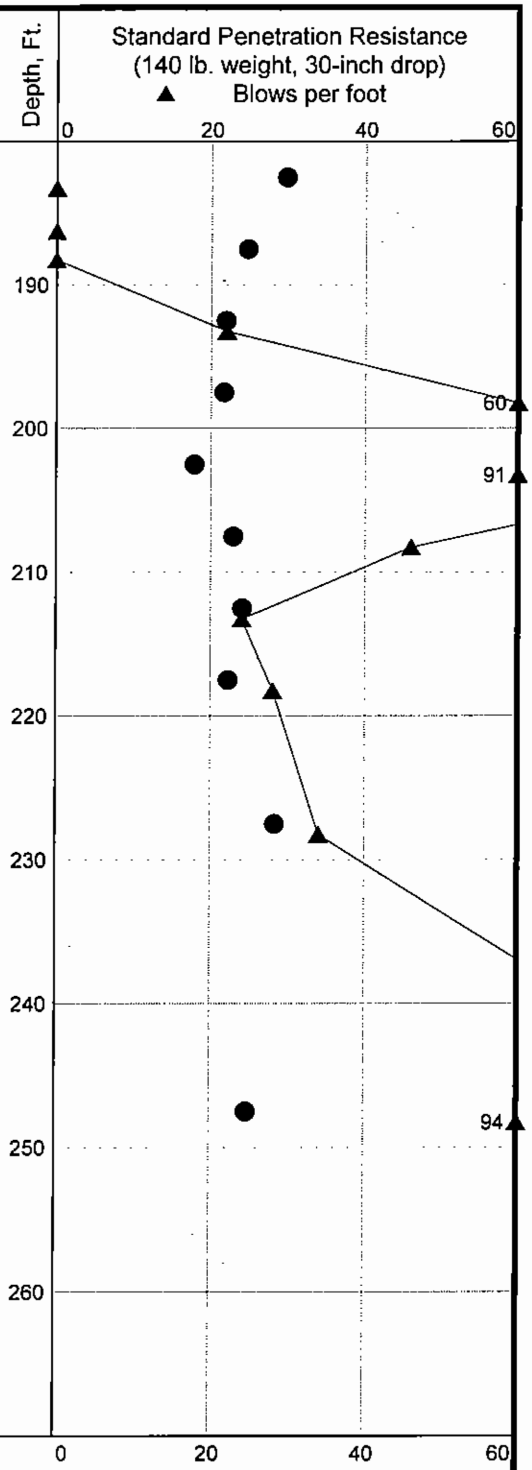
FIG. A.2-11
Sheet 2 of 3

REVISED FOR ADDENDUM NO. 095-1 *REV 3*

SOIL DESCRIPTION

Coordinates: N: 215,769 E: 1,270,515
Surface Elevation: 17.2 Ft. (NAVD-88)

Depth, Ft.	SOIL DESCRIPTION	PID, ppm	Samples
181.0	Very soft, gray-brown, sandy, clayey SILT; wet; abundant shell fragments; (He) ML.	1	41 42 43
190.0	Medium dense, gray-brown, gravelly, silty, clayey SAND; moist; (Hrw/Qvrl) SC.		44
197.0	Very dense, gray, silty, fine SAND grading to slightly silty, fine to medium SAND; wet; interbedded; scattered iron-oxide-stained bands; (Qpgo) SM/SP-SM.		45 46 47
208.5	Hard, gray, slightly sandy to sandy, silty CLAY, trace of gravel, grading to silty CLAY; (Qpgm) CL.		48 49 50 51
249.0	BOTTOM OF BORING COMPLETED 10/10/2003		



Note: Soil descriptions and PID readings above 5.2 feet are based on observations made during vacuum excavation.

LEGEND

- * Sample Not Recovered
- Ground Water Level ATD
- Standard Penetration Test
- 3.0" O.D. Osterberg Sample

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. The boring was performed using Mud Rotary drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Seattle Monorail Project
Seattle, Washington

LOG OF BORING SD-110

March 2004 21-1-09910-091

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A.2-11
Sheet 3 of 3

REVISED FOR ADDENDUM NO. 095-1 *REV 3*

Log: AM Rev: WDN Typ: EET

MASTER_LOG2 21-09910.GPJ TEMP.GDT 4/1/04

SOIL DESCRIPTION

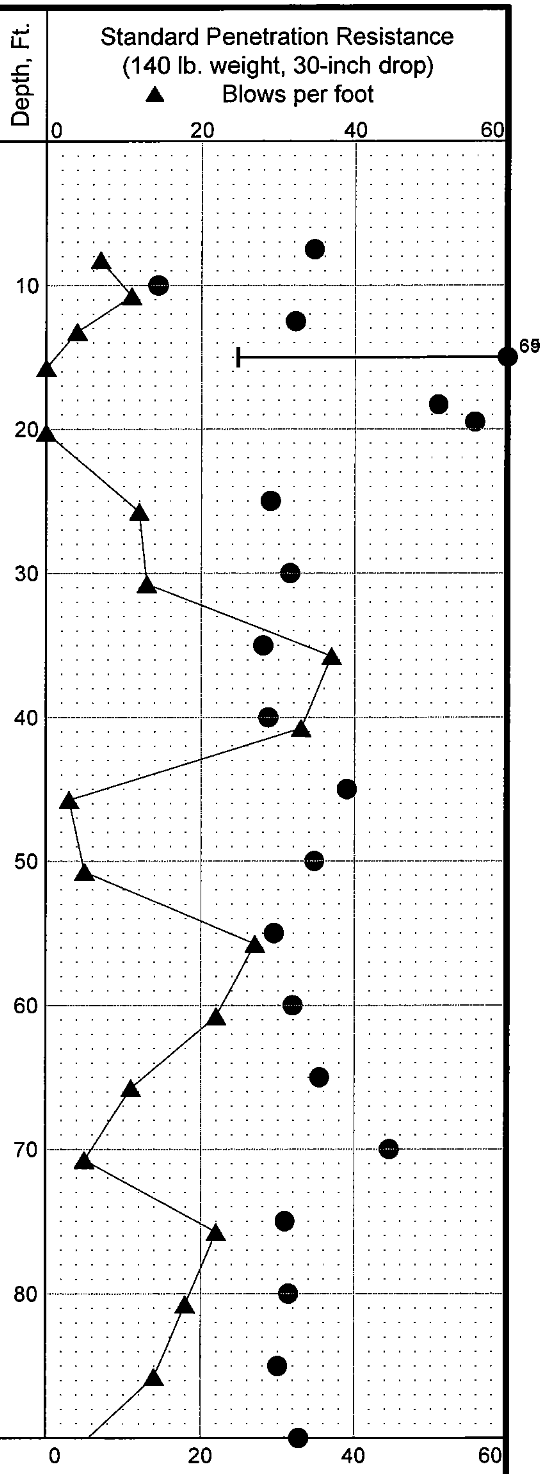
Coordinates: N: 215,943 E: 1,271,076

Surface Elevation: 18.9 Ft. (NAVD-88)

Soil Description	Depth, Ft.
ASPHALT	0.2
Dense, dark brown, silty, sandy GRAVEL; moist; crushed rock, brick, and concrete rubble; (Hf) GM.	2.0
Loose to medium dense, dark and light gray, silty, gravelly SAND; wet; asphalt, brick, wood and concrete fragments; (Hf) SM.	12.0 14.5
Loose, dark gray, slightly silty, fine SAND; wet; massive scattered organic fragments; (Ha) SP-SM.	
Very soft, dark gray and gray, silty CLAY, trace of fine sand; wet; bedded to laminated with scattered organic-rich seams; (Hl/He) CH/CL.	23.5
Medium dense and dense, dark gray, slightly silty, fine SAND; wet; massive to bedded, scattered organic-rich seams, scattered shell fragments; (Ha) SP-SM.	
Very loose to loose, dark gray, silty, fine SAND to fine sandy SILT; wet; massive to bedded, abundant organic fragments, scattered shell fragments; (He) SM/ML.	43.0
Medium dense, dark gray, slightly silty, fine SAND; wet; massive, scattered organic fragments; (Ha) SP-SM.	53.0
Medium dense to loose, dark gray, fine sandy SILT; wet; massive to bedded, abundant organic-rich seams; (He) ML.	63.0
Medium dense, dark gray, silty, fine SAND; wet; massive, abundant organic fragments; (He) SM.	73.0
CONTINUED NEXT SHEET	88.0

Samples	PID, ppm
1 ⌶	0
2 ⌶	0
3 ⌶	0
4 ⌶	0
5 ⏀	0
6 ⌶	0
7 ⌶	0
8 ⌶	0
9 ⌶	0
10 ⌶	0
11 ⌶	0
12 ⌶	0
13 ⌶	0
14 ⌶	0
15 ⌶	0
16 ⌶	0
17 ⌶	0
18 ⌶	0
19 ⌶	0

Ground Water



LEGEND

- * Sample Not Recovered
- ⌶ Standard Penetration Test
- ⏀ 3.0" O.D. Osterberg Sample

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit

Natural Water Content

NOTES

1. The boring was performed using Mud Rotary drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Seattle Monorail Project
Seattle, Washington

LOG OF BORING SD-112

December 2003 21-1-09910-091

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A.2-14
Sheet 1 of 3

REV 3

Log: KH Rev: WDN Typ: LKD

MASTER LOG2 21-09910.GPJ SHAN WIL.GDT 12/19/03

SOIL DESCRIPTION

Coordinates: N: 215,943 E: 1,271,076

Surface Elevation: 18.9 Ft. (NAVD-88)

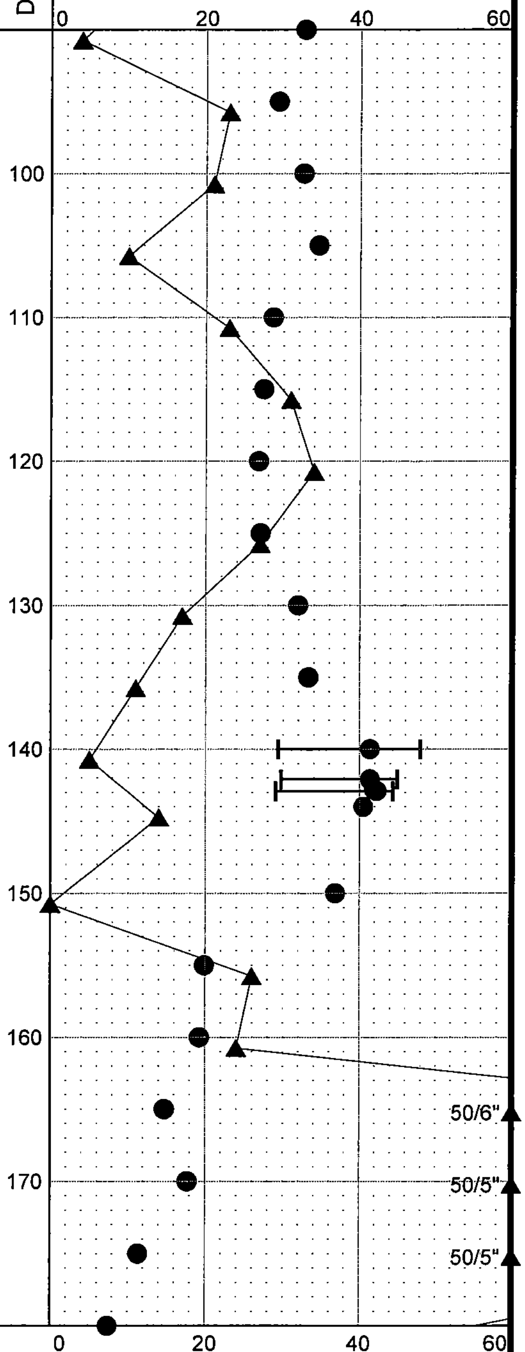
SOIL DESCRIPTION	Depth, Ft.
Loose, dark gray, fine sandy SILT; wet; massive, abundant organic fragments, scattered shell fragments; (He) ML.	93.0
Medium dense, dark gray, silty, fine SAND; wet; massive to bedded abundant organic fragments, slightly silty at top; (He) SM.	113.0
Dense to medium dense, slightly silty, fine SAND; wet; massive, scattered pumice fragments, grades to silty, fine sand at bottom; (Ha) SP-SM.	128.0
Medium dense, dark gray, silty, fine SAND to fine sandy SILT; wet; massive, abundant very fine organic fragments; (He) ML/SM.	138.0
Medium stiff to very soft, dark olive-gray, clayey SILT; moist; massive, abundant shell fragments; (He) ML.	153.0
Medium dense, gray, slightly gravelly to gravelly, silty SAND; wet; locally trace of clay, massive, abundant shell debris and wood fragments; (Hb) SM.	164.0
Very dense, gray, slightly silty SAND grading to silty, gravelly SAND; moist; massive, scattered silt pockets at bottom; (Qpgo/Qva) SP-SM/SM.	176.0
Dense, gray, silty, sandy GRAVEL, trace of	

CONTINUED NEXT SHEET

PID, ppm	Samples
0	20
0	21
0	22
0	23
0	24
0	25
0	26
0	27
0	28
0	29
0	30
0	31
0	32
0	33
0	34
0	35
0	36
0	37
0	38

Ground Water: None Observed During Drilling

Standard Penetration Resistance
(140 lb. weight, 30-inch drop)
▲ Blows per foot



LEGEND

- * Sample Not Recovered
- Standard Penetration Test
- 3.0" O.D. Osterberg Sample

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. The boring was performed using Mud Rotary drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Seattle Monorail Project
Seattle, Washington

LOG OF BORING SD-112

December 2003 21-1-09910-091

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A.2-14
Sheet 2 of 3

MASTER LOG2 21-09910.GPJ SHAN WIL.GDT 12/19/03 Log: KH Rev: WDN Typ: LKD

REV 3

SOIL DESCRIPTION

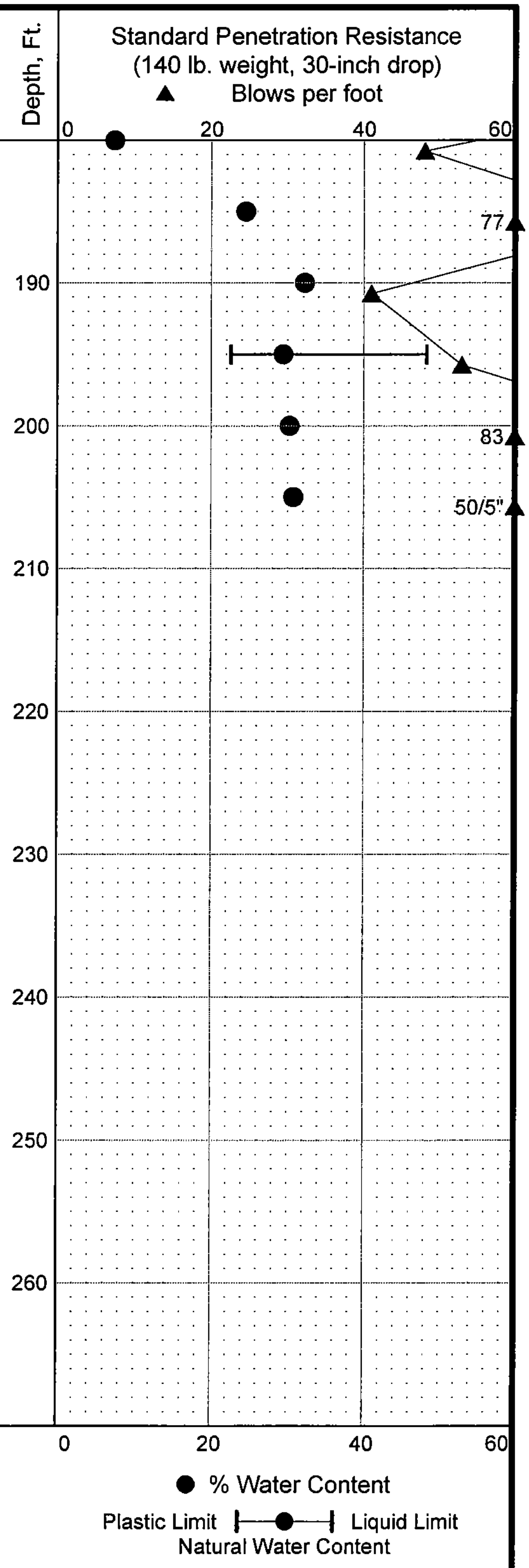
Coordinates: N: 215,943 E: 1,271,076
Surface Elevation: 18.9 Ft. (NAVD-88)

Soil Description	Depth, Ft.
clay to slightly gravelly and sandy SILT, trace of clay; moist; massive; (Qpgm) GM/ML.	188.0
Hard, gray, silty CLAY to clayey SILT; moist; locally trace of fine sand at top; massive; (Qpgl) CL/ML.	206.4

PID, ppm	Samples
0	39
0	40
0	41
0	42
0	43
0	44

BOTTOM OF BORING
COMPLETED 8/20/2003

Notes:
1. Soil descriptions above 7.0 feet are based on observations made during vacuum excavation.
2. PID readings during vacuum excavation were 0 ppm.



LEGEND
- * Sample Not Recovered
- Standard Penetration Test
- 3.0" O.D. Osterberg Sample

NOTES
1. The boring was performed using Mud Rotary drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Seattle Monorail Project
Seattle, Washington

LOG OF BORING SD-112

December 2003 21-1-09910-091

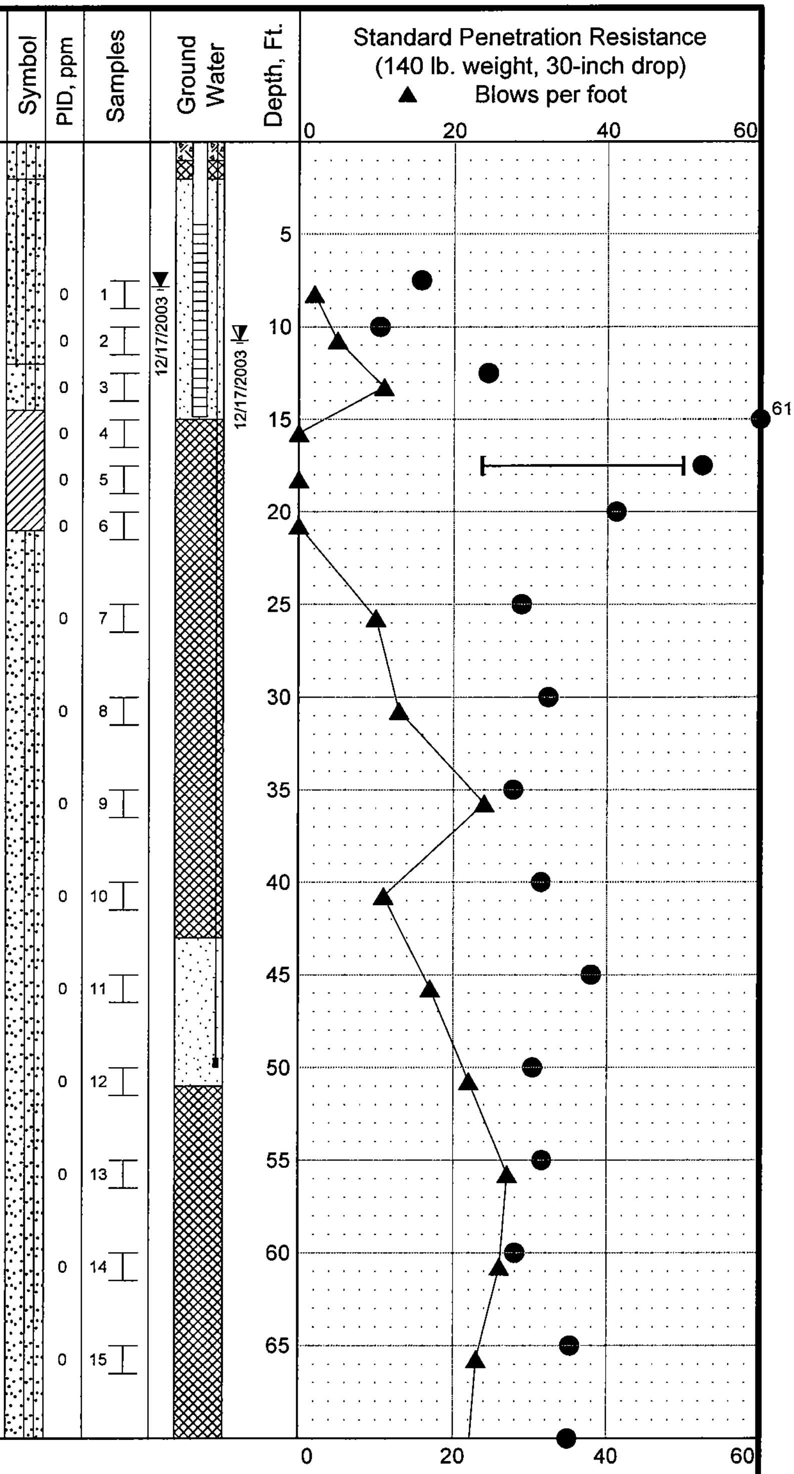
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A.2-14
Sheet 3 of 3

SOIL DESCRIPTION

Coordinates: N: 216,468 E: 1,271,098
Surface Elevation: 18.9 Ft. (NAVD-88)

Soil Description	Depth, Ft.
Very dense, brown, gravelly, silty SAND; moist to dry; scattered brick debris; (Hf) SM.	2.0
Very loose to medium dense, gray, slightly fine gravelly, silty SAND to slightly clayey, silty, sandy GRAVEL; wet; massive, scattered organic fragments and wood debris; (Hf) SM/GM.	12.0
Medium dense, dark gray, slightly silty, gravelly SAND; wet; massive, abundant organics, abundant shell fragments; (Ha/Hf) SP-SM.	14.5
Very soft, gray to dark gray, silty CLAY; wet; bedded, scattered wood fragments, scattered organic-rich seams at bottom; (Hf/He) CL/CH.	21.0
Medium dense, dark gray, slightly silty, fine SAND; wet; massive to bedded, scattered to abundant very fine organic fragments, scattered seams with trace of silt; (Ha) SP-SM. - Seam of fine sandy silt between 40.0 and 46.5 feet.	



CONTINUED NEXT SHEET

LEGEND

- * Sample Not Recovered
- ⌶ Standard Penetration Test
- ⊡ Piezometer Screen and Sand Filter
- ▧ Bentonite-Cement Grout
- ▩ Bentonite Chips/Pellets
- ▨ Bentonite Grout
- ▼ Ground Water Level in Well
- ▼ Ground Water Level in VWP

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. The boring was performed using Mud Rotary drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Seattle Monorail Project
Seattle, Washington

LOG OF BORING SD-113

December 2003 21-1-09910-091

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A.2-15
Sheet 1 of 3

REV 3

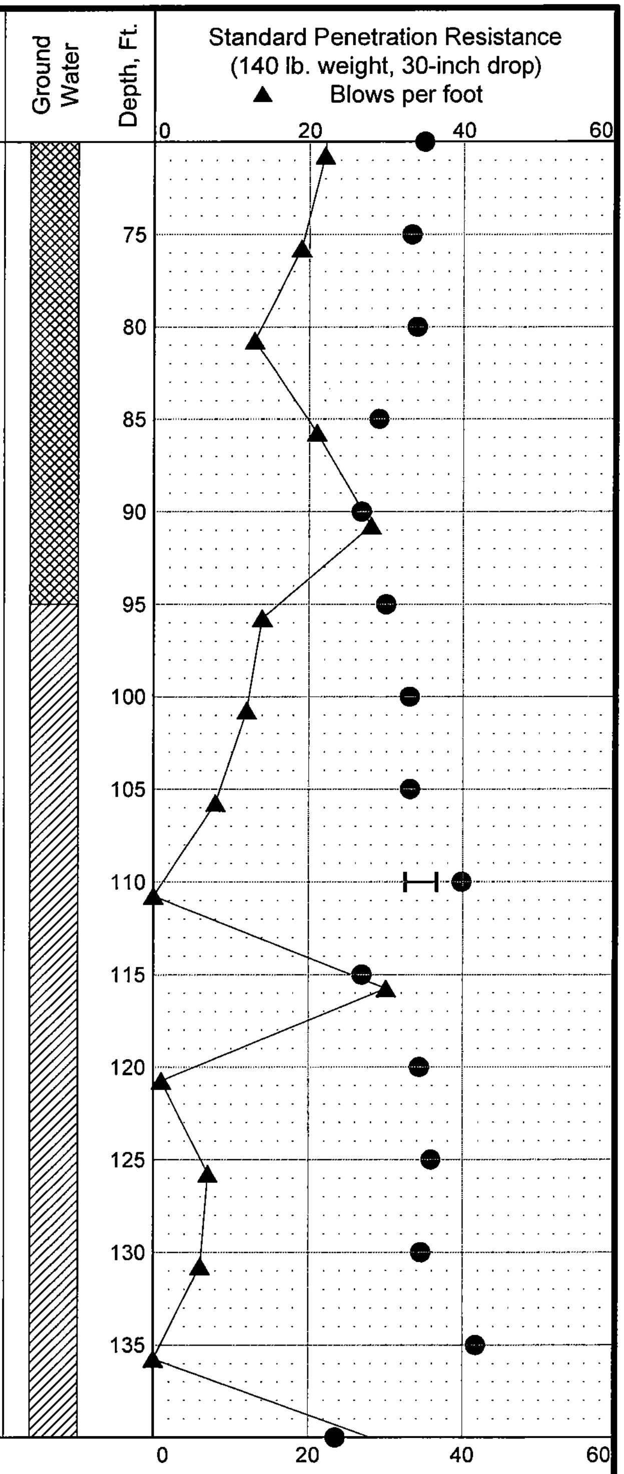
SOIL DESCRIPTION

Coordinates: N: 216,468 E: 1,271,098

Surface Elevation: 18.9 Ft. (NAVD-88)

SOIL DESCRIPTION	Depth, Ft.	PID, ppm	Samples
Medium dense, slightly silty SAND; (Ha) SP-SM (cont.)	73.0	0	16
Medium dense, dark gray, silty, fine to medium SAND and fine sandy SILT; moist to wet; massive, scattered to abundant very fine organic fragments; (Ha) SM/ML.	88.0	0 0 0	17 18 19
Medium dense, dark gray, slightly silty, fine SAND; moist; massive, abundant very fine organic fragments; (Ha) SP-SM.	93.0	0	20
Medium dense to loose, dark gray, fine sandy SILT to silty, fine SAND; wet; massive to bedded, abundant very fine organic fragments; (Ha) ML/SM.	108.0	0 0 0	21 22 23
Very soft, dark gray (oxidizes to gray-brown) SILT, trace of fine sand and clay; moist; massive; (He) ML.	114.8	0	24
Medium dense, dark gray, slightly silty, fine SAND; moist; massive; (Ha) SP-SM.	118.0	0	25
Very loose and loose, dark gray, fine sandy SILT; moist to wet; massive to bedded; scattered organic-rich seams; scattered seams of silty, fine sand, locally clayey at bottom; (He) ML.	137.5	0 0 0 0	26 27 28 29

CONTINUED NEXT SHEET



LEGEND

- * Sample Not Recovered
- I Standard Penetration Test
- ☐ Piezometer Screen and Sand Filter
- ▧ Bentonite-Cement Grout
- ▩ Bentonite Chips/Pellets
- ▨ Bentonite Grout
- ▼ Ground Water Level in Well
- ▽ Ground Water Level in VWP

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit

Natural Water Content

NOTES

1. The boring was performed using Mud Rotary drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Seattle Monorail Project
Seattle, Washington

LOG OF BORING SD-113

December 2003 21-1-09910-091

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A.2-15
Sheet 2 of 3

REV 3

MASTER LOG2 21-09910.GPJ SHAN WIL.GDT 12/19/03

Log: KH Rev: WDN Typ: LKD

SOIL DESCRIPTION

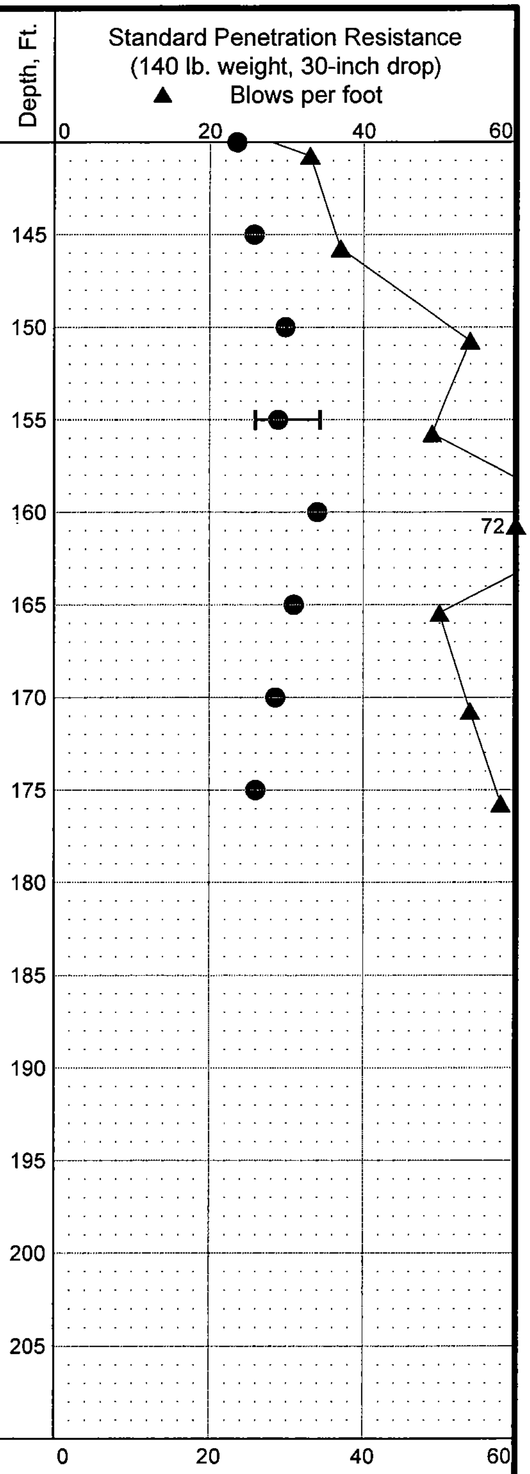
Coordinates: N: 216,468 E: 1,271,098
Surface Elevation: 18.9 Ft. (NAVD-88)

SOIL DESCRIPTION	Depth, Ft.	PID, ppm	Samples
Interbedded, dense, gray, gravelly, silty SAND and hard, gray to green-gray, slightly clayey SILT; moist; bedded, scattered shell debris at top; (Hrw/Qvrl) ML/SM.		0 0	30 31
	148.0		
Hard, gray, slightly clayey to clayey SILT; moist; bedded; (Qpgl) ML.		0 0	32 33
	158.0		
Hard, gray, silty CLAY; moist; massive, scattered dropstones at top; (Qpgl) CL.		0 0 0 0	34 35 * 36 37
	176.5		

BOTTOM OF BORING
COMPLETED 8/13/2003

Notes:

1. Soil descriptions above 7.0 feet are based on observations made during vacuum excavation.
2. PID readings during vacuum excavation were 0 ppm.



LEGEND

* Sample Not Recovered
⌶ Standard Penetration Test

▤ Piezometer Screen and Sand Filter
▧ Bentonite-Cement Grout
⊠ Bentonite Chips/Pellets
▨ Bentonite Grout
▼ Ground Water Level in Well
▽ Ground Water Level in VWP

● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. The boring was performed using Mud Rotary drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Seattle Monorail Project
Seattle, Washington

LOG OF BORING SD-113

December 2003 21-1-09910-091

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A.2-15
Sheet 3 of 3

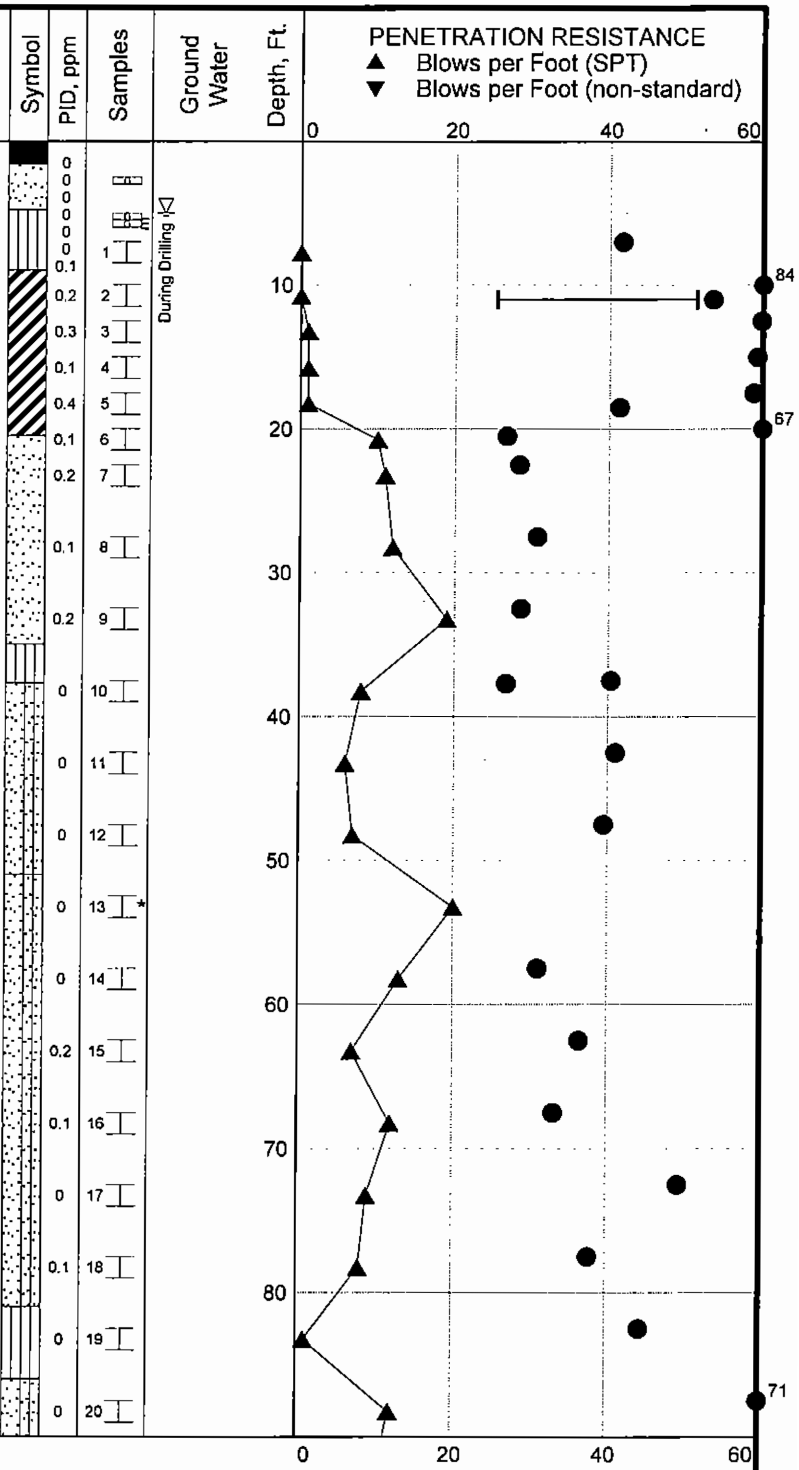
SOIL DESCRIPTION

Coordinates: N: 215,931 E: 1,270,655

Surface Elevation: 18.0 Ft. (NAVD-88)

SOIL DESCRIPTION	Depth, Ft.
2" ASPHALT, 17" GRAVEL Base/subbase.	1.6
Loose, dark gray, fine to medium SAND, trace of silt to silty, fine SAND; moist; scattered organics; (Hf) SP/SM.	4.8
Very soft, dark gray, slightly fine sandy, slightly clayey SILT; wet; massive, abundant organics; (Hf/He) ML.	9.0
Very soft, dark gray, silty CLAY, trace of fine sand; wet; bedded, abundant organics, scattered silt and peat seams at top; (Hf/He) CH/CL.	20.5
Loose to medium dense, dark gray, fine to medium SAND, trace of silt; wet; massive, scattered organic and shell fragments; (Ha) SP.	35.0
Medium stiff, olive-gray, slightly fine sandy, clayey SILT; moist; bedded, scattered organic and shell fragments; (He) ML.	37.7
Loose, dark gray, slightly silty, fine to medium SAND; wet; massive to bedded, abundant wood and shell fragments; (Ha) SP-SM.	51.0
Medium dense and loose, dark gray, slightly silty to silty, fine SAND and fine sandy SILT, trace of clay; wet; interbedded, scattered seams of clean sand, scattered shell fragments, abundant organics; (Ha) SP-SM/ML.	81.0
Very loose, dark gray, fine sandy SILT, trace of clay; wet; massive to bedded, abundant organics, scattered shell fragments; (Ha) ML	86.0

~~CONTINUED NEXT SHEET~~



● % Water Content

Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

- * Sample Not Recovered
- ⊻ Ground Water Level ATD
- E Environmental Sample Obtained
- G Grab Sample
- ⌶ Standard Penetration Test
- Ⓞ 3.0" O.D. Osterberg Sample
- M Pressuremeter Test (f=failed)
- P 3" O.D. Pitcher Sample

NOTES

1. The boring was performed using Mud Rotary drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Seattle Monorail Project
Seattle, Washington

LOG OF BORING SD-122

March 2004 21-1-09910-091

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A.2-24
Sheet 1 of 3

REVISED FOR ADDENDUM NO. 095-1

REV 3

MASTER_LOG2 21-09910.GPJ TEMP.GDT 4/1/04

Log: AM Rev: WDN Typ: LKD

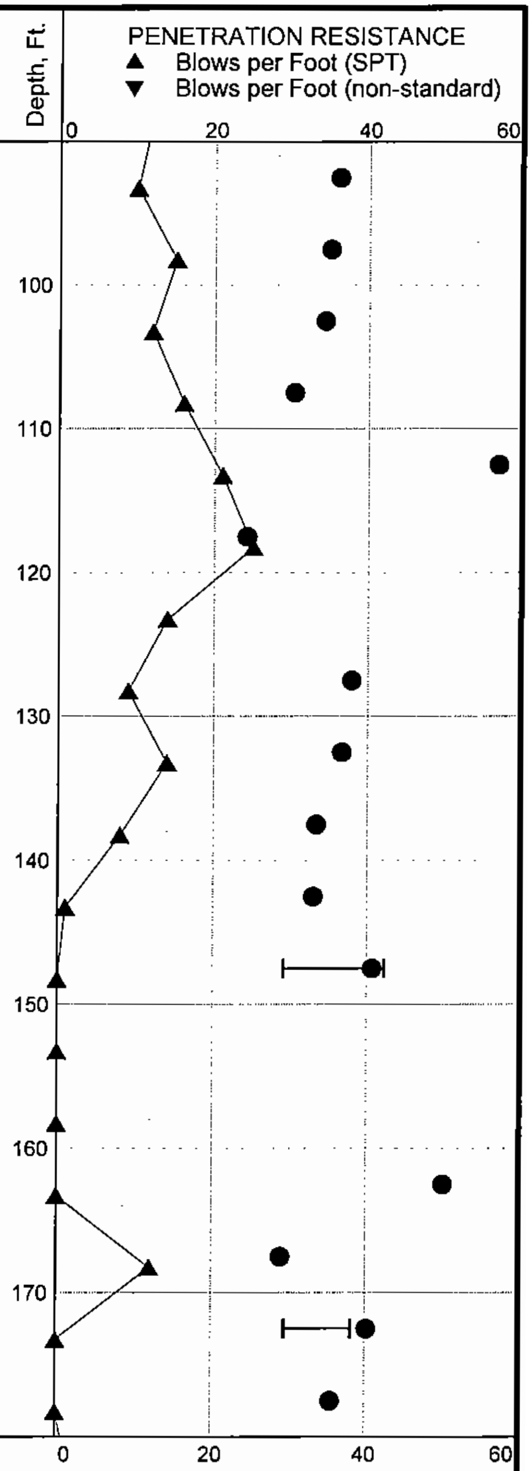
SOIL DESCRIPTION

Coordinates: N: 215,931 E: 1,270,655
Surface Elevation: 18.0 Ft. (NAVD-88)

Soil Description	Depth, Ft.
Medium dense, dark gray, slightly silty to silty, fine SAND; wet; locally trace of clay, abundant wood fragments at top; (Ha) SP-SM/SM.	101.0
Medium dense, dark gray, silty, fine SAND grading to clean to slightly silty, fine to medium SAND; wet; bedded with scattered slightly silty seams at bottom; (Ha) SM/SP-SM.	121.0
Medium dense and loose, dark gray, fine sandy SILT to medium stiff, slightly fine sandy, clayey SILT; wet; massive to bedded, scattered organics; (Ha) ML.	141.0
Very soft, dark gray, slightly clayey SILT, trace of fine sand to silty CLAY; moist to wet; massive, abundant organic and shell fragments; (He) ML/CH.	166.0
Medium dense, dark gray, fine sandy SILT; wet; faintly bedded, partly cohesionless, abundant organics; (He/Ha) ML.	171.0
Very soft, dark gray, clayey SILT, trace of fine sand; moist to wet; massive, scattered shell fragments; (He) ML/CL.	

CONTINUED NEXT SHEET

PID, ppm	Samples
0.2	21 I
0.2	22 I
0.1	23 I
0.1	24 I
0.1	25 I
0	26 I
0.1	27 I
0	28 I
0.1	29 I
0.1	30 I
0.1	31 I
0	32 Ⓘ
	33 I
	34 I*
	35 I*
	36 Ⓘ
0.2	37 I
0.2	38 I
0.2	39 I
0.1	40 I



● % Water Content

Plastic Limit |—●—| Liquid Limit
Natural Water Content

LEGEND

*	Sample Not Recovered
E	Environmental Sample Obtained
G	Grab Sample
I	Standard Penetration Test
Ⓘ	3.0" O.D. Osterberg Sample
M	Pressuremeter Test (f=failed)
P	3" O.D. Pitcher Sample
▽	Ground Water Level ATD

NOTES

1. The boring was performed using Mud Rotary drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Seattle Monorail Project
Seattle, Washington

LOG OF BORING SD-122

March 2004 21-1-09910-091

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A.2-24
Sheet 2 of 3

REVISED FOR ADDENDUM NO. 095-1

REV 3

Log: AM Rev: WDN Typ: LKD

MASTER LOG2 21-09910.GPJ TEMP.GDT 4/1/04

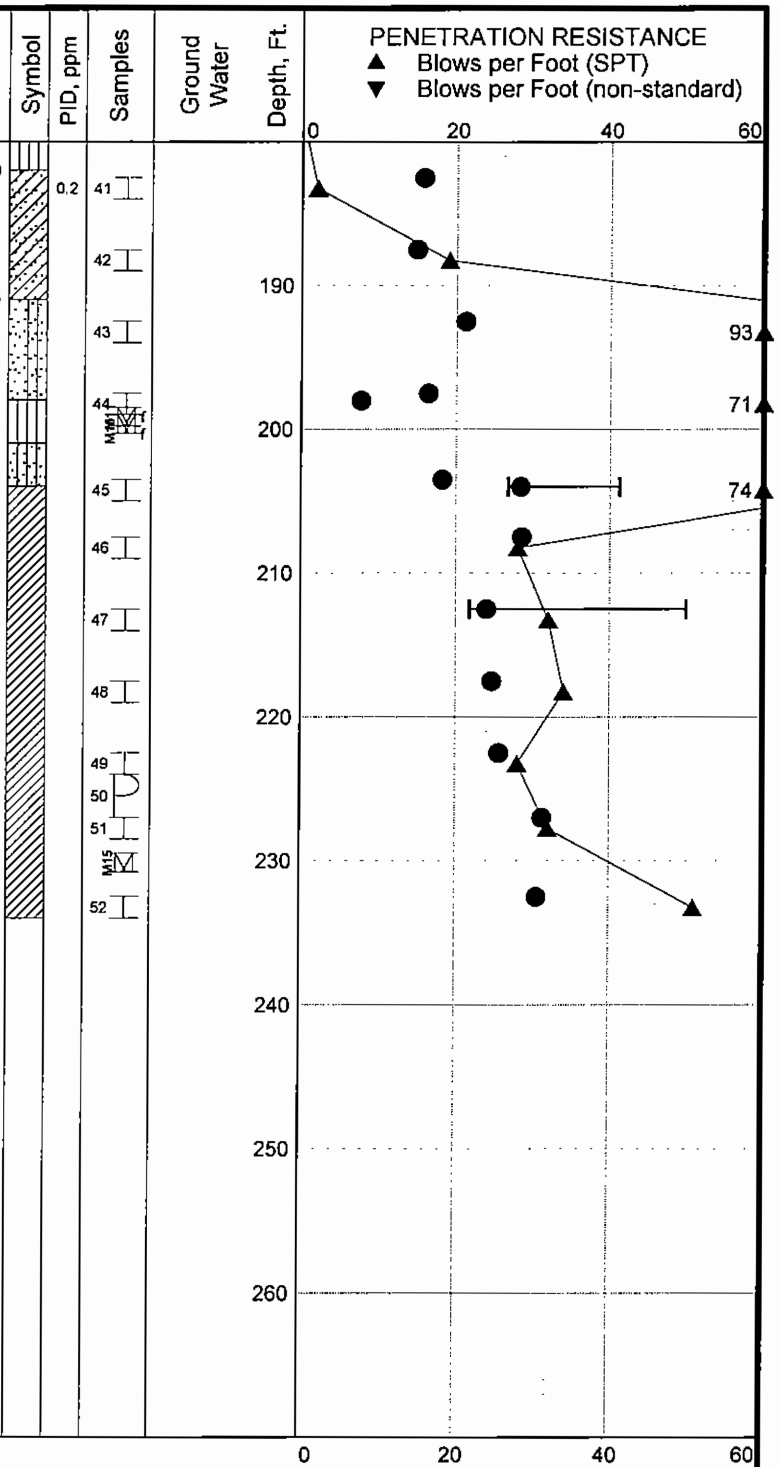
SOIL DESCRIPTION

Coordinates: N: 215,931 E: 1,270,655

Surface Elevation: 18.0 Ft. (NAVD-88)

Depth, Ft.	Soil Description
182.0	Very loose to medium dense, green-gray, slightly silty, gravelly, clayey SAND to very soft to stiff, green-gray, sandy, silty CLAY, trace of gravel; moist; massive to bedded, scattered organic fragments, scattered sheared seams at bottom; (Hrw/Qvrl) SC/CL.
191.0	
198.0	Very dense, brown, slightly silty SAND; moist; massive; (Qpgo) SP-SM.
201.0	Very dense, gray-brown, sandy, gravelly SILT; moist; massive; (Qpgt) ML/GM.
204.0	Very dense, dark gray, silty, fine to medium SAND; moist; bedded with scattered sandy silt seams, scattered organics; (Qpgo) SM. Very stiff and hard, gray, silty CLAY, trace of sand; moist; massive, scattered gravel dropstones; (Qpgl) CL/CH. - Seam of light gray, clayey silt at 204.0 feet. - gravel inferred from drill action at 224 feet.
234.0	BOTTOM OF BORING COMPLETED 9/22/2003

Notes: Soil descriptions and PID readings above 7.0 feet are based on observations made during vacuum excavation.



● % Water Content

Plastic Limit ├──●──┤ Liquid Limit
Natural Water Content

LEGEND

- * Sample Not Recovered
- ⊻ Ground Water Level ATD
- E Environmental Sample Obtained
- Ⓖ Grab Sample
- Ⅰ Standard Penetration Test
- Ⓘ 3.0" O.D. Osterberg Sample
- M Pressuremeter Test (f=failed)
- P 3" O.D. Pitcher Sample

NOTES

1. The boring was performed using Mud Rotary drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Seattle Monorail Project
Seattle, Washington

LOG OF BORING SD-122

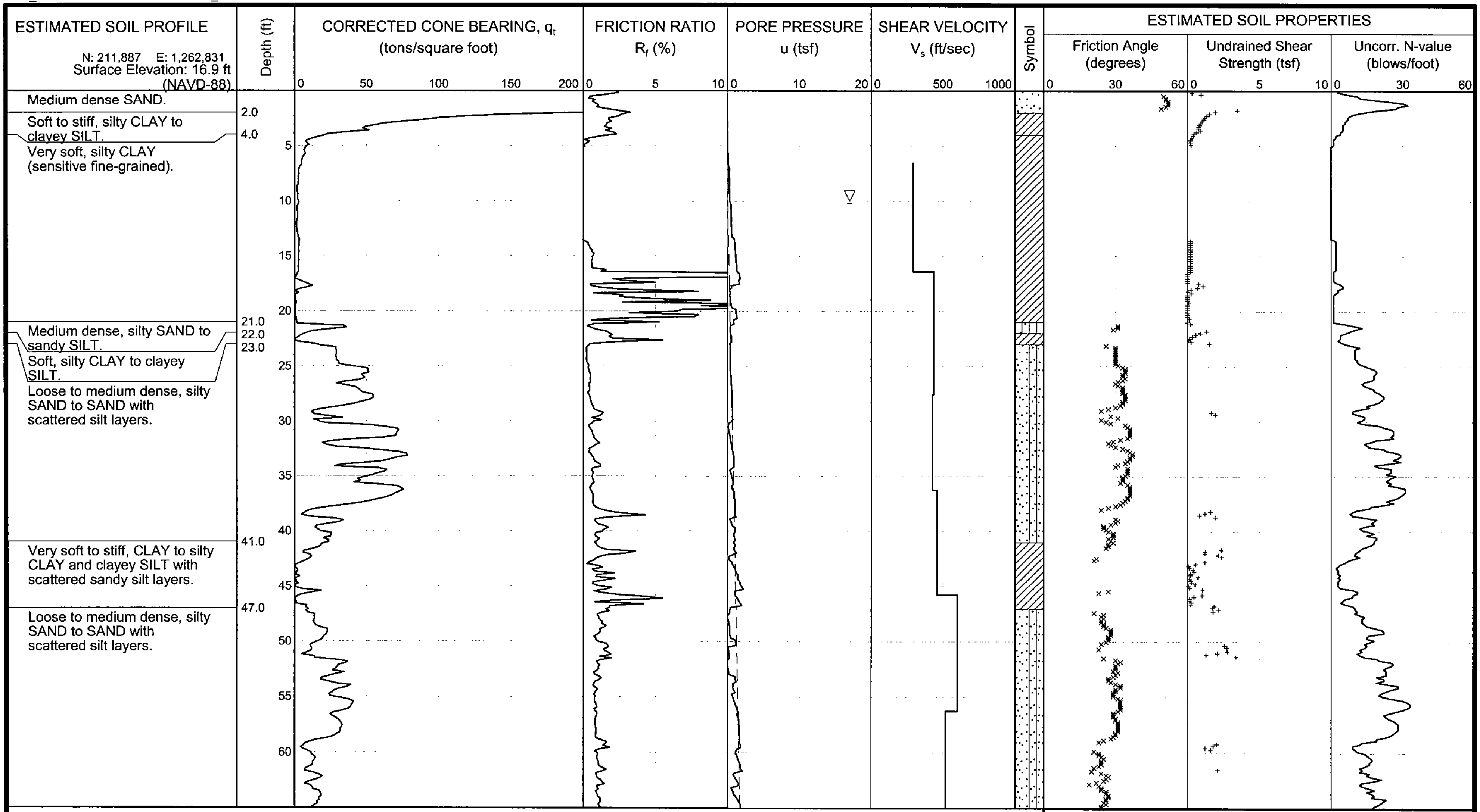
March 2004 21-1-09910-091

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A.2-24
Sheet 3 of 3

REVISED FOR ADDENDUM NO. 095-1

REV 3



Medium dense SAND.

2.0 Soft to stiff, silty CLAY to clayey SILT.

4.0 Very soft, silty CLAY (sensitive fine-grained).

21.0 Medium dense, silty SAND to sandy SILT.

22.0 Soft, silty CLAY to clayey SILT.

23.0 Loose to medium dense, silty SAND to SAND with scattered silt layers.

41.0 Very soft to stiff, CLAY to silty CLAY and clayey SILT with scattered sandy silt layers.

47.0 Loose to medium dense, silty SAND to SAND with scattered silt layers.

NOTES:
1. The stratification lines represent the approximate boundaries between soil types; the transition may be gradual.
2. The estimated soil properties are based on analyses performed using published correlations and equations. The method used for estimating the properties listed above are:

Property	Method
Friction Angle	Durgunoglu & Mitchell
Uncorrected N-Value (N60)	Robertson & Campanella
Undrained Shear Strength	$\frac{qc - \sigma v}{Nk}$ where:

qc = Measured Cone Bearing
Nk = 12.5
σ v = Total Overburden Stress

3. Log of probe is based on piezocone probe data provided by Northwest Cone Exploration.
4. The pore pressure was measured behind the tip of the penetrometer. Hydrostatic pore pressure based on the estimated groundwater depth is also shown above (dashed line).

FIG. A.2-27
Sheet 1 of 2

Seattle Monorail Project
Seattle, Washington

LOG OF PROBE SD-203

December 2003
21-1-09910-091

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A.2-27
Sheet 1 of 2

REV 3

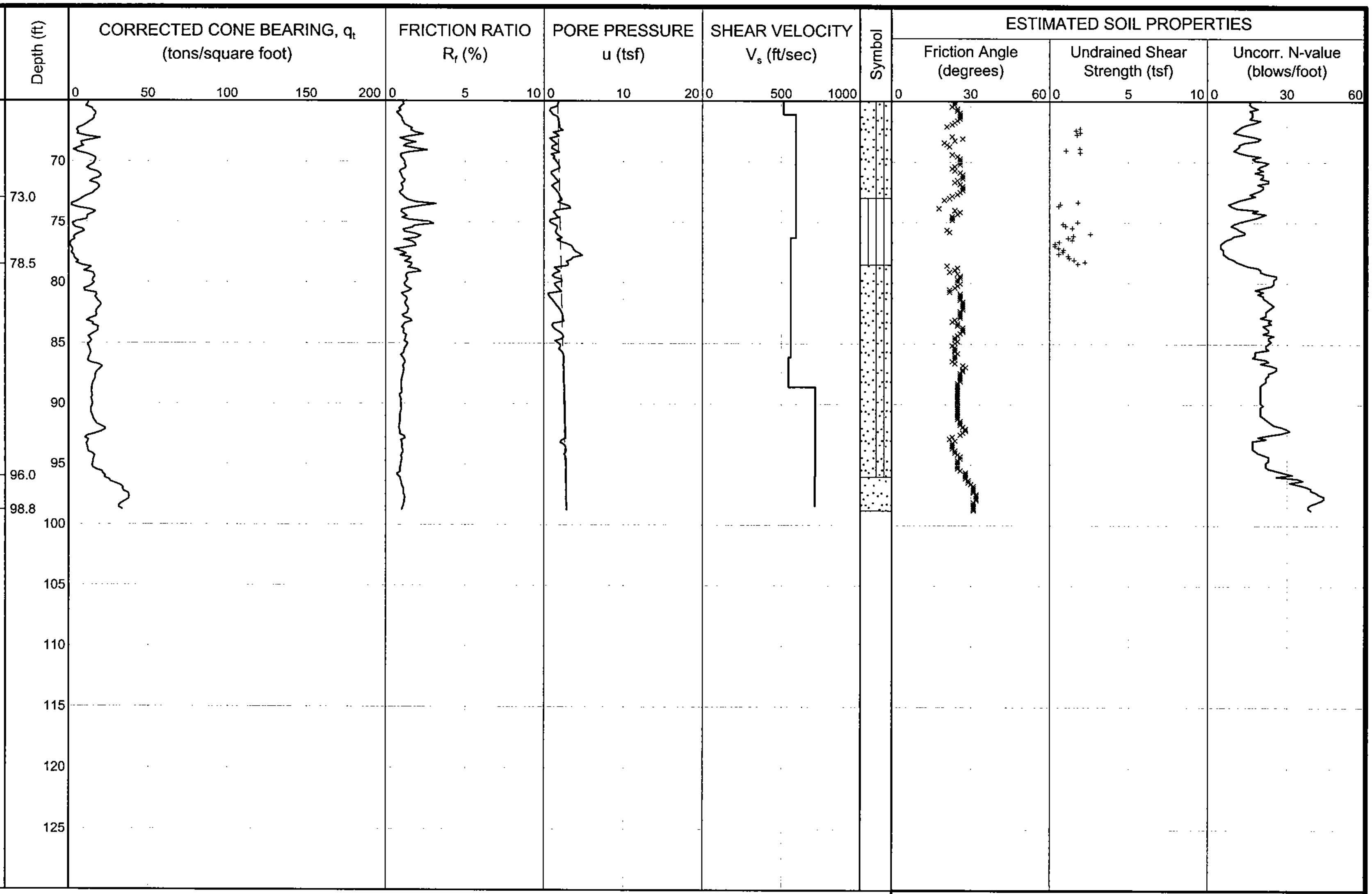
CPT_SEISMIC 21-09910.GPJ SHAN_WIL.GDT 12/22/03

ESTIMATED SOIL PROFILE

N: 211,887 E: 1,262,831
Surface Elevation: 16.9 ft
(NAVD-88)

Depth (ft)	ESTIMATED SOIL PROFILE
73.0	Medium stiff to stiff, clayey SILT to silty CLAY with scattered sandy silt layers.
78.5	Medium dense, silty SAND to SAND.
96.0	Dense SAND.
98.8	BOTTOM OF PROBE COMPLETED 10/28/03

NOTE: SD-203 abandoned prior to reaching design depth. See log of SD-203A for continuation.



NOTES:

1. The stratification lines represent the approximate boundaries between soil types; the transition may be gradual.
2. The estimated soil properties are based on analyses performed using published correlations and equations. The method used for estimating the properties listed above are:

Property	Method
Friction Angle	Durgunoglu & Mitchell
Uncorrected N-Value (N60)	Robertson & Campanella
Undrained Shear Strength	$\frac{qc - \sigma v}{Nk}$ where: qc = Measured Cone Bearing Nk = 12.5 σ v = Total Overburden Stress

3. Log of probe is based on piezocone probe data provided by Northwest Cone Exploration.
4. The pore pressure was measured behind the tip of the penetrometer. Hydrostatic pore pressure based on the estimated groundwater depth is also shown above (dashed line).

FIG. A.2-27
Sheet 2 of 2

Seattle Monorail Project
Seattle, Washington

LOG OF PROBE SD-203

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21-1-09910-091

SHANNON & WILSON, INC.
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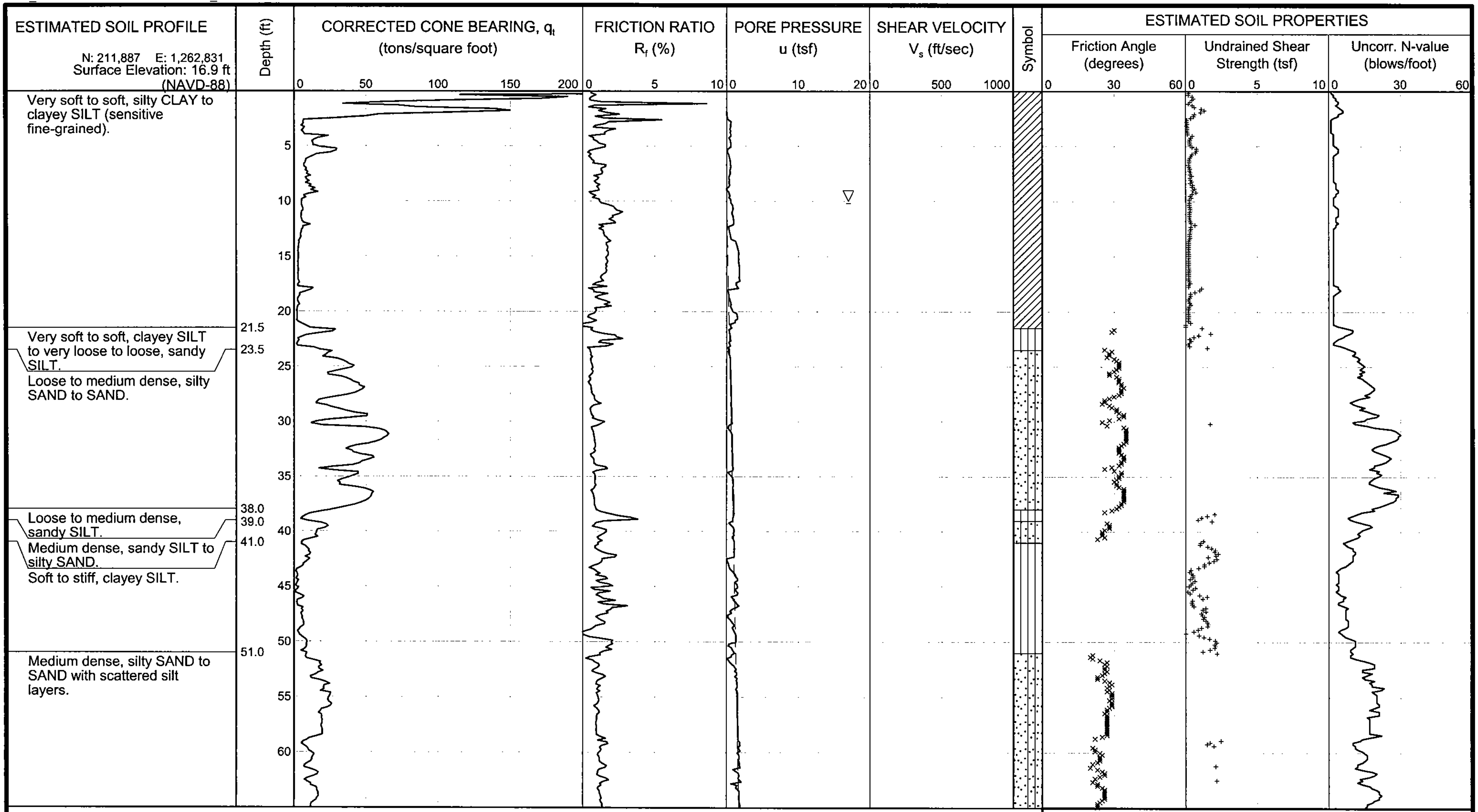
FIG. A.2-27
Sheet 2 of 2

REV 3

CPT_SEISMIC 21-09910.GPJ SHAN_WIL.GDT 12/22/03



NOTES:
1. The stratification lines represent the approximate boundaries between soil types; the transition may be gradual.
2. The estimated soil properties are based on analyses performed using published correlations and equations. The method used for estimating the properties listed above are:

Property	Method
Friction Angle	Durgunoglu & Mitchell
Uncorrected N-Value (N60)	Robertson & Campanella
Undrained Shear Strength	$\frac{qc - \sigma v}{Nk}$ where: qc = Measured Cone Bearing Nk = 12.5 σ v = Total Overburden Stress

3. Log of probe is based on piezocone probe data provided by Northwest Cone Exploration.
4. The pore pressure was measured behind the tip of the penetrometer. Hydrostatic pore pressure based on the estimated groundwater depth is also shown above (dashed line).

FIG. A.2-28
Sheet 1 of 3

Seattle Monorail Project
Seattle, Washington

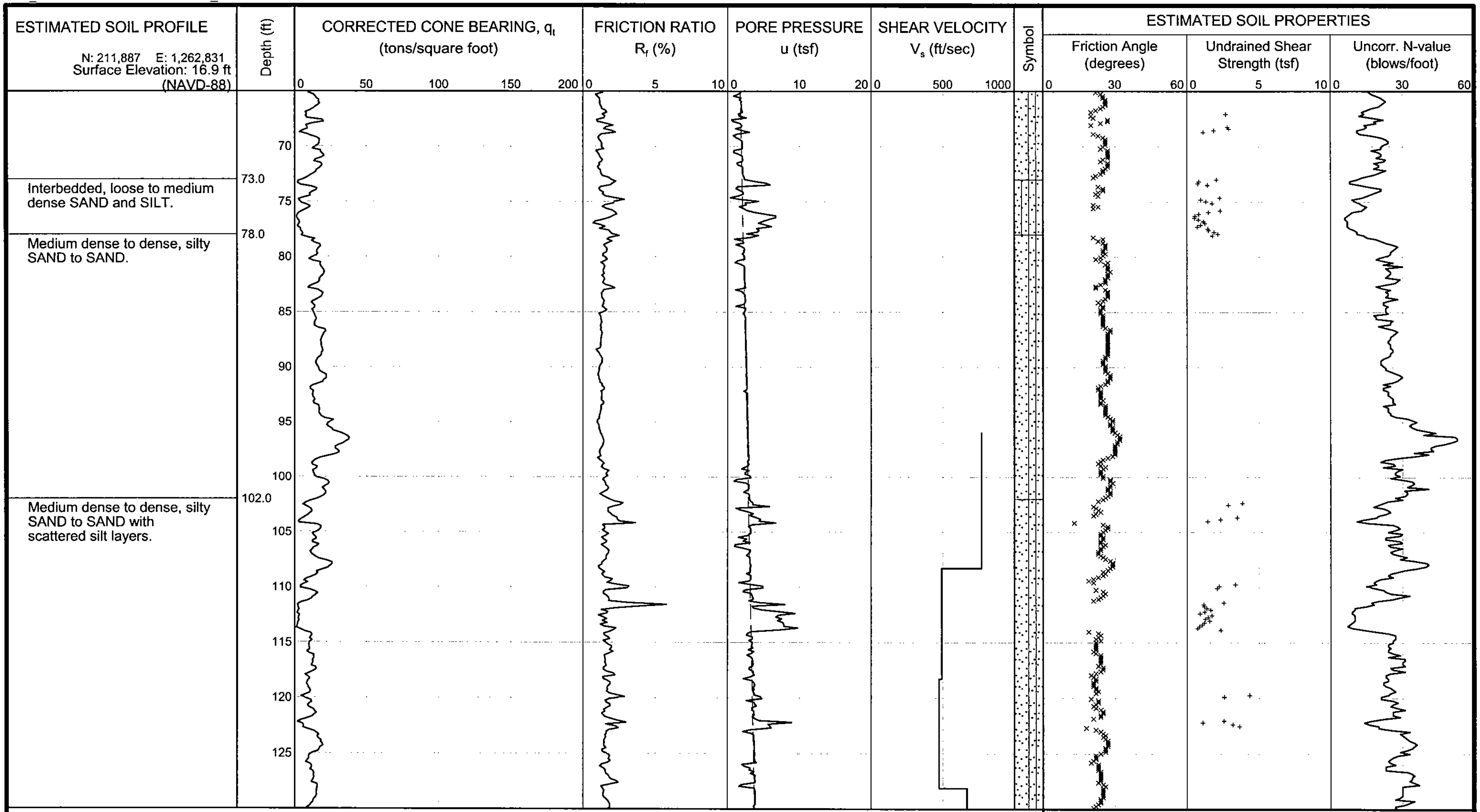
LOG OF PROBE SD-203A

December 2003
21-1-09910-091

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A.2-28
Sheet 1 of 3

REV 3



NOTES:
1. The stratification lines represent the approximate boundaries between soil types; the transition may be gradual.
2. The estimated soil properties are based on analyses performed using published correlations and equations. The method used for estimating the properties listed above are:

Property	Method
Friction Angle	Durgunoglu & Mitchell
Uncorrected N-Value (N60)	Robertson & Campanella
Undrained Shear Strength	$\frac{qc - \sigma v}{Nk}$ where: qc = Measured Cone Bearing Nk = 12.5 σ v = Total Overburden Stress

3. Log of probe is based on piezocone probe data provided by Northwest Cone Exploration.
4. The pore pressure was measured behind the tip of the penetrometer. Hydrostatic pore pressure based on the estimated groundwater depth is also shown above (dashed line).

FIG. A.2-28
Sheet 2 of 3

Seattle Monorail Project
Seattle, Washington

LOG OF PROBE SD-203A

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SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A.2-28
Sheet 2 of 3

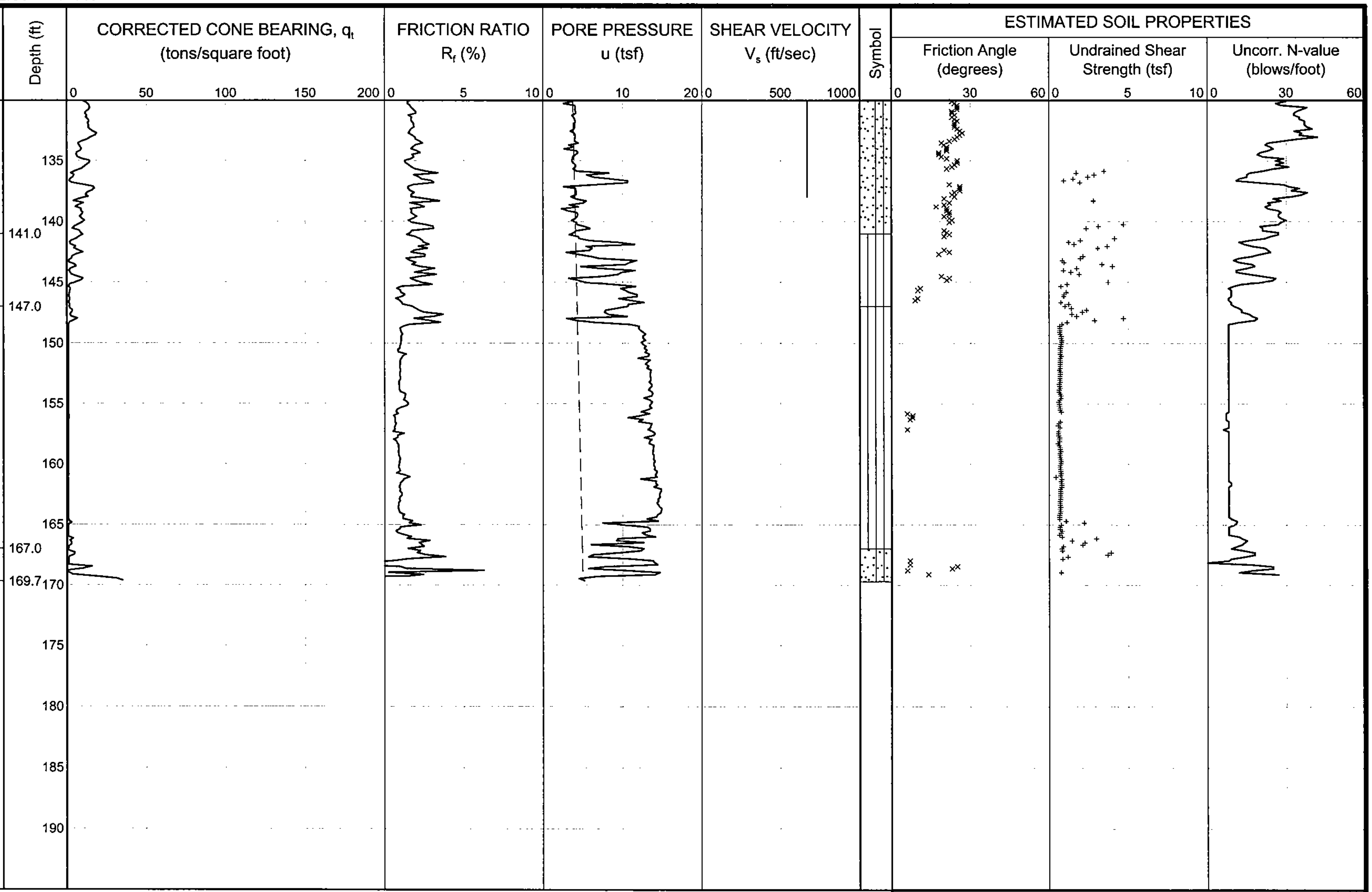
REV 3

ESTIMATED SOIL PROFILE

N: 211,887 E: 1,262,831
Surface Elevation: 16.9 ft
(NAVD-88)

Depth (ft)	Soil description
141.0	Medium stiff to stiff, silty CLAY to clayey SILT with scattered silty sand and sandy silt layers.
147.0	Soft to medium stiff, silty CLAY to clayey SILT.
167.0	Loose to medium dense, silty SAND to SAND.
169.7	BOTTOM OF PROBE COMPLETED 10/31/03

NOTE: SD-203A is a continuation of SD-203, which was terminated prior to reaching design depth.



NOTES:

1. The stratification lines represent the approximate boundaries between soil types; the transition may be gradual.
2. The estimated soil properties are based on analyses performed using published correlations and equations. The method used for estimating the properties listed above are:

Property	Method
Friction Angle	Durgunoglu & Mitchell
Uncorrected N-Value (N60)	Robertson & Campanella
Undrained Shear Strength	$\frac{qc - \sigma v}{Nk}$ where: qc = Measured Cone Bearing Nk = 12.5 σ v = Total Overburden Stress

3. Log of probe is based on piezocone probe data provided by Northwest Cone Exploration.
4. The pore pressure was measured behind the tip of the penetrometer. Hydrostatic pore pressure based on the estimated groundwater depth is also shown above (dashed line).

FIG. A.2-28
Sheet 3 of 3

Seattle Monorail Project
Seattle, Washington

LOG OF PROBE SD-203A

December 2003
21-1-09910-091

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A.2-28
Sheet 3 of 3

REV 3

APPENDIX C

IN SITU TESTING

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LIST OF SUBAPPENDICES

APPENDIX C.1

PRESSUREMETER TESTS

APPENDIX C.1

PRESSUREMETER TESTS

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TABLE

Table No.

REPORT

Report to Shannon & Wilson, Inc., from Hughes InSitu Engineering, Inc. (HIE): "Pressuremeter Testing Seattle Monorail, C-274," dated November 2003.

TABLE C-1
SUMMARY OF PRESSUREMETER TESTING

Boring No.	Test Name[1]	Depth (feet)		Date of Test	Geologic Unit[2]	Initial Shear Modulus[4] (psi)	Unload-Reload Shear Modulus[5] (psi)	Limit Pressure (psi)	Undrained Cohesion[6,7] (psi)	Effective Friction Angle[6] (degrees)
		Top	Bott.							
WS-103	M20	26.5	27.8	24-Sep	Qvd/Qvt	5,000	43,000	980	-	44
WS-103	M21	46	47.3	24-Sep	Qva	9,300	30,500	1,200	-	42
WS-103	M22	53	54.3	25-Sep	Qva	3,400	18,800	1,000	-	42
WS-106	M18	59	60.3	24-Sep	Qvro/Qva	2,300	15,000	770	(120)	(42)
WS-109	M30	28.5	29.8	26-Sep	Qpgl: Qpgm/Qpgo	*hole too large*				
WS-109	M29	30	31.3	26-Sep	Qpgm/Qpgo	*hole too large*				
WS-112	M24	16	17.3	25-Sep	Qvro	550	1,700	150	24	-
WS-112	M23	17.5	18.8	25-Sep	Qvro: Qvri	600	2,200	125	22	-
WS-112	M26	43	44.3	25-Sep	Qpgm	*hole too large*				
WS-112	M25	44.5	45.8	25-Sep	Qpgm	2,300	10,000	750	-	44
WS-113	M33	28	29.3	29-Sep	Qvri	*hole too large*				
WS-113	M34	38	39.3	29-Sep	Qvrl	*hole too large*				
WS-113	M37	54	55.3	30-Sep	Qvrl	1,400	3,800	300	45	-
WS-113	M38	74	75.3	30-Sep	Qpnl	3,700	9,000	570	-	42
WS-114	M46	110	111.3	2-Oct	Qpnl	4,500	17,400	900	-	40
WS-118	M40	51.5	52.8	30-Sep	Qpgl	*hole too large*				
WS-118	M39	53	54.3	30-Sep	Qpgl	3,000	6,900	730	150	-
SD-122	M11	198	199.3	19-Sep	Qpgt/Qvt	*equipment leak*				
SD-122	M11a	198.5	199.8	19-Sep	Qpgt/Qvt	*damaged membrane*				
SD-122	M10	199	200.3	19-Sep	Qpgt/Qvt	*hole too large*				
SD-122	M15	229.5	230.8	22-Sep	Qpgl	8,800	31,000	1,340	(170)	(40)
DT-101	M42	37	38.3	1-Oct	Ha	*hole too large*				
DT-102	M19	78	79.3	24-Sep	Qpgl	7,000	18,000	630	100	-
DT-106	M28	11	12.3	26-Sep	Qpgl	1,700	7,500	635	-	44
DT-106	M27	12.5	13.8	26-Sep	Qpgl	1,800	8,200	430	80	-
SC-102	M41	52.5	53.8	1-Oct	Qpnf	19,000	130,000	3,000	-	44
SC-103	M43	17.5	18.8	2-Oct	Qpnf	*hole too large*				
SC-103	M44	22.5	23.8	2-Oct	Qpnf	-	36,000	>400	>70	-
SC-103	M45	26	27.3	2-Oct	Qpgl	3,000	4,900	200	35	-
SC-104	M9	36.5	37.8	18-Sep	Qvt/Qvd	4,000	27,500	900	-	40
SC-104	M8	38	39.3	18-Sep	Qvt/Qvd	5,200	36,000	1,400	-	44
SC-105	M47	18.5	19.8	6-Oct	Qvt	2,000	34,000	700	-	40
SC-105	M49	39.5	40.8	6-Oct	Qpgl	2,700	10,000	540	80	-
SC-105	M48	40.5	41.8	6-Oct	Qpgl	2,800	10,000	480	70	-
SC-106	M32	20.5	21.8	29-Sep	Qvt	*hole too large*				
SC-106	M31	22	23.3	29-Sep	Qvt	*hole too large*				
SC-106	M36	51.5	52.8	29-Sep	Qpgl	3,700	3,000	350	65	-
SC-106	M35	53	54.3	29-Sep	Qpgl	3,500	3,600	404	80	-

TABLE C-1
SUMMARY OF PRESSUREMETER TESTING

Boring No.	Test Name[1]	Depth (feet)		Date of Test	Geologic Unit[2]	Initial Shear Modulus[4] (psi)	Unload-Reload Shear Modulus[5] (psi)	Limit Pressure (psi)	Undrained Cohesion[6,7] (psi)	Effective Friction Angle[6] (degrees)
		Top	Bott.							
IB-114	M55	62	63.3	10-Oct	Qpnf	19,000	170,000	1,450	180	-
IB-114	M56	79	80.3	10-Oct	Qpnl	3,200	25,000	940	-	40
IB-116	M52	38	39.3	8-Oct	Qpgl	800	12,000	420	70	-
IB-116	M53	56	57.3	8-Oct	Qpnl	6,000	46,000	900	120	-
IB-116	M54	57	58.3	8-Oct	Qpnl	5,200	35,000	950	(120)	(37)
IB-117	M50	53	54.3	7-Oct	Qpgo	4,300	24,000	1,200	-	44
IB-117	M51	73	74.3	7-Oct	Qpnf	2,600	12,000	950	-	40
BX-104	M57	28.5	29.8	13-Oct	Qpgm	*blown membrane/shield, not entirely in pilot hole*				
BX-104	M58	43	44.3	13-Oct	Qpgm	*test not attempted - could not push instrument into pilot hole*				
BX-104	M59	52.7	54	14-Oct	Qpgo/Qpnf	*hole collapsed, test not performed*				
BX-104	M60	62	63.3	14-Oct	Qpgo/Qpnf	2,500	14,000	550	-	40
BX-105	M61	19.5	20.8	15-Oct	Qpgm	2,100	24,000	450	70	-
BX-105	M62	45	46.3	15-Oct	Qpgo/Qpnf	7,400	85,000	1,350	-	40
BX-106	M63	18.5	19.8	16-Oct	Qpgm	2,000	75,000	720	95	-
BX-106	M64	38	39.3	16-Oct	Qpgo/Qpnf	9,000	55,000	1,300	180	-
BX-106	M65	60	61.3	16-Oct	Qpgo/Qpnf: Qpgl	*gravels encountered in pilot hole-could not insert instrument*				
BX-106	M66	74	75.3	17-Oct	Qpgl	3,100	16,000	770	120	-
BD-101	M12	11	12.3	22-Sep	Qvt/Qvd	2,200	37,000	540	-	40
BD-101	M13	33	34.3	22-Sep	Qvd	*cable joint separated*				
BD-101	M14	38	39.3	22-Sep	Qvd	2,800	39,000	1,100	170	-
BD-101	M17	66.5	67.8	23-Sep	Qpgm	3,500	11,000	780	(140)	(44)
BD-101	M16	68	69.3	23-Sep	Qpgm	4,400	9,000	850	(130)	(44)
BD-105	M2	41.5	42.8	15-Sep	Qva	5,300	33,000	1,800	-	45
BD-105	M1	43	44.3	15-Sep	Qva	6,500	33,000	2,000	-	45
BD-107	M3	43	44.3	15-Sep	Qva/Qvd	*hole too big - shielding broke in hole*				
BD-109	M5	9.5	10.8	17-Sep	Qvt	2,000	28,000	850	(100)	(35)
BD-109	M4	11	12.3	17-Sep	Qva	1,800	28,000	800	(100)	(35)
BD-109	M7	31.5	32.8	18-Sep	Qva	3,800	30,000	1,000	-	40
BD-109	M6	33	34.3	18-Sep	Qva	2,700	28,000	1,350	-	43
					Total Succesful Tests >	**47**				

NOTES:

1. See the boring logs in Appendix A for indicators of the test locations.
2. See Table A-1 in Appendix A for a detailed description of these units. If units are presented as X:Y, the test was performed at a transition between two soil layers (See boring logs in Appendix A).
3. psi = pounds per square inch
4. The initial modulus used to determine Menard modulus.
5. The secant modulus along the unload-reload curve.
6. If parentheses are around the values then the material has both cohesive and frictional properties. The analysis required the assumption of a friction angle from which an effective cohesive intercept can be calculated.
7. The cohesive values are the undrained cohesive strength assuming zero friction angle or the effective cohesive intercept if a friction angle is given (See note 6 above).

Pressuremeter Testing
SEATTLE MONORAIL

submitted to

Shannon & Wilson, Inc.

400 North 34th Street, Suite 100
Seattle, WA 98103

December 2003
C-274

HUGHES INSITU ENGINEERING INC.
Suite 804, 938 Howe Street, Vancouver B.C. Canada V6Z-1N9
Phone (604) 331-4451 Fax (604) 331-4452

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Photograph 1. View of existing monorail near Hole DT-106

1.0 INTRODUCTION

This report outlines the results of a pressuremeter study, conducted September 15–October 17, 2003, in 22 holes along the route of the proposed Seattle Monorail. The holes were drilled by three local drilling companies; Geotech, Holocene and PacRim. Hughes Insitu Engineering Ltd., under contract to Shannon and Wilson, Inc. performed pressuremeter testing. Ms. Monique Nykamp, P.E. of Shannon & Wilson, Inc., Seattle, supervised the detailed field work.

2.0 OBJECT OF THE PRESSUREMETER INVESTIGATION

The object of this investigation was to determine the general *in-situ* stiffness and strength of the granular materials sands silts and till along the proposed route of the Monorail.

3.0 PRESSUREMETER

The pressuremeter used for this study is a monocell pressuremeter. At the center of the pressuremeter are three electronic displacement sensors, spaced 120 degrees apart. Over these sensors is the flexible membrane, clamped at each end, which is pressurized to deform the adjacent material. A protective sheet of stainless steel strips covers the membrane. The pressuremeter was expanded by regulating the flow of gas from a bottle of compressed nitrogen. The electronic signals from displacement sensors and the pressure sensor are transmitted by cable to the surface. During the test, the average expansion against pressure curve is displayed on a computer screen.

The essential details of the instrument are shown in Fig. 1.

4.0 HOLE FORMATION

In general a four-inch diameter the hole was advanced to the test level. Depending on the stability of the material, this hole was sometimes cased. A pilot hole was then drilled with a 2^{15}/16-inch diameter tricone bit for a distance of 5-6 feet below the base of the four-inch diameter hole. The aim of this process was to cut a hole close to three inches in diameter, five feet long. The pressuremeter was then lowered into this pocket and a test conducted at the bottom of the test pocket. If the pressuremeter could be placed at the bottom of the hole, a second test was conducted approximately 1.5 feet further up the hole. In this manner, pairs of tests could be obtained at various selected depths down the hole.

This method of cutting the hole was not always successful, particularly in the granular materials with little silt binder. These pilot holes were either washout oversize or the hole caved in. In total, 74 tests were attempted, of which data were obtained in 49 tests. The tests covered a considerable range of material strength. The extremes of these tests are illustrated in Fig. 2, where tests 28 and 41 are plotted to the same scale.

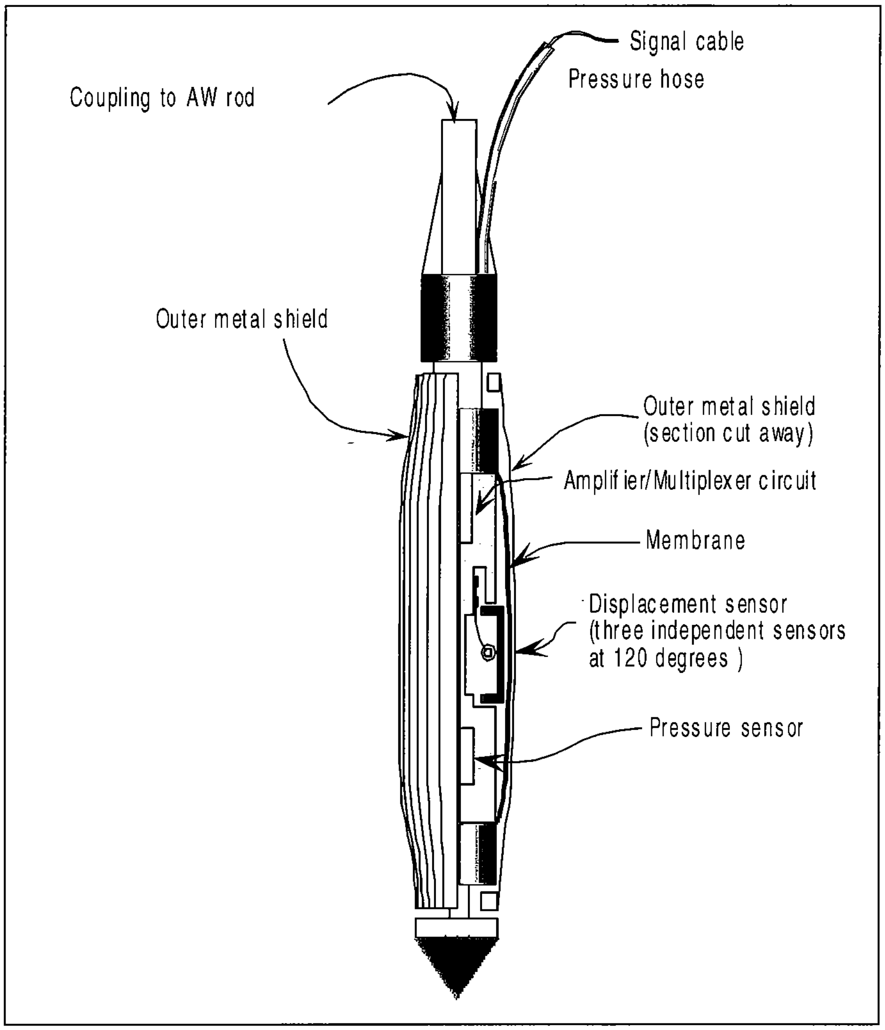


Fig. 1. Schematic outline of pressuremeter

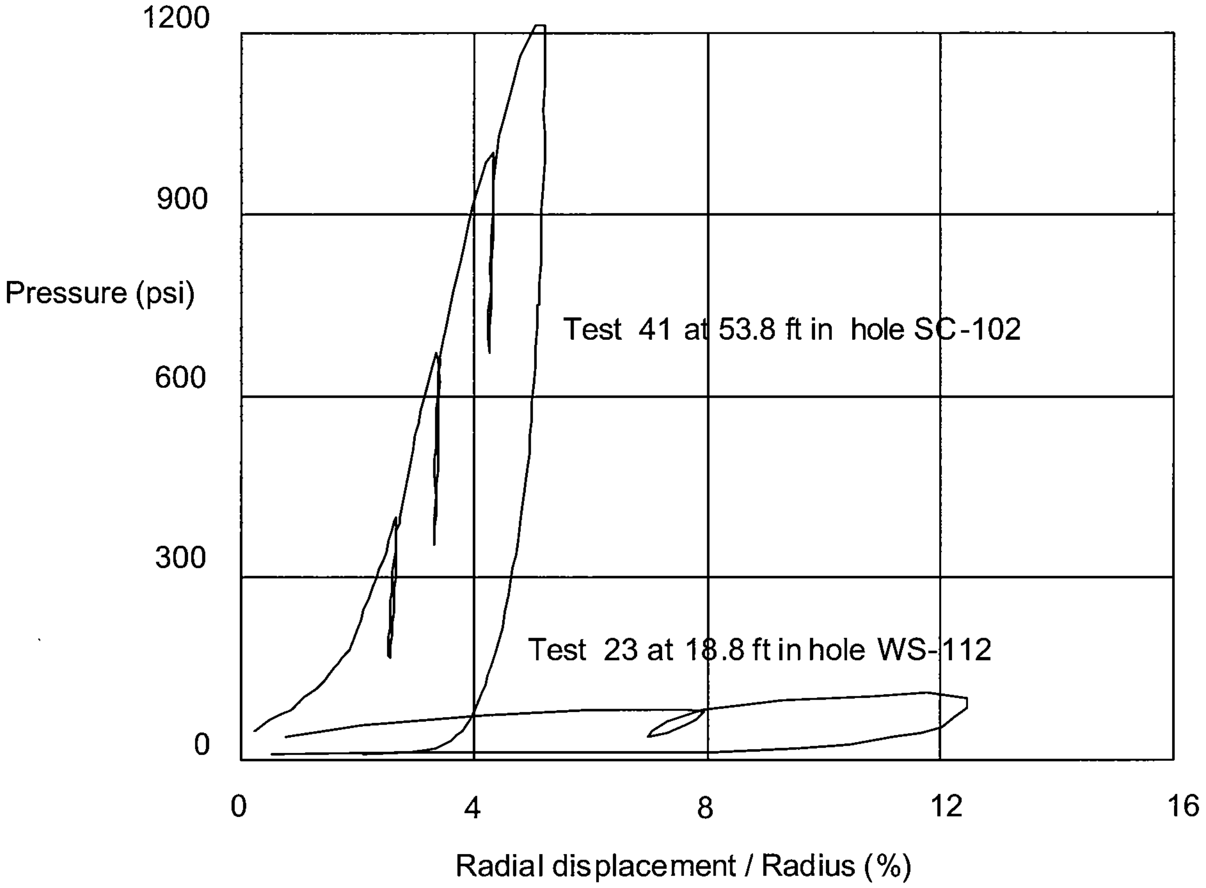


Fig. 2. Range of pressuremeter data from West Seattle to South Seattle

5.0 TEST PROCEDURE

After the pressuremeter was inserted to the bottom of the hole, the membrane was expanded by controlling the flow of compressed nitrogen into the pressuremeter, increasing the pressure in small steps. An example of the ideal pressuremeter tests is illustrated by Test 55 in Figure 3. The pressure was increased until one of the following conditions applied:

- The pressure was in excess of 1000 psi. This level of stress was considered to produce shear stresses within the rock well above those likely to be encountered during construction.
- One of the strain sensors reached a limit.
- During this expansion several unload-reload loops were conducted to determine the low strain shear modulus. Prior to this unload, the pressure was held constant for four minutes to obtain a qualitative indication of the creep behaviour of the matrix.

If the material surrounding the pressuremeter is assumed to extend to infinity, and to behave in an idealized manner, as a linear elastic, homogeneous material, which does not fail under shear or tension, then the displacement on the boundary of the pressuremeter, u_{α}, for a given pressure, P, is given by:

$$u_{\alpha} = \mathrm{P}.\alpha\ (1+\mu)\ /\ E \qquad 1)$$

where E is the Young's Modulus, α the radius of the pressuremeter cavity, and μ the Poisson's ratio.

As the shear modulus, G, and the Young's modulus, E, are related by the following relationship:

$$E=2.G.(1+\mu) \qquad 2)$$

Equation 1 reduces to:

$$u_{\alpha} =0.5P.\alpha\ /\ G \qquad 3)$$

Hence, the shear modulus G is given by:

$$\mathrm{G} = 0.5\Delta(\mathrm{Pressure})/\Delta(\mathrm{radial\ displacement/radius}) \qquad 4)$$

The pressuremeter data is often characterized by the modulus determined from the initial slope of the pressuremeter curve. In many instances this is not clearly defined as the pressuremeter curve does not always show a distinct linear section near the start as shown in Figure 3. Hence the choice of the initial modulus is subjective. The shear modulus values for the average slope of the initial part of the pressuremeter curve of all of the tests are summarized in the Table. The modulus for the average slope of the pressuremeter curve expressed as a Young's modulus (assuming a Poisson's ratio of 0.33) is the same as the "pressuremeter modulus" defined in the

American Society for Testing and Materials (ASTM) D4719-94, Section 9.5. Also included in the Table is the modulus determined from any unload-reload loops. This modulus is much more clearly defined and can be used to give an of the true elastic properties of the material.

6.0 STANDARD PRESSUREMETER PARAMETERS: LIMIT PRESSURE AND SHEAR STRENGTH

As a quantitative measure of the strength of the material, the "limit pressure", P_L, is commonly used. This is the pressure, which is calculated to occur when the pressuremeter has been assumed to deform the material by doubling the initial volume of the cavity. If the material being tested is assumed to behave as an elastic cohesive material, then the equation governing the pressure-displacement curve is given by:

$$P = P_L + c.\log_e (u_\alpha/\alpha) \qquad 5)$$

where P_L is the theoretical limit pressure at infinite expansion.

$$P_L = P_O + c + c.\log_e [G/c] \qquad 6)$$

Here, c is the undrained cohesive strength, P_O is the total in-situ lateral stress, and G the shear modulus. For typical values of G and c the ratio G/c lies between 50-100. Hence, the limit pressure is approximately 5 times the shear strength (assuming P_o is small relative to c).

From Equation 5, a plot of pressure P against the log of u_α/α will be a straight line (shown in Figure 4 for Test 55), provided the shear strength remains constant with. The slope of this line will give a measure of the shear strength c. The limit pressure, as defined by the ASTM code D4719, Section 9.6, is the pressure at which the cavity has doubled in size. This doubling in size occurs when u_α/α is equal to 41%. (The origin of the strain used in the log/normal plots is the assumed origin at the in-situ stress state).

The shear strengths calculated by this method for Seattle materials are usually an over estimate of the insitu shear strength hence they have not been reported in the Table

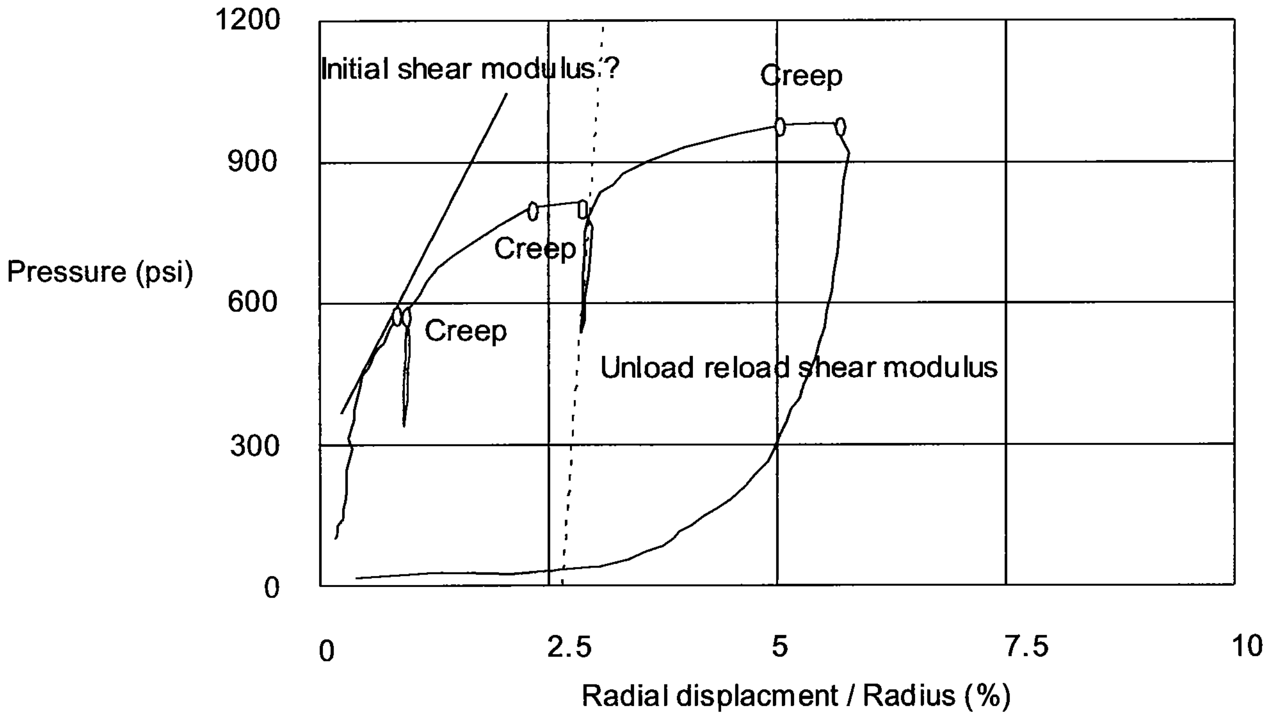


Fig. 3 Basic pressuremeter tests (Test 55)

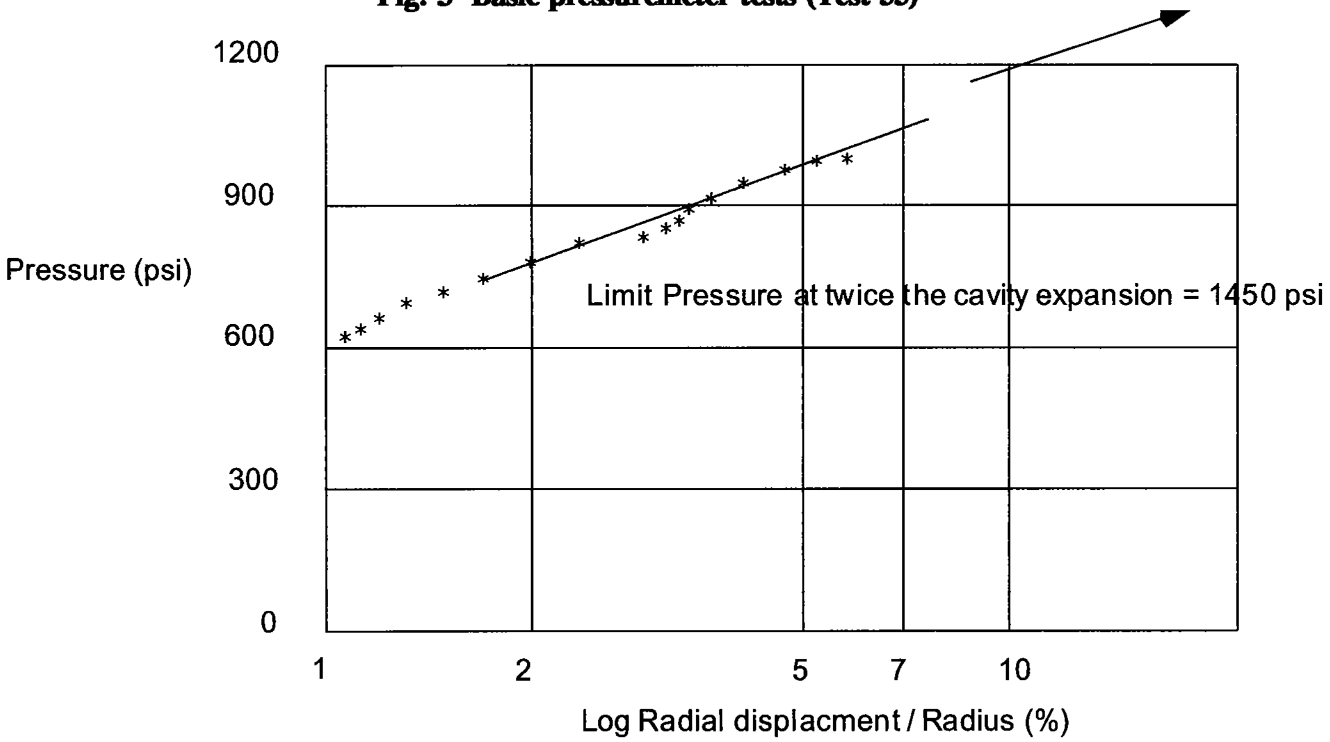


Fig. 4. Limit Pressuremeter determined from pressuremeter test 55

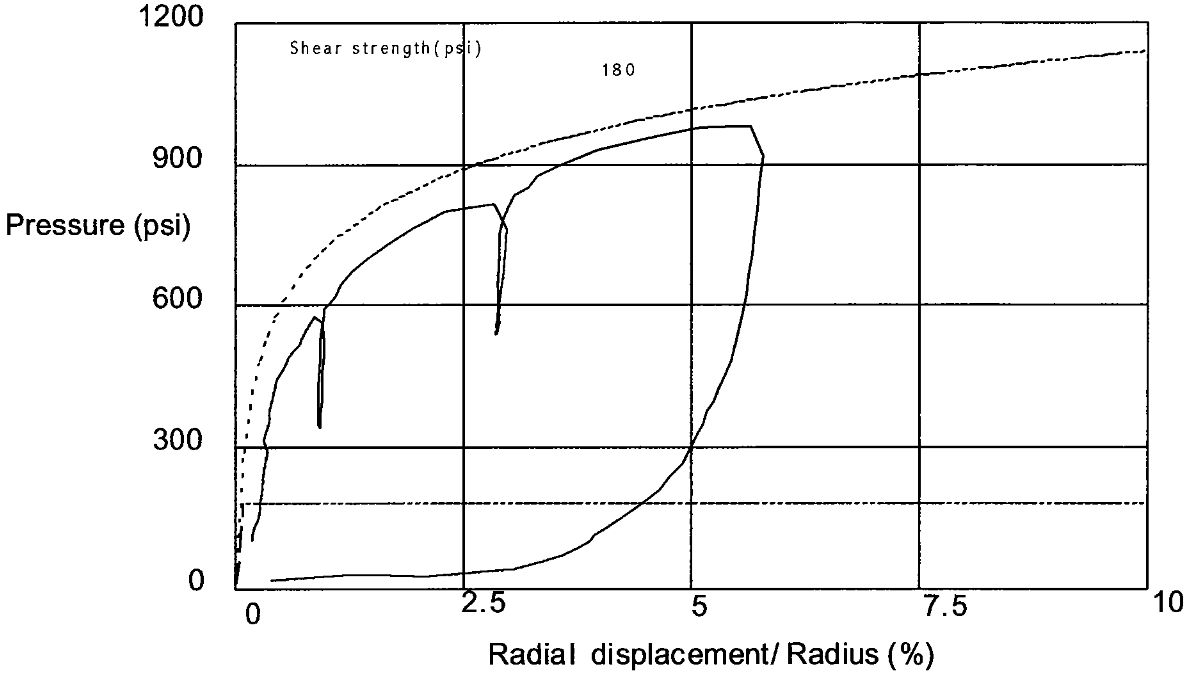


Fig.5. Cohesive model analysis for test 55 at 63.3 ft in hole IB-114

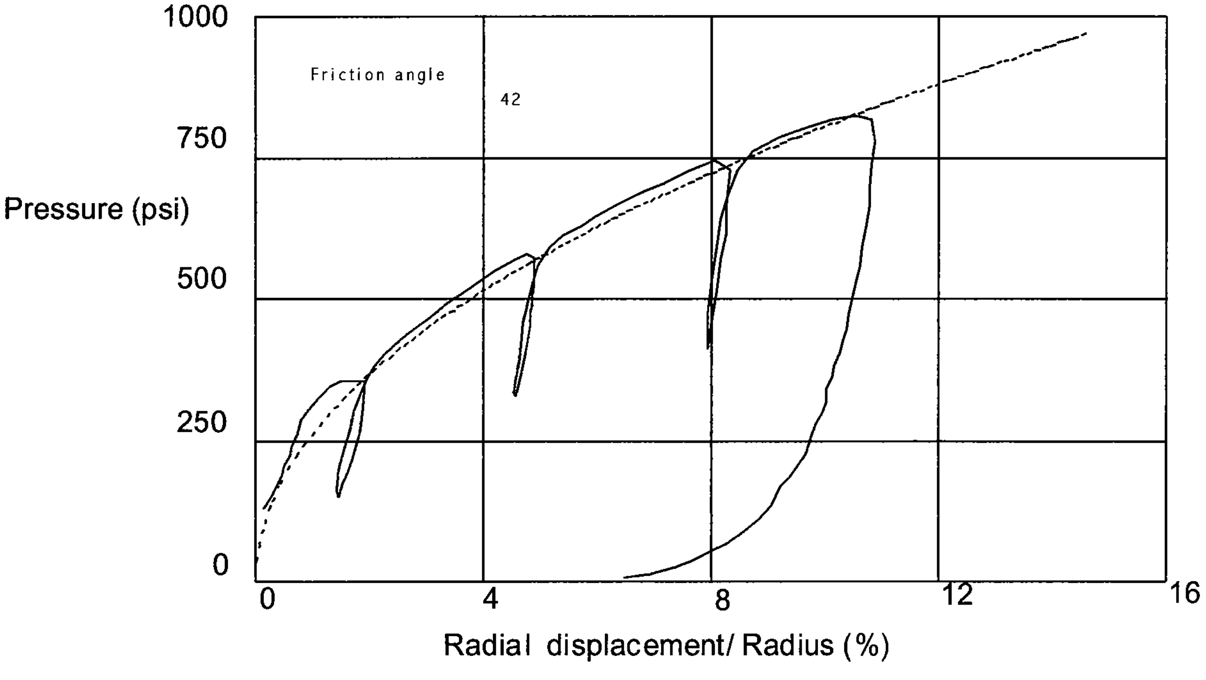


Fig. 6. Frictional model analysis for test 21 at 47.3 ft in hole WS -103

Table 1. Basic material properties from pressuremeter tests

Test	Hole	Depth (feet) ^{5}	Initial shear modulus (psi)	Unload-reload Shear modulus (psi)	Limit Pressure (psi)	Cohesion (psi)^2	Friction angle^3
1	BD-105	44.2	6,500	33,000	2,000	-	45
2	BD-105	42.8	5,300	33,000	1,800	-	45
4	BD-109	12.3	1,800	28,000	800	201	35^1
5	BD-109	10.8	2,000	28,000	850	20^1	35^1
6	BD-109	34.3	2,700	28,000	1,350	-	43
7	BD-109	32.8	3,800	30,000	1,000	-	40
8	SC-104	39.3	5,200	36,000	1,400	-	44
9	SC-104	37.8	4,000	27,500	900	-	40
11	SC-122	199.3	5,400	16,000	550	20^1	35^1
12	BD-101	11	2,200	37,000	540	-	40
14	BD-101	39.3	2,800	39,000	1,100	170	-
15	SD-122	230.8	8,800	31,000	1,340	70^1	35^1
16	BD-101	69.3	4,400	9,000	850	70^1	35^1
17	BD-101	67.8	3,500	11,000	780	50^1	35^1
18	WS-106	60.3	2,300	15,000	770	50^1	35^1
19	DT-102	79.3	7,000	18,000	630	100	-
20	WS-103	27.8	5,000	43,000	980	-	44
21	WS-103	47.3	9,300	30,500	1,200	-	42
22	WS-103	53	3,400	18,800	1,000	-	42
23	WS-112	18.8	600	2,200	125	22	-
24	WS-112	17.3	550	1,700	150	24	-
25	WS-112	45.8	2,300	10,000	750	-	44
27	DT-106	13.8	1,800	8,200	430	80	-
28	DT-106	12.3	1,700	7,500	635	-	44
35	SC-106	54.3	3,500	3,600	404	80	-
36	SC-106	52.8	3,700	3,000	350	65	-
37	WS-113	55.3	1,400	3,800	300	45	-
38	WS-113	75.3	3,700	9,000	570	-	42

Table 1. Basic material properties from pressuremeter tests							
Test	Hole	Depth (feet) [5]	Initial shear modulus (psi)	Unload-reload Shear modulus (psi)	Limit Pressure (psi)	Cohesion (psi)[2]	Friction angle[3]
39	WS-118	54.5	3,000	6,900	730	150	-
41	SC-102	53.8	19,000	130,000	3,000	-	44
44	SC-103	23.8	-	36,000	>400	>70	-
45	SC-103	27.3	3,000	4,900	200	35	-
46	WS-114	111.3	4,500	17,400	900	-	40
47	SC-105	19.8	2,000	34,000	700	-	40
48	SC-105	41.8	2,800	10,000	480	70	-
49	SC-105	40.8	2,700	10,000	540	80	-
50	IB-117	54.3	4,300	24,000	1,200	-	44
51	IB-117	74.3	2,600	12,000	950	-	40
52	IB-116	39.3	800	12,000	420	70	-
53	IB-116	57.3	6,000	46,000	900	120	-
54	IB-116	58.3	5,200	35,000	950	301	35[1]
55	IB-114	63.3	19,000	170,000	1,450	180	-
56	IB-114	80.3	3,200	25,000	940		40
60	BX-104	63.3	2,500	14,000	550	-	40
61	BX-105	20.8	2,100	24,000	450	70	-
62	BX-105	46.3	7,400	85,000	1,350	-	40
63	BX-106	19.8	2,000	75,000	720	95	-
64	BX-106	39.3	9,000	55,000	1,300	180	-
66	BX-106	75.3	3,100	16,000	770	120	-

Notes

[1] These tests indicate a material that has both cohesive and frictional properties. The analysis required the assumption of a friction angle (35 degrees) from which an effective cohesive intercept can be calculated.

[2] In this column the cohesive values are the undrained cohesive strength assuming zero friction angle or the effective cohesive intercept if a friction angle is given (see Note 1 above).

[3] In this column the friction values are effective friction angle.

[4] The materials are divided into three types by shading: purely frictional, purely cohesive and a combination of effective cohesion and friction.

[5] The depths refer to the bottom of the test section. The whole test section is 16 inches in length.

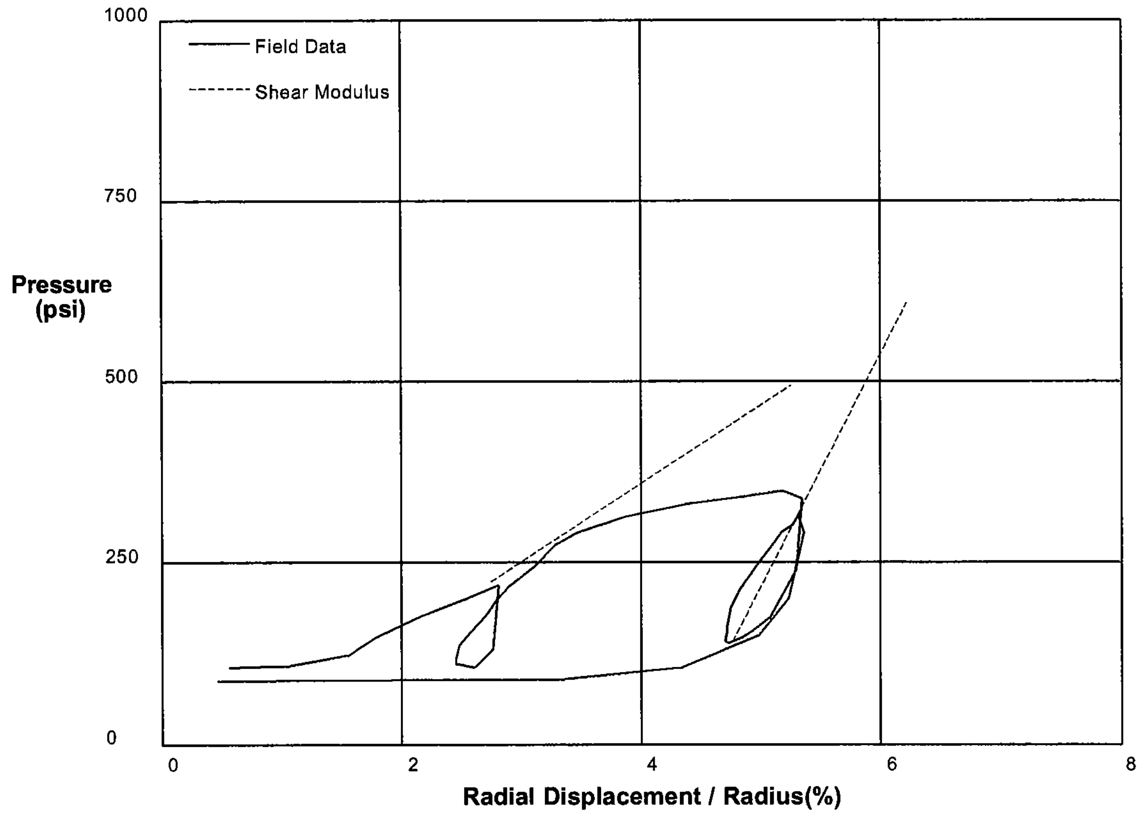
Appendix

Pressure expansion curves for pressuremeter tests

PRESSUREMETER DATA **Shannon & Wilson, Inc.**

SEATTLE MONORAIL PROJECT **9-19-03**

Hole No. SD-122 **Depth 199.3 ft** **File C:\DATA\C-274\MONO11.P**



Shear Modulus 5416 psi

Shear Modulus 16127 psi

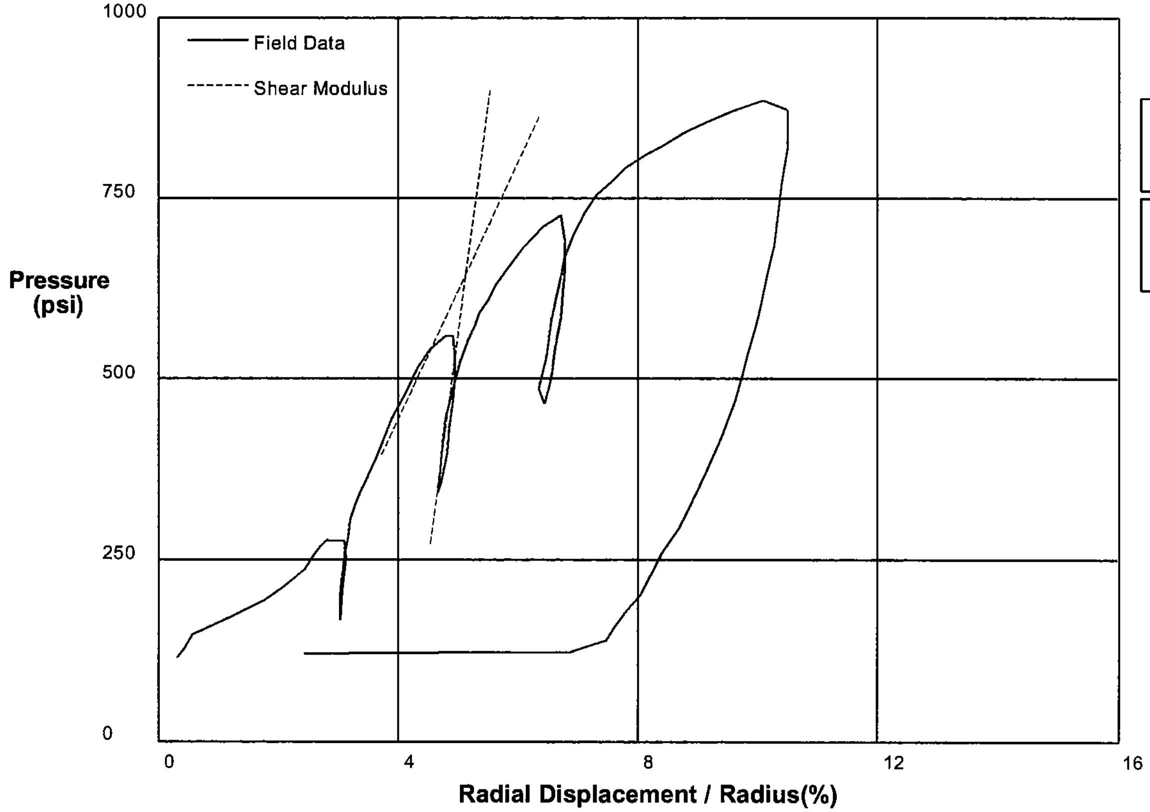
shift 0

HUGHES

PRESSUREMETER DATA **Shannon & Wilson, Inc.**

SEATTLE MONORAIL PROJECT **Sept 22, 2003**

Hole No. SD-122 **Depth 230.8 ft** **File C:\DATA\C-274\MONO15.P**



Shear Modulus 8825 psi

Shear Modulus 31250 psi

shift 0

HUGHES

APPENDIX C.3

DOWNHOLE SEISMIC TESTS

Report to Shannon & Wilson, Inc., from GEOVision Geophysical Services: "Seattle Monorail Borings BX-102, BX-107, IB-104, IB-111, IB-115, SD-101, SD-108, SD-110, SD-116 and WS-105 Suspension P & S Velocities", dated November 14, 2003.

GEOVision
geophysical services
a division of Blackhawk Geometrics

SEATTLE MONORAIL

BORINGS BX-102, BX-107, IB-104, IB-111, IB-115, SD-101, SD-108, SD-110, SD-116 AND WS-105

SUSPENSION P & S VELOCITIES

December 8, 2003

SEATTLE MONORAIL
BORINGS BX-102, BX-107, IB-104, IB-111, IB-115, SD-101, SD-108, SD-110, SD-116 AND WS-105
SUSPENSION P & S VELOCITIES

Prepared for

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(206)-695-6800

Prepared by

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1151 Pomona Road, Unit P
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(909) 549-1234
Project 3437

December 8, 2003
Report 3437-02

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APPENDIX A: Suspension velocity measurement quality assurance suspension source to receiver analysis results

APPENDIX A FIGURES

APPENDIX A TABLES

INTRODUCTION

OYO suspension velocity measurements were performed in eight land borings and two marine along the proposed Seattle Monorail alignment, as an element of the site exploration program for the Seattle Monorail Extension Project. Suspension logging data acquisition was performed between August 27 and October 17, 2003 by Rob Steller of Geovision. The work was performed under subcontract with Shannon and Wilson, with Monique Nykamp and Tyler Stevens as the field liaisons for Shannon and Wilson.

This report describes the field measurements, data analysis, and results of this work.

SCOPE OF WORK

This report presents the results of suspension velocity measurements collected between August 27 and October 17, 2003, in the uncased borings located in Seattle, as designated below. The purpose of these studies was to supplement stratigraphic information obtained from Shannon and Wilson' soil and rock sampling program and to acquire shear wave velocities and compressional wave velocities as a function of depth, which, in turn, can be used to characterize ground response to earthquake motion.

BORING DESIGNATION	DATE LOGGED	LAND/ MARINE	ELEVATION (FT)	COORDINATES (NAD83)	
				NORTHING	EASTING
BX-102	10/8/03	MARINE	21.56	243332.854	1260195.106
BX-107	10/11/03	MARINE	21.65	244716.878	1260149.470
IB-104	9/12/03	LAND	20.26	232158.582	1262086.640
IB-111	10/09/03	LAND	17.74	235917.865	1260036.899
IB-115	10/10/03	LAND	50.19	237769.611	1260066.768
SD-101	8/27/03	LAND	124.39	228414.372	1268103.177
SD-108	8/28/03	LAND	14.98	215043.522	1269773.036
SD-110	10/10/03	LAND	N/A	N/A	N/A
SD-116	8/30/03	LAND	17.39	218011.328	1271125.366
WS-105	10/27/03	LAND	306.05	206303.723	1256793.041

Table 1. Boring locations and logging dates

The OYO Model 170 Suspension Logging Recorder and Suspension Logging Probe were used to obtain in-situ horizontal shear and compressional wave velocity measurements at 1.64 ft intervals. The acquired data was analyzed and a profile of velocity versus depth was produced for both compressional and horizontally polarized shear waves.

A detailed reference for the velocity measurement techniques used in this study is:

> Guidelines for Determining Design Basis Ground Motions, Report TR-102293, Electric Power Research Institute, Palo Alto, California, November 1993, Sections 7 and 8.

SUSPENSION INSTRUMENTATION

Suspension soil velocity measurements were performed using the Model 170 Suspension Logging system, manufactured by OYO Corporation. This system directly determines the average velocity of a 3.28 ft high segment of the soil column surrounding the boring of interest by measuring the elapsed time between arrivals of a wave propagating upward through the soil column. The receivers that detect the wave, and the source that generates the wave, are moved as a unit in the boring producing relatively constant amplitude signals at all depths.

The suspension system probe consists of a combined reversible polarity solenoid horizontal shear-wave source (S_H) and compressional-wave source (P), joined to two biaxial receivers by a flexible isolation cylinder, as shown in Figures 1 and 2. The separation of the two receivers is 3.28 ft, allowing average wave velocity in the region between the receivers to be determined by inversion of the wave travel time between the two receivers. The total length of the probe as used in these surveys was 19 or 22 ft, depending upon the source to receiver 1 (S-R1) isolation, with the center point of the receiver pair located 12.1 or 15.4 ft, respectively, above the bottom end of the probe, as illustrated in Figures 1 and 2. S-R1 isolation for each boring is listed in table 2. The probe receives control signals from, and sends the amplified receiver signals to, instrumentation on the surface via an armored 7 conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured to provide probe depth data.

The entire probe is suspended by the cable and centered in the boring by nylon "whiskers", therefore, source motion is not coupled directly to the boring walls; rather, the source motion creates a horizontally propagating impulsive pressure wave in the fluid filling the boring and surrounding the source. This pressure wave is converted to P and S_H-waves in the surrounding soil and rock as it impinges upon the boring wall. These waves propagate through the soil and rock surrounding the boring, in turn causing a pressure wave to be generated in the fluid surrounding the receivers as the soil waves pass their location. Separation of the P and S_H-waves at the receivers is performed using the following steps:

1. Orientation of the horizontal receivers is maintained parallel to the axis of the source, maximizing the amplitude of the recorded S_H-wave signals.
2. At each depth, S_H-wave signals are recorded with the source actuated in opposite directions, producing S_H-wave signals of opposite polarity, providing a characteristic S_H-wave signature distinct from the P-wave signal.
3. The 7.02 or 10.30 ft separation of source and receiver 1 permits the P-wave signal to pass and damp significantly before the slower S_H-wave signal arrives at the receiver. In faster soils or rock, the isolation cylinder is extended to allow greater separation of the P- and S_H-wave signals.
4. In saturated soils, the received P-wave signal is typically of much higher frequency than the received S_H-wave signal, permitting additional separation of the two signals by low pass filtering.
5. Direct arrival of the original pressure pulse in the fluid is not detected at the receivers because the wavelength of the pressure pulse in fluid is significantly greater than the dimension of the fluid annulus surrounding the probe (meter versus centimeter scale), preventing significant energy transmission through the fluid medium.

In operation, a distinct, repeatable pattern of impulses is generated at each depth as follows:

1. The source is fired in one direction producing dominantly horizontal shear with some vertical compression, and the signals from the horizontal receivers situated parallel to the axis of motion of the source are recorded.
2. The source is fired again in the opposite direction and the horizontal receiver signals are recorded.
3. The source is fired again and the vertical receiver signals are recorded. The repeated source pattern facilitates the picking of the P and S_H-wave arrivals; reversal of the source changes the polarity of the S_H-wave pattern but not the P-wave pattern.

The data from each receiver during each source activation is recorded as a different channel on the recording system. The Model 170 has six channels (two simultaneous recording channels), each with a 12 bit 1024 sample record. The recorded data is displayed on a CRT display and on paper tape output as six channels with a common time scale. Data is stored on 3.5 inch floppy diskettes for further processing. Up to 8 sampling sequences can be summed to improve the signal to noise ratio of the signals.

Review of the displayed data on the CRT or paper tape allows the operator to set the gains, filters, delay time, pulse length (energy), sample rate, and summing number to optimize the quality of the data before recording. Verification of the calibration of the Model 170 digital recorder is performed every twelve months using a NIST traceable frequency source and counter, as outlined in Appendix B.

SUSPENSION MEASUREMENT PROCEDURES

All borings were logged as uncased borings filled with bentonite based drilling fluid or clear water. Prior to entering the land borings, the mid-point of the receivers was placed at grade, and the mechanical and electronic depth counters were set to zero. On the two marine borings, the mid-point of the receivers was lowered to mud line, and the mechanical and electronic depth counters were set to zero. The probe was lowered to the bottom of the boring, then returned to the bottom of the conductor casing or the surface, stopping at 1.64 ft intervals to collect data, as summarized in Table 2.

At each measurement depth the measurement sequence of two opposite horizontal records and one vertical record was performed, and the gains were adjusted as required. The data from each depth was printed on paper tape, checked, and recorded on diskette before moving to the next depth. Upon completion of the measurements, the probe zero depth indication at grade or mud line was verified prior to removal from the boring.

BORING NUMBER	RUN NUMBER	MEASURED DEPTH RANGE (FEET)	DEPTH AS DRILLED (FEET)	AUGER OR CONDUCTOR CASING DEPTH (FEET)	LOST TO COLLAPSE (FEET)	S-R1 ISOLATION (FEET)	DATE LOGGED
BX-102	1	21.3 – 64.0	77	CASING AT 17 FT	0.9	7.02	10/8/03
BX-102	2	9.8 – 21.3	77	CASING AT 12 FT	0	7.02	10/8/03
BX-107	1	9.8 – 204.4	218	CASING AT 9 FT	1.5	7.02	10/11/03
IB-104	1	19.7 – 71.5	85.3	AUGER AT 20 FT	1.7	7.02	9/12/03
IB-111	1	11.5 – 76.4	90	AUGER AT 10 FT	1.5	7.02	10/09/03
IB-115	1	24.6 – 109.9	130	AUGER AT 25 FT	8.0	7.02	10/10/03
SD-101	1	3.3 –192.9	210	NONE	1.7	10.30	8/27/03
SD-108	1	8.2 – 226.4	246.5	NONE	4.7	10.30	8/28/03
SD-110	1	21.3 – 231.0	247	AUGER AT 18 FT	3.9	7.02	10/10/03
SD-116	1	16.4 – 103.3	120	AUGER AT 15 FT	1.3	10.30	8/30/03
WS-105	1	8.2 – 146.0	162.5	AUGER AT 10 FT	4.4	7.02	10/27/03

Table 2. Logging dates and depth ranges

SUSPENSION DATA ANALYSIS

The recorded digital records were analyzed to locate the first minima on the vertical axis records, indicating the arrival of P-wave energy. The difference in travel time between receiver 1 and receiver 2 (R1-R2) arrivals was used to calculate the P-wave velocity for that 3.28 ft segment of the soil column. When observable, P-wave arrivals on the horizontal axis records were used to verify the velocities determined from the vertical axis data.

The P-wave velocity calculated from the travel time over the 7.02 or 10.30 ft interval from source to receiver 1 (S-R1) was calculated and plotted for quality assurance of the velocity derived from the travel time between receivers. In this analysis, the depth values as recorded were increased by 5.15 or 6.79 ft, dependant upon S-R1 isolation, to correspond to the mid-point of the S-R1 interval, as illustrated in Figures 1 and 2. Travel times were obtained by picking the first break of the P-wave signal at receiver 1 and subtracting 3.9 milliseconds, the calculated and experimentally verified delay from the source trigger pulse to source impact. This delay corresponds to the duration of acceleration of the solenoid before impact.

The recorded digital records were studied to establish the presence of clear S_H-wave pulses, as indicated by the presence of opposite polarity pulses on each pair of horizontal records. Ideally, the S_H-wave signals from the 'normal' and 'reverse' source pulses are very nearly inverted images of each other. Digital FFT - IFFT lowpass filtering was used to remove the higher frequency P-wave signal from the S_H-wave signal. Different filter cutoffs were used to separate P- and S_H-waves at different depths, ranging from 500 Hz in the slowest zones to 5000 Hz in the regions of highest velocity. At each depth, the filter frequency was selected to be at least twice the fundamental frequency of the S_H-wave signal being filtered.

Generally, the first maxima was picked for the 'normal' signals and the first minima for the 'reverse' signals, although other points on the waveform were used if the first pulse was distorted. The absolute arrival time of the 'normal' and 'reverse' signals may vary by +/- 0.2 milliseconds, due to differences in the actuation time of the solenoid source caused by constant mechanical bias in the source or by boring inclination. This variation does not affect the R1-R2 velocity determinations, as the differential time is measured between arrivals of waves created by the same source actuation. The final velocity value is the average of the values obtained from the 'normal' and 'reverse' source actuations.

As with the P-wave data, S_H-wave velocity calculated from the travel time over the 7.02 or 10.30 ft interval from source to receiver 1 was calculated and plotted for verification of the velocity derived from the travel time between receivers. In this analysis, the depth values were increased by 5.15 or 6.79 ft to correspond to the mid-point of the S-R1 interval. Travel times were obtained by picking the first break of the S_H-wave signal at the near receiver and subtracting 3.9 milliseconds, the calculated and experimentally verified delay from the beginning of the record at the source trigger pulse to source impact.

Figure 3 shows an example of R1 - R2 measurements on the filtered record from SD-110 at a depth of 59.1 ft. In Figure 3, the time difference over the 3.28 ft interval of 5.85 milliseconds for the horizontal signals is equivalent to an S_H-wave velocity of 561 ft/sec. Whenever possible, time differences were determined from several phase points on the S_H-waveform records to verify the data obtained from the first arrival of the S_H-wave pulse. Figure 4 displays the same record before filtering of the S_H-waveform record with an 800 Hz FFT - IFFT digital lowpass filter, illustrating the presence of higher frequency P-wave energy at the beginning of the record, and distortion of the lower frequency S_H-wave by residual P-wave signal.

SUSPENSION RESULTS

Suspension R1-R2 P- and S_H-wave velocities are plotted in Figures 5 – 14. The suspension velocity data presented in these Figures are presented in Tables 3 – 12. P- and S_H-wave velocity data from R1-R2 analysis and quality assurance analysis of S-R1 data are plotted together in Figures A1 – A10 to aid in visual comparison. It must be noted that R1-R2 data is an average velocity over a 3.28 ft segment of the soil column; S-R1 data is an average over 7.02 or 10.30 ft, creating a significant smoothing relative to the R1-R2 plots. S-R1 data are presented in tabular format in Tables A1 – A10. Good correspondence between the shape of the P- and S_H-wave velocity curves is observed for all these data sets. The velocities derived from S-R1 and R1-R2 data are in good agreement, providing verification of the higher resolution R1-R2 data.

Calibration procedures and records for the suspension measurement system are presented in Appendix B.

SUMMARY

Discussion of Suspension Results

Both P- and S_H-wave velocities were measured using the Suspension in eight land and two marine borings along the proposed Seattle Monorail alignment. All the borings were located in an urban area with substantial traffic nearby, but no significant contamination of the recorded data from cultural vibration was observed. In several instances, nearby train traffic necessitated the suspension of data collection until the train had passed.

All of the South of Downtown borings (SD-101, SD-108, SD-110 and SD-116) exhibited significant variation in the P-wave velocities below water table, despite relatively constant S_H-wave velocites in the same regions. This is caused by entrained gas bubbles in the soil, generally caused by decomposition of organic material in the soil.

Quality Assurance

These velocity measurements along the proposed Seattle Monorail alignment were performed using industry-standard or better methods for both measurements and analyses. All work was performed under Geovision quality assurance procedures, which include:

- Use of NIST-traceable calibrations, where applicable, for field and laboratory instrumentation
- Use of standard field data logs
- Use of independent verification of data by comparison of receiver-to-receiver and source-to-receiver velocities
- Independent review of calculations and results by a registered professional engineer, geologist, or geophysicist.

Data Reliability

P- and S_H-wave velocity measurement using the Suspension Method gives average velocities over a 3.28 ft interval of depth. This high resolution results in the scatter of values shown in the graphs. Individual measurements are very reliable with estimated precision of +/- 5%. Standardized field procedures and quality assurance checks add to the reliability of these data.

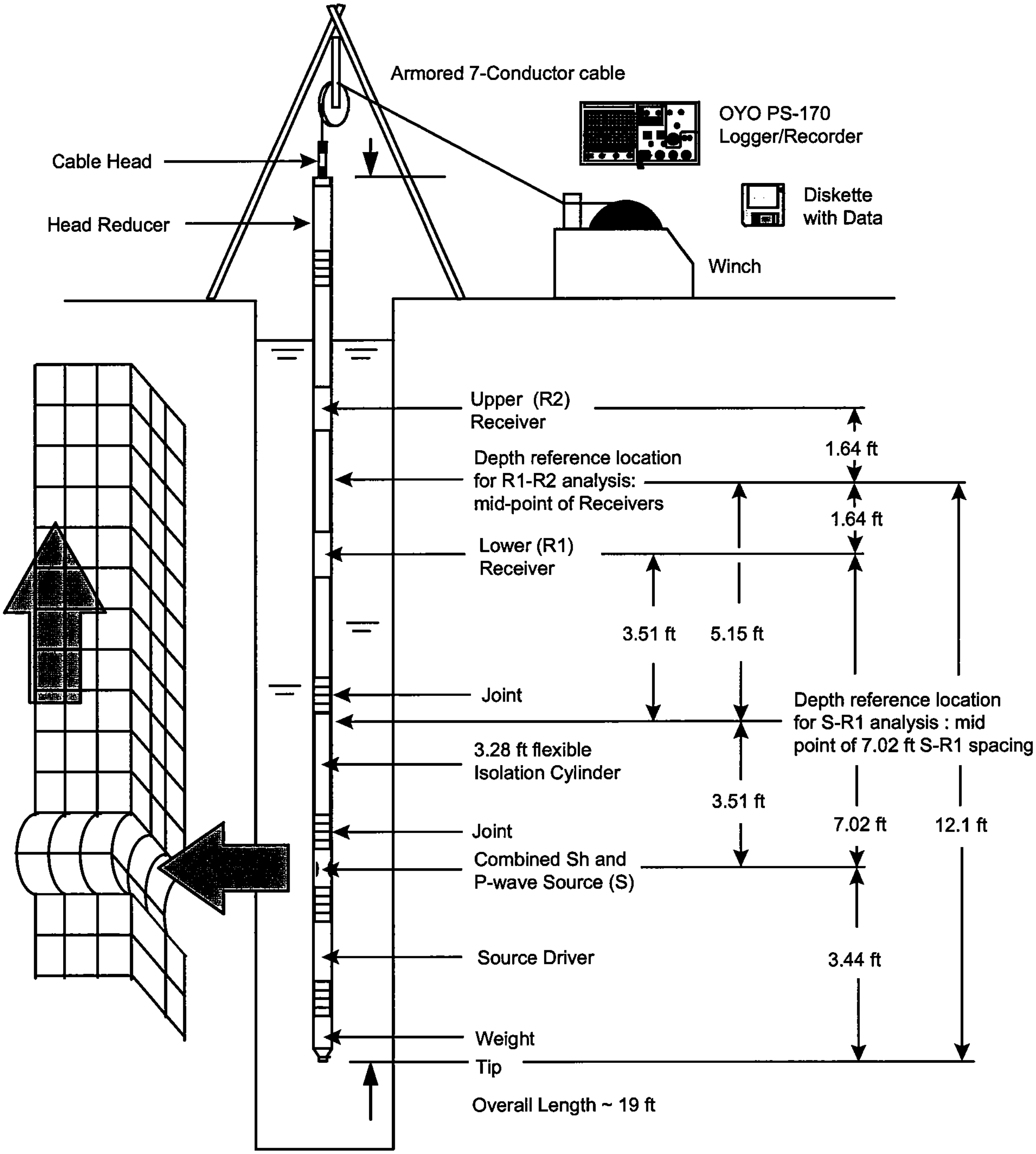

Figure 1. Concept illustration of P-S logging system with 7.02 S-R1 isolation

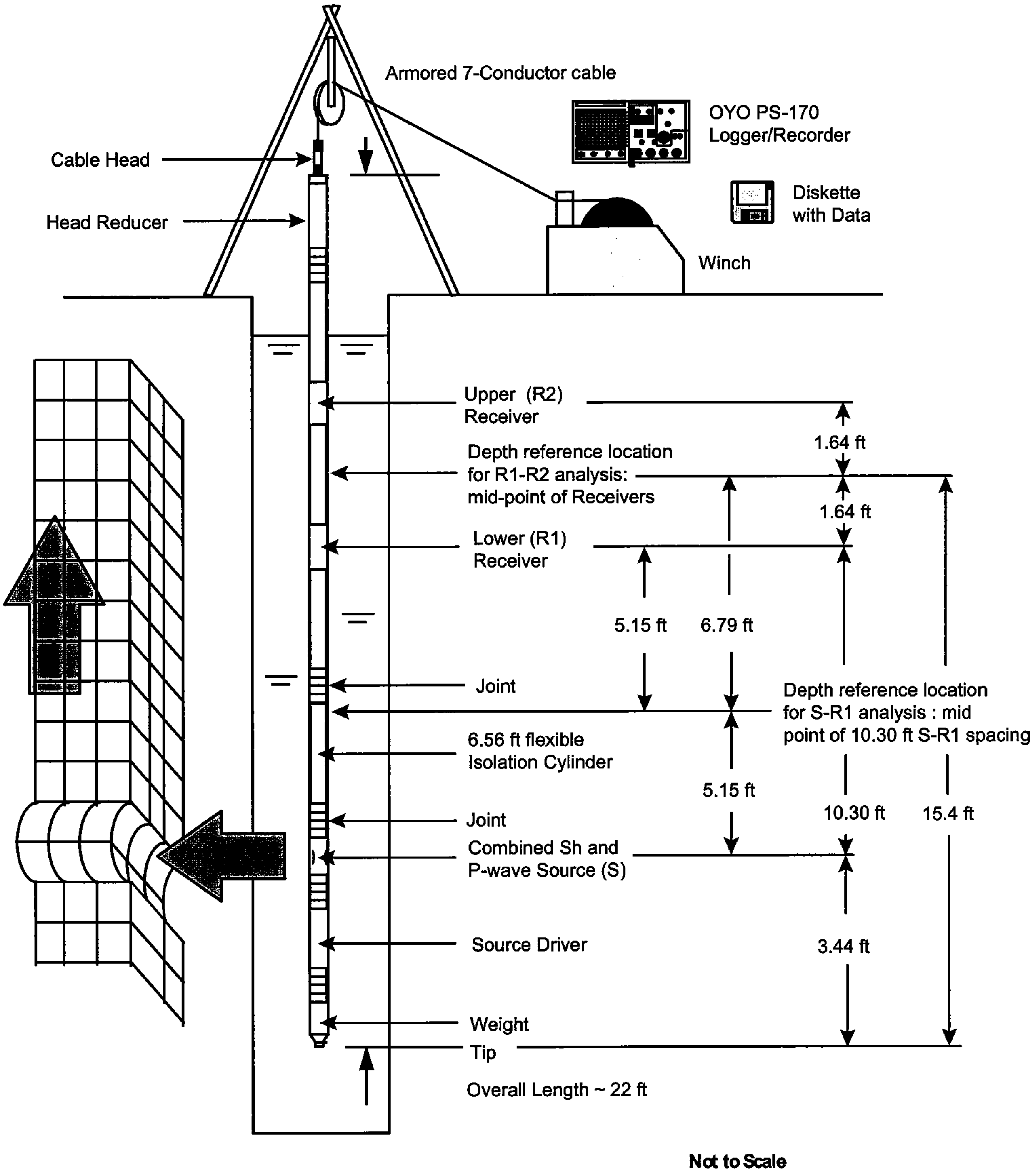

Figure 2. Concept illustration of P-S logging system with 10.30 S-R1 isolation

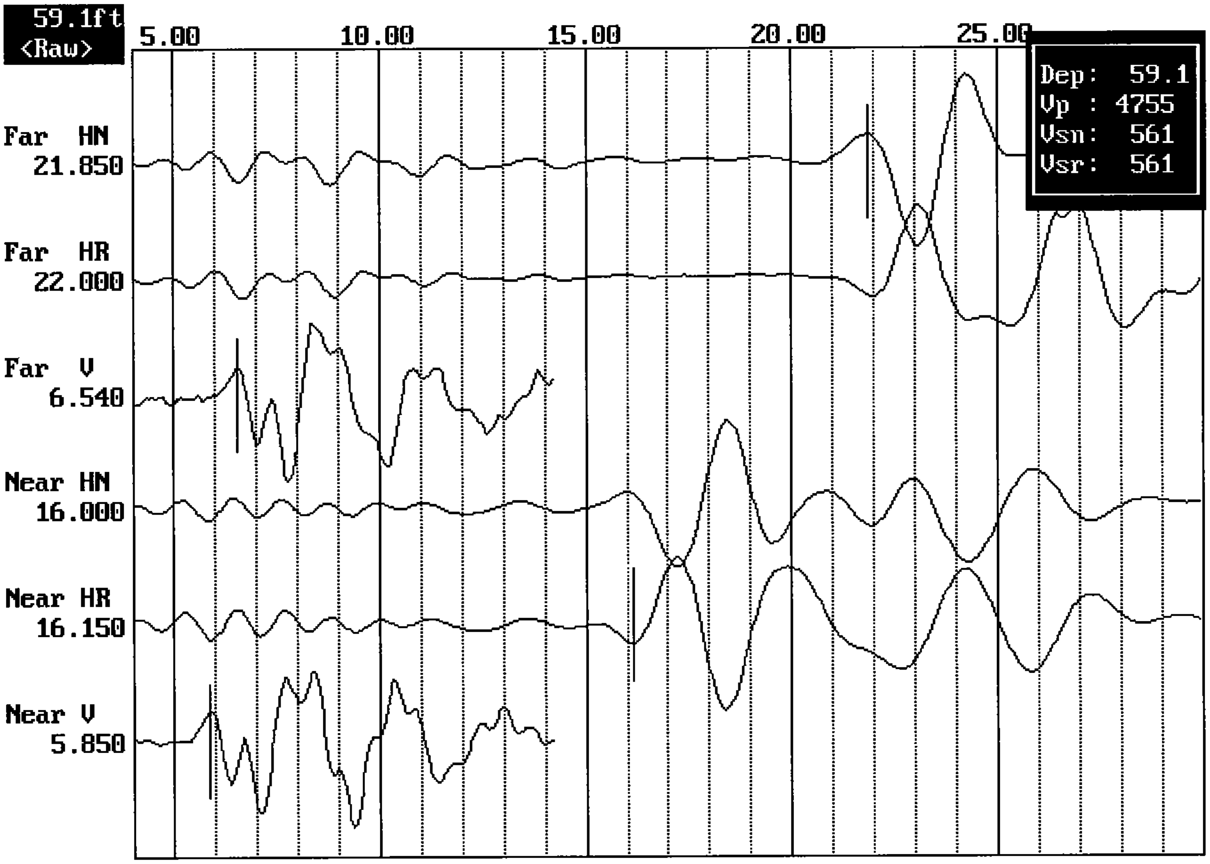

Figure 3. Filtered (800 Hz lowpass) record from Boring SD-110 at 59.1 ft

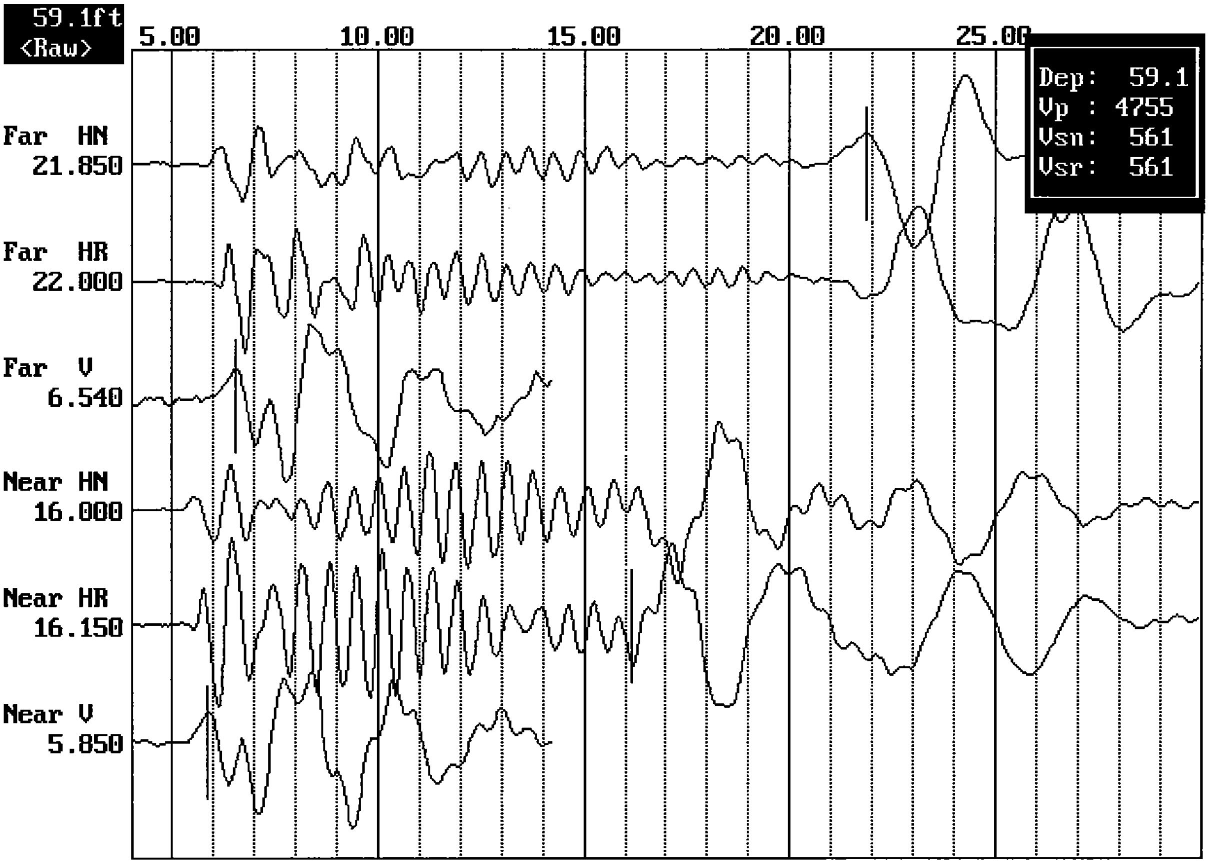

Figure 4. Unfiltered record from Boring SD-110 at 59.1 ft

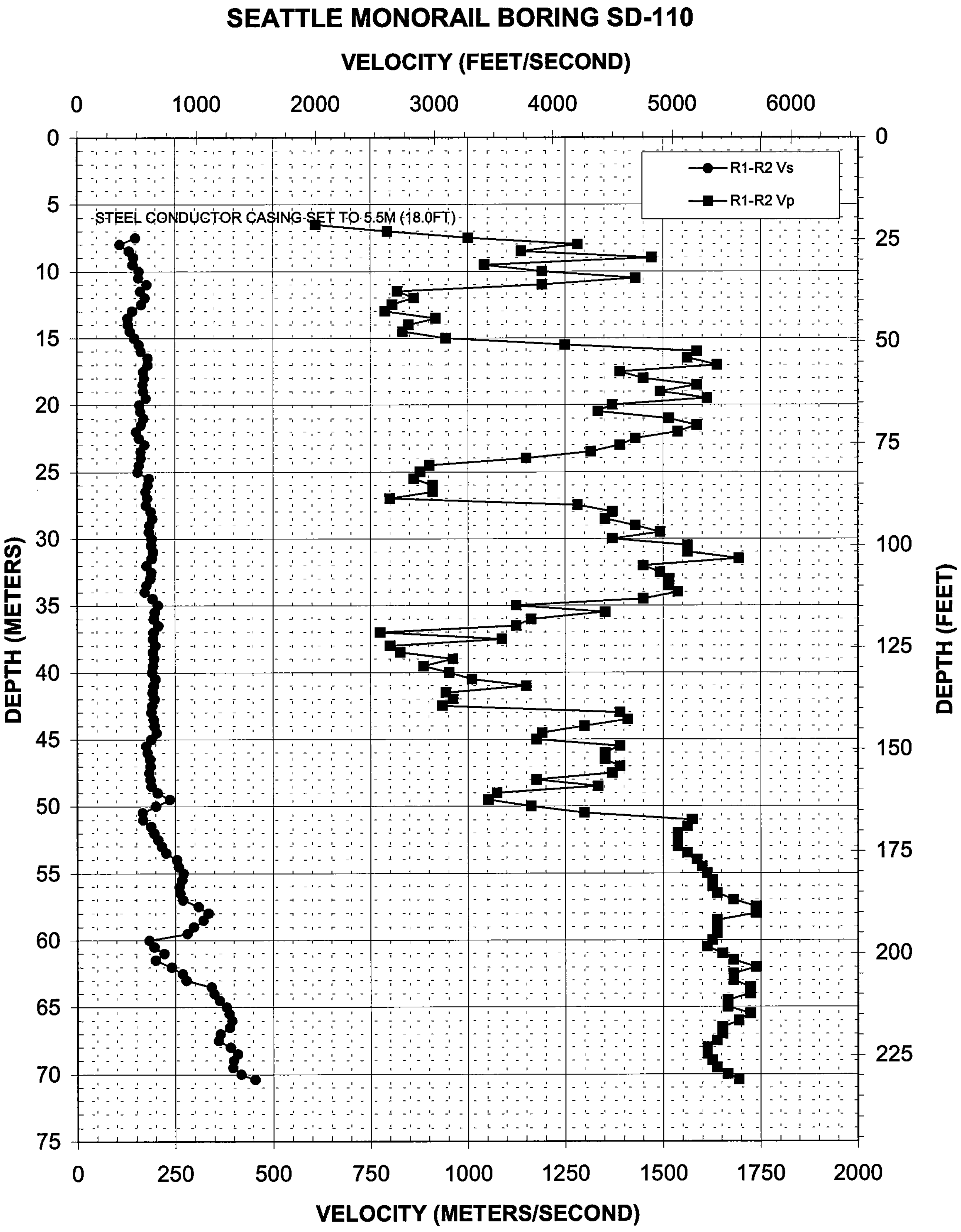

Figure 12. Boring SD-110, Suspension P- and S_H-wave velocities

Depth		Pick Times						Velocity			
(m)	(feet)	Far-Hn (millisec)	Far-Hr (millisec)	Far-V (millisec)	Near-Hn (millisec)	Near-Hr (millisec)	Near-V (millisec)	V-S_H (m/sec)	V-P (m/sec)	V-S_H (ft/sec)	V-P (ft/sec)
6.5	21.3			8.78			7.14		610		2001
7.0	23.0			7.92			6.66		794		2604
7.5	24.6	22.30	23.95	6.92	15.60	17.25	5.92	149	1000	490	3281
8.0	26.2	26.05	26.10	6.78	16.70	17.10	6.00	109	1282	358	4206
8.5	27.9	23.85	24.25	6.60	16.25	16.85	5.72	133	1136	437	3728
9.0	29.5	22.85	22.70	6.44	15.85	15.85	5.76	144	1471	474	4825
9.5	31.2	22.40	22.45	7.92	15.35	15.35	6.96	141	1042	464	3418
10.0	32.8	21.70	21.60	8.32	15.65	15.00	7.48	158	1190	519	3906
10.5	34.4	22.55	22.05	8.24	16.40	15.45	7.54	157	1429	515	4687
11.0	36.1	23.05	23.40	8.00	17.45	17.75	7.16	178	1190	583	3906
11.5	37.7	24.20	24.35	8.38	18.00	18.10	7.16	161	820	527	2689
12.0	39.4	24.95	24.95	8.28	19.15	19.25	7.12	174	862	571	2828
12.5	41.0	25.30	25.45	8.33	19.30	19.30	7.09	165	806	540	2646
13.0	42.7	25.55	25.55	8.25	18.55	18.35	6.98	141	787	462	2583
13.5	44.3	25.25	25.30	7.67	17.50	17.55	6.58	129	917	423	3010
14.0	45.9	24.30	24.35	7.52	16.70	16.60	6.34	130	847	427	2780
14.5	47.6	23.05	23.15	7.24	15.70	15.70	6.04	135	833	443	2734
15.0	49.2	22.30	22.55	6.98	15.70	15.45	5.92	146	943	479	3095
15.5	50.9	21.60	21.80	6.62	15.30	15.45	5.82	158	1250	519	4101
16.0	52.5	21.35	21.30	6.50	15.20	15.20	5.87	163	1587	536	5208
16.5	54.1	21.35	21.10	6.39	15.75	15.60	5.75	180	1563	591	5126
17.0	55.8	21.15	20.85	6.37	15.50	15.45	5.76	181	1639	594	5378
17.5	57.4	21.35	21.40	6.40	15.30	15.65	5.68	169	1389	556	4557
18.0	59.1	21.85	22.00	6.54	16.00	16.15	5.85	171	1449	561	4755
18.5	60.7	21.80	21.90	6.51	15.90	15.90	5.88	168	1587	551	5208
19.0	62.3	22.00	23.15	6.59	16.20	17.15	5.92	169	1493	556	4897
19.5	64.0	21.90	22.10	6.52	16.10	16.50	5.90	175	1613	576	5292
20.0	65.6	22.20	22.80	6.52	16.15	16.30	5.79	159	1370	523	4494
20.5	67.3	22.20	22.60	6.56	16.05	16.35	5.81	161	1333	529	4374
21.0	68.9	22.00	22.40	6.48	16.20	16.45	5.82	170	1515	558	4971
21.5	70.5	22.55	22.50	6.39	16.40	16.45	5.76	164	1587	538	5208
22.0	72.2	22.60	22.65	6.45	15.95	16.05	5.80	151	1538	495	5047
22.5	73.8	22.85	22.90	6.76	16.50	16.60	6.06	158	1429	519	4687
23.0	75.5	22.25	22.25	6.91	16.45	16.45	6.19	172	1389	566	4557
23.5	77.1	22.15	22.25	7.09	16.00	16.05	6.33	162	1316	531	4317
24.0	78.7	22.05	22.20	7.32	15.90	16.10	6.45	163	1149	536	3771
24.5	80.4	21.60	21.70	7.89	15.25	15.35	6.78	157	901	517	2956
25.0	82.0	21.55	21.80	7.91	15.00	15.40	6.77	154	877	507	2878
25.5	83.7	20.80	20.90	7.62	15.45	15.40	6.46	184	862	605	2828
26.0	85.3	20.30	20.55	7.47	14.65	15.10	6.37	180	909	591	2983
26.5	86.9	20.54	20.60	6.89	14.76	14.92	5.79	175	909	573	2983
27.0	88.6	20.40	20.50	7.07	14.86	14.90	5.82	180	800	589	2625
27.5	90.2	20.18	20.30	6.56	14.40	14.72	5.78	176	1282	578	4206
28.0	91.9	19.88	19.90	6.52	14.46	14.68	5.79	188	1370	617	4494
28.5	93.5	19.82	19.88	6.42	14.64	14.66	5.68	192	1351	631	4434
29.0	95.1	19.84	19.80	6.44	14.32	14.50	5.74	185	1429	606	4687
29.5	96.8	19.94	20.08	6.39	14.52	14.60	5.72	183	1493	602	4897
30.0	98.4	20.16	20.34	6.41	14.92	15.12	5.68	191	1370	627	4494
30.5	100.1	19.88	20.04	6.32	14.76	14.64	5.68	190	1562	624	5126
31.0	101.7	20.02	20.18	6.36	14.96	14.96	5.72	195	1562	638	5126

Table 10. Boring SD-110, Suspension R1-R2 depth, pick times, and velocities

Depth		Pick Times						Velocity			
(m)	(feet)	Far-Hn (millisec)	Far-Hr (millisec)	Far-V (millisec)	Near-Hn (millisec)	Near-Hr (millisec)	Near-V (millisec)	V-S_H (m/sec)	V-P (m/sec)	V-S_H (ft/sec)	V-P (ft/sec)
31.5	103.3	20.42	20.54	6.34	15.08	15.38	5.75	190	1695	625	5561
32.0	105.0	20.50	20.56	6.36	14.90	14.90	5.67	178	1449	583	4755
32.5	106.6	20.26	20.38	6.34	15.04	15.04	5.67	189	1493	621	4897
33.0	108.3	19.62	23.28	6.45	14.74	17.48	5.79	187	1515	614	4971
33.5	109.9	19.88	19.92	6.57	14.26	14.28	5.91	178	1515	583	4971
34.0	111.5	19.64	19.80	6.60	13.90	13.98	5.95	173	1538	568	5047
34.5	113.2	18.76	18.96	6.64	13.64	13.72	5.95	193	1449	633	4755
35.0	114.8	18.98	19.04	6.95	14.12	14.24	6.06	207	1124	679	3686
35.5	116.5	19.14	19.16	7.81	14.10	14.16	7.07	199	1351	654	4434
36.0	118.1	19.36	19.36	7.92	14.24	14.30	7.06	196	1163	645	3815
36.5	119.8	19.14	19.20	7.64	14.34	14.38	6.75	208	1124	682	3686
37.0	121.4	19.24	19.38	8.08	14.14	14.26	6.79	196	775	642	2543
37.5	123.0	19.62	19.70	7.55	14.46	14.54	6.63	194	1087	636	3566
38.0	124.7	19.42	19.50	7.76	14.42	14.50	6.51	200	800	656	2625
38.5	126.3	19.46	19.52	7.96	14.30	14.38	6.75	194	826	637	2711
39.0	128.0	19.50	19.60	7.32	14.42	14.50	6.28	196	962	645	3155
39.5	129.6	19.38	19.50	7.35	14.24	14.32	6.22	194	885	636	2903
40.0	131.2	19.58	19.68	7.10	14.36	14.48	6.05	192	952	630	3125
40.5	132.9	19.62	19.70	7.22	14.62	14.70	6.23	200	1010	656	3314
41.0	134.5	19.62	19.70	7.07	14.50	14.58	6.20	195	1149	641	3771
41.5	136.2	19.58	19.66	6.97	14.42	14.48	5.91	193	943	635	3095
42.0	137.8	19.58	19.66	6.68	14.52	14.58	5.64	197	962	647	3155
42.5	139.4	19.62	19.70	6.61	14.42	14.46	5.54	192	935	629	3066
43.0	141.1	20.16	20.24	6.54	14.88	14.94	5.82	189	1389	620	4557
43.5	142.7	20.10	20.18	6.52	14.98	15.04	5.81	195	1408	640	4621
44.0	144.4	19.94	19.96	6.49	14.88	14.88	5.72	197	1299	647	4261
44.5	146.0	19.96	20.04	6.52	15.04	15.12	5.68	203	1190	667	3906
45.0	147.6	20.14	20.22	6.48	14.88	14.94	5.63	190	1176	623	3860
45.5	149.3	20.54	20.62	6.21	14.86	14.94	5.49	176	1389	578	4557
46.0	150.9	20.52	20.56	6.37	14.94	15.02	5.63	180	1351	590	4434
46.5	152.6	20.56	20.64	6.36	15.20	15.28	5.62	187	1351	612	4434
47.0	154.2	20.35	20.45	6.26	15.00	15.10	5.54	187	1389	613	4557
47.5	155.8	20.80	20.90	6.35	15.35	15.45	5.62	183	1370	602	4494
48.0	157.5	21.15	21.30	6.71	15.85	15.95	5.86	188	1176	616	3860
48.5	159.1	20.55	20.65	7.15	15.25	15.40	6.40	190	1333	622	4374
49.0	160.8	20.25	20.30	7.00	15.35	15.45	6.07	205	1075	673	3528
49.5	162.4	20.14	20.22	7.05	15.92	15.98	6.10	236	1053	776	3454
50.0	164.0	20.20	20.30	6.37	15.22	15.32	5.51	201	1163	659	3815
50.5	165.7	20.50	20.60	6.27	14.52	14.58	5.50	167	1299	547	4261
51.0	167.3	19.98	20.00	6.13	14.04	14.06	5.49	168	1575	552	5167
51.5	169.0	18.86	18.88	6.12	13.48	13.62	5.48	188	1563	617	5126
52.0	170.6	18.08	18.08	6.12	12.96	13.04	5.47	197	1538	646	5047
52.5	172.2	17.62	17.68	6.10	12.74	12.86	5.45	206	1538	676	5047
53.0	173.9	17.08	17.16	6.09	12.48	12.50	5.44	216	1538	709	5047
53.5	175.5	16.82	16.84	6.08	12.40	12.46	5.44	227	1563	746	5126
54.0	177.2	16.30	16.26	6.05	12.36	12.34	5.42	254	1587	835	5208
54.5	178.8	16.08	16.14	6.02	12.22	12.28	5.39	259	1600	850	5249
55.0	180.4	15.78	15.84	5.99	12.10	12.16	5.37	272	1613	892	5292
55.5	182.1	15.44	15.56	5.96	11.72	11.82	5.35	268	1626	880	5335
56.0	183.7	15.70	15.74	5.96	11.86	11.92	5.34	261	1626	857	5335

Table 10, continued. Boring SD-110, Suspension R1-R2 depth, pick times, and velocities

Depth		Pick Times						Velocity			
(m)	(feet)	Far-Hn (millisec)	Far-Hr (millisec)	Far-V (millisec)	Near-Hn (millisec)	Near-Hr (millisec)	Near-V (millisec)	V-S_H (m/sec)	V-P (m/sec)	V-S_H (ft/sec)	V-P (ft/sec)
56.5	185.4	16.00	15.96	5.97	12.14	12.22	5.36	263	1639	863	5378
57.0	187.0	15.94	16.00	5.98	12.26	12.28	5.39	270	1681	887	5514
57.5	188.6	16.04	16.12	5.97	12.82	12.88	5.40	310	1739	1016	5706
58.0	190.3	16.00	16.02	5.98	13.02	13.02	5.41	334	1739	1097	5706
58.5	191.9	16.72	16.78	6.04	13.60	13.70	5.43	323	1639	1058	5378
59.0	193.6	17.24	18.54	6.05	14.00	15.06	5.44	298	1639	976	5378
59.5	195.2	17.62	17.72	5.99	14.08	14.16	5.38	282	1639	924	5378
60.0	196.9	17.88	17.96	5.98	12.46	12.50	5.37	184	1626	603	5335
60.5	198.5	17.84	17.94	6.00	12.74	12.84	5.38	196	1613	643	5292
61.0	200.1	15.80	16.70	6.01	11.16	12.32	5.41	222	1653	727	5423
61.5	201.8	15.16	16.22	5.98	10.30	11.08	5.38	200	1681	656	5514
62.0	203.4	14.06	15.08	6.00	9.94	10.88	5.43	240	1739	789	5706
62.5	205.1	13.00	13.86	6.00	9.30	10.12	5.40	269	1681	882	5514
63.0	206.7	12.63	13.56	6.07	8.97	10.04	5.48	279	1681	914	5514
63.5	208.3	11.74	12.74	6.03	8.82	9.83	5.45	343	1724	1126	5657
64.0	210.0	11.52	12.48	6.00	8.70	9.57	5.42	349	1724	1145	5657
64.5	211.6	11.47	12.41	6.07	8.69	9.68	5.47	363	1667	1191	5468
65.0	213.3	11.53	12.54	6.00	8.92	9.90	5.40	381	1667	1250	5468
65.5	214.9	11.62	12.57	6.00	9.05	9.99	5.42	388	1724	1274	5657
66.0	216.5	11.50	12.47	6.01	8.98	9.92	5.42	394	1695	1294	5561
66.5	218.2	11.54	12.64	5.99	8.95	10.09	5.39	389	1653	1277	5423
67.0	219.8	11.48	12.37	5.99	8.77	9.61	5.39	366	1653	1200	5423
67.5	221.5	11.30	12.30	5.98	8.50	9.56	5.37	361	1639	1184	5378
68.0	223.1	11.80	11.92	6.00	9.24	9.38	5.38	392	1613	1287	5292
68.5	224.7	11.02	11.96	5.97	8.64	9.46	5.35	410	1613	1345	5292
69.0	226.4	11.06	11.92	5.96	8.52	9.46	5.34	400	1626	1312	5335
69.5	228.0	10.92	11.80	5.96	8.38	9.30	5.35	397	1639	1302	5378
70.0	229.7	10.72	11.70	5.96	8.38	9.26	5.36	418	1667	1373	5468
70.4	231.0	10.60	11.55	5.96	8.40	9.35	5.37	455	1695	1491	5561

Table 10, continued. Boring SD-110, Suspension R1-R2 depth, pick times, and velocities

APPENDIX A

SUSPENSION VELOCITY MEASUREMENT QUALITY ASSURANCE SUSPENSION SOURCE TO RECEIVER ANALYSIS RESULTS

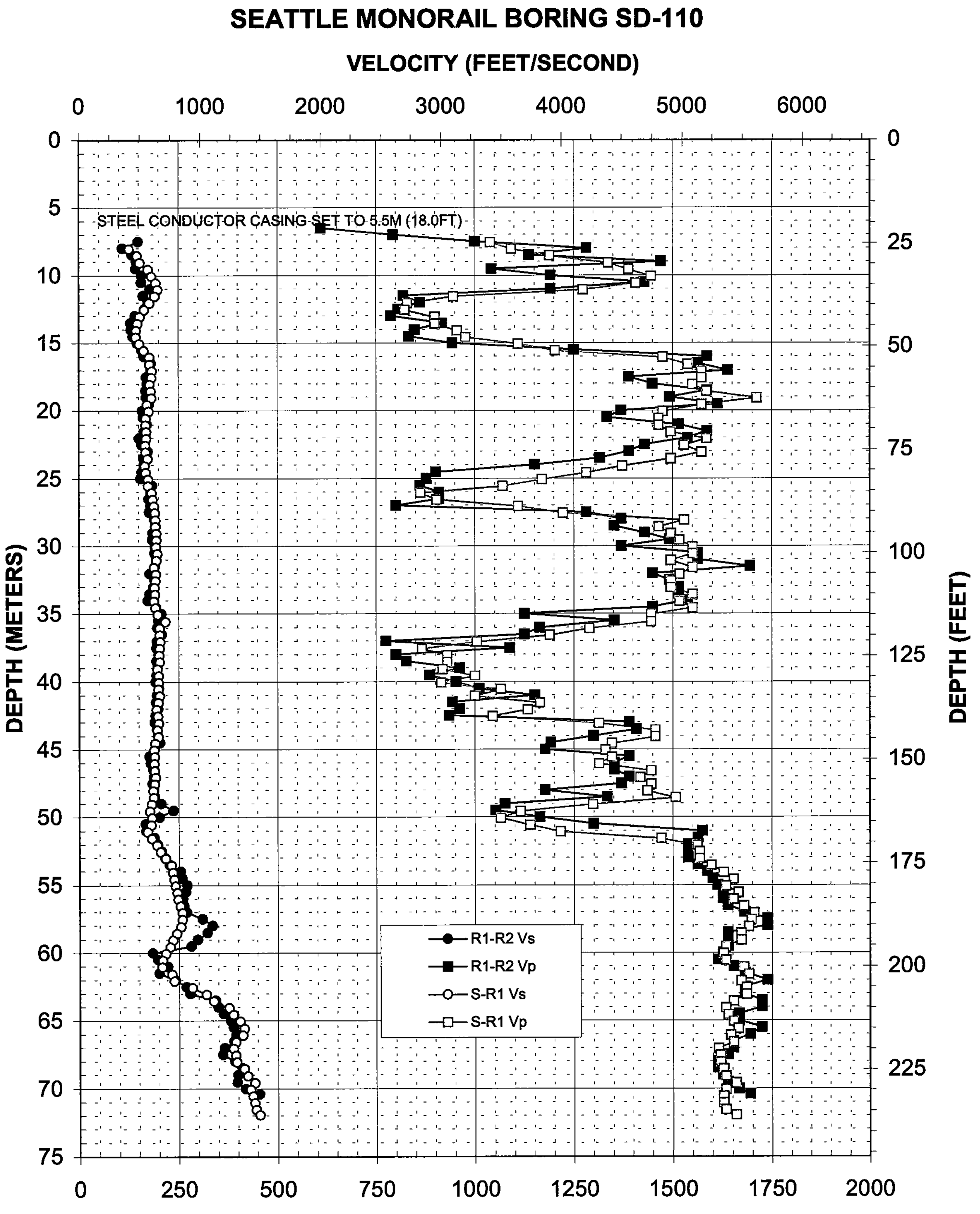

Figure A-8. Borehole SD-110, R1 - R2 high resolution analysis and S-R1 quality assurance analysis P- and S_H-wave data

	Velocity			Velocity	
Depth (meters)	V-S_H (m/sec)	V-p (m/sec)	Depth (feet)	V- S_H (ft/sec)	V-p (ft/sec)
7.6		1039	24.8		3408
8.1	126	1092	26.5	414	3582
8.6	146	1189	28.1	480	3901
9.1	153	1338	29.8	503	4388
9.6	173	1390	31.4	569	4559
10.1	183	1446	33.0	599	4744
10.6	193	1408	34.7	633	4619
11.1	197	1274	36.3	647	4179
11.6	190	947	38.0	624	3107
12.1	178	829	39.6	583	2721
12.6	165	823	41.2	540	2700
13.1	153	899	42.9	503	2950
13.6	148	899	44.5	484	2950
14.1	145	955	46.2	474	3134
14.6	143	977	47.8	470	3206
15.1	152	1109	49.4	498	3638
15.6	163	1202	51.1	535	3944
16.1	178	1476	52.7	583	4842
16.6	178	1540	54.4	583	5051
17.1	184	1574	56.0	602	5162
17.6	183	1574	57.6	600	5162
18.1	178	1551	59.3	583	5088
18.6	181	1585	60.9	592	5201
19.1	181	1712	62.6	595	5617
19.6	172	1574	64.2	564	5162
20.1	175	1476	65.8	573	4842
20.6	169	1466	67.5	553	4809
21.1	169	1466	69.1	553	4809
21.6	169	1497	70.8	555	4910
22.1	169	1585	72.4	555	5201
22.6	167	1529	74.0	549	5015
23.1	169	1574	75.7	553	5162
23.6	173	1497	77.3	566	4910
24.1	166	1372	79.0	544	4501
24.6	169	1281	80.6	553	4204
25.1	174	1169	82.3	571	3837
25.6	174	1070	83.9	571	3510
26.1	183	863	85.5	600	2831
26.6	185	903	87.2	608	2962
27.1	188	1109	88.8	617	3638
27.6	191	1223	90.5	627	4012
28.1	191	1529	92.1	628	5015
28.6	191	1466	93.7	628	4809
29.1	194	1497	95.4	637	4910
29.6	194	1518	97.0	637	4979
30.1	193	1551	98.7	635	5088
30.6	196	1551	100.3	644	5088
31.1	194	1497	101.9	637	4910
31.6	189	1551	103.6	619	5088
32.1	193	1518	105.2	633	4979
32.6	191	1497	106.9	628	4910
33.1	189	1497	108.5	621	4910
33.6	191	1551	110.1	626	5088
34.1	189	1518	111.8	619	4979
34.6	191	1551	113.4	628	5088
35.1	197	1446	115.1	647	4744
35.6	217	1446	116.7	711	4744
36.1	202	1289	118.3	661	4230
36.6	202	1189	120.0	664	3901
37.1	205	1005	121.6	671	3296
37.6	202	866	123.3	661	2843
38.1	201	930	124.9	659	3053
38.6	202	930	126.5	664	3053
39.1	196	918	128.2	644	3013
39.6	200	1000	129.8	656	3281
40.1	200	915	131.5	657	3000
40.6	199	1065	133.1	651	3493
41.1	202	1000	134.7	664	3281
41.6	199	1163	136.4	651	3816
42.1	194	1132	138.0	637	3715
42.6	198	1044	139.7	649	3425
43.1	199	1313	141.3	654	4307
43.6	196	1456	142.9	644	4776
44.1	199	1456	144.6	651	4776
44.6	191	1346	146.2	626	4416
45.1	189	1329	147.9	619	4361
45.6	189	1346	149.5	621	4416
46.1	189	1313	151.1	619	4307
46.6	190	1446	152.8	624	4744
47.1	191	1417	154.4	628	4650

Table A-8. Borehole SD-110, S - R1 quality assurance analysis P- and S_H -wave data

Depth (meters)	Velocity		Depth (feet)	Velocity	
	V-S_H (m/sec)	V-p (m/sec)		V- S_H (ft/sec)	V-p (ft/sec)
47.6	190	1446	156.1	624	4744
48.1	186	1436	157.7	611	4712
48.6	188	1507	159.4	616	4944
49.1	182	1297	161.0	598	4255
49.6	177	1115	162.6	580	3657
50.1	183	1065	164.3	600	3493
50.6	181	1138	165.9	592	3735
51.1	171	1216	167.6	561	3989
51.6	181	1471	169.2	594	4825
52.1	196	1562	170.8	642	5125
52.6	205	1568	172.5	671	5144
53.1	217	1568	174.1	711	5144
53.6	232	1597	175.8	760	5240
54.1	235	1627	177.4	770	5339
54.6	239	1653	179.0	784	5422
55.1	242	1634	180.7	794	5360
55.6	247	1665	182.3	809	5464
56.1	249	1653	184.0	816	5422
56.6	254	1678	185.6	834	5507
57.1	259	1705	187.2	850	5594
57.6	259	1698	188.9	850	5572
58.1	255	1692	190.5	838	5550
58.6	245	1672	192.2	805	5485
59.1	235	1672	193.8	770	5485
59.6	228	1634	195.4	747	5360
60.1	217	1627	197.1	711	5339
60.6	209	1634	198.7	686	5360
61.1	208	1678	200.4	683	5507
61.6	233	1692	202.0	763	5550
62.1	239	1672	203.6	784	5485
62.6	285	1685	205.3	936	5528
63.1	320	1685	206.9	1049	5528
63.6	339	1653	208.6	1111	5422
64.1	377	1634	210.2	1236	5360
64.6	388	1640	211.8	1272	5380
65.1	405	1653	213.5	1330	5422
65.6	416	1665	215.1	1363	5464
66.1	412	1646	216.8	1353	5401
66.6	393	1653	218.4	1291	5422
67.1	388	1615	220.0	1272	5299
67.6	393	1621	221.7	1291	5319
68.1	396	1621	223.3	1300	5319
68.6	416	1627	225.0	1363	5339
69.1	425	1634	226.6	1393	5360
69.6	442	1659	228.2	1451	5443
70.1	431	1634	229.9	1416	5360
70.6	439	1627	231.5	1439	5339
71.1	442	1627	233.2	1451	5339
71.6	446	1634	234.8	1463	5360
72.0	455	1659	236.1	1494	5443

Table A-8, continued. Borehole SD-110, S - R1 quality assurance analysis P- and S_H -wave data

APPENDIX D

GEOTECHNICAL LABORATORY TESTING

APPENDIX D

GEOTECHNICAL LABORATORY TESTING

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TABLE D-2
SUMMARY OF LABORATORY TESTING - SODO

Boring No.	Top Depth (feet)	Sample No.	Sample Type[1]	Blow Count (blows/foot)	USCS[2]	Geologic Unit[3]	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses[4]				Plasticity[5]			Other Tests Performed[6]			
									Gravel (%)	Sand (%)	Fines (%)	<2μm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
SD-101	10.0	1	SPT	7	SP-SM	HF	31.7												
SD-101	12.5	2	SPT	7	SM	HF	90.2												
SD-101	15.0	3	SPT	1	SM	HF	34.6												
SD-101	17.5	4	SPT	2	SM	HF	36.2				45.2								
SD-101	20.0	5	SPT	15	SP	HA	32.7												
SD-101	25.0	6	SPT	19	SP	HA	27.0												
SD-101	30.0	7	SPT	23	SP	HA	25.8												
SD-101	35.0	8	SPT	4	ML	HE	35.7				95.4								
SD-101	40.0	9	SPT	20	SP	HA	24.8				7.0								
SD-101	45.0	10	SPT	23	SP	HA	25.8												
SD-101	50.0	11	SPT	5	ML	HA	39.3												
SD-101	55.0	12	SPT	24	SP-SM	HA	27.9												
SD-101	60.0	13	SPT	38	SP-SM	HA	27.2		0.0	91.9	8.1								
SD-101	65.0	14	SPT	25	SP-SM	HA	29.1												
SD-101	70.0	15	SPT	24	SM	HA	36.7												
SD-101	75.0	16	SPT	23	SM	HA	33.5												
SD-101	80.0	17	SPT	24	SP-SM	HA	34.7				28.0								
SD-101	85.0	18	SPT	11	ML	HA	33.5				54.3								
SD-101	90.0	19	SPT	21	SM	HA	28.8												
SD-101	95.0	20	SPT	12	SM	HA	33.8				59.9								
SD-101	100.0	21	SPT	14	SM	HA	29.6												
SD-101	105.0	22	SPT	8	ML	HA	34.3												
SD-101	110.0	23	SPT	6	ML	HA	30.6												
SD-101	115.0	24	SPT	33	SP-SM	HA	29.4												
SD-101	120.0	25	SPT	38	SP-SM	HA	25.9												
SD-101	125.0	26	SPT	27	ML	HE	29.1												
SD-101	130.0	27	SPT	25	ML	HE	30.6												
SD-101	135.0	28	SPT	33	ML	HE	35.7												
SD-101	140.0	29	SPT	23	ML	HA	35.5												
SD-101	145.0	30	SPT	15	ML	HA	34.5												

TABLE D-2
SUMMARY OF LABORATORY TESTING - SODO

Boring No.	Top Depth (feet)	Sample No.	Sample Type[1]	Blow Count (blows/foot)	USCS[2]	Geologic Unit[3]	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses[4]				Plasticity[5]			Other Tests Performed[6]			
									Gravel (%)	Sand (%)	Fines (%)	<2µm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
SD-101	150.0	31	SPT	8	ML	HE	32.2												
SD-101	155.0	32	SPT	0	ML	HE	38.3						35	27					
SD-101	157.5	33	OSTER	-	ML	HE	29.5	117											
SD-101	160.0	34	SPT	50/4"	SC	QPGM	10.5												
SD-101	165.0	35	SPT	92	SC	QPGM	7.3												
SD-101	170.0	36	SPT	50/3"	SC	QPGM	9.2												
SD-101	175.0	37	SPT	50/3"	SM	QPGM	8.2												
SD-101	180.0	38	SPT	50/4"	SM	QPGM	8.3												
SD-101	185.0	39	SPT	84/11"	ML	QPGM	11.3												
SD-101	190.0	40	SPT	50/4"	ML	QPGM	7.2												
SD-101	195.0	41	SPT	50/4"	ML	QPGM	11.6		18.6	29.1	52.3								
SD-101	200.0	42	SPT	50/5"	ML	QPGM	10.0												
SD-101	205.0	43	SPT	50/5"	SM	QPGM	10.2												
SD-101	210.0	44	SPT	100/2"	SM	QPGM	8.0												
SD-102	5.0	1	SPT	6	SM	HF	18.5												
SD-102	7.5	2	SPT	7	SP-SM	HF	23.7												
SD-102	10.0	3	SPT	8	SP-SM	HF	27.6												
SD-102	12.5	4	SPT	15	GM	HF	13.3												
SD-102	15.0	5	SPT	7	ML	HF	18.6												
SD-102	20.0	7	SPT	4	GP-GM	HF	32.4												
SD-102	25.0	8	SPT	7	GP-GM	HF	20.8												
SD-102	30.0	9	SPT	5	GP-GM	HF	19.6												
SD-102	35.0	10	SPT	2	ML	HE	34.2												
SD-102	40.0	11	SPT	19	SP-SM	HA	29.6												
SD-102	45.0	12	SPT	25	SP-SM	HA	28.6		0.0	91.5	8.5								
SD-102	50.0	13	SPT	21	SP-SM	HA	30.0												
SD-102	55.0	14	SPT	25	SP-SM	HA	27.3												
SD-102	60.0	15	SPT	25	SP-SM	HA	27.9												
SD-102	65.0	16	SPT	16	SM	HA	37.1												
SD-102	70.0	17	SPT	21	SM	HA	33.2												

TABLE D-2
SUMMARY OF LABORATORY TESTING - SODO

Boring No.	Top Depth (feet)	Sample No.	Sample Type[1]	Blow Count (blows/foot)	USCS[2]	Geologic Unit[3]	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses[4]				Plasticity[5]			Other Tests Performed[6]			
									Gravel (%)	Sand (%)	Fines (%)	<2µm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
SD-102	75.0	18	SPT	21	SM	HA	30.9												
SD-102	80.0	19	SPT	18	SM	HA	32.7												
SD-102	85.0	20	SPT	23	SM	HA	29.6												
SD-102	90.0	21	SPT	19	SM	HA	32.6		0.0	65.0	35.0								
SD-102	95.0	22	SPT	19	SM	HA	32.3												
SD-102	100.0	23	SPT	17	SM	HA	31.9												
SD-102	105.0	24	SPT	11	ML	HA	34.7												
SD-102	110.0	25	SPT	24	ML	HA	31.0				65.8								
SD-102	115.0	26	SPT	27	ML	HA	29.5												
SD-102	120.0	27	SPT	26	ML	HA	31.4												
SD-102	125.0	28	SPT	29	SP	HA	30.2												
SD-102	130.0	29	SPT	36	SM	HA	28.8												
SD-102	135.0	30	SPT	31	SM	HA	31.6												
SD-102	140.0	31	SPT	33	SM	HA	32.9												
SD-102	145.0	32	SPT	60	SP	HA	27.0												
SD-102	150.0	33	SPT	9	ML	HE	33.2												
SD-102	155.0	34	SPT	17	ML	HE	33.8												
SD-102	160.0	35	SPT	39	ML	HE	34.8												
SD-102	165.0	36	SPT	13	ML	HE	34.9												
SD-102	170.0	37	SPT	13	ML	HE	31.6												
SD-102	175.0	38	SPT	0	ML	HE	42.7												
SD-102	180.0	39	SPT	0	ML	HE	43.0				99.2	23.5	40	28					
SD-102	185.0	40	SPT	11	ML	HE	41.4												
SD-102	190.0	41	SPT	50/4"	SM	QPGT	12.1												
SD-102	195.0	42	SPT	50/5"	ML	QPGM	20.2												
SD-102	200.0	43	SPT	50/4"	ML	QPGM	8.7												
SD-102	205.0	44	SPT	50/5"	ML	QPGM	23.2												
SD-102	210.0	45	SPT	50/6"	ML	QPGM	19.2						0	0	NP				
SD-102	215.0	46	SPT	50/5"	ML	QPGM	27.0												
SD-102	220.0	47	SPT	50/5"	ML	QPGM	14.5												

(see page 36 for notes)

TABLE D-2
SUMMARY OF LABORATORY TESTING - SODO

Boring No.	Top Depth (feet)	Sample No.	Sample Type[1]	Blow Count (blows/foot)	USCS[2]	Geologic Unit[3]	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses[4]				Plasticity[5]			Other Tests Performed[6]			
									Gravel (%)	Sand (%)	Fines (%)	<2μm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
SD-102	225.0	48	SPT	50/6"	ML	QPGM	23.1												
SD-103	7.0	1	SPT	3	SP-SM	HF	29.6												
SD-103	7.5	1	SPT	3	SP-SM	HF	29.6												
SD-103	10.0	2	SPT	6	SP-SM	HF	30.8		0.0	93.3	6.7								
SD-103	12.5	3	SPT	4	SP-SM	HF	32.5												
SD-103	15.0	4	SPT	1	CL	HF	58.1												
SD-103	17.5	5	SPT	12	CL	HF	51.7												
SD-103	20.0	6	SPT	2	CL	HF	33.7												
SD-103	22.5	7	SPT	6	SP-SM	HA	27.9												
SD-103	27.5	8	SPT	18	SP-SM	HA	29.9												
SD-103	32.5	9	SPT	0	ML	HE	38.6						25	22					
SD-103	37.5	10	SPT	25	SP-SM	HA	29.1												
SD-103	42.5	11	SPT	7	SP-SM	HA	34.3				18.2								
SD-103	47.5	12	SPT	13	SP-SM	HA	40.9												
SD-103	52.5	13	SPT	10	SP-SM	HA	30.8												
SD-103	57.5	14	SPT	1	ML	HE	43.0												
SD-103	62.5	15	SPT	23	SP-SM	HA	36.5												
SD-103	67.5	16	SPT	17	SP-SM	HA	32.0		0.0	87.2	12.8								
SD-103	72.5	17	SPT	20	SP-SM	HA	29.4												
SD-103	77.5	18	SPT	25	SP-SM	HA	27.5												
SD-103	82.5	19	SPT	26	SP-SM	HA	28.8												
SD-103	87.5	20	SPT	16	SP-SM	HA	31.5												
SD-103	92.5	21	SPT	20	SP-SM	HA	26.9												
SD-103	97.5	22	SPT	6	SM	HA	35.6				53.8								
SD-103	102.5	23	SPT	17	SM	HA	34.3												
SD-103	107.5	24	SPT	13	SM	HA	32.8												
SD-103	112.5	25	SPT	21	SM	HA	29.6				26.6								
SD-103	117.5	26	SPT	16	SM	HA	36.4												
SD-103	122.5	27	SPT	18	SM	HA	28.7												
SD-103	127.5	28	SPT	10	ML	HE	37.1												X

(see page 36 for notes)

TABLE D-2
SUMMARY OF LABORATORY TESTING - SODO

Boring No.	Top Depth (feet)	Sample No.	Sample Type[1]	Blow Count (blows/foot)	USCS[2]	Geologic Unit[3]	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses[4]				Plasticity[5]			Other Tests Performed[6]			
									Gravel (%)	Sand (%)	Fines (%)	<2μm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
SD-103	132.5	29	SPT	31	SM	HA	30.2												
SD-103	137.5	30	SPT	19	SM	HA	31.8												
SD-103	142.5	31	SPT	21	SM	HA	34.0												
SD-103	147.5	32	SPT	25	SM	HA	30.5												
SD-103	148.0	32	SPT	25	SM	HA	44.8												
SD-103	152.5	33	SPT	29	SM	HA	33.8												
SD-103	157.5	34	SPT	34	SM	HA	25.4												
SD-103	162.5	35	SPT	2	ML	HE	35.1						31	26					
SD-103	167.5	36	SPT	1	ML	HE	35.0				90.3	10.8							
SD-103	172.5	37	SPT	3	ML	HE	34.1												
SD-103	177.5	38	SPT	5	ML	HE	30.4												
SD-103	182.5	40	SPT	0	ML	HE	39.3						34	29					
SD-103	190.0	42	OSTER	-	ML	HE												X	
SD-103	197.5	44	SPT	3	MH	HE	45.3						51	36					
SD-103	202.5	45	SPT	2	MH	HE	48.4												
SD-103	207.5	46	SPT	1	MH	HE	48.7												
SD-103	212.5	47	SPT	2	MH	HE	32.8												
SD-103	217.5	48	SPT	3	MH	HE	40.8												
SD-103	222.5	49	SPT	0	MH	HE	45.5						55	32					
SD-103	225.0	50	OSTER	-	MH	HE												X	
SD-103	227.5	51	SPT	4	MH	HE	47.8												
SD-103	232.5	52	SPT	86/9"	SC	QPGM	14.3												
SD-103	237.5	53	SPT	31	CH	QPGM	21.1												
SD-103	242.5	54	SPT	61	CH	QPGM	21.6												
SD-103	247.5	55	SPT	65	CH	QPGM	20.6												
SD-103	252.5	56	SPT	65	CL	QPGM	23.7												
SD-103	257.5	57	SPT	70	CL	QPGM	23.1												
SD-103	262.5	58	SPT	69	CL	QPGM	24.0												
SD-103	267.5	59	SPT	88	CL	QPGM	28.0												
SD-104	7.2	1	SPT	3	SP-SM	HF	32.6		0.2	92.8	7.0								

(see page 36 for notes)

TABLE D-2
SUMMARY OF LABORATORY TESTING - SODO

Boring No.	Top Depth (feet)	Sample No.	Sample Type[1]	Blow Count (blows/foot)	USCS[2]	Geologic Unit[3]	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses[4]				Plasticity[5]			Other Tests Performed[6]			
									Gravel (%)	Sand (%)	Fines (%)	<2μm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
SD-104	10.0	2	SPT	4	SP-SM	HF	32.0												
SD-104	12.5	3	SPT	0	SP-SM	HF	56.1												
SD-104	13.2	3	SPT	0	CL	HF	43.1												
SD-104	15.1	4	OSTER	-	CL	HF	43.7						27	17					
SD-104	15.5	4	OSTER	-	SP-SM	HA	29.0												
SD-104	17.5	5	SPT	8	SP-SM	HA	35.0												
SD-104	20.0	6	SPT	13	SP-SM	HA	30.0												
SD-104	25.0	7	SPT	18	SP-SM	HA	29.9												
SD-104	30.0	8	SPT	27	SP-SM	HA	24.3		0.1	93.8	6.2								
SD-104	35.0	9	SPT	28	SP-SM	HA	25.0												
SD-104	40.0	10	SPT	26	SP-SM	HA	24.3												
SD-104	45.0	11	SPT	10	SP-SM	HA	56.5												
SD-104	50.0	12	SPT	10	SP-SM	HA	31.8												
SD-104	55.0	13	SPT	21	SP-SM	HA	39.1												
SD-104	60.0	14	SPT	38	SP	HA	23.9												
SD-104	65.0	15	SPT	20	SP	HA	33.5												
SD-104	70.0	16	SPT	26	SP	HA	32.5												
SD-104	75.0	17	SPT	18	SM	HA	37.6												
SD-104	80.0	18	SPT	16	SM	HA	32.9												
SD-104	85.0	19	SPT	22	SM	HA	32.2												
SD-104	90.0	20	SPT	28	SM	HA	29.5												
SD-104	95.0	21	SPT	25	SM	HA	31.5												X
SD-104	100.0	22	SPT	26	SM	HA	41.6												
SD-104	105.0	23	SPT	11	ML	HA	34.7												
SD-104	105.8	23	SPT	11	ML	HA	33.0												
SD-104	110.0	24	SPT	31	ML	HA	31.6				27.3								
SD-104	110.5	24	SPT	31	ML	HA	36.9												
SD-104	115.0	25	SPT	27	ML	HA	31.2												
SD-104	115.6	25	SPT	27	ML	HA	35.8												
SD-104	120.0	26	SPT	28	ML	HA	34.0												

TABLE D-2
SUMMARY OF LABORATORY TESTING - SODO

Boring No.	Top Depth (feet)	Sample No.	Sample Type[1]	Blow Count (blows/foot)	USCS[2]	Geologic Unit[3]	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses[4]				Plasticity[5]			Other Tests Performed[6]			
									Gravel (%)	Sand (%)	Fines (%)	<2μm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
SD-104	125.0	27	SPT	11	ML	HA	36.6												
SD-104	130.0	28	SPT	21	ML	HA	36.9												
SD-104	130.8	28	SPT	21	ML	HA	32.4												
SD-104	135.5	29	SPT	14	ML	HA	33.9												
SD-104	136.0	29	SPT	14	ML	HA	32.3												
SD-104	140.5	30	SPT	31	ML	HA	28.7												
SD-104	141.0	30	SPT	31	ML	HA	32.4												
SD-104	145.0	31	SPT	38	ML	HA	31.0												
SD-104	150.0	32	SPT	41	ML	HA	25.3												
SD-104	155.0	33	SPT	21	ML	HA	27.5												
SD-104	155.5	33	SPT	21	ML	HA	39.7												
SD-104	160.0	34	SPT	9	ML	HE	40.1												
SD-104	162.5	35	OSTER	-	ML	HE	31.7												
SD-104	164.3	35	OSTER	-	ML	HE	33.0	114											
SD-104	165.0	36	SPT	18	ML	HE	30.1												
SD-104	167.6	37	OSTER	-	ML	HE	33.4												
SD-104	168.3	37	OSTER	-	ML	HE	34.3												
SD-104	170.0	38	SPT	12	ML	HE	32.8												
SD-104	172.5	39	OSTER	-	ML	HE	47.0										X		
SD-104	173.1	39	OSTER	-	ML	HE	34.4	114					0	0	NP				
SD-104	175.0	40	SPT	16	ML	HE	29.9												
SD-104	180.0	41	SPT	16	ML	HE	36.6												
SD-104	185.0	42	SPT	7	ML	HE	35.1												
SD-104	190.0	43	SPT	6	ML	HE	40.5												
SD-104	192.7	44	OSTER	-	MH	HE	45.6												
SD-104	193.7	44	OSTER	-	MH	HE	42.1												
SD-104	195.0	45	SPT	3	MH	HE	43.6						44	35					
SD-104	196.1	45	SPT	3	MH	HE	45.1												
SD-104	200.0	46	SPT	2	MH	HE	44.5												
SD-104	202.5	47	OSTER	-	MH	HE	32.1												

TABLE D-2
SUMMARY OF LABORATORY TESTING - SODO

									Grain-Size Analyses[4]				Plasticity[5]			Other Tests Performed[6]			
Boring No.	Top Depth (feet)	Sample No.	Sample Type[1]	Blow Count (blows/foot)	USCS[2]	Geologic Unit[3]	Water Content (%)	Wet Unit Weight (pcf)	Gravel (%)	Sand (%)	Fines (%)	<2μm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
SD-104	205.0	48	SPT	2	MH	HE	49.8												
SD-104	208.1	49	OSTER	-	MH	HE	52.2												
SD-104	209.0	49	OSTER	-	MH	HE	52.1						67	36			X		
SD-104	210.0	50	SPT	2	MH	HE	52.3												
SD-104	215.4	51	OSTER	-	ML	HE	35.3	112											
SD-104	216.5	51	OSTER	-	ML	HE	34.9	111											
SD-104	217.5	52	SPT	1	ML	HE	38.8						44	28					
SD-104	218.5	52	SPT	1	ML	HE	39.9												
SD-104A	165.4	1	OSTER	-	ML	HE	32.2												
SD-104A	166.0	1	OSTER	-	ML	HE	33.3												
SD-104A	170.0	2	SPT	7	ML	HE	39.4												
SD-104A	175.1	3	OSTER	-	SM	HA	35.9												
SD-104A	180.0	4	SPT	22	ML	HE	35.0												
SD-104A	182.7	5	OSTER	-	ML	HE	39.9												
SD-104A	183.3	5	OSTER	-	ML	HE	35.6						33	26		X			
SD-104A	183.9	5	OSTER	-	ML	HE	40.3												
SD-104A	185.0	6	SPT	5	ML	HE	38.1						33	29					
SD-104A	187.6	7	OSTER	-	ML	HE	38.8												
SD-104A	188.9	7	OSTER	-	ML	HE	43.3												
SD-104A	190.0	8	SPT	2	ML	HE	43.2												
SD-104A	191.2	8	SPT	2	ML	HE	40.4												
SD-104A	192.7	9	OSTER	-	ML	HE	76.6												
SD-104A	193.7	9	OSTER	-	ML	HE	41.2												
SD-104A	194.2	9	OSTER	-	ML	HE	44.0												
SD-104A	195.0	10	SPT	1	ML	HE	41.9												
SD-104A	197.6	11	OSTER	-	MH	HE	47.8												
SD-104A	199.1	11	OSTER	-	MH	HE	41.6												
SD-104A	200.0	12	SPT	15	MH	HE	34.2									X			
SD-104A	202.5	13	OSTER	-	MH	HE	46.2						55	30		X			
SD-104A	203.1	13	OSTER	-	MH	HE	45.7												

TABLE D-2
SUMMARY OF LABORATORY TESTING - SODO

Boring No.	Top Depth (feet)	Sample No.	Sample Type[1]	Blow Count (blows/foot)	USCS[2]	Geologic Unit[3]	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses[4]				Plasticity[5]			Other Tests Performed[6]			
									Gravel (%)	Sand (%)	Fines (%)	<2μm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
SD-104A	203.3	13	OSTER	-	MH	HE	47.4						55	31					
SD-104A	203.8	13	OSTER	-	MH	HE	45.6												
SD-104A	205.0	14	SPT	1	MH	HE	50.1												
SD-104A	208.1	15	OSTER	-	MH	HE	52.9						69	35		X			
SD-104A	208.7	15	OSTER	-	MH	HE	50.7												
SD-104A	210.0	16	SPT	2	MH	HE	57.0				99.4	27.9							
SD-104A	213.4	17	OSTER	-	MH	HE	48.2												
SD-104A	214.1	17	OSTER	-	MH	HE	44.1												
SD-104A	215.0	18	SPT	1	MH	HE	41.9												
SD-104A	218.1	19	OSTER	-	ML	HE	39.9												
SD-104A	218.7	19	OSTER	-	ML	HE	36.8												
SD-104A	219.5	20	SPT	12	ML	HE	37.9												
SD-104A	222.9	21	OSTER	-	ML	HE	43.0												
SD-104A	223.4	21	OSTER	-	ML	HE	39.8												
SD-104A	224.3	21	OSTER	-	ML	HE	36.4												
SD-104A	225.0	22	SPT	7	ML	HE	53.6												
SD-104A	228.3	23	OSTER	-	MH	HE	50.0						63	35		X			
SD-104A	228.9	23	OSTER	-	MH	HE	52.3												
SD-104A	229.5	24	SPT	1	MH	HE	59.4												
SD-104A	235.0	25	SPT	0	MH	HE	53.1						73	37					
SD-104A	240.6	26	OSTER	-	MH	HE	54.2						71	35		X			
SD-104A	241.2	26	OSTER	-	MH	HE	51.3									X			
SD-104A	242.0	27	SPT	6	MH	HE	50.9												
SD-104A	245.0	28	SPT	4	MH	HE	45.3												
SD-104A	250.0	29	SPT	15	MH	HE	36.0												
SD-104A	250.5	29	SPT	15	MH	HE	39.4												
SD-104A	255.0	30	SPT	65/11.5"	MH	HE	39.5												
SD-104A	260.0	31	SPT	50/5"	CH	QPGM	17.3												
SD-104A	265.0	32	SPT	50/5"	ML	QPGM	12.4		7.6	28.4	64.0								
SD-104A	270.0	33	SPT	50/5"	ML	QPGM	15.7												

TABLE D-2
SUMMARY OF LABORATORY TESTING - SODO

Boring No.	Top Depth (feet)	Sample No.	Sample Type[1]	Blow Count (blows/foot)	USCS[2]	Geologic Unit[3]	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses[4]				Plasticity[5]			Other Tests Performed[6]			
									Gravel (%)	Sand (%)	Fines (%)	<2µm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
SD-104A	275.0	34	SPT	50/6"	ML	QPGL	21.0												
SD-104A	280.0	35	SPT	50/3"	ML	QPGL	24.4												
SD-105	6.5	1	SPT	7	SP-SM	HF	27.2												
SD-105	15.0	4	SPT	2	SM	HF	54.9												
SD-105	20.0	6	SPT	10	SP-SM	HA	33.0												
SD-105	22.5	7	SPT	6	SP-SM	HA	34.1												
SD-105	27.5	8	SPT	16	SP-SM	HA	30.9		0.4	93.4	6.3								
SD-105	32.5	9	SPT	14	SP-SM	HA	28.3												
SD-105	37.5	10	SPT	0/18"	ML	HE	38.3												
SD-105	37.6	10	SPT	0/18"	ML	HE	40.1												
SD-105	42.5	12	SPT	14	SM	HA	26.7												
SD-105	57.5	15	SPT	21	SP-SM	HA	31.5												
SD-105	62.5	16	SPT	38	SP-SM	HA	22.2												
SD-105	67.5	17	SPT	24	SP-SM	HA	33.3		0.2	89.9	9.9								
SD-105	72.5	18	SPT	15	SM	HA	35.0												
SD-105	77.5	19	SPT	13	SM	HA	26.8												
SD-105	82.5	20	SPT	14	ML	HE	32.3												
SD-105	87.5	21	SPT	4	ML	HE	34.1												
SD-105	92.5	22	SPT	6	ML	HE	36.3												
SD-105	97.5	23	SPT	1	ML	HE	35.4												
SD-105	102.5	24	SPT	14	SM	HA	44.4												
SD-105	107.5	25	SPT	6	SM	HA	33.2				56.3								
SD-105	112.5	26	SPT	22	SM	HA	32.3												
SD-105	117.5	27	SPT	28	SP-SM	HA	23.6												
SD-105	122.5	28	SPT	14	SP-SM	HA	27.2												
SD-105	123.5	28	SPT	14	SP-SM	HA	35.9												
SD-105	127.5	29	SPT	20	SP-SM	HA	27.3												
SD-105	132.5	30	SPT	7	ML	HE	52.9												
SD-105	137.5	31	SPT	30	SP-SM	HA	24.9												
SD-105	142.5	32	SPT	27	SP-SM	HA	23.5				9.0								

(see page 36 for notes)

TABLE D-2
SUMMARY OF LABORATORY TESTING - SODO

Boring No.	Top Depth (feet)	Sample No.	Sample Type[1]	Blow Count (blows/foot)	USCS[2]	Geologic Unit[3]	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses[4]				Plasticity[5]			Other Tests Performed[6]			
									Gravel (%)	Sand (%)	Fines (%)	<2µm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
SD-105	147.5	33	SPT	19	SP-SM	HA	33.2												
SD-105	152.5	34	SPT	11	ML	HE	37.4												
SD-105	153.3	34	SPT	11	ML	HE	34.1												
SD-105	157.5	35	SPT	16	ML	HE	29.5												
SD-105	158.0	35	SPT	16	ML	HE	38.4				96.7	10.7							
SD-105	162.5	36	SPT	26	SM	HA	30.7												
SD-105	167.5	37	SPT	1	ML	HE	33.1						37	28					
SD-105	168.0	37	SPT	1	ML	HE	36.3												
SD-105	172.5	38	SPT	14	ML	HE	32.8												
SD-105	173.0	38	SPT	14	ML	HE	37.1												
SD-105	177.5	39	SPT	4	ML	HE	34.6												
SD-105	178.5	39	SPT	4	ML	HE	31.4												
SD-105	182.5	40	SPT	1	ML	HE	35.5												
SD-105	183.5	40	SPT	1	ML	HE	38.7												
SD-105	187.5	41	SPT	0	ML	HE	47.6						41	32					
SD-105	188.0	41	SPT	0	ML	HE	43.3												
SD-105	192.5	42	SPT	2	ML	HE	44.9												
SD-105	193.5	42	SPT	2	ML	HE	40.0												
SD-105	197.6	43	OSTER	-	ML	HE	48.0	106											
SD-105	198.3	43	OSTER	-	ML	HE	47.6												
SD-105	202.5	44	SPT	2	MH	HE	50.5												
SD-105	203.5	44	SPT	2	MH	HE	51.6												
SD-105	207.5	45	SPT	3	MH	HE	40.8				93.8	24.2	58	29					
SD-105	208.5	45	SPT	3	MH	HE	41.7												
SD-105	212.5	46	SPT	3	MH	HE	34.3												
SD-105	217.5	47	SPT	3	MH	HE	47.0												
SD-105	227.5	49	SPT	86	ML	QPGL	21.1												
SD-105	232.5	50	SPT	67	ML	QPGL	22.0												
SD-105	237.5	51	SPT	82	ML	QPGL	22.7												
SD-105	242.5	52	SPT	85	ML	QPGL	26.3												

(see page 36 for notes)

TABLE D-2
SUMMARY OF LABORATORY TESTING - SODO

Boring No.	Top Depth (feet)	Sample No.	Sample Type[1]	Blow Count (blows/foot)	USCS[2]	Geologic Unit[3]	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses[4]				Plasticity[5]			Other Tests Performed[6]			
									Gravel (%)	Sand (%)	Fines (%)	<2µm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
SD-106	7.2	1	SPT	12	SP-SM	HF	16.6												
SD-106	10.0	2	SPT	5	SP-SM	HF	29.8												
SD-106	15.0	4	SPT	3	SP-SM	HF	96.1												
SD-106	25.0	7	SPT	15	SP-SM	HF	29.4												
SD-106	30.0	8	SPT	23	SP	HA	26.7		0.0	95.3	4.7								
SD-106	35.0	9	SPT	8	SM	HA	39.1												
SD-106	40.0	10	SPT	18	SP-SM	HA	33.2		0.0	92.9	7.1								
SD-106	45.0	11	SPT	16	SP-SM	HA	37.7												
SD-106	45.7	11	SPT	16	SP-SM	HA	37.3												
SD-106	50.0	12	SPT	17	SP-SM	HA	34.5												
SD-106	55.0	13	SPT	2	ML	HE	40.4						36	28					
SD-106	58.6	14	OSTER	-	ML	HE	45.2												
SD-106	59.0	14	OSTER	-	ML	HE	44.2												
SD-106	60.0	15	SPT	0	ML	HE	41.2												
SD-106	65.0	16	SPT	12	ML	HE	36.9												
SD-106	66.0	16	SPT	12	SP	HA	24.7												
SD-106	70.0	17	SPT	43	SP	HA	23.1		0.0	95.1	4.9								
SD-106	75.0	18	SPT	25	SP	HA	30.9												
SD-106	80.0	19	SPT	11	SM	HA	37.8												
SD-106	85.0	20	SPT	31	SP-SM	HA	30.6												
SD-106	90.0	21	SPT	25	SP-SM	HA	29.4												
SD-106	95.0	22	SPT	33	SP-SM	HA	28.6												
SD-106	100.0	23	SPT	56	SP-SM	HA	23.0		0.0	93.5	6.5								
SD-106	105.0	24	SPT	27	SP-SM	HA	30.3												
SD-106	110.0	25	SPT	36	SP-SM	HA	25.5												
SD-106	115.0	26	SPT	35	SP-SM	HA	28.7												
SD-106	120.0	27	SPT	25	SM	HA	28.9												
SD-106	125.0	28	SPT	23	SM	HA	27.6												
SD-106	130.0	29	SPT	20	SP-SM	HA	28.4												
SD-106	135.0	30	SPT	21	SP-SM	HA	29.1												

(see page 36 for notes)

TABLE D-2
SUMMARY OF LABORATORY TESTING - SODO

Boring No.	Top Depth (feet)	Sample No.	Sample Type[1]	Blow Count (blows/foot)	USCS[2]	Geologic Unit[3]	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses[4]				Plasticity[5]			Other Tests Performed[6]			
									Gravel (%)	Sand (%)	Fines (%)	<2µm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
SD-106	135.8	30	SPT	21	ML	HE	31.1												
SD-106	140.0	31	SPT	13	ML	HE	30.4												
SD-106	145.6	32	OSTER	-	ML	HE	38.4												
SD-106	147.0	33	SPT	22	ML	HE	33.0				76.2		31	29					
SD-106	150.0	34	SPT	8	ML	HE	30.8												
SD-106	155.0	35	SPT	19	ML	HE	37.6												
SD-106	160.0	36	SPT	28	ML	HE	29.7												
SD-106	165.0	37	SPT	5	ML	HE	28.9												
SD-106	170.0	38	SPT	15	ML	HE	32.2												
SD-106	175.0	39	SPT	16	ML	HE	33.4												
SD-106	180.0	40	SPT	4	ML	HE	38.6												
SD-106	185.0	41	SPT	0	ML	HE	41.3						51	31					
SD-106	190.0	42	SPT	4	ML	HE	44.4												
SD-106	191.0	42	SPT	4	CH	HE	44.6						49	33					
SD-106	195.0	43	SPT	5	CH	HE	38.8												
SD-106	196.0	43	SPT	5	CH	HE	50.7												
SD-106	200.0	44	SPT	3	CH	HE	49.7				99.4	28.7	65	31					
SD-106	205.0	45	SPT	7	CH	HE	53.4												
SD-106	210.0	46	SPT	14	CL	QVRL	27.6		2.3	4.4	93.3	14.6							
SD-106	210.6	46	SPT	14	CL	QVRL	25.3						37	21					
SD-106	215.0	47	SPT	61	CL	QVRL	27.9												
SD-106	215.8	47	SPT	61	CL	QPGL	24.0												
SD-106	220.0	48	SPT	50/6"	CL	QPGL	24.4												
SD-106	225.0	49	SPT	50/5"	CL	QPGL	25.0												
SD-106	230.0	50	SPT	50/5"	CL	QPGL	25.5												
SD-106	235.0	51	SPT	50/5"	CL	QPGL	18.2												
SD-106	240.0	52	SPT	50/6"	CL	QPGL	23.4												
SD-106	240.9	52	SPT	50/6"	CL	QPGL	20.7												
SD-107	7.2	1	SPT	3	SP	HF	18.7		0.0	96.7	3.3								
SD-107	10.0	2	SPT	7	SP	HF	26.4												X

(see page 36 for notes)

TABLE D-2
SUMMARY OF LABORATORY TESTING - SODO

Boring No.	Top Depth (feet)	Sample No.	Sample Type[1]	Blow Count (blows/foot)	USCS[2]	Geologic Unit[3]	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses[4]				Plasticity[5]			Other Tests Performed[6]			
									Gravel (%)	Sand (%)	Fines (%)	<2μm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
SD-107	12.5	3	SPT	12	SP	HF	26.3												
SD-107	15.0	4	SPT	14	SP	HF	26.1												
SD-107	17.5	5	SPT	6	ML	HA	33.9												
SD-107	20.0	6	SPT	11	SP	HA	27.7												
SD-107	25.0	7	SPT	15	SP	HA	27.4				4.2								
SD-107	30.0	8	SPT	31	SP	HA	23.9												
SD-107	35.0	9	SPT	21	SP	HA	24.2												
SD-107	40.0	10	SPT	12	SM	HA	32.9				11.6								
SD-107	45.0	11	SPT	35	SM	HA	24.6												
SD-107	50.0	12	SPT	27	SP-SM	HA	27.8												
SD-107	55.0	13	SPT	14	ML	HA	36.5												
SD-107	60.0	14	SPT	3	ML	HA	36.4												
SD-107	65.0	15	SPT	12	ML	HA	32.0				50.2								
SD-107	70.0	16	SPT	2	ML	HA	38.3				86.9								
SD-107	72.7	17	OSTER	-	ML	HA							32	26					
SD-107	73.7	17	OSTER	-	ML	HA	37.2	111											
SD-107	74.5	18	SPT	9	ML	HA	32.9												
SD-107	80.0	19	SPT	1	ML	HE	35.0						34	26					
SD-107	85.0	20	SPT	31	ML	HE	34.2												
SD-107	86.2	20	SPT	31	SP	HA	30.0												
SD-107	90.0	21	SPT	37	SP	HA	25.3												
SD-107	95.0	22	SPT	17	SM	HA	32.4												
SD-107	100.0	23	SPT	22	SM	HA	33.9				23.0								
SD-107	105.0	24	SPT	27	SM	HA	29.7												
SD-107	110.0	25	SPT	26	SM	HA	29.0												
SD-107	115.0	26	SPT	19	ML	HA	31.8				51.2	6.8							
SD-107	120.0	27	SPT	22	ML	HA	30.8												
SD-107	125.0	28	SPT	26	SP	HA	28.1												
SD-107	130.0	29	SPT	30	SP	HA	26.3												
SD-107	135.0	30	SPT	25	SM	HA	29.8												

(see page 36 for notes)

TABLE D-2
SUMMARY OF LABORATORY TESTING - SODO

Boring No.	Top Depth (feet)	Sample No.	Sample Type[1]	Blow Count (blows/foot)	USCS[2]	Geologic Unit[3]	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses[4]				Plasticity[5]			Other Tests Performed[6]			
									Gravel (%)	Sand (%)	Fines (%)	<2µm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
SD-107	140.0	31	SPT	30	SM	HA	33.9				34.2								
SD-107	145.0	32	SPT	28	SM	HA	28.4												X
SD-107	150.0	33	SPT	29	SM	HA	28.7												
SD-107	151.0	33	SPT	29	ML	HA	31.4												
SD-107	155.0	34	SPT	30	ML	HA	27.4												
SD-107	165.0	36	SPT	16	ML	HE	31.2												
SD-107	165.9	36	SPT	16	ML	HE	30.9												
SD-107	170.0	37	SPT	21	ML	HE	29.2												
SD-107	175.0	38	SPT	11	ML	HE	34.8												
SD-107	180.0	39	SPT	12	ML	HE	35.3												
SD-107	181.2	39	SPT	12	ML	HE	35.5												
SD-107	182.7	40	OSTER	-	ML	HE	43.8												
SD-107	183.1	40	OSTER	-	ML	HE	40.6												
SD-107	184.5	41	SPT	8	ML	HE	43.0				99.6	15.8	48	31					
SD-107	190.0	42	SPT	2/12"	ML	HE	46.4												
SD-107	195.0	43	SPT	28	CL	HRW	27.0												
SD-107	200.0	44	SPT	51	CL	HRW	24.9												
SD-107	205.0	45	SPT	43	CL	QPGM	26.3												
SD-107	205.9	45	SPT	43	CL	QPGM	23.4												
SD-107	210.0	46	SPT	72/11"	CL	QPGM	24.2												
SD-107	210.9	46	SPT	72/11"	CL	QPGL	26.7												
SD-107	215.0	47	SPT	50/6"	CL	QPGL	23.9												
SD-107	220.0	48	SPT	50/6"	CL	QPGL	27.3												
SD-107	225.0	49	SPT	50/6"	CL	QPGL	31.9												
SD-108	8.0	1	SPT	9	SP-SM	HF	26.7												
SD-108	11.5	3	3SS	5	SM	HF	71.0												
SD-108	13.0	4	SPT	2	SM	HF	156.6												
SD-108	20.0	7	SPT	11	SP-SM	HA	31.9												
SD-108	25.0	8	SPT	12	SP-SM	HA	33.2												
SD-108	30.0	9	SPT	14	SP-SM	HA	27.4				5.2								

(see page 36 for notes)

TABLE D-2
SUMMARY OF LABORATORY TESTING - SODO

Boring No.	Top Depth (feet)	Sample No.	Sample Type^1	Blow Count (blows/foot)	USCS^2	Geologic Unit^3	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses^4				Plasticity^5			Other Tests Performed^6			
									Gravel (%)	Sand (%)	Fines (%)	<2µm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
SD-108	35.0	10	SPT	28	SP-SM	HA	25.7												
SD-108	40.0	11	SPT	18	SP-SM	HA	31.6												
SD-108	45.0	12	SPT	4	ML	HA	36.0						30	27					X
SD-108	50.0	13	SPT	18	SP-SM	HA	33.0				8.5								
SD-108	55.0	14	SPT	13	SP-SM	HA	32.1												
SD-108	60.0	15	SPT	22	SP-SM	HA	30.9												
SD-108	65.0	16	SPT	25	SM	HA	30.1				7.6								
SD-108	70.0	17	SPT	25	SM	HA	36.6												
SD-108	85.0	20	SPT	8	ML	HE	35.6												
SD-108	90.0	21	SPT	6	ML	HE	30.0												
SD-108	95.0	22	SPT	0	CL	HE	33.9												
SD-108	105.0	24	SPT	0	CL	HE	33.8						33	25					
SD-108	109.0	26	SPT	29	ML	HA	26.6												
SD-108	115.0	27	SPT	18	ML	HE	31.9												
SD-108	120.0	28	SPT	32	SM	HA	30.7												
SD-108	125.0	29	SPT	23	SM	HA	35.5				64.4								
SD-108	130.0	30	SPT	47	SM	HA	29.7												
SD-108	135.0	31	SPT	42	SM	HA	32.4												
SD-108	140.0	32	SPT	20	ML	HE	32.8												
SD-108	145.0	33	SPT	47	SM	HA	27.4												
SD-108	150.0	34	SPT	33	SM	HA	32.2												
SD-108	155.0	35	SPT	33	SM	HA	28.0												
SD-108	160.0	36	SPT	3	CL	HE	40.2						40	29					
SD-108	165.0	37	SPT	35	ML	HA	30.7												
SD-108	170.0	38	SPT	12	ML	HA	31.6												
SD-108	175.0	39	SPT	3	ML	HE	35.0				97.2	12.4							
SD-108	180.0	40	SPT	0	ML	HE	39.2						39	30					
SD-108	182.5	41	OSTER	-	ML	HE	43.1						45	32			X		
SD-108	183.1	41	OSTER	-	ML	HE	43.9												
SD-108	184.0	42	SPT	29	ML	HE	41.9						49	32					

(see page 36 for notes)

TABLE D-2
SUMMARY OF LABORATORY TESTING - SODO

Boring No.	Top Depth (feet)	Sample No.	Sample Type[1]	Blow Count (blows/foot)	USCS[2]	Geologic Unit[3]	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses[4]				Plasticity[5]			Other Tests Performed[6]			
									Gravel (%)	Sand (%)	Fines (%)	<2µm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
SD-108	190.0	43	SPT	0	ML	HE	46.1												
SD-108	195.0	44	SPT	64	CL	QPGL	30.1						38	24					
SD-108	200.0	45	SPT	50/5"	CL	QVGL	29.9						42	20					
SD-108	205.0	46	SPT	60	CL	QVGL	25.5												
SD-108	210.0	47	SPT	50/6"	CH	QPGM	22.7												
SD-108	215.0	48	SPT	81	CH	QPGM	25.8												
SD-108	220.0	49	SPT	50/5"	CH	QPGM	27.6												
SD-108	225.0	50	SPT	69	CH	QPGM	21.8												
SD-108	230.0	51	SPT	54	CH	QPGM	29.6												
SD-108	235.0	52	SPT	73	CH	QPGM	21.8												
SD-108	240.0	53	SPT	76	CH	QPGM	17.8												
SD-108	245.0	54	SPT	41	CH	QPGM	32.1												
SD-109	5.3	-	GRAB	-	SM	HF													X
SD-109	7.5	1	SPT	3	SM	HF	33.7												
SD-109	12.5	3	SPT	3	SM	HF	36.4												
SD-109	13.0	3	SPT	3	SM	HF	30.6												
SD-109	15.0	4	SPT	8	SM	HF	40.3												
SD-109	16.0	4	SPT	8	SM	HF	29.0												
SD-109	17.5	5	SPT	13	SM	HF	30.2				20.2								
SD-109	20.0	6	SPT	4	SM	HF	30.9												
SD-109	22.5	7	SPT	12	SP-SM	HA	26.8												
SD-109	27.5	8	SPT	14	SP-SM	HA	25.2												
SD-109	32.5	9	SPT	20	SP-SM	HA	27.0												
SD-109	37.5	10	SPT	21	SP-SM	HA	25.0		1.9	89.5	8.6								
SD-109	42.5	11	SPT	24	SP-SM	HA	26.5												
SD-109	47.5	12	SPT	8	SP-SM	HA	33.2				4.9								
SD-109	52.5	13	SPT	9	SP-SM	HA	46.6												
SD-109	57.5	14	SPT	18	SM	HA	33.3												
SD-109	62.5	15	SPT	0	SM	HE	41.7												
SD-109	64.0	16	OSTER	-	SM	HE	29.6												

(see page 36 for notes)

TABLE D-2
SUMMARY OF LABORATORY TESTING - SODO

Boring No.	Top Depth (feet)	Sample No.	Sample Type[1]	Blow Count (blows/foot)	USCS[2]	Geologic Unit[3]	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses[4]				Plasticity[5]			Other Tests Performed[6]			
									Gravel (%)	Sand (%)	Fines (%)	<2μm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
SD-109	64.3	16	OSTER	-	SM	HE	37.7												
SD-109	67.5	17	SPT	23	SP	HA	28.7												
SD-109	72.5	18	SPT	20	SP	HA	34.2												
SD-109	77.5	19	SPT	20	SP	HA	30.5				4.3								
SD-109	82.5	20	SPT	3	SM	HA	37.1												
SD-109	85.6	21	OSTER	-	SM	HA	33.7												
SD-109	86.6	21	OSTER	-	SM	HA	32.2												
SD-109	87.0	22	SPT	13	SM	HA	32.8												
SD-109	92.5	23	SPT	18	SM	HA	30.7												
SD-109	97.5	24	SPT	22	SP-SM	HA	28.2												
SD-109	102.5	25	SPT	4	SM	HA	36.0												
SD-109	107.5	26	SPT	6	SM	HA	38.8				59.9								
SD-109	112.5	27	SPT	12	SM	HA	52.4												
SD-109	113.6	27	SPT	12	SM	HA	36.4												
SD-109	117.5	28	SPT	23	SM	HA	31.9												
SD-109	118.3	28	SPT	23	SM	HA	27.8												
SD-109	122.5	29	SPT	19	SM	HA	35.5												
SD-109	127.5	30	SPT	14	SM	HA	33.9												
SD-109	132.5	31	SPT	3	ML	HE	31.3												
SD-109	137.5	32	SPT	4	CL	HE	40.9						40	30					
SD-109	142.5	33	SPT	6	CL	HE	39.8				99.2	14.5							
SD-109	145.5	34	OSTER	-	CL	HE	43.8												
SD-109	147.5	35	SPT	3	CL	HE	34.4												
SD-109	152.5	36	SPT	25	SM	HA	34.4												
SD-109	157.5	37	SPT	24	SM	HA	31.6												
SD-109	162.5	38	SPT	2	ML	HE	37.0												
SD-109	167.5	39	SPT	13	ML	HE	32.4												
SD-109	172.5	40	SPT	22	SP-SM	HA	27.7												
SD-109	177.5	41	SPT	26	SP-SM	HA	24.4												
SD-109	182.5	42	SPT	12	CL	HE	39.1												

(see page 36 for notes)

TABLE D-2
SUMMARY OF LABORATORY TESTING - SODO

Boring No.	Top Depth (feet)	Sample No.	Sample Type[1]	Blow Count (blows/foot)	USCS[2]	Geologic Unit[3]	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses[4]				Plasticity[5]			Other Tests Performed[6]			
									Gravel (%)	Sand (%)	Fines (%)	<2µm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
SD-109	187.5	43	SPT	13	CL	HE	43.5												
SD-109	192.5	44	SPT	4	CL	HE	47.9												
SD-109	197.5	45	SPT	2	CL	HE	44.1		0.0	11.9	88.1	23.0							
SD-109	202.5	46	SPT	10	SM	HRW	22.3												
SD-109	207.5	47	SPT	4	CH	QVRL	34.6						50	27					
SD-109	212.5	48	SPT	50/6"	SM	QPGO	21.9												
SD-109	217.5	49	SPT	50/5"	SP-SM	QPGO	20.5												
SD-109	227.5	51	SPT	50/6"	SP-SM	QPGO	9.0												
SD-109	232.5	52	SPT	35	CH	QPGL	34.6												
SD-110	5.0	1	SPT	2	GM	HF	10.4												
SD-110	7.5	2	SPT	4	ML	HF	37.9												
SD-110	10.0	3	SPT	1	SM	HF	40.7												
SD-110	12.5	4	SPT	9	SM	HF	23.2												
SD-110	15.0	5	SPT	0	CH	HE	60.4						58	25					
SD-110	17.5	6	SPT	2	CH	HE	59.1												
SD-110	18.4	6	SPT	2	ML	HE	37.6												
SD-110	20.0	7	SPT	10	SP-SM	HA	28.4												
SD-110	22.5	8	SPT	11	SP-SM	HA	28.1		0.0	94.3	5.7								
SD-110	27.5	9	SPT	8	SP-SM	HA	29.2												
SD-110	32.5	10	SPT	17	SP-SM	HA	28.8												
SD-110	37.5	11	SPT	24	SP-SM	HA	23.7												
SD-110	42.5	12	SPT	6	SM	HA	42.4												
SD-110	47.5	13	SPT	3	SM	HA	42.5												
SD-110	52.5	14	SPT	15	SP-SM	HA	35.3												
SD-110	57.5	15	SPT	15	SP-SM	HA	33.5				9.7								
SD-110	62.5	16	SPT	15	SP-SM	HA	26.7												
SD-110	67.5	17	SPT	3	SM	HA	33.8												
SD-110	72.5	18	SPT	9	SM	HA	30.0												
SD-110	77.5	19	SPT	15	SM	HA	38.3												
SD-110	82.5	20	SPT	6	SM	HA	35.7				44.5								

(see page 36 for notes)

TABLE D-2
SUMMARY OF LABORATORY TESTING - SODO

Boring No.	Top Depth (feet)	Sample No.	Sample Type[1]	Blow Count (blows/foot)	USCS[2]	Geologic Unit[3]	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses[4]				Plasticity[5]			Other Tests Performed[6]			
									Gravel (%)	Sand (%)	Fines (%)	<2µm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
SD-110	87.5	21	SPT	12	SM	HA	30.7												
SD-110	92.5	22	SPT	10	SM	HA	34.1												
SD-110	97.5	23	SPT	16	SM	HA	34.1												
SD-110	102.5	24	SPT	12	SM	HA	29.5												
SD-110	107.5	25	SPT	11	SM	HA	37.7												
SD-110	112.5	26	SPT	2	ML	HE	32.5												
SD-110	117.5	27	SPT	14	SP-SM	HA	36.7												
SD-110	122.5	28	SPT	21	SP-SM	HA	26.8												
SD-110	127.5	29	SPT	14	SP-SM	HA	32.3												
SD-110	132.5	30	SPT	4	SM	HA	34.3												
SD-110	137.5	31	SPT	2	ML	HE	37.6												
SD-110	142.5	32	SPT	1	ML	HE	36.6						41	30					
SD-110	147.5	33	SPT	0	ML	HE	22.8												
SD-110	152.5	35	SPT	0	ML	HE	42.8												
SD-110	162.5	37	SPT	0	ML	HE	45.6												
SD-110	167.5	38	SPT	27	SM	HA	42.9												
SD-110	172.5	39	SPT	0	ML	HE	39.8												
SD-110	177.5	40	SPT	0	ML	HE	38.9												
SD-110	182.5	41	SPT	0	ML	HE	29.7												
SD-110	187.5	43	SPT	0	ML	HE	24.7		2.1	56.8	41.1	11.6							
SD-110	192.5	44	SPT	22	SC	HRW	21.9												
SD-110	197.5	45	SPT	60	SM	QPGO	21.6												
SD-110	202.5	46	SPT	91	SM	QPGO	17.8												
SD-110	207.5	47	SPT	46	SM	QPGO	22.9												
SD-110	212.5	48	SPT	24	CL	QPGM	24.1												
SD-110	217.5	49	SPT	28	CL	QPGM	22.2												
SD-110	227.5	50	SPT	34	CL	QPGM	28.3												
SD-110	247.5	51	SPT	94	CL	QPGM	24.7												
SD-111	7.0	1	SPT	3	SP-SM	HF	4.0												
SD-111	12.5	2	SPT	3	SP-SM	HF	39.0												

(see page 36 for notes)

TABLE D-2
SUMMARY OF LABORATORY TESTING - SODO

Boring No.	Top Depth (feet)	Sample No.	Sample Type[1]	Blow Count (blows/foot)	USCS[2]	Geologic Unit[3]	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses[4]				Plasticity[5]			Other Tests Performed[6]			
									Gravel (%)	Sand (%)	Fines (%)	<2µm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
SD-111	15.0	3	SPT	0	CH	HF	63.0												
SD-111	17.5	4	SPT	0	CH	HF	53.3						53	25					
SD-111	20.0	5	SPT	17	SM	HA	31.5												
SD-111	25.0	6	SPT	15	SP-SM	HA	26.7												
SD-111	30.0	7	SPT	29	SP-SM	HA	27.3												
SD-111	35.0	8	SPT	35	SP-SM	HA	27.4				7.1								
SD-111	35.2	8	SPT	35	SP-SM	HA	74.2												
SD-111	40.0	9	SPT	24	SP-SM	HA	32.2												
SD-111	45.0	10	SPT	12	SP-SM	HA	36.8												X
SD-111	50.0	11	SPT	5	ML	HE	35.5												
SD-111	55.0	12	SPT	18	SP-SM	HA	38.2												
SD-111	60.0	13	SPT	27	SP-SM	HA	29.1												
SD-111	65.0	14	SPT	28	SP-SM	HA	34.2		0.0	90.8	9.2								
SD-111	70.0	15	SPT	21	SM	HA	39.9												
SD-111	75.0	16	SPT	10	SM	HA	32.0												
SD-111	80.0	17	SPT	16	SM	HA	33.1												
SD-111	85.0	18	SPT	23	SM	HA	33.1												
SD-111	90.0	19	SPT	9	SM	HA	34.7												
SD-111	95.0	20	SPT	31	SM	HA	29.3												
SD-111	100.0	21	SPT	23	SM	HA	31.1												
SD-111	105.0	22	SPT	21	ML	HE	32.9				52.7								
SD-111	110.0	23	SPT	11	ML	HE	36.5												
SD-111	115.0	24	SPT	15	SM	HA	28.3												
SD-111	120.0	25	SPT	34	SM	HA	29.4												
SD-111	125.0	26	SPT	22	SM	HA	40.5												
SD-111	130.0	27	SPT	27	SM	HA	29.3												
SD-111	135.0	28	SPT	28	SM	HA	37.9												
SD-111	140.0	29	SPT	10	SM	HA	29.2												
SD-111A	130.0	1	SPT	34	SM	HA	32.4												
SD-111A	135.0	2	SPT	27	SM	HA	32.0												

(see page 36 for notes)

TABLE D-2
SUMMARY OF LABORATORY TESTING - SODO

Boring No.	Top Depth (feet)	Sample No.	Sample Type[1]	Blow Count (blows/foot)	USCS[2]	Geologic Unit[3]	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses[4]				Plasticity[5]			Other Tests Performed[6]			
									Gravel (%)	Sand (%)	Fines (%)	<2μm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
SD-111A	140.0	3	SPT	3	SM	HA	32.3												
SD-111A	145.0	4	SPT	49	SP-SM	HA	26.1												
SD-111A	150.0	5	SPT	0	ML	HE	35.8						34	27					
SD-111A	155.0	6	SPT	0	ML	HE	35.4												
SD-111A	160.0	7	SPT	0	ML	HE	38.1												
SD-111A	165.0	8	SPT	0	ML	HE	45.0						48	30					
SD-111A	170.2	9	OSTER	-	ML	HE	33.0	115											
SD-111A	171.4	9	OSTER	-	SM	HB	23.5	121											
SD-111A	172.5	10	SPT	3	SM	HB	19.3												
SD-111A	175.0	11	SPT	25	SM	HB	22.0												
SD-111A	180.0	12	SPT	14	CL	QVRL	31.9						41	19					
SD-111A	185.0	13	SPT	50/5"	SP-SM	QPGO	21.7												
SD-111A	190.0	14	SPT	50/4"	SP-SM	QPGO	21.8												
SD-111A	195.0	15	SPT	50/5"	SP-SM	QPGO	17.5												
SD-111A	200.0	16	SPT	50/4"	SP-SM	QPGO	14.7												
SD-111A	205.0	17	SPT	90/11"	SC	QPGM	12.4												
SD-111A	210.0	18	SPT	50/4"	SC	QPGM	10.9												
SD-111A	215.0	19	SPT	53	CH	QPGL	26.0												
SD-112	7.5	1	SPT	7	SM	HF	34.7												
SD-112	10.0	2	SPT	11	SM	HF	14.4												
SD-112	12.5	3	SPT	4	SP-SM	HA	32.2		0.0	93.8	6.2								
SD-112	15.0	4	SPT	0	CH	HL	69.0						65	25					
SD-112	18.3	5	OSTER	-	CH	HL	50.9	106											
SD-112	19.5	6	SPT	0	CH	HL	55.7												
SD-112	25.0	7	SPT	12	SP-SM	HA	29.0												
SD-112	30.0	8	SPT	13	SP-SM	HA	31.5				15.9								
SD-112	35.0	9	SPT	37	SP-SM	HA	28.0												
SD-112	40.0	10	SPT	33	SP-SM	HA	28.7												
SD-112	45.0	11	SPT	3	SM	HE	39.0				26.7								
SD-112	50.0	12	SPT	5	SM	HE	34.7												

TABLE D-2
SUMMARY OF LABORATORY TESTING - SODO

Boring No.	Top Depth (feet)	Sample No.	Sample Type[1]	Blow Count (blows/foot)	USCS[2]	Geologic Unit[3]	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses[4]				Plasticity[5]			Other Tests Performed[6]			
									Gravel (%)	Sand (%)	Fines (%)	<2μm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
SD-112	55.0	13	SPT	27	SP-SM	HA	29.5												
SD-112	60.0	14	SPT	22	SP-SM	HA	31.9												
SD-112	65.0	15	SPT	11	ML	HE	35.4												
SD-112	70.0	16	SPT	5	ML	HE	44.6												
SD-112	75.0	17	SPT	22	SM	HE	30.9				24.3								
SD-112	80.0	18	SPT	18	SM	HE	31.4												
SD-112	85.0	19	SPT	14	SM	HE	30.0												
SD-112	90.0	20	SPT	4	ML	HE	32.8												
SD-112	95.0	21	SPT	23	SM	HE	29.3												
SD-112	100.0	22	SPT	21	SM	HE	32.6												
SD-112	105.0	23	SPT	10	SM	HE	34.6												
SD-112	110.0	24	SPT	23	SM	HE	28.7				45.5								
SD-112	115.0	25	SPT	31	SP-SM	HA	27.4												
SD-112	120.0	26	SPT	34	SP-SM	HA	26.8												
SD-112	125.0	27	SPT	27	SP-SM	HA	27.0												
SD-112	130.0	28	SPT	17	ML	HE	32.0												
SD-112	135.0	29	SPT	11	ML	HE	33.3												
SD-112	140.0	30	SPT	5	ML	HE	41.4						48	29					
SD-112	142.1	31	OSTER	-	ML	HE	41.4	109					45	30		X			
SD-112	142.8	31	OSTER	-	ML	HE	41.9	108											
SD-112	142.9	31	OSTER	-	ML	HE	42.3						44	29		X			
SD-112	144.0	32	SPT	14	ML	HE	40.5												
SD-112	150.0	33	SPT	0	ML	HE	36.9												
SD-112	155.0	34	SPT	26	SM	HB	19.9		12.1	70.9	17.1								
SD-112	160.0	35	SPT	24	SM	HB	19.2												
SD-112	165.0	36	SPT	50/6"	SP-SM	QPGO	14.8												
SD-112	170.0	37	SPT	50/5"	SP-SM	QPGO	17.7												
SD-112	175.0	38	SPT	50/5"	SP-SM	QPGO	11.4												
SD-112	180.0	39	SPT	48	GM	QPGM	7.4												
SD-112	185.0	40	SPT	77	GM	QPGM	24.5												

(see page 36 for notes)

TABLE D-2
SUMMARY OF LABORATORY TESTING - SODO

Boring No.	Top Depth (feet)	Sample No.	Sample Type[1]	Blow Count (blows/foot)	USCS[2]	Geologic Unit[3]	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses[4]				Plasticity[5]			Other Tests Performed[6]			
									Gravel (%)	Sand (%)	Fines (%)	<2µm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
SD-112	190.0	41	SPT	41	CL	QPGL	32.2												
SD-112	195.0	42	SPT	53	CL	QPGL	29.4						48	23					
SD-112	200.0	43	SPT	83	CL	QPGL	30.3												
SD-112	205.0	44	SPT	50/5"	CL	QPGL	30.8												
SD-113	7.5	1	SPT	2	SM	HF	15.8												
SD-113	10.0	2	SPT	5	SM	HF	10.5				31.3								
SD-113	12.5	3	SPT	11	SP-SM	HA	24.4												
SD-113	15.0	4	SPT	0	CL	HF	60.7												
SD-113	17.5	5	SPT	0	CL	HF	52.4						50	24					
SD-113	20.0	6	SPT	0	CL	HF	41.2												X
SD-113	25.0	7	SPT	10	SP-SM	HA	28.8												
SD-113	30.0	8	SPT	13	SP-SM	HA	32.3		0.0	92.9	7.1								
SD-113	35.0	9	SPT	24	SP-SM	HA	27.8												
SD-113	40.0	10	SPT	11	SP-SM	HA	31.4												
SD-113	45.0	11	SPT	17	SP-SM	HA	37.9												
SD-113	50.0	12	SPT	22	SP-SM	HA	30.3		0.1	93.3	6.6								
SD-113	55.0	13	SPT	27	SP-SM	HA	31.5												
SD-113	60.0	14	SPT	26	SP-SM	HA	28.0												
SD-113	65.0	15	SPT	23	SP-SM	HA	35.2												
SD-113	70.0	16	SPT	22	SP-SM	HA	34.9												
SD-113	75.0	17	SPT	19	SM	HA	33.2												
SD-113	80.0	18	SPT	13	SM	HA	34.0												
SD-113	85.0	19	SPT	21	SM	HA	29.0				18.8								
SD-113	90.0	20	SPT	28	SP-SM	HA	26.8												
SD-113	95.0	21	SPT	14	ML	HA	29.9												
SD-113	100.0	22	SPT	12	ML	HA	33.1				48.1								
SD-113	105.0	23	SPT	8	ML	HA	33.1												
SD-113	110.0	24	SPT	0	ML	HE	39.8						37	32					
SD-113	115.0	25	SPT	30	SP-SM	HA	26.9												
SD-113	120.0	26	SPT	1	ML	HE	34.3												

(see page 36 for notes)

TABLE D-2
SUMMARY OF LABORATORY TESTING - SODO

Boring No.	Top Depth (feet)	Sample No.	Sample Type^1	Blow Count (blows/foot)	USCS^2	Geologic Unit^3	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses^4				Plasticity^5			Other Tests Performed^6			
									Gravel (%)	Sand (%)	Fines (%)	<2µm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
SD-113	125.0	27	SPT	7	ML	HE	35.8				74.3								
SD-113	130.0	28	SPT	6	ML	HE	34.5				70.6	7.7							
SD-113	135.0	29	SPT	0	ML	HE	41.7												
SD-113	140.0	30	SPT	33	ML	HRW	23.5												
SD-113	145.0	31	SPT	37	ML	HRW	25.8												
SD-113	150.0	32	SPT	54	ML	QPGL	29.8												
SD-113	155.0	33	SPT	49	ML	QPGL	28.9						34	26					
SD-113	160.0	34	SPT	72	CL	QPGL	34.0												
SD-113	165.0	35	SPT	50	CL	QPGL	31.0												
SD-113	170.0	36	SPT	54	CL	QPGL	28.6												
SD-113	175.0	37	SPT	58	CL	QPGL	26.0												
SD-114	7.0	1	SPT	4	CH	HF	26.9												
SD-114	12.5	3	SPT	15	CH	HF	33.5												
SD-114	15.0	4	SPT	1	CH	HF	45.6												
SD-114	17.5	5	SPT	1	CH	HF	36.8												
SD-114	20.0	6	SPT	1	CH	HF	47.0						50	27					
SD-114	25.0	7	SPT	12	SP	HA	28.2												
SD-114	30.0	8	SPT	15	SP	HA	27.0		0.1	94.6	5.3								
SD-114	35.0	9	SPT	17	SP-SM	HA	32.1												
SD-114	40.0	10	SPT	10	SP-SM	HA	32.8												
SD-114	45.0	11	SPT	13	SP-SM	HA	33.3												
SD-114	50.0	12	SPT	12	SP-SM	HA	42.6												X
SD-114	55.0	13	SPT	16	SP-SM	HA	31.5		0.0	89.3	10.7								
SD-114	60.0	14	SPT	2	SM	HE	33.1												
SD-114	60.5	14	SPT	2	SM	HE	34.3												
SD-114	63.0	15	OSTER	-	SM	HE	36.5												
SD-114	63.3	15	OSTER	-	SM	HE	33.9												
SD-114	65.0	16	SPT	11	SM	HE	30.9												
SD-114	70.0	17	SPT	11	SM	HA	43.2												
SD-114	75.0	18	SPT	3	ML	HE	36.1												

(see page 36 for notes)

TABLE D-2
SUMMARY OF LABORATORY TESTING - SODO

Boring No.	Top Depth (feet)	Sample No.	Sample Type[1]	Blow Count (blows/foot)	USCS[2]	Geologic Unit[3]	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses[4]				Plasticity[5]			Other Tests Performed[6]			
									Gravel (%)	Sand (%)	Fines (%)	<2μm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
SD-114	80.0	19	SPT	21	SM	HA	31.4												
SD-114	85.0	20	SPT	31	SM	HA	29.4		0.0	83.7	16.3								
SD-114	90.0	21	SPT	21	SM	HA	38.5												
SD-114	95.0	22	SPT	14	SM	HA	35.2												
SD-114	100.0	23	SPT	3	ML	HE	39.0												
SD-114	105.0	24	SPT	5	ML	HE	36.6						30	27					
SD-114	107.8	25	OSTER	-	ML	HE	33.9	120											
SD-114	108.6	25	OSTER	-	ML	HE	33.7	113											
SD-114	108.8	25	OSTER	-	ML	HE	34.5						34	27			X		
SD-114	110.0	26	SPT	3	ML	HE	35.5												
SD-114	120.0	28	SPT	50/4"	SC	QPGM	15.4												
SD-114	125.0	29	SPT	100/10"	SC	QPGM	16.6												
SD-114	130.0	30	SPT	92	SC	QPGM	7.9												
SD-114	135.0	31	SPT	50/5"	CL	QPGL	33.5												
SD-114	140.0	32	SPT	83/11"	CL	QPGL	31.9												
SD-114	145.0	33	SPT	71	CL	QPGL	33.0												
SD-114	150.0	34	SPT	76	CL	QPGL	34.1												
SD-114	155.0	35	SPT	42	CL	QPGL	31.0												
SD-114	160.0	36	SPT	43	CH	QPGM	29.5												
SD-115	12.5	3	SPT	1	CH	HF	67.4												
SD-115	15.0	4	SPT	0	CH	HF	62.3						59	24					
SD-115	17.5	5	SPT	0	CH	HF	61.1												X
SD-115	20.0	6	SPT	0	CH	HF	63.8												
SD-115	25.0	7	SPT	2	SM	HE	27.9				50.8								
SD-115	30.0	8	SPT	18	SM	HE	28.5		0.0	93.6	6.4								
SD-115	35.0	9	SPT	25	SM	HE	30.6												
SD-115	40.0	10	SPT	24	SP	HA	66.1												
SD-115	40.3	10	SPT	24	SP	HA	27.1				4.1								
SD-115	45.0	11	SPT	30	SP	HA	27.5												
SD-115	50.0	12	SPT	22	SP-SM	HA	63.1												

(see page 36 for notes)

TABLE D-2
SUMMARY OF LABORATORY TESTING - SODO

Boring No.	Top Depth (feet)	Sample No.	Sample Type[1]	Blow Count (blows/foot)	USCS[2]	Geologic Unit[3]	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses[4]				Plasticity[5]			Other Tests Performed[6]			
									Gravel (%)	Sand (%)	Fines (%)	<2μm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
SD-115	50.3	12	SPT	22	SP-SM	HA	25.9		0.0	93.1	6.9								
SD-115	55.0	13	SPT	5	SP-SM	HA	33.8												
SD-115	55.8	13	SPT	5	ML	HE	37.6												
SD-115	60.0	14	SPT	4	ML	HE	30.4												
SD-115	65.0	15	SPT	4	ML	HE	34.4				63.1								
SD-115	70.0	16	SPT	2	ML	HE	37.9						32	29					
SD-115	75.0	17	SPT	18	SP-SM	HA	28.8												
SD-115	80.0	18	SPT	5	ML	HE	34.7												
SD-115	85.0	19	SPT	2	ML	HE	35.4												
SD-115	90.0	20	SPT	27	GM	HRW	8.0												
SD-115	95.0	21	SPT	54	GM	HRW	12.6												
SD-115	95.5	21	SPT	54	CL	QPGL	28.8												
SD-115	100.0	22	SPT	46	CL	QPGL	33.8						57	20					
SD-115	105.0	23	SPT	50/4"	ML	QPGM	22.4												
SD-115	110.0	24	SPT	54	ML	QPGM	27.7												
SD-115	120.0	26	SPT	50/5"	ML	QPGM	26.1												
SD-115	125.0	27	SPT	50/6"	SM	QPGM	11.0		20.6	53.0	26.4								
SD-115	130.0	28	SPT	50/3"	ML	QPGM	24.2												
SD-115	135.0	29	SPT	56	ML	QPGL	35.2												
SD-116	3.0	-	GRAB	-	SM	HF													X
SD-116	12.5	2	SPT	2	SM	HF	48.1												
SD-116	15.0	3	SPT	2	CH	HF	67.8												
SD-116	17.5	4	SPT	0	CH	HF	55.8						52	25					
SD-116	20.0	5	SPT	0	CH	HF	60.8												
SD-116	21.0	5	SPT	0	SP-SM	HA	40.7												
SD-116	25.0	6	SPT	11	SP-SM	HA	31.7				7.5								
SD-116	30.0	7	SPT	10	SP-SM	HA	30.0												
SD-116	35.0	8	SPT	25	SM	HA	30.3				44.5								
SD-116	40.0	9	SPT	25	SM	HA	36.5												
SD-116	45.0	10	SPT	18	SM	HA	33.6												

(see page 36 for notes)

TABLE D-2
SUMMARY OF LABORATORY TESTING - SODO

Boring No.	Top Depth (feet)	Sample No.	Sample Type[1]	Blow Count (blows/foot)	USCS[2]	Geologic Unit[3]	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses[4]				Plasticity[5]			Other Tests Performed[6]			
									Gravel (%)	Sand (%)	Fines (%)	<2µm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
SD-116	50.0	11	SPT	0	ML	HE	35.3												
SD-116	60.0	13	SPT	0	ML	HE	40.0						36	28					
SD-116	65.0	14	SPT	0	ML	HE	44.0												X
SD-116	70.0	15	SPT	44	GW-GM	HRW	10.0												
SD-116	75.0	16	SPT	85	CL	QPGM	21.1												X
SD-116	80.0	17	SPT	50/6"	CL	QPGM	27.9												
SD-116	85.0	18	SPT	50/5"	CL	QPGM	28.3												
SD-116	90.0	19	SPT	50/3"	SC	QPGM	21.1												
SD-116	95.0	20	SPT	50/4"	SC	QPGM	19.5												
SD-116	100.0	21	SPT	57	SC	QPGM	25.4												
SD-116	105.0	22	SPT	50/4"	SC	QPGM	17.1												
SD-116	110.0	23	SPT	50/3"	SC	QPGM	12.0												
SD-116	115.0	24	SPT	50/3"	SC	QPGM	14.0												
SD-116	120.0	25	SPT	86	ML	QPGL	34.6												
SD-117	4.5	-	GRAB	-	SP-SM	HF													
SD-117	15.0	3	SPT	27	GP	HF	9.2												X
SD-117	17.5	4	SPT	7	GP	HF	18.4												
SD-117	25.0	6	SPT	2	ML	HE	49.9						55	35					
SD-117	30.0	7	SPT	0	ML	HE	39.9												
SD-117	35.0	8	SPT	0	CL	HE	47.6						44	30					
SD-117	42.0	10	SPT	3	CL	HE	41.8				99.2	19.7							
SD-117	45.1	11	OSTER	-	CL	HE	44.2												
SD-117	46.1	11	OSTER	-	CL	HE	46.5												
SD-117	47.0	12	SPT	1	CL	HE	41.4						43	27					
SD-117	50.0	13	SPT	0	CL	HE	52.5												
SD-117	55.0	14	SPT	0	CL	HE	45.3												
SD-117	60.0	15	SPT	14	CH	QVRL	39.2						49	22					X
SD-117	65.0	16	SPT	9	CH	QVRL	35.3												
SD-117	70.0	17	SPT	50/5"	SC	QPGM	9.7												
SD-117	75.0	18	SPT	50/5"	SC	QPGM	12.7												

(see page 36 for notes)

TABLE D-2
SUMMARY OF LABORATORY TESTING - SODO

Boring No.	Top Depth (feet)	Sample No.	Sample Type[1]	Blow Count (blows/foot)	USCS[2]	Geologic Unit[3]	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses[4]				Plasticity[5]			Other Tests Performed[6]			
									Gravel (%)	Sand (%)	Fines (%)	<2µm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
SD-117	80.0	19	SPT	50/5"	SC	QPGM	16.9												
SD-117	85.0	20	SPT	70	SC	QPGM	17.3												
SD-117	90.0	21	SPT	50/5"	SM	QPNF	8.1												
SD-117	95.0	22	SPT	50/5"	SM	QPNF	17.5												
SD-117	100.0	23	SPT	90/10"	SM	QPNF	13.2												
SD-117	105.0	24	SPT	50/6"	SM	QPNF	18.5												
SD-117	110.0	25	SPT	50/4"	SM	QPNF	24.9												
SD-118	10.0	1	SPT	4	SM	HF	27.4		2.5	71.9	25.6								
SD-118	12.5	2	SPT	13	SM	HF	26.2												
SD-118	15.0	3	SPT	14	SM	HF	26.6												
SD-118	17.5	4	SPT	3	SM	HF	26.6												
SD-118	20.0	5	SPT	1	CL	HE	40.3												
SD-118	25.0	6	SPT	0	CL	HE	46.5												
SD-118	27.0	7	OSTER	-	CL	HE	47.2												
SD-118	27.5	7	OSTER	-	CL	HE	54.3												
SD-118	30.0	8	SPT	1	CL	HE	45.2												
SD-118	35.0	9	SPT	0	CL	HE	47.9				99.2	22.0	48	30					X
SD-118	40.0	10	SPT	0	CL	HE	43.3												
SD-118	50.0	12	SPT	1	CL	HE	30.9												
SD-118	55.0	13	SPT	14	SM	HE	65.4												
SD-118	55.3	13	SPT	14	CH	QVRL	32.9												
SD-118	60.0	14	SPT	29	GC	QPNF	16.7												
SD-118	61.5	15	OSTER	-	GC	QPNF	34.3						36	21					
SD-118	61.8	15	OSTER	-	GC	QPNF	13.6												
SD-118	65.0	16	SPT	84	GC	QPNF	9.1												
SD-118	70.0	17	SPT	65	GC	QPNF	6.3												
SD-118	70.8	17	SPT	65	SM	QPNF	68.3												
SD-118	80.0	18	SPT	73	SM	QPNF	12.4		28.2	50.0	21.8								
SD-118	80.8	18	SPT	73	SM	QPNF	23.4												
SD-118	85.0	19	SPT	85/11"	SM	QPNF	11.0												

(see page 36 for notes)

TABLE D-2
SUMMARY OF LABORATORY TESTING - SODO

Boring No.	Top Depth (feet)	Sample No.	Sample Type[1]	Blow Count (blows/foot)	USCS[2]	Geologic Unit[3]	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses[4]				Plasticity[5]			Other Tests Performed[6]			
									Gravel (%)	Sand (%)	Fines (%)	<2μm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
SD-118	90.0	20	SPT	50/6"	GP	QPNF	12.9												
SD-118	95.0	21	SPT	78	GP	QPNF	10.6		53.6	43.1	3.3								
SD-118	100.0	22	SPT	38	GP	QPNF	10.8												
SD-118	105.0	23	SPT	31	GP	QPNF	5.7												
SD-119	3.5	-	GRAB	-	SM	HF													X
SD-119	8.0	1	SPT	1	SM	HF	28.7		4.4	60.6	34.9								
SD-119	15.0	4	SPT	7	PT	HF	94.4												
SD-119	17.5	5	SPT	50/5"	PT	HF	164.5												
SD-119	20.0	6	SPT	3	GP-GM	HF	11.2												
SD-119	20.5	6	SPT	3	GP-GM	HF	57.8						60	39					
SD-119	34.0	11	3SS	-	CL	HE	57.1												
SD-119	39.0	13	3SS	-	CL	HE	43.9												
SD-119	42.5	14	SPT	1	CL	HE	44.6						51	29					
SD-119	47.5	15	SPT	4	CL	HE	49.0												
SD-119	52.5	16	SPT	8	OL	HP	210.1												
SD-119	53.5	16	SPT	8	CH	QVRL	28.3												
SD-119	57.5	17	SPT	12	CH	QVRL	83.3												
SD-119	62.5	18	SPT	65	GW-GM	QPNF	19.8		0.0	92.7	7.3								X
SD-119	67.5	19	SPT	47	GW-GM	QPNF	10.1												
SD-119	77.5	21	SPT	50/3"	GW-GM	QPNF	12.0												
SD-119	82.5	22	SPT	50/6"	GW-GM	QPNF	13.0												
SD-119	87.5	23	SPT	50/6"	GW-GM	QPNF	11.3												
SD-119	99.3	28	SPT	101/7"	SM	QPNF	9.6												
SD-119	102.5	29	SPT	100/6"	SM	QPNF	13.0												
SD-119	107.5	30	SPT	150/7"	SM	QPNF	11.2												
SD-119	112.5	31	SPT	108/7"	SM	QPNF	11.3												
SD-119	117.5	32	SPT	100/6"	SM	QPNF	10.9												
SD-120	10.0	1	SPT	2	SM	HF	21.0				20.7								
SD-120	12.5	2	SPT	3	SM	HF	21.1												
SD-120	15.0	3	SPT	34	GP	HF	15.1												

(see page 36 for notes)

TABLE D-2
SUMMARY OF LABORATORY TESTING - SODO

Boring No.	Top Depth (feet)	Sample No.	Sample Type[1]	Blow Count (blows/foot)	USCS[2]	Geologic Unit[3]	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses[4]				Plasticity[5]			Other Tests Performed[6]			
									Gravel (%)	Sand (%)	Fines (%)	<2µm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
SD-120	17.5	4	SPT	30	GP	HF	16.7												
SD-120	25.0	6	SPT	6	SP-SM	HB	19.5				20.0								
SD-120	30.0	7	SPT	16	SP-SM	HB	14.0												
SD-120	35.0	8	SPT	36	SP-SM	HB	11.5		35.2	55.9	8.9								
SD-120	40.0	9	SPT	52	SP-SM	HB	9.8												
SD-120	45.0	10	SPT	23	SM	HB	21.6												
SD-120	50.0	11	SPT	50/5"	GM	HLS	12.9												
SD-120	55.0	12	SPT	91/10"	ML	HLS	34.1												
SD-120	55.4	12	SPT	91/10"	ML	HLS	20.6												
SD-120	60.0	13	SPT	50/4"	SP-SM	QPNF	19.1		0.0	92.8	7.2								
SD-120	65.0	14	SPT	50/3"	ML	QPNL	52.1												
SD-120	70.0	15	SPT	50/5.5"	ML	QPNL	25.7												
SD-120	75.0	16	SPT	50/5.5"	ML	QPNL	24.8												
SD-120	80.0	17	SPT	99/10"	ML	QPNL	26.7												
SD-120	85.0	18	SPT	100/10"	ML	QPNL	23.8												
SD-120	90.0	19	SPT	50/4"	SP-SM	QPNF	17.6												
SD-120	95.0	20	SPT	50/5"	SP-SM	QPNF	19.4												
SD-120	100.0	21	SPT	50/5"	SP-SM	QPNF	16.4												
SD-120	105.0	22	SPT	50/5"	SP-SM	QPNF	14.4												
SD-120	110.0	23	SPT	50/5.5"	CH	QPNL	29.6												
SD-120	115.0	24	SPT	99/10"	CH	QPNL	35.9												
SD-120	120.0	25	SPT	85/10"	CH	QPNL	29.2												
SD-121	7.0	1	SPT	28	GP-GM	HF	5.5												
SD-121	10.5	3	SPT	4	GP-GM	HF	8.4												
SD-121	15.0	5	SPT	1	GP-GM	HF	30.9				23.5								
SD-121	17.5	6	SPT	4	SM	HF	66.6												
SD-121	20.0	7	SPT	2	SM	HF	73.6												
SD-121	21.0	7	SPT	2	ML	HE	51.8												
SD-121	23.5	8	SPT	5	ML	HE	48.8												
SD-121	27.5	9	SPT	23	SC	HB	11.9												

(see page 36 for notes)

TABLE D-2
SUMMARY OF LABORATORY TESTING - SODO

Boring No.	Top Depth (feet)	Sample No.	Sample Type^1	Blow Count (blows/foot)	USCS^2	Geologic Unit^3	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses^4				Plasticity^5			Other Tests Performed^6			
									Gravel (%)	Sand (%)	Fines (%)	<2μm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
SD-121	32.5	10	SPT	40	SC	HB	11.6		22.6	67.0	10.4								
SD-121	42.5	12	SPT	30	SC	HB	7.9												
SD-121	52.5	14	SPT	26	GC	HLS	23.8						55	23					
SD-121	57.5	15	SPT	44	GC	HLS	5.7												
SD-121	62.5	16	SPT	50	GC	HLS	17.4												
SD-121	67.5	17	SPT	67	ML	QPNL	47.9												
SD-121	72.5	18	SPT	66	ML	QPNL	23.0												
SD-121	73.5	18	SPT	66	ML	QPNL	23.2												
SD-121	77.5	19	SPT	100	ML	QPNL	30.3												
SD-121	82.5	20	SPT	50/5"	ML	QPNL	22.3												
SD-121	87.5	21	SPT	50/5"	SP-SM	QPNF	18.0												
SD-121	92.5	22	SPT	50/4.5"	SP-SM	QPNF	21.5												
SD-121	97.5	23	SPT	60/6"	SP-SM	QPNF	25.5												
SD-121	102.5	24	SPT	50/5"	SP-SM	QPNF	18.0												
SD-121	107.5	25	SPT	62/5.5"	SP-SM	QPNF	15.2												
SD-122	2.5	-	GRAB	-	SP	HF													X
SD-122	7.0	1	SPT	0	ML	HF	41.6												
SD-122	10.0	2	SPT	0	CH	HF	84.1												
SD-122	11.0	2	SPT	0	CH	HF	53.5						51	25					
SD-122	12.5	3	SPT	1	CH	HF	59.8												
SD-122	15.0	4	SPT	1	CH	HF	59.3												
SD-122	17.5	5	SPT	1	CH	HF	58.9												
SD-122	18.5	5	SPT	1	CH	HF	41.3												
SD-122	20.0	6	SPT	10	CH	HF	66.6												
SD-122	20.5	6	SPT	10	SP	HA	26.6												
SD-122	22.5	7	SPT	11	SP	HA	28.3												
SD-122	27.5	8	SPT	12	SP	HA	30.7												
SD-122	32.5	9	SPT	19	SP	HA	28.6												
SD-122	37.5	10	SPT	8	ML	HE	40.4												
SD-122	37.7	10	SPT	8	SP-SM	HA	26.7												

(see page 36 for notes)

TABLE D-2
SUMMARY OF LABORATORY TESTING - SODO

Boring No.	Top Depth (feet)	Sample No.	Sample Type[1]	Blow Count (blows/foot)	USCS[2]	Geologic Unit[3]	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses[4]				Plasticity[5]			Other Tests Performed[6]			
									Gravel (%)	Sand (%)	Fines (%)	<2μm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
SD-122	42.5	11	SPT	6	SP-SM	HA	41.0				11.0								
SD-122	47.5	12	SPT	7	SP-SM	HA	39.5												
SD-122	57.5	14	SPT	13	SP-SM	HA	30.9												
SD-122	62.5	15	SPT	7	SP-SM	HA	36.4												
SD-122	67.5	16	SPT	12	SP-SM	HA	33.1				10.7								
SD-122	72.5	17	SPT	9	SP-SM	HA	49.4												
SD-122	77.5	18	SPT	8	SP-SM	HA	37.7												
SD-122	82.5	19	SPT	1	ML	HA	44.4												
SD-122	87.5	20	SPT	12	SP-SM	HA	71.3												
SD-122	92.5	21	SPT	10	SP-SM	HA	36.1												
SD-122	97.5	22	SPT	15	SP-SM	HA	35.0												
SD-122	102.5	23	SPT	12	SM	HA	34.3												
SD-122	107.5	24	SPT	16	SM	HA	30.3												
SD-122	112.5	25	SPT	21	SM	HA	57.0												
SD-122	117.5	26	SPT	25	SM	HA	24.2												
SD-122	127.5	28	SPT	9	ML	HA	37.9				55.8								
SD-122	132.5	29	SPT	14	ML	HA	36.6												
SD-122	137.5	30	SPT	8	ML	HA	33.3												
SD-122	142.5	31	SPT	1	ML	HE	32.9												
SD-122	147.5	33	SPT	0	ML	HE	40.7				96.8	15.3	42	29					
SD-122	160.0	36	OSTER	-	ML	HE												X	
SD-122	162.5	37	SPT	0	ML	HE	50.1											X	
SD-122	167.5	38	SPT	12	ML	HE	28.9												
SD-122	172.5	39	SPT	0	ML	HE	40.2						38	29					
SD-122	177.5	40	SPT	0	ML	HE	35.5												
SD-122	182.5	41	SPT	2	SC	HRW	15.7												
SD-122	187.5	42	SPT	19	SC	HRW	14.9												
SD-122	192.5	43	SPT	93	SP-SM	QPGO	21.2												
SD-122	197.5	44	SPT	71	SP-SM	QPGO	16.4												
SD-122	198.0	44	SPT	71	ML	QPGT	7.7												

TABLE D-2
SUMMARY OF LABORATORY TESTING - SODO

Boring No.	Top Depth (feet)	Sample No.	Sample Type[1]	Blow Count (blows/foot)	USCS[2]	Geologic Unit[3]	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses[4]				Plasticity[5]			Other Tests Performed[6]			
									Gravel (%)	Sand (%)	Fines (%)	<2µm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
SD-122	203.5	45	SPT	74	SM	QPGO	18.2												
SD-122	204.0	45	SPT	74	CL	QPGL	28.4						41	27					
SD-122	207.5	46	SPT	28	CL	QPGL	28.5												
SD-122	212.5	47	SPT	32	CL	QPGL	24.0						50	22					
SD-122	217.5	48	SPT	34	CL	QPGL	24.6												
SD-122	222.5	49	SPT	28	CL	QPGL	25.6												
SD-122	227.0	51	SPT	32	CL	QPGL	31.3												
SD-122	232.5	52	SPT	51	CL	QPGL	30.6												
SD-205	10.0	2	SPT	50/5"	SM	HF	16.3												
SD-205	12.5	3	SPT	8	SM	HF	72.2												
SD-205	17.5	5	SPT	8	SM	HF	35.4				22.7								
SD-205	20.0	6	SPT	2	SM	HF	33.2												
SD-205	25.0	7	SPT	2	OH	HE	45.8												
SD-205	35.0	9	SPT	0	OH	HE	50.9						52	27					
SD-205	40.0	10	SPT	0	OH	HE	52.2												
SD-205	45.0	11	SPT	0	OH	HE	56.7												
SD-205	50.5	13	SPT	4	OH	HE	37.8												
SD-205	55.0	14	SPT	9	PT	HP	264.0												
SD-205	56.0	14	SPT	9	CL	QVRL	31.4												
SD-205	60.0	15	SPT	74	SM	QPNF	15.0												
SD-205	65.0	16	SPT	93/11"	GM	QPNF	7.1												
SD-205	70.0	17	SPT	50/6"	GM	QPNF	13.3												
SD-205	75.0	18	SPT	50/2"	GM	QPNF	5.0												
SD-205	85.0	20	SPT	100/5"	GM	QPNF	8.8												
SD-205	90.0	21	SPT	150/5"	GM	QPNF	12.4												
SD-205	95.0	22	SPT	83/6"	SP-SM	QPNF	12.8												
SD-205	100.0	23	SPT	83/6"	SP-SM	QPNF	13.0												
SD-205	105.0	24	SPT	133/6"	SP-SM	QPNF	18.0												
SD-205	110.0	25	SPT	78/6"	SP-SM	QPNF	15.3												
SD-205	115.0	26	SPT	150/5"	SM	QPNF	20.7												

TABLE D-2
SUMMARY OF LABORATORY TESTING - SODO

Boring No.	Top Depth (feet)	Sample No.	Sample Type[1]	Blow Count (blows/foot)	USCS[2]	Geologic Unit[3]	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses[4]				Plasticity[5]			Other Tests Performed[6]			
									Gravel (%)	Sand (%)	Fines (%)	<2µm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
SD-205	125.0	28	SPT	250/4"	SM	QPNF	11.3												
SD-205	130.0	29	SPT	300/3"	SM	QPNF	7.5												
SD-206	7.5	1	SPT	8	CL	HF	22.7												
SD-206	10.0	2	SPT	4	CL	HF	16.2												
SD-206	12.5	3	SPT	3	CL	HF	16.5												
SD-206	15.0	4	SPT	7	CL	HF	13.7												
SD-206	17.5	5	SPT	6	SM	HF	16.6												
SD-206	18.5	5	SPT	6	SM	HF	18.1												
SD-206	20.0	6	SPT	5	SM	HF	22.7												
SD-206	21.0	6	SPT	5	SM	HF	24.8												
SD-206	30.0	8	SPT	5	SM	HF	29.6												
SD-206	35.0	9	SPT	12	GP-GM	HB	31.6												
SD-206	40.0	10	SPT	11	PT	HE	330.3												
SD-206	50.0	12	SPT	5	GM	HB	22.4		0.3	67.3	32.5								
SD-206	55.0	13	SPT	12	GM	HB	12.4												
SD-206	60.0	14	SPT	42	GM	HB	11.8												
SD-206	65.0	15	SPT	26	SC	HLS	16.1		0.4	66.9	32.7	11.2	35	16					
SD-206	70.0	16	SPT	19	SC	HLS	23.1												
SD-206	75.0	17	SPT	59	SC	HLS	12.9												
SD-206	80.0	18	SPT	56	SC	HLS	16.8												
SD-206	85.0	19	SPT	43	SC	HLS	11.3												
SD-206	95.0	21	SPT	22	SC	HLS	17.7												
SD-206	100.0	22	SPT	8	CL	HLS	21.3		2.7	29.6	67.7	12.0							
SD-206	105.0	23	SPT	50/3"	CL	HLS	10.5												
SD-206A	60.0	1	SPT	57	SC	HLS	11.0												
SD-206A	70.0	2	SPT	31	SC	HLS	20.6		5.2	44.7	50.1	17.9							
SD-206A	80.0	3	SPT	90	SC	HLS	11.0												
SD-206A	90.0	4	SPT	89	SC	HLS	13.6												
SD-206A	95.0	5	SPT	60	SC	HLS	17.5												
SD-206A	100.0	6	SPT	44	SC	HLS	17.5		11.6	56.8	31.6	9.2							

(see page 36 for notes)

TABLE D-2
SUMMARY OF LABORATORY TESTING - SODO

Boring No.	Top Depth (feet)	Sample No.	Sample Type[1]	Blow Count (blows/foot)	USCS[2]	Geologic Unit[3]	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses[4]				Plasticity[5]			Other Tests Performed[6]			
									Gravel (%)	Sand (%)	Fines (%)	<2μm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
SD-206A	105.0	7	SPT	91	SC	HLS	17.9												
SD-206A	110.0	8	SPT	50/4"	SP-SM	QPNF	17.2		1.8	87.8	10.4								
SD-206A	115.0	9	SPT	100/5.5"	SP-SM	QPNF	18.6												
SD-206A	120.0	10	SPT	100/4"	SP-SM	QPNF	13.3												
SD-206A	125.0	11	SPT	100/5"	SP-SM	QPNF	7.8												
SD-206A	130.0	12	SPT	50/6"	ML	QPNL	26.7												
SD-206A	135.0	13	SPT	50/6"	ML	QPNL	26.1												
TOTAL NUMBER OF TESTS:							1048	14	46		112	21	81			9	4	4	19

NOTES:

1. SPT = Standard Penetration Test (split-spoon) sample. 3SS = 3-inch Split Spoon. PT = Pitcher Tube sample. OSTER = Osterberg tube sample. GRAB = Grab Sample.
2. USCS = Unified Soil Classification System. See Figure A-1 in Appendix A for explanation of classifications.
3. See Table A-1 for a description of the geologic units.
4. See Appendix D.1 for plots of the grain-size curves. Gravel = percent larger than 3/4 inch. Sand = percent of soil between 3/4 inch and 0.08 mm. Fines = percent passing the No. 200 sieve (0.08 mm). 2 mm = micrometers = clay fraction
5. See Appendix D.2 for plasticity (Atterberg Limits) plots.
6. See Appendix D.3 through D.6 for triaxial test, consolidation test, cyclic shear test, and corrosion test results.

APPENDIX D.1

GRAIN SIZE DISTRIBUTION

APPENDIX D.1

GRAIN SIZE DISTRIBUTION

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Figure No.

LIST OF FIGURES (CONT.)

Figure No.

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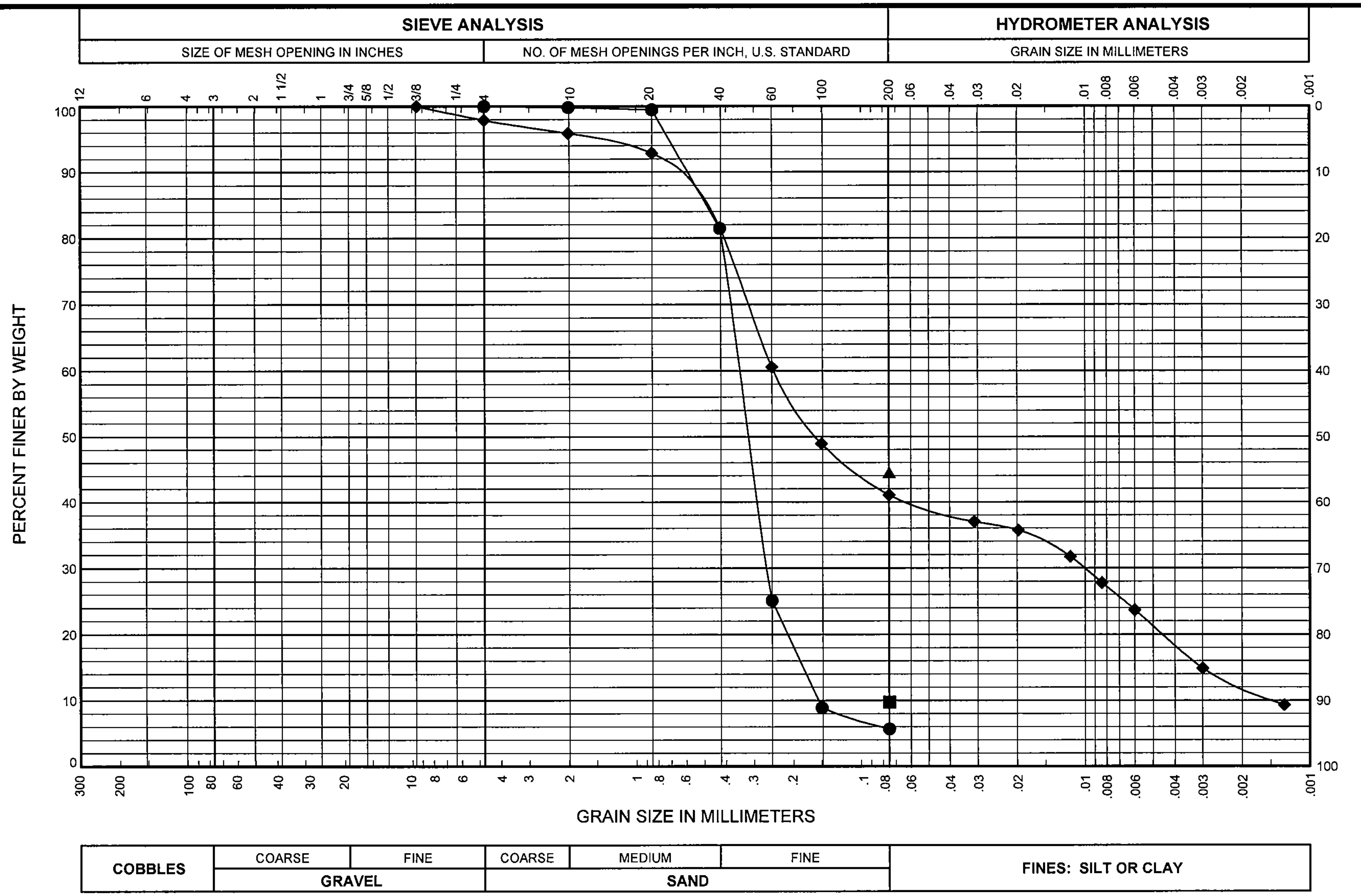
Figure No.



BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● SD-110, S-8	22.5	SP-SM	Dark gray-brown, slightly silty, fine to medium SAND	5.7	28.1			
■ SD-110, S-15	57.5	SP-SM	Dark gray-brown, slightly silty, fine to medium SAND; scattered organics	9.7	33.5			
▲ SD-110, S-20	82.5	SM	Dark gray-brown, silty, fine SAND, trace of gravel; scattered organics	44.5	35.7			
◆ SD-110, S-43	187.5	SC	Gray-brown, silty, clayey SAND, trace of gravel; scattered shell fragments	41.1	24.7			

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Seattle, Washington

GRAIN SIZE DISTRIBUTION
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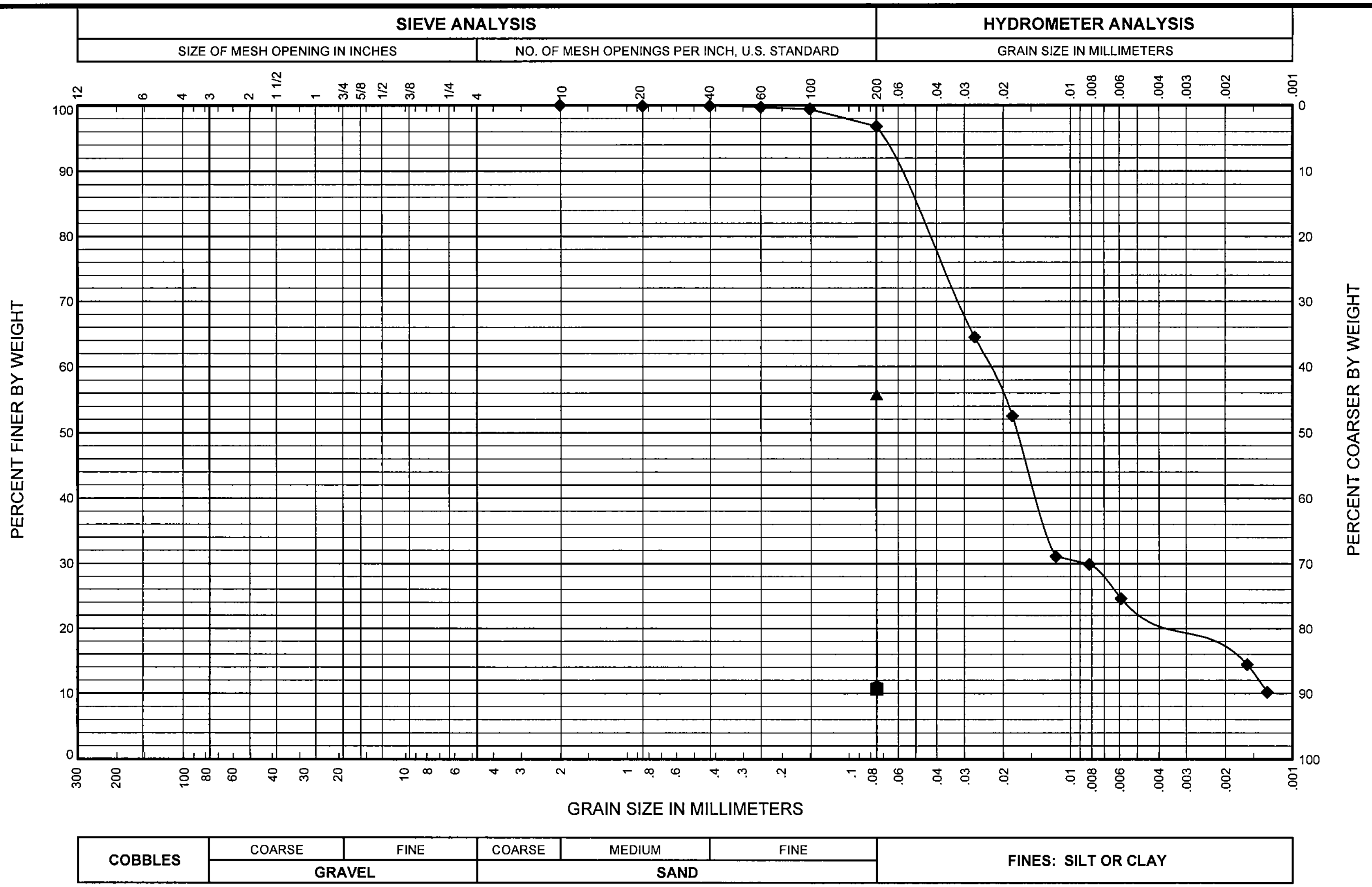
FIG. D.1-28

GSA-SMP 21-09910.GPJ SHAN WIL.GDT 12/17/03



BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● SD-122, S-11	42.5	SP-SM	Dark gray, slightly silty, fine to medium SAND; scattered wood fragments	11.0	41.0			
■ SD-122, S-16	67.5	SP-SM	Dark gray, slightly silty, fine SAND; scattered organics	10.7	33.1			
▲ SD-122, S-28	127.5	ML	Dark brown-gray, fine sandy SILT; scattered organics	55.8	37.9			
◆ SD-122, S-33	147.5	ML	Dark gray-brown, clayey SILT, trace of sand; scattered shell fragments	96.8	40.7	42	29	13

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BORING SD-122

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FIG. D.1-40

FIG. D.1-40

APPENDIX D.2

ATTERBERG LIMITS

APPENDIX D.2

ATTERBERG LIMITS

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Figure No.

LIST OF FIGURES (CONT.)

Figure No.

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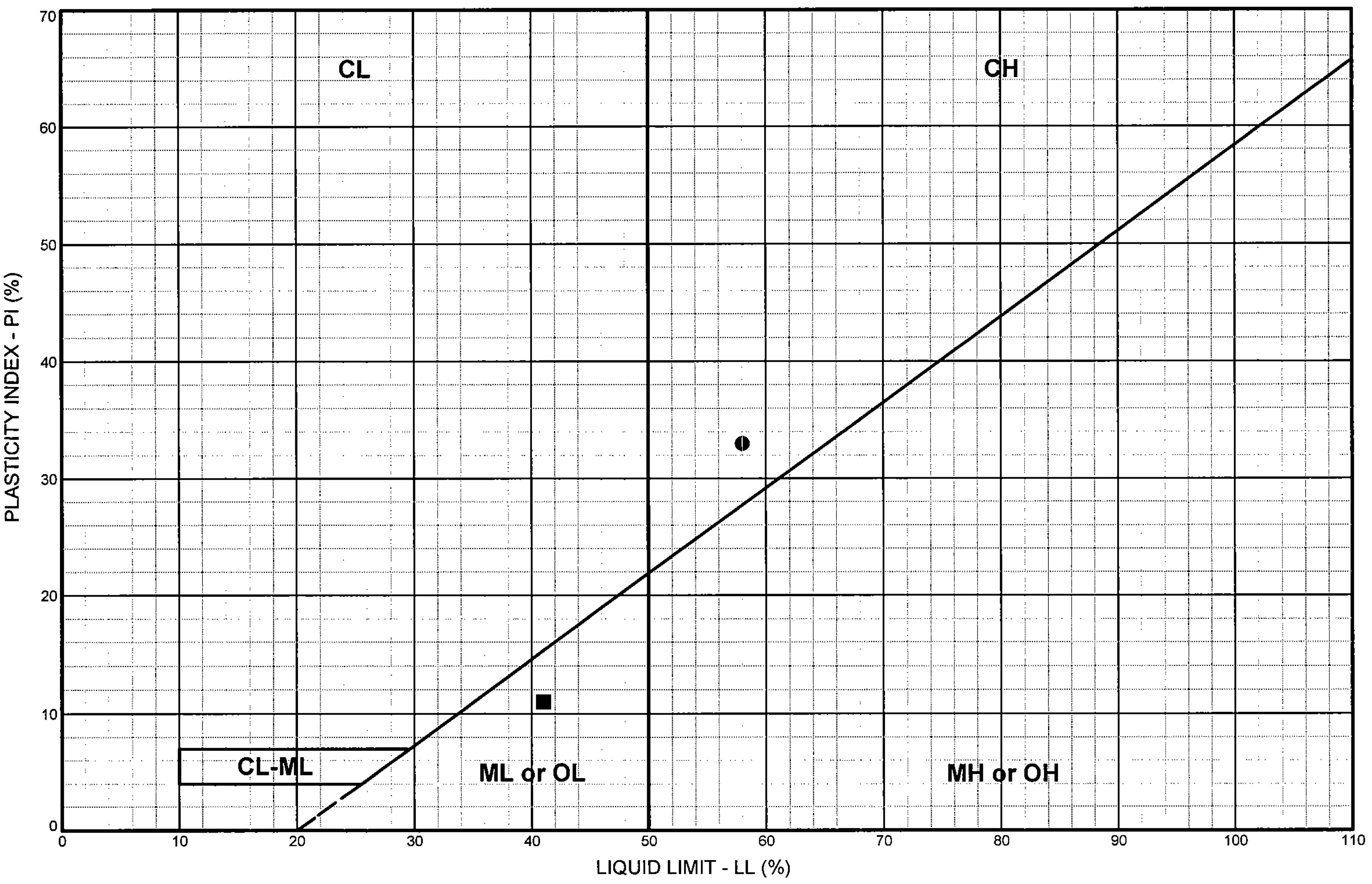
Figure No.



LEGEND

- **CL:** Low plasticity inorganic clays; sandy and silty clays
- **CH:** High plasticity inorganic clays
- **ML or OL:** Inorganic and organic silts and clayey silts of low plasticity
- **MH or OH:** Inorganic and organic silts and clayey silts of high plasticity
- **CL-ML:** Silty clays and clayey silts

BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	LL %	PL %	PI %	NAT. W.C. %	PASS. #200, %
● SD-110, S-5	15.0	CH	Gray, silty CLAY	58	25	33	60.4	
■ SD-110, S-32	142.5	ML	Dark gray, clayey SILT; scattered shell fragments	41	30	11	36.6	

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PLASTICITY CHART
BORING SD-110

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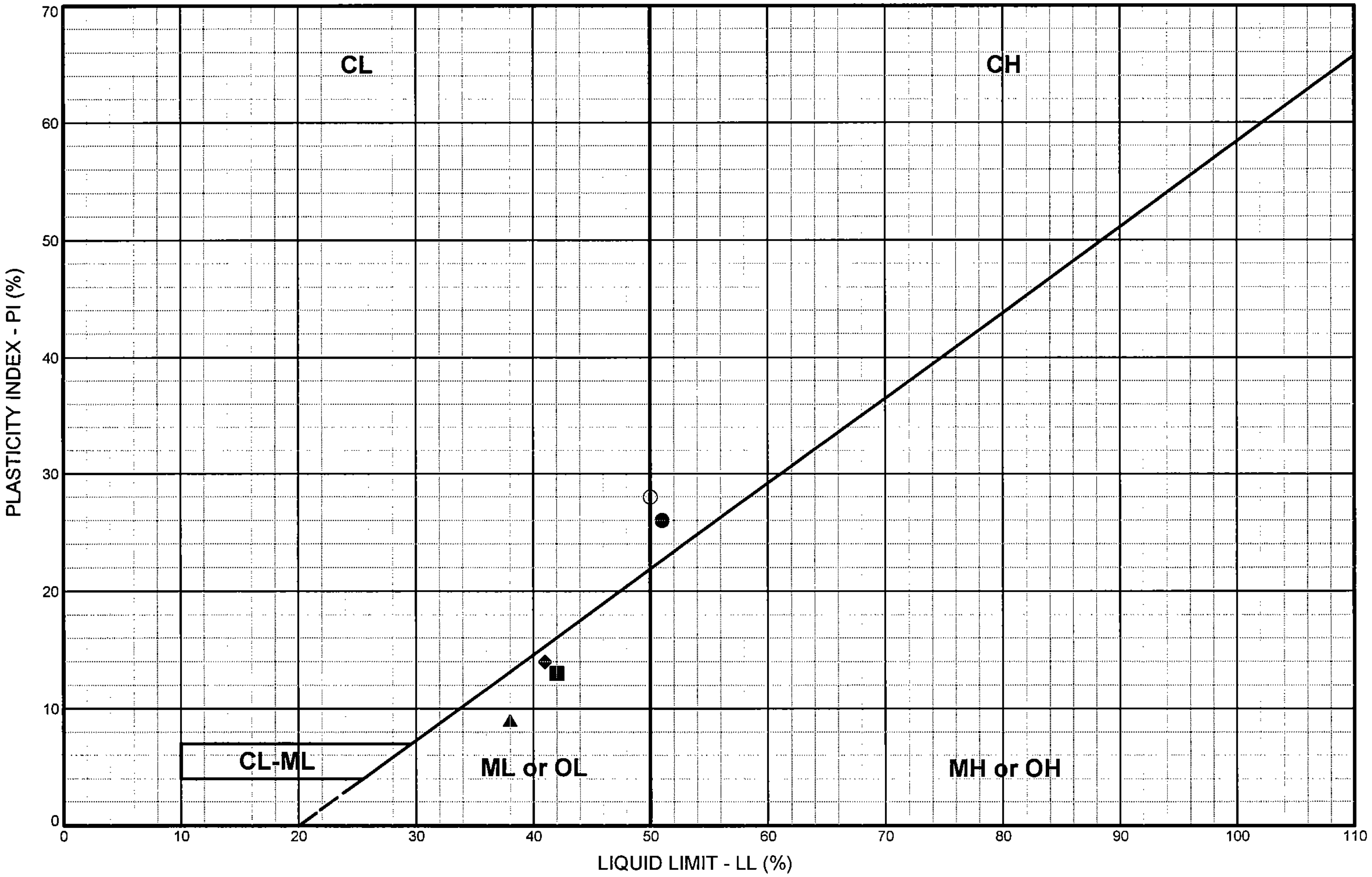
FIG. D.2-24

FIG. D.2-24



LEGEND

CL: Low plasticity inorganic clays; sandy and silty clays

CH: High plasticity inorganic clays

ML or OL: Inorganic and organic silts and clayey silts of low plasticity

MH or OH: Inorganic and organic silts and clayey silts of high plasticity

CL-ML: Silty clays and clayey silts

BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	LL %	PL %	PI %	NAT. W.C. %	PASS. #200, %
● SD-122, S-2	11.0	CH	Gray, silty CLAY	51	25	26	53.5	
■ SD-122, S-33	147.5	ML	Dark gray-brown, clayey SILT, trace of sand; scattered shell fragments	42	29	13	40.7	96.8
▲ SD-122, S-39	172.5	ML	Gray-brown, clayey SILT; scattered shell fragments	38	29	9	40.2	
◆ SD-122, S-45	204.0	ML	Gray, clayey SILT, trace of fine sand	41	27	14	28.4	
○ SD-122, S-47	212.5	CL/CH	Dark gray, silty CLAY, trace of sand	50	22	28	24.0	

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PLASTICITY CHART
BORING SD-122

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FIG. D.2-36

FIG. D.2-36

ATTACHMENT 18

Revised Subappendix D.5 for Appendix D:

Subappendix D.5 and cyclic shear test report of previous report (see attached).

APPENDIX D.5

CYCLIC SHEAR TESTS

Report to Shannon & Wilson, Inc., from Oregon State University (OSU), ~~01/21/2004 (63 sheets)~~"Cyclic Testing of Silt-Rich Soils from the Seattle Monorail Alignment, Seattle, Washington", dated January 21, 2004.

CYCLIC TESTING OF SILT-RICH SOILS
FROM THE SEATTLE MONORAIL ALIGNMENT
SEATTLE, WASHINGTON

SUMMARY REPORT PREPARED FOR
SHANNON & WILSON, INC.
SEATTLE, WA

January 21, 2004

Stephen E. Dickenson, Ph.D.
Associate Professor

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Graduate Research Assistant

Geotechnical Engineering Group
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202 Apperson Hall
Oregon State University
Corvallis, Oregon 97331

INTRODUCTION

This summary report presents the results of a geotechnical laboratory testing program conducted for the Seattle office of Shannon & Wilson, Inc (S&W). The purpose of the testing was to evaluate the nonlinear cyclic behavior of low to moderate plasticity silts from the alignment of the proposed Seattle Monorail located adjacent to Elliot Bay in Seattle. High quality samples of silty soils were transported to the Portland office of S&W then delivered by personnel from Oregon State University (OSU) to the Geotechnical Laboratory on campus. The laboratory program consisted of a suite of cyclic stress-controlled triaxial tests performed to elucidate the variation of stiffness and damping with shear strain during loading. The triaxial procedures consisted of anisotropic consolidation to match the in situ mean effective confining stress, followed by multi-stage cyclic loading at increasingly large deviatoric stresses in order to evaluate the reduction in stiffness and increase in damping with shear strain. The low strain soil stiffness (G_{max}, or associated shear wave velocity V_s) used to normalize the stiffness at moderate strains was obtained using bender elements that produce and receive shear waves in the soils prior to cyclic loading. Hysteric damping was computed from the stress-strain response of the soil measured during cyclic testing. In order to determine the undrained strength ratio (s_u/σ_c') of the silts after cyclic loading a monotonic ramp test was performed by slowly increasing the deviator stress until the sample failed or the rating of the load cell was reached.

Specific aspects of the testing program are outlined in the following sections. Five tests were performed on silt-rich soils from the project site. The results of the first test are not presented in this report due to irregularities in the test specimen. This specimen failed along a silty sand seam during preparation and handling. The specimen was tested as a "preparation and practice" sample but the test results are not applicable for the project. Four subsequent tests were successfully performed and the results are presented herein.

TESTING EQUIPMENT

Cyclic testing was performed using the CKC e/p pneumatic loader under the control of ATS software (Automated Testing System, version 3.12). Axial loads were measured with a +/- 500 pound capacity Interface load cell. Axial deformations were measured with a Schaevitz Engineering 2.00 inch LVDT. Air and pore water pressures were measured with Validyne transducers of varying sensitivities. All of the instrumentation and other components of the system were calibrated prior to testing.

SPECIMEN PREPARATION AND TESTING

Extrusion and Measurement

Shannon & Wilson provided the undisturbed samples to the geotechnical group at Oregon State University. When a specimen interval was identified in the sample tube an 8 to 10 inch section was carefully cut from the remaining tube using a pipe cutter to minimize vibrations and tube deformation. The specimen was then extruded from the tube by hand. This technique greatly reduces the soil densification and disturbance that commonly occurs when the entire sample is extruded to yield each specimen and the extrusion loads must overcome the soil-tube adhesion mobilized along the entire sample tube. Once about 1/2 inch of the specimen was extruded, it was trimmed and the material was collected for water content measurements. With the specimen fully extruded it was quickly and carefully set onto the pre-weighted base cap and porous stone. A moist weight was then recorded. The top cap and porous stone were then put into position and a thin membrane was placed around the specimen and sealed at the top and base caps with o-rings. The sample was then placed in the triaxial cell and confined under a vacuum of approximately 2 psi. Measurements of the specimen height and diameter were then recorded both before and after the application of the confining pressure.

Saturation and Consolidation

Immediately after the specimen dimensions were measured, the triaxial cell was assembled around the specimen. The vacuum created a differential pressure such that de-aired water would flow from the bottom to the top of the specimen, thus de-airing the sample. The triaxial cell was then placed into the loading frame with the ATS testing system active and filled with de-aired water. Once the sample vacuum reached zero, the sample was back pressure saturated maintaining an effective confining stress of approximately 2 psi.

Changes in the height and volume of the specimens were monitored and recorded throughout the preparation process. Sample saturation was typically monitored prior to consolidation. A "B-value" of 0.96 or greater, was required preceding cyclic testing to guarantee adequate saturation of the specimen. Samples were first isotropically consolidated to the estimated in situ horizontal earth pressure by using an at-rest earth pressure coefficient to 0.6. The isotropic consolidation process was followed the controlled application of an axial deviator load until the vertical stress was equal to the estimated vertical effective stress in the field. The specimen was allowed to consolidate under the anisotropic load.

Cyclic Loading

The staged cyclic loading consisted of 5 uniform, stress-controlled, sinusoidal loading cycles under undrained conditions at a frequency of 0.1 Hz. The cyclic stress ratio (CSR), defined as the peak cyclic single amplitude deviatoric stress divided by two times the effective consolidation stress (Equation 1) is a normalized measure used to denote the intensity of the cyclic loading.

$$\mathrm{CSR} = \frac{\sigma_{\mathrm{dev}}}{2\sigma'_{\mathrm{con}}}$$

Equation 1

The first stage of cyclic testing consisted of 5 cycles of loading at a very low CSR. The deviatoric load was specified on the basis of system precision and reproducibility, as well as LVDT precision. Test data was recorded by the ATS data acquisition software at 10 to 30 readings per second. These measurements included (a) axial deviatoric load, (b) axial strain, (c) pore pressure, (d) effective confining stress, and (d) chamber pressure.

Several recent laboratory testing programs have demonstrated the complications associated with measuring representative pore pressures in fine-grained soils during relatively quick cyclic loading. The issue is related to the low permeability of the soil, the length of time required for cyclic excess pore pressures to equilibrate throughout the specimen, and for these pore pressures to be measured at the transducers. In triaxial testing, the central portion of the soil specimen is subjected to the most representative loading. This is due to friction mobilized at the end caps of the specimen. The pore pressures generated toward the central portion of the specimen must then propagate to the ends of the specimen where they are measured. In fine-grained soils there is a lag between the generation of the pore pressures in the center of the specimen and the measurement made externally. It is common for cyclic testing of sandy soils to be conducted at a loading frequency of 1 Hz. This is appropriate for sand however this loading rate has been demonstrated to be too fast to allow for accurate pore pressure measurements in silts. A loading rate of 0.1 Hz has been used to reduce the effects of this lag on the measured pore pressures. A loading rate of 0.1 Hz was used in all cyclic tests performed in this investigation.

The excess pore pressures induced by cyclic loading were monitored between each 5 cycle load increment. The specimen was allowed to re-consolidate prior to subsequent loading if significant pore pressure generation was observed. Progressively larger CSR values were used during the subsequent tests in order to measure the stress-strain behavior of the specimens. A stress-controlled undrained static test was performed following the cyclic tests. Data recorded from these tests included the same measurements as those taken during the cyclic test (deviatoric stress, axial strain, effective confining stress, and chamber pressure). Due to the slower rate of loading, data was recorded every 20 seconds.

Pertinent soil properties and index properties for each of the specimens are provided in Table 1.

Table 1: Specimen Properties

Test No.	Boring No.	Sample No.	Depth (ft)	Insitu Water Content (%)	In Situ Unit Weight (pcf)	σ_c' (psi)	Gmax (psi)	LL	PI
1	SD-122	S-36	160	47	104	46.8	9648	41	14
2	SD-122	S-36	161	48	104	47.2	9327	41	14
3	SD-103	S-42	190	42	108	47.2	11933	43	15
4	SD-103	S-50	225	46	107	56.2	12970	59	30

ESTIMATION OF SHEAR MODULUS AND DAMPING RATIO

The low-strain shear modulus was obtained for each specimen using bender elements. Excitation of the bender piezo-crystal at the base of the sample generates a shear pulse that is transmitted to a bender element at the top of the specimen. The time different between the signal and the receiver is used to obtain the shear wave velocity of the specimen at that confining stress. The V_s value is then converted to G_{max}.

The stiffness of the soil at larger strains was determined from the stress-strain (i.e., hysteresis) loops measured during cyclic loading. A short duration loading consisting of 5 cycles was adequate to obtain the stiffness at each load increment. The axial strains computed from the axial deformation measured with a LVDT was converted to shear strain by multiplying the axial strain by 1.73 (Vucetic and Dobry, 1986). The modulus at each cyclic loading was estimated using Equation 2 (refer to Figure 1 for notation). The shear strain used to represent this secant shear modulus is the average of shear strains in compression (γ_{pc}) and extension ((γ_{pc}).

$$G_{eq} = \frac{\tau_{pc} + \tau_{pe}}{\gamma_{pc} + \gamma_{pe}} \qquad \textbf{Equation 2}$$

Damping ratio was computed by way of Equation 2. A_{loop} is the area of hysteresis loop of stress versus strain during cyclic testing. A trapezoid method is used to estimate the A_{loop}.

$$\xi = \frac{A_{loop}}{2\pi G_{sec}\gamma_{avg}^2} \qquad \textbf{Equation 3}$$

It should be noted that since the specimens were anisotropically consolidated they are subjected to a deviatoric stress prior to cyclic loading as they would be in the field. When cyclic loads corresponding to small CSR values are applied compressive stresses are much smaller than the static deviatoric stress required for the anisotropic consolidation and there is no stress reversal as shown in Figure 2. As the loads increase a condition is reached where the cyclic stresses are large enough to result in stress reversal. At this point the hysteresis loops measured in cyclic stress-controlled triaxial tests are often not symmetric. This behavior was observed and the variation in the modulus values (i.e., symmetric versus non-symmetric loops) was evaluated.

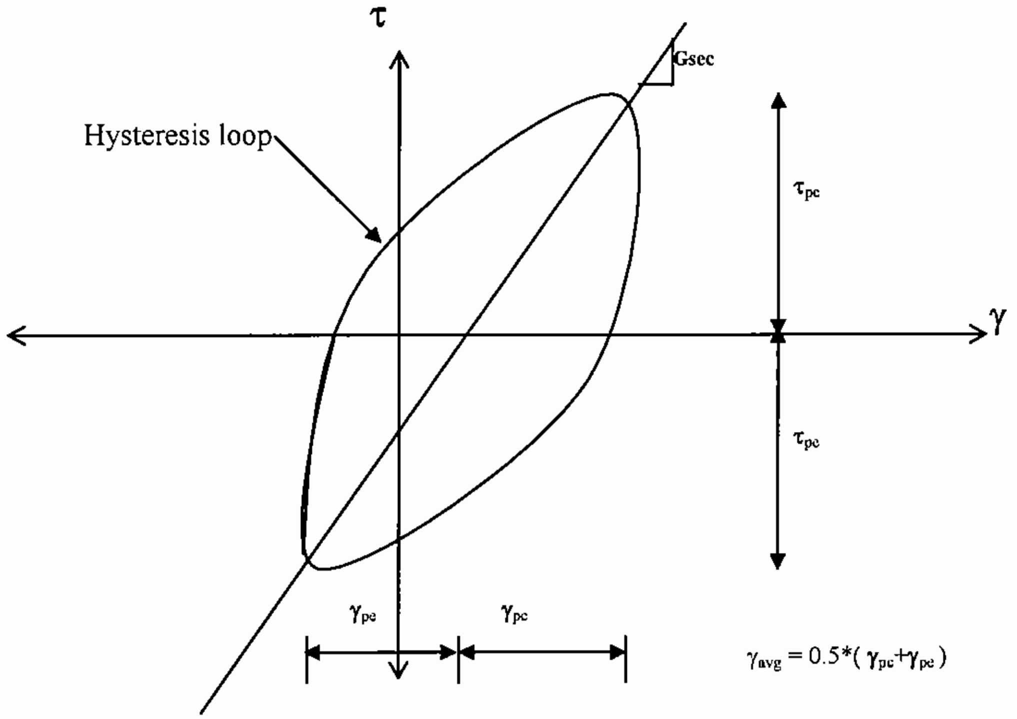


Figure 1: Stress and strain notation used in this data report.

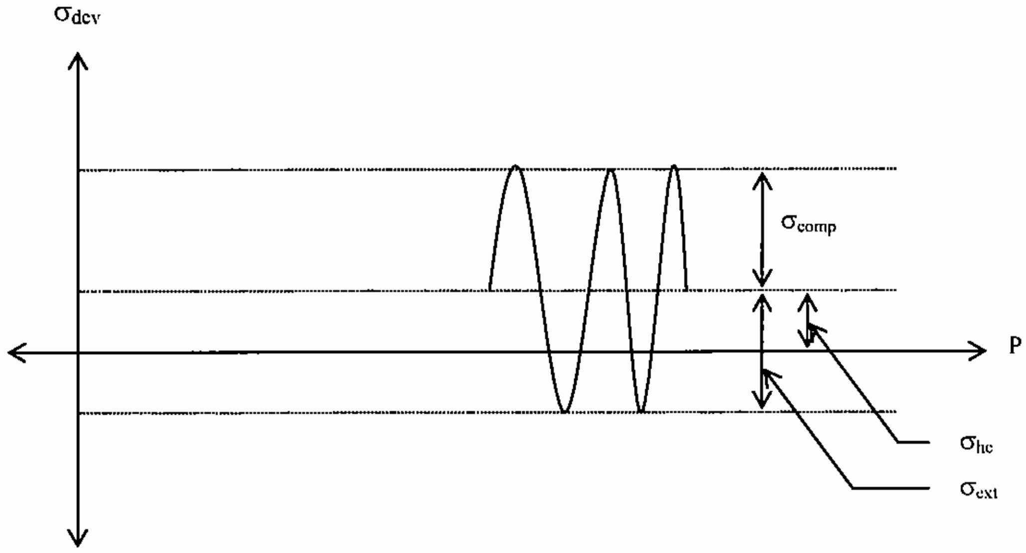


Figure 2: Deviatoric stress notation used in this data report.

TESTING RESULTS

The stress-strain plots for each of the load sequences for all 4 tests are shown in Appendix A. The modulus reduction data obtained during cyclic testing of the 4 representative samples are summarized in Tables 2.1 to 2.4. The post-cyclic stress-strain behavior of the specimens under monotonic undrained loading is illustrated in Appendix A. These plots can be used to determine the undrained strength ratio (s_u/σ'_m) of the silty soils.

Plots showing the variation of modulus with shear strain are presented in Appendix B. A summary of this data is provided in Figure 3. The overall trends obtained from the cyclic testing are supported by the trends of Vucetic and Dobry (1991) for fine-grained soils with Plasticity Indexes between 0 and 30. The 4 specimens tested had PI values between 14 and 30. It is apparent that the measured trends of modulus with shear strain start to diverge from the established ranges at low shear strain. We feel that this is due more to the limitations of the testing and instrumentation equipment than true soil behavior. The reasons for this assertion are two-fold: (1) the low-strain modulus values are deemed representative due to the relatively high precision of the bender element wave measurement system, and (2) the hysteresis loops shear strains below roughly 0.05 to 0.03 percent are difficult to interpret due to the very small deformations that are associated with these strains and the robust equipment is required to test the soils at the high stresses required for this project. There is obviously a need to balance system sensitivity with higher capacity load cells having lower precision. The data obtained in this investigation supports the use of the established curves for soils having a PI of 15 to 30.

The data for soil damping is presented in Tables 3.1 to 3.4 and in Appendix C. The collective damping data for is shown in Figure 4. The data obtained in this investigation is shown with the variation in damping with shear strain developed by Vucetic and Dobry (1991). The curves for soil with PI 30 and 50 are annotated on the figure. The damping data is consistent with other fine grained soils having PI in this range. This range of PI is slightly higher than that indicated by the modulus relationship however it is in good accord with PI of 30. Based on the cyclic testing performed in this investigation it appears that the material may exhibit slightly more damping than anticipated based on general relationships established for other fine grained soils.

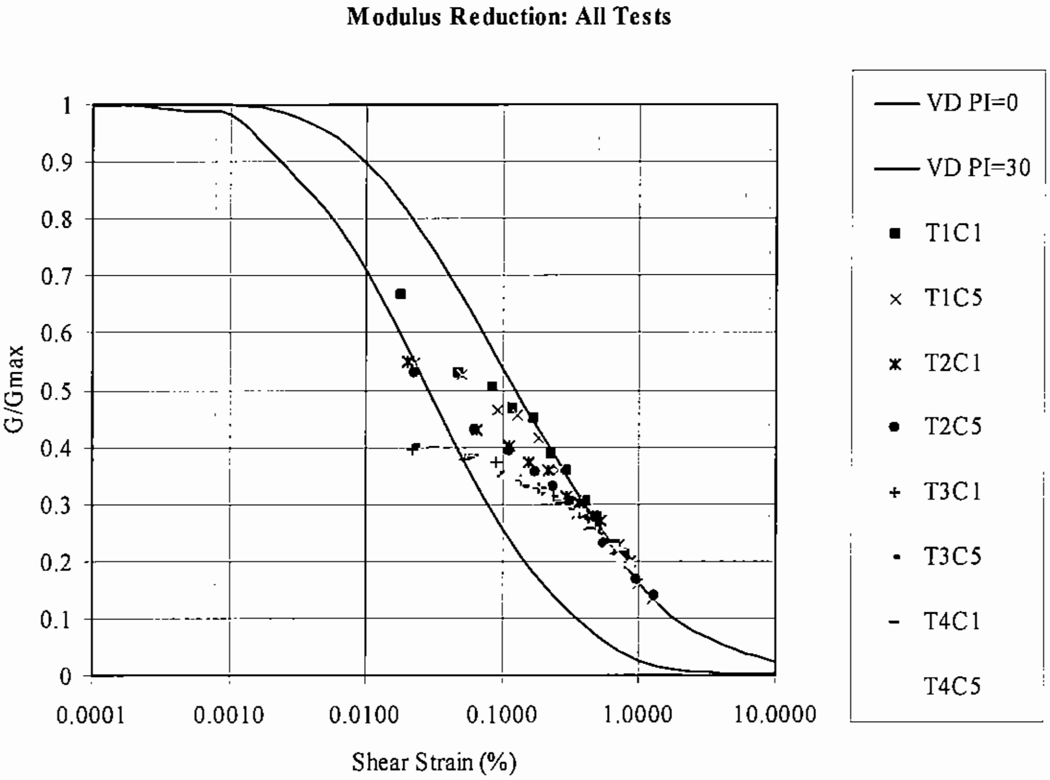


Figure 3: Variation of Soil Modulus with Shear Strain for Four Specimens of Silt.

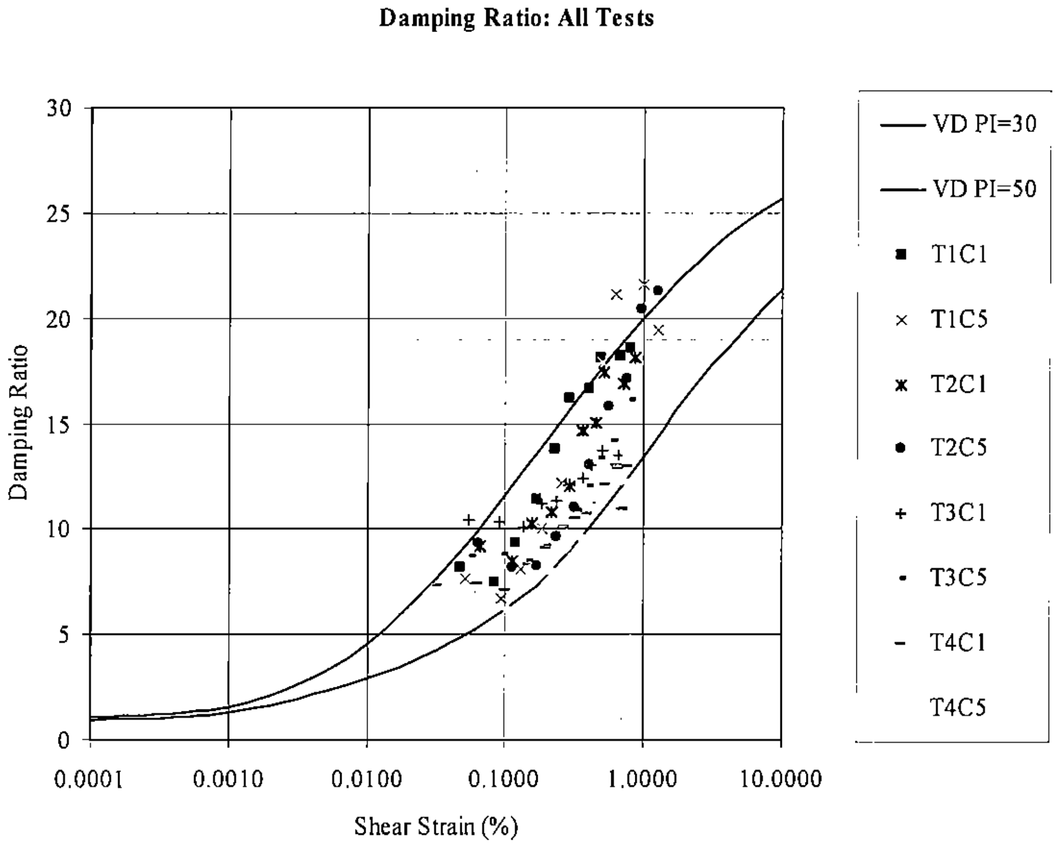


Figure 4: Variation of Soil Damping with Shear Strain for Four Specimens of Silt.

Table 2.1: Stress-strain data for test No. 1 (Boring SD 122, Sample S-36, Depth 160 feet)

Loading Step	Test No. 1														
	G_{max} =	9648	psi: Estimating from bender elements												
			Load Cycle No. 1							Load Cycle No. 5					
	σ_{hc}' (psi)	σ_{ext}' (psi)	τ_{pc} (psi)	τ_{pe} (psi)	γ_{pc} (%)	γ_{pe} (%)	G_{eq} (psi)	γ_{avg} (%)	G/G_{max}	τ_{pc} (psi)	τ_{pe} (psi)	γ_{pc} (%)	γ_{pe} (%)	G_{eq} (psi)	γ_{avg} (%)	G/G_{max}
1st	25.2	2.0	1.4	-1.0	0.025	-0.012	6438	0.018	0.667	1.4	-1.0	0.034	-0.012	5275	0.023	0.547
2nd	25.4	5.0	2.6	-2.3	0.052	-0.044	5104	0.048	0.529	2.7	-2.5	0.057	-0.045	5098	0.051	0.528
3rd	25.3	8.1	4.3	-4.0	0.090	-0.080	4853	0.085	0.503	4.3	-4.0	0.105	-0.080	4486	0.093	0.465
4th	25.2	11.0	5.6	-5.2	0.137	-0.102	4519	0.120	0.468	6.0	-5.4	0.180	-0.080	4385	0.130	0.454
5th	25.1	14.0	7.9	-6.8	0.226	-0.112	4349	0.169	0.451	7.6	-7.2	0.330	-0.040	4000	0.185	0.415
6th	25.1	17.2	8.9	-8.5	0.330	-0.135	3742	0.233	0.388	9.0	-8.6	0.520	0.010	3451	0.255	0.358
7th	25.0	20.3	10.5	-10.0	0.430	-0.160	3475	0.295	0.360	10.8	-10.0	0.820	0.110	2930	0.355	0.304
8th	25.1	23.6	12.0	-11.8	0.570	-0.240	2938	0.405	0.305	12.5	-11.8	1.280	0.260	2382	0.510	0.247
9th	24.9	26.5	13.5	-13.0	0.710	-0.280	2677	0.495	0.277	14.0	-13.2	1.620	0.360	2159	0.630	0.224
10th	24.9	29.6	15.0	-14.8	0.920	-0.440	2191	0.680	0.227	15.2	-15.0	2.420	0.450	1533	0.985	0.159
11th	24.7	32.5	16.5	-16.0	1.000	-0.600	2031	0.800	0.211	17.0	-16.2	2.505	-0.060	1294	1.283	0.134

Table 2.2: Stress-strain data for test No. 2 (Boring SD 122, Sample S-36, Depth 161 feet)

Loading Step	Test No. 2														
	G_{max} =	9327	psi: Estimating from bender elements												
			Load Cycle No. 1							Load Cycle No. 5					
	σ_{hc}' (psi)	σ_{ext}' (psi)	τ_{pc} (psi)	τ_{pe} (psi)	γ_{pc} (%)	γ_{pe} (%)	G_{eq} (psi)	γ_{avg} (%)	G/G_{max}	τ_{pc} (psi)	τ_{pe} (psi)	γ_{pc} (%)	γ_{pe} (%)	G_{eq} (psi)	γ_{avg} (%)	G/G_{max}
1st	25.5	1.9	1.1	-1.0	0.022	-0.019	5122	0.021	0.549	1.3	-0.9	0.034	-0.011	4934	0.023	0.529
2nd	25.5	4.9	2.6	-2.6	0.078	-0.052	4000	0.065	0.429	2.7	-2.5	0.082	-0.045	4016	0.064	0.431
3rd	25.4	8.0	4.2	-4.2	0.124	-0.100	3750	0.112	0.402	4.2	-4.1	0.146	-0.080	3673	0.113	0.394
4th	25.3	10.9	5.7	-5.3	0.190	-0.125	3492	0.158	0.374	6.0	-5.5	0.245	-0.100	3319	0.173	0.356
5th	25.2	14.0	7.4	-7.2	0.280	-0.157	3341	0.219	0.358	7.6	-7.0	0.382	-0.090	3093	0.236	0.332
6th	25.3	17.4	8.8	-8.4	0.370	-0.220	2915	0.295	0.313	9.2	-8.7	0.550	-0.080	2841	0.315	0.305
7th	25.0	20.4	10.4	-10.0	0.495	-0.230	2814	0.363	0.302	10.8	-10.0	0.822	0.000	2530	0.411	0.271
8th	25.0	23.6	12.0	-11.6	0.605	-0.300	2608	0.453	0.280	12.2	-11.8	1.210	0.100	2162	0.555	0.232
9th	24.9	26.5	13.5	-13.0	0.670	-0.380	2524	0.525	0.271	13.9	-13.5	1.700	0.180	1803	0.760	0.193
10th	24.8	29.6	15.0	-15.0	0.920	-0.500	2113	0.710	0.227	15.8	-15.0	2.250	0.300	1579	0.975	0.169
11th	24.8	32.6	16.5	-16	1.08	-0.66	1868	0.870	0.200	17.0	-16.5	2.820	0.250	1304	1.285	0.140

Table 2.3: Stress-strain data for test No. 3 (Boring SD 103, Sample S-42, Depth 190 feet)

Loading Step	Test No. 3															
	G_{max} =	11933	psi: Estimating from bender elements													
			Load Cycle No. 1							Load Cycle No. 5						
	σ_{hc}' (psi)	σ_{ext}' (psi)	τ_{pc} (psi)	τ_{pc} (psi)	γ_{pc} (%)	γ_{pc} (%)	G_{eq} (psi)	γ_{avg} (%)	G/G_{max}	τ_{pc} (psi)	τ_{pc} (psi)	γ_{pc} (%)	γ_{pc} (%)	G_{eq} (psi)	γ_{avg} (%)	G/G_{max}
1st	26.9	1.7	1.2	-0.9	0.033	-0.011	4740	0.022	0.397	1.4	-0.8	0.035	-0.010	4778	0.023	0.400
2nd	27.4	4.9	2.5	-2.4	0.066	-0.042	4537	0.054	0.380	2.6	-2.5	0.078	-0.034	4554	0.056	0.382
3rd	27.4	8.2	4.1	-3.9	0.115	-0.065	4444	0.090	0.372	4.2	-4.0	0.145	-0.050	4205	0.098	0.352
4th	27.0	10.9	5.8	-5.4	0.165	-0.110	4073	0.138	0.341	6.0	-5.4	0.212	-0.077	3945	0.145	0.331
5th	27.1	14.2	7.3	-7.0	0.233	-0.134	3896	0.184	0.327	7.6	-7.1	0.312	-0.078	3769	0.195	0.316
6th	27.0	17.3	8.9	-8.6	0.290	-0.180	3723	0.235	0.312	9.2	-8.7	0.410	-0.090	3580	0.250	0.300
7th	26.9	20.5	11.0	-10.0	0.370	-0.210	3621	0.290	0.303	10.9	-10.4	0.560	-0.090	3277	0.325	0.275
8th	26.9	23.7	12.1	-11.7	0.470	-0.255	3283	0.363	0.275	12.5	-11.9	0.705	-0.090	3069	0.398	0.257
9th	26.9	26.9	14.0	-13.4	0.540	-0.300	3262	0.420	0.273	14.0	-13.5	0.860	-0.100	2865	0.480	0.240
10th	26.8	29.8	15.0	-15.0	0.640	-0.380	2941	0.510	0.246	15.7	-15.2	1.060	-0.120	2619	0.590	0.219
11th	26.7	34.2	17	-16.5	0.77	-0.55	2538	0.660	0.213	18.0	-17.5	1.480	-0.100	2247	0.790	0.188

Table 2.4: Stress-strain data for test No. 4 (Boring SD 122, Sample S-50, Depth 225 feet)

Loading Step	Test No. 4															
	G_{max} =	12970	psi: Estimating from bender elements													
		Load Cycle No. 1								Load Cycle No. 5						
	σ_{hc}' (psi)	σ_{ext}' (psi)	τ_{pc} (psi)	τ_{pc} (psi)	γ_{pc} (%)	γ_{pc} (%)	G_{eq} (psi)	γ_{avg} (%)	G/G_{max}	τ_{pc} (psi)	τ_{pc} (psi)	γ_{pc} (%)	γ_{pc} (%)	G_{eq} (psi)	γ_{avg} (%)	G/G_{max}
1st	30.3	2.8	1.8	-1.5	0.043	-0.020	5159	0.032	0.398	2.1	-1.3	0.056	-0.012	5015	0.034	0.387
2nd	30.6	6.0	3.2	-3.0	0.068	-0.056	4976	0.062	0.384	3.5	-3.0	0.079	-0.056	4815	0.068	0.371
3rd	30.6	9.2	4.6	-4.4	0.110	-0.090	4500	0.100	0.347	4.9	-4.6	0.130	-0.080	4524	0.105	0.349
4th	30.5	12.7	6.6	-6.2	0.158	-0.130	4444	0.144	0.343	7.0	-6.2	0.182	-0.114	4459	0.148	0.344
5th	30.6	16.6	8.6	-8.2	0.225	-0.170	4253	0.198	0.328	8.9	-8.3	0.282	-0.145	4028	0.214	0.311
6th	30.4	20.4	10.5	-10.0	0.305	-0.215	3942	0.260	0.304	11.0	-10.2	0.390	-0.170	3786	0.280	0.292
7th	30.5	23.5	12.0	-11.7	0.360	-0.270	3762	0.315	0.290	12.5	-11.7	0.482	-0.215	3472	0.349	0.268
8th	30.4	26.6	13.5	-13.0	0.430	-0.330	3487	0.380	0.269	13.8	-13.1	0.520	-0.260	3449	0.390	0.266
9th	30.4	29.7	15.0	-14.6	0.497	-0.395	3318	0.446	0.256	15.0	-15.0	0.660	-0.300	3125	0.480	0.241
10th	30.4	32.8	16.6	-16.1	0.580	-0.460	3144	0.520	0.242	17.0	-16.4	0.860	-0.320	2831	0.590	0.218
11th	30.4	36.6	18.6	-18.1	0.71	-0.56	2890	0.6350	0.223	19.0	-18.2	1.070	-0.400	2531	0.735	0.195
12th	30.4	39.6	18.5	-20	0.7	-0.6	2962	0.6500	0.228	17.8	-19.8	0.87	-0.54	2667	0.7050	0.206
13th	30.5	41.9	18.8	-21	0.68	-0.7	2884	0.6900	0.222	18.1	-21	0.82	-0.66	2642	0.7400	0.204
14th	30.5	42.7	21.5	-21	0.85	-0.65	2833	0.7500	0.218	22	-21	1.22	-0.5	2500	0.8600	0.193

Table 3.1: Damping data No. 1 (Boring SD 122, Sample S-36, Depth 160 feet)

Loading Step	Test No. 1							
	Load Cycle No. 1				Load Cycle No. 5			
	τ_{avg} (psi)	γ_{avg} (%)	A_{loop} (psi)	ξ (%)	τ_{avg} (psi)	γ_{avg} (%)	A_{loop} (psi)	ξ (%)
1st	1.18	0.018	0.000	12.5	1.2	0.023	0.000	9.5
2nd	2.45	0.048	0.001	8.2	2.6	0.051	0.001	7.6
3rd	4.13	0.085	0.002	7.4	4.2	0.093	0.002	6.7
4th	5.40	0.120	0.004	9.3	5.7	0.130	0.004	8.1
5th	7.35	0.169	0.009	11.4	7.4	0.185	0.009	10.0
6th	8.70	0.233	0.018	13.8	8.8	0.255	0.017	12.2
7th	10.25	0.295	0.031	16.2	10.4	0.355	0.034	14.7
8th	11.90	0.405	0.050	16.6	12.2	0.510	0.070	17.9
9th	13.25	0.495	0.075	18.2	13.6	0.630	0.114	21.1
10th	14.90	0.680	0.116	18.2	15.1	0.985	0.202	21.6
11th	16.25	0.800	0.152	18.6	16.6	1.283	0.260	19.5

Table 3.2: Damping data for test No. 2 (Boring SD 122, Sample S-36, Depth 161 feet)

Loading Step	Test No. 2							
	Load Cycle No. 1				Load Cycle No. 5			
	τ_{avg} (psi)	γ_{avg} (%)	A_{loop} (psi)	ξ (%)	τ_{avg} (psi)	γ_{avg} (%)	A_{loop} (psi)	ξ (%)
1st	1.05	0.021	0.000	14.3	1.1	0.023	0.000	13.7
2nd	2.60	0.065	0.001	9.1	2.6	0.064	0.001	9.3
3rd	4.20	0.112	0.002	8.5	4.2	0.113	0.002	8.2
4th	5.50	0.158	0.006	10.2	5.7	0.173	0.005	8.2
5th	7.30	0.219	0.011	10.8	7.3	0.236	0.010	9.6
6th	8.60	0.295	0.019	12.0	9.0	0.315	0.019	11.0
7th	10.20	0.363	0.034	14.6	10.4	0.411	0.035	13.0
8th	11.80	0.453	0.050	15.0	12.0	0.555	0.066	15.8
9th	13.25	0.525	0.076	17.4	13.7	0.760	0.112	17.1
10th	15.00	0.710	0.113	16.9	15.4	0.975	0.193	20.4
11th	16.25	0.870	0.161	18.1	16.8	1.285	0.288	21.3

Table 3.3: Damping data for test No. 3 (Boring SD 103, Sample S-42, Depth 190 feet)

Loading Step	Test No. 3							
	Load Cycle No. 1				Load Cycle No. 5			
	τ_{avg} (psi)	γ_{avg} (%)	A_{loop} (psi)	ξ (%)	τ_{avg} (psi)	γ_{avg} (%)	A_{loop} (psi)	ξ (%)
1st	1.05	0.022	0.000	12.1	1.1	0.023	0.000	14.8
2nd	2.45	0.054	0.001	10.4	2.6	0.056	0.001	8.7
3rd	4.00	0.090	0.002	10.4	4.1	0.098	0.002	8.8
4th	5.60	0.138	0.005	10.1	5.7	0.145	0.004	8.5
5th	7.15	0.184	0.009	11.2	7.4	0.195	0.008	9.2
6th	8.75	0.235	0.015	11.4	9.0	0.250	0.014	10.1
7th	10.50	0.290	0.023	12.1	10.7	0.325	0.024	10.9
8th	11.90	0.363	0.034	12.4	12.2	0.398	0.037	12.0
9th	13.70	0.420	0.047	13.0	13.8	0.480	0.055	13.3
10th	15.00	0.510	0.066	13.7	15.5	0.590	0.081	14.2
11th	16.75	0.660	0.094	13.5	17.8	0.790	0.142	16.1

Table 3.4: Damping data for test No. 4 (Boring SD 122, Sample S-50, Depth 225 feet)

Loading Step	Test No. 4							
	Load Cycle No. 1				Load Cycle No. 5			
	τ_{avg} (psi)	γ_{avg} (%)	A_{loop} (psi)	ξ (%)	τ_{avg} (psi)	γ_{avg} (%)	A_{loop} (psi)	ξ (%)
1st	1.63	0.032	0.0002	7.3	1.7	0.034	0.000	9.4
2nd	3.09	0.062	0.001	7.4	3.3	0.068	0.001	6.9
3rd	4.50	0.100	0.002	7.1	4.8	0.105	0.002	6.1
4th	6.40	0.144	0.005	8.3	6.6	0.148	0.005	7.6
5th	8.40	0.198	0.010	9.1	8.6	0.214	0.009	8.0
6th	10.25	0.260	0.017	10.1	10.6	0.280	0.017	9.1
7th	11.85	0.315	0.025	10.5	12.1	0.349	0.026	9.6
8th	13.25	0.380	0.034	10.7	13.5	0.390	0.037	11.2
9th	14.80	0.446	0.046	11.2	15.0	0.480	0.050	11.1
10th	16.35	0.520	0.065	12.1	16.7	0.590	0.078	12.6
11th	18.35	0.635	0.096	13.1	18.6	0.735	0.117	13.6
12th	19.25	0.650	0.101	12.9	18.8	0.705	0.103	12.4
13th	19.90	0.690	0.094	10.9	19.6	0.740	0.069	7.6
14th	21.25	0.750	0.130	13.0	21.5	0.860	0.157	13.5

References

Mladen Vucetic and Ricardro Dobry (1986). "Degradation of Marine Clays Under Cyclic Loading." *Journal of Geotechnical Engineering.*, ASCE, 114(2), 133-149

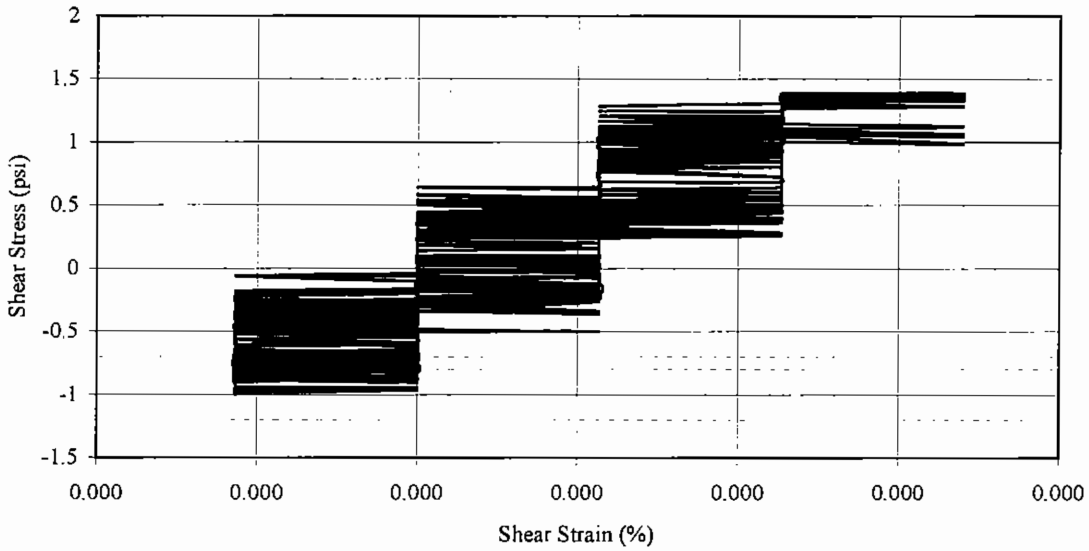
Mladen Vucetic and Ricardro Dobry (1991). "Effect of Soil Plasticity on Cyclic Response." *Journal of Geotechnical Engineering.*, ASCE, 117(1), 89-107

Appendix A

Cyclic Stress-Strain Data for the Four Tests

Test 1
Boring SD-122, Sample No. S-36

Boring SD-122, Sample No. S-36
Modulus Reduction Test, Loading No. 1,
Sample Depth 160', σ_c' = 46 psi, CSR = 0.026



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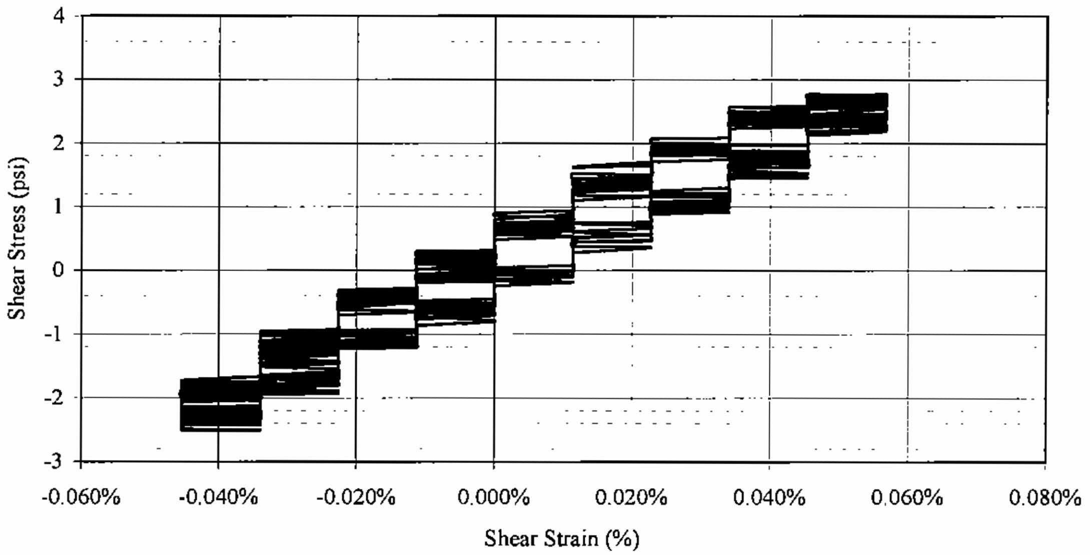
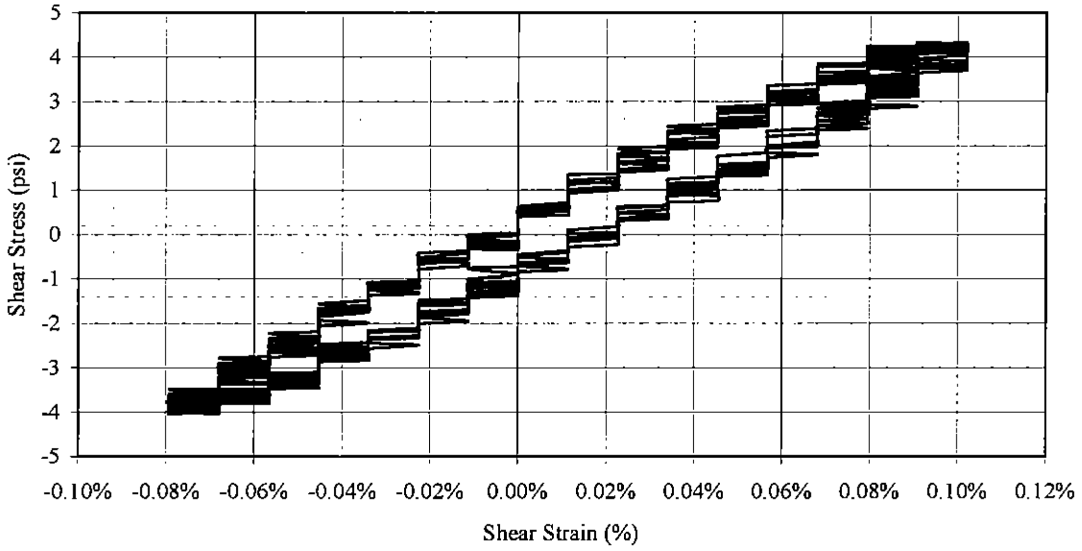
Modulus Reduction Test, Loading No. 2,
Sample Depth 160', σ_c' = 46 psi, CSR = 0.056



Boring SD-122, Sample No. S-36
Modulus Reduction Test, Loading No. 3,
Sample Depth 160', σ_c' = 46 psi, CSR = 0.089



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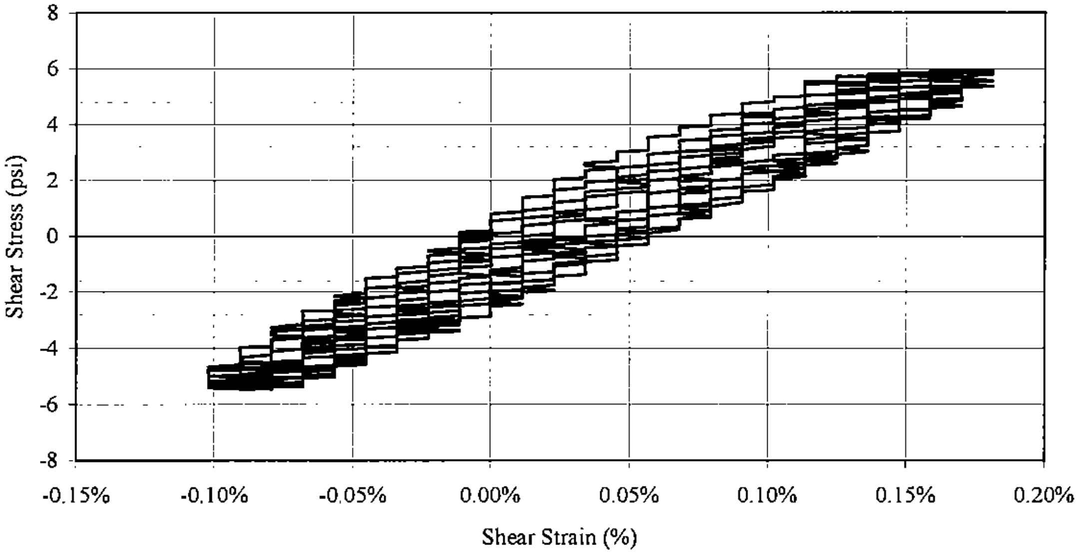
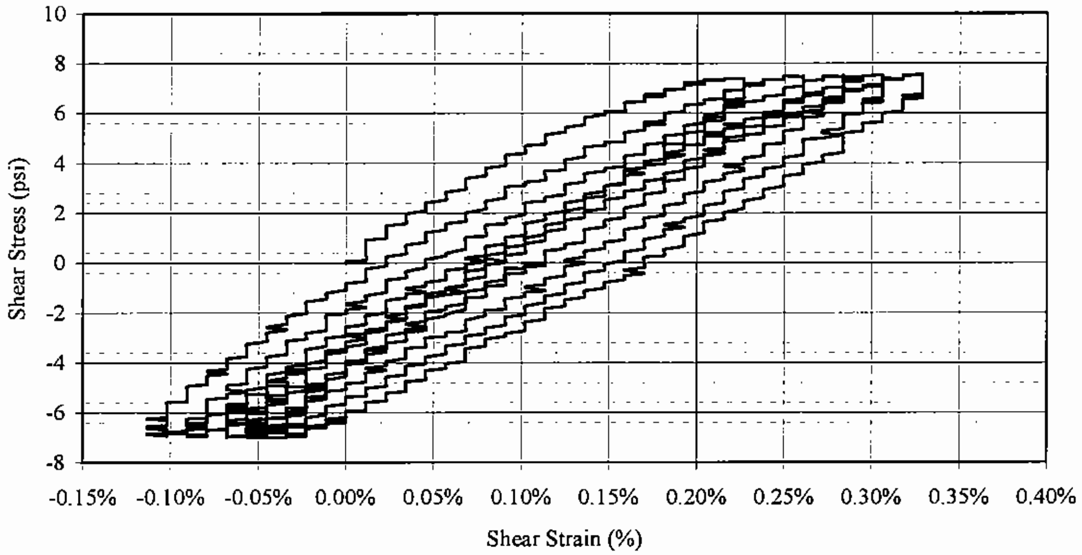
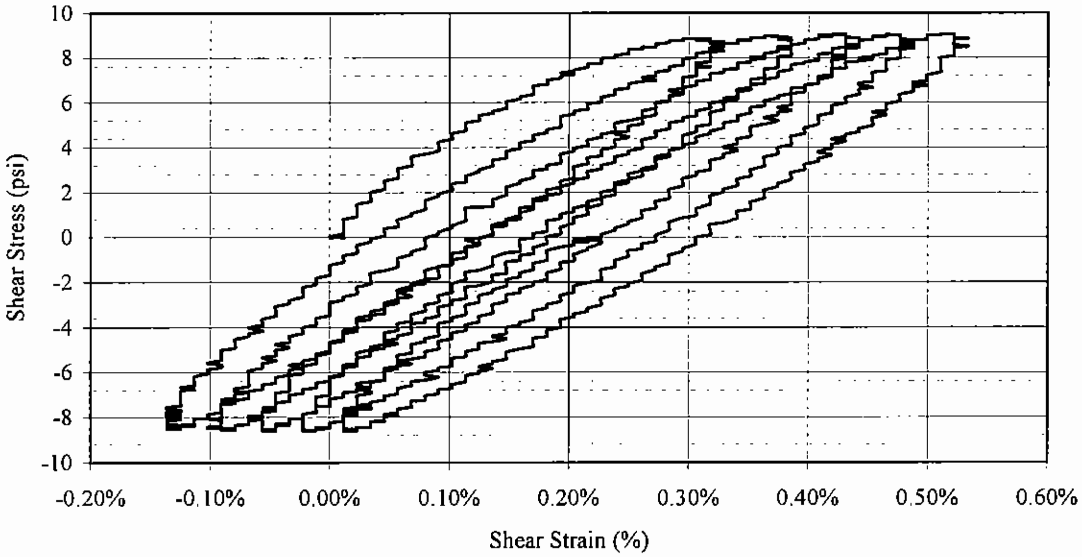
Modulus Reduction Test, Loading No. 4,
Sample Depth 160', σ_c'= 46 psi, CSR = 0.122

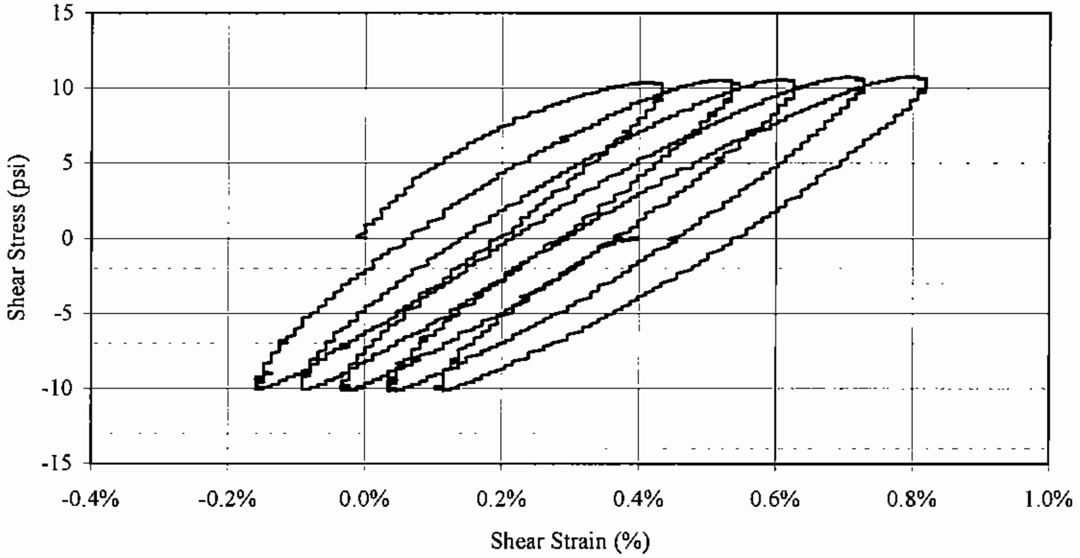


Boring SD-122, Sample No. S-36
Modulus Reduction Test, Loading No. 5,
Sample Depth 160', σ_c'= 46 psi, CSR = 0.155

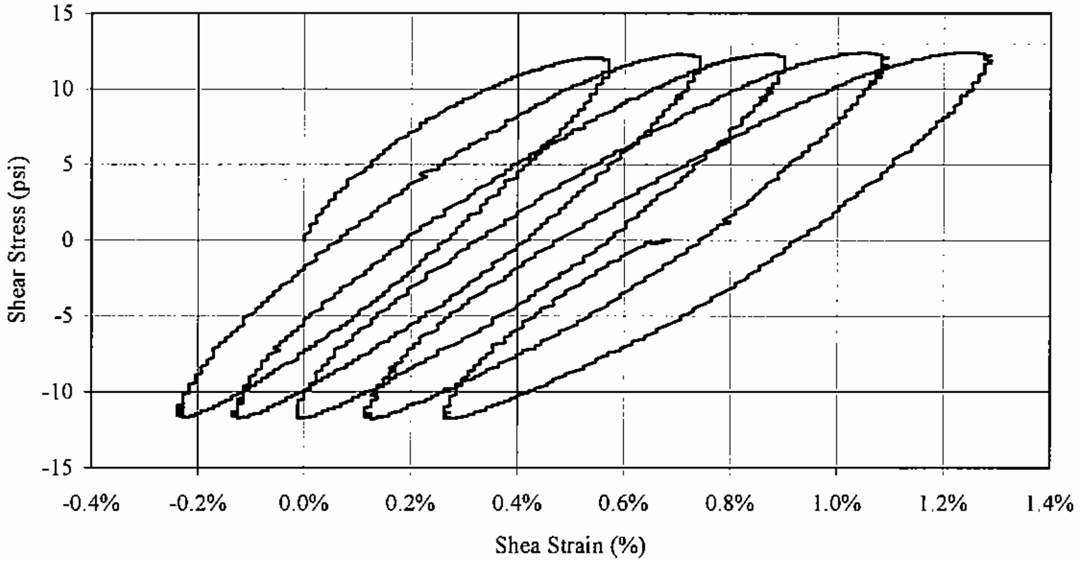


Boring SD-122, Sample No. S-36
Modulus Reduction Test, Loading No. 6,
Sample Depth 160', σ_c'= 46 psi, CSR = 0.188

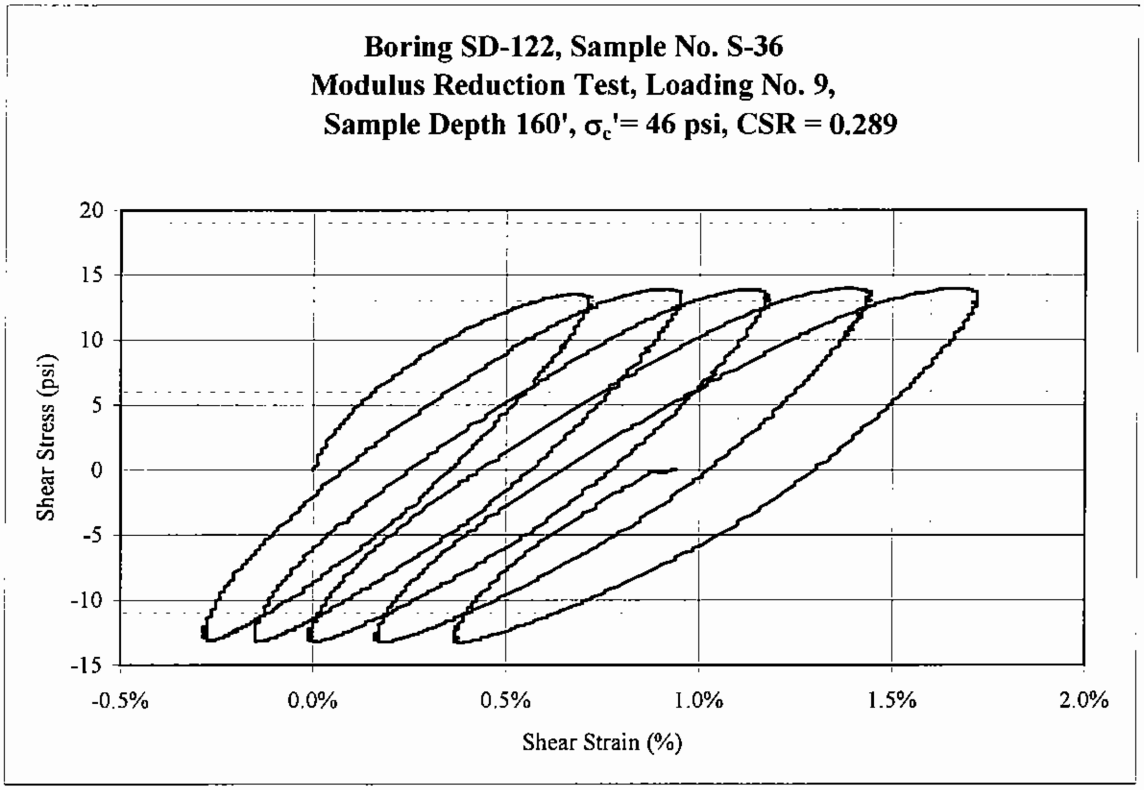




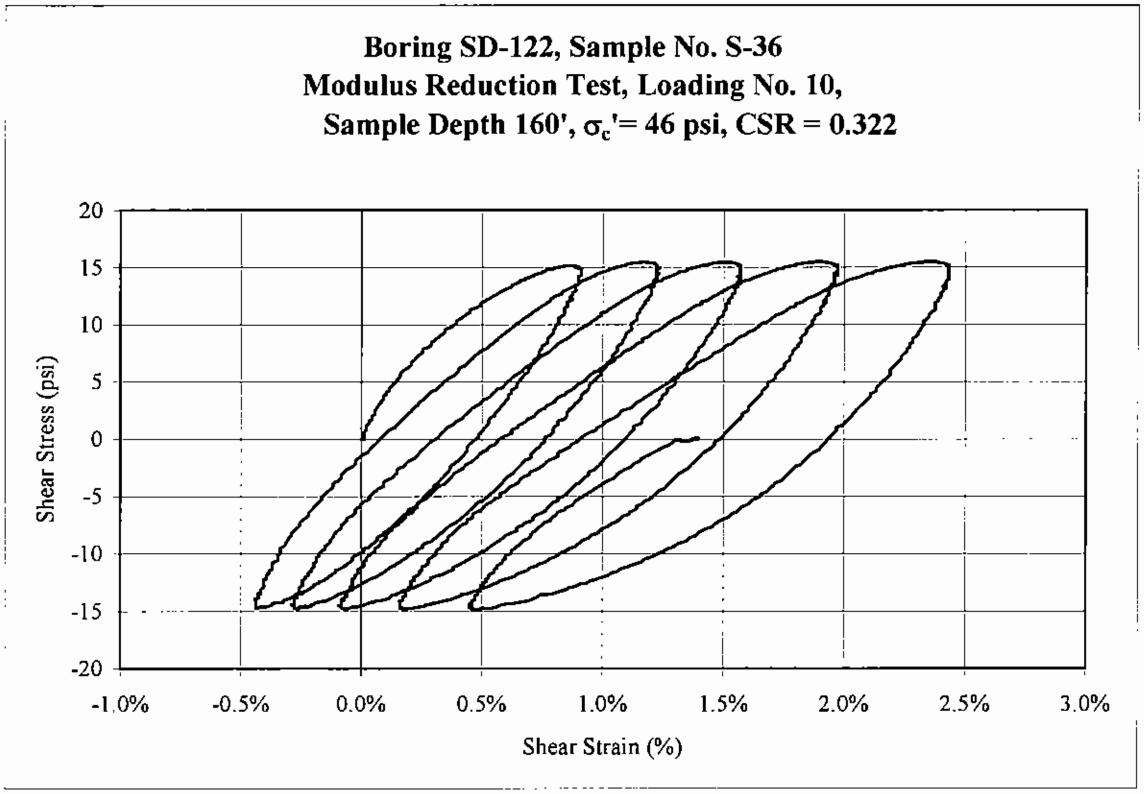
Boring SD-122, Sample No. S-36
Modulus Reduction Test, Loading No. 7,
Sample Depth 160', σ_c'= 46 psi, CSR = 0.223



Boring SD-122, Sample No. S-36
Modulus Reduction Test, Loading No. 8,
Sample Depth 160', σ_c'= 46 psi, CSR = 0.258

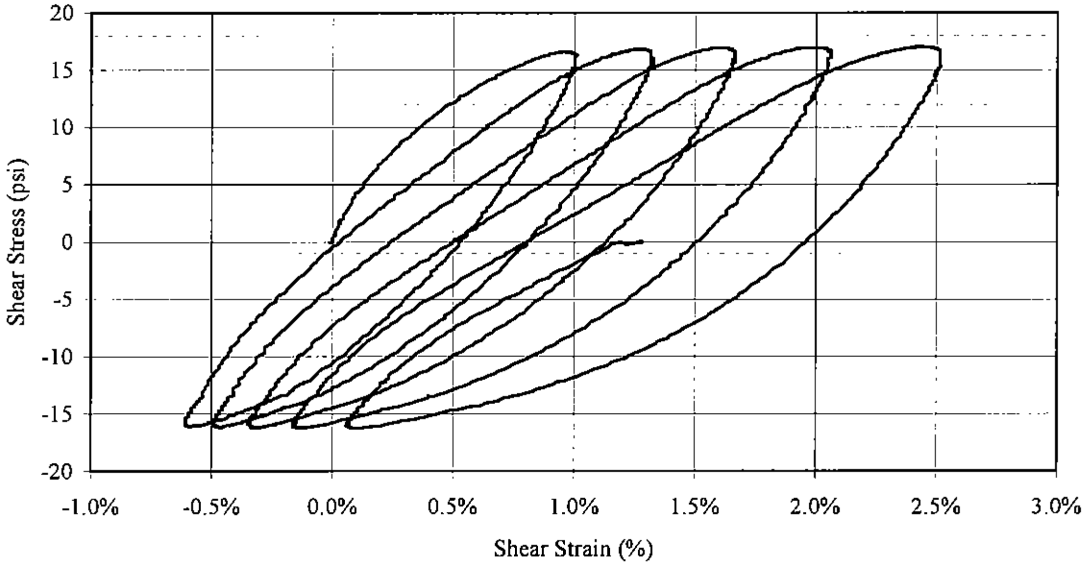


Boring SD-122, Sample No. S-36
Modulus Reduction Test, Loading No. 9,
Sample Depth 160', σ_c'= 46 psi, CSR = 0.289

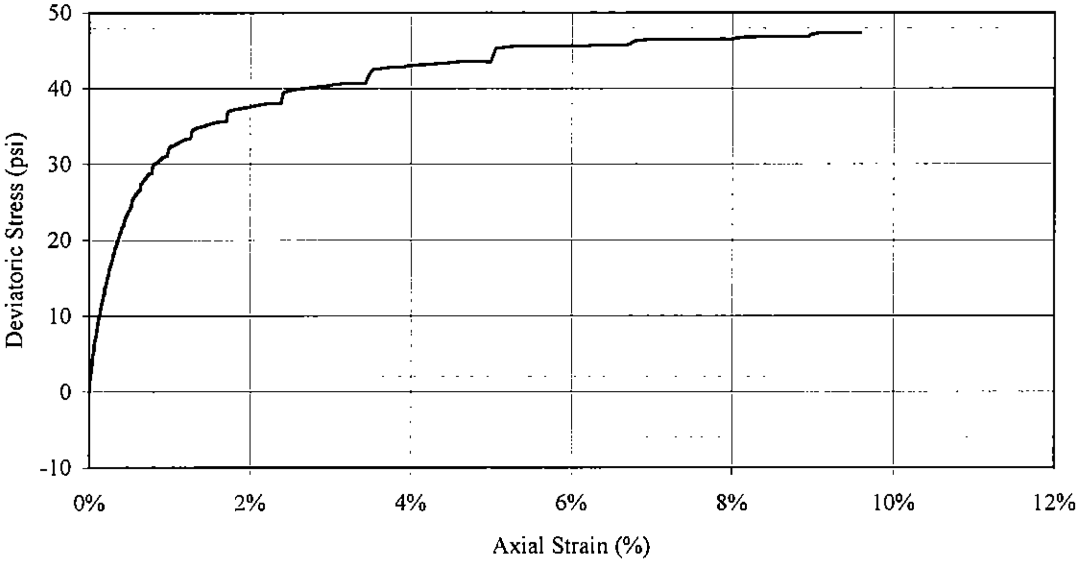


Boring SD-122, Sample No. S-36
Modulus Reduction Test, Loading No. 10,
Sample Depth 160', σ_c'= 46 psi, CSR = 0.322

Boring SD-122, Sample No. S-36
Modulus Reduction Test, Loading No. 11,
Sample Depth 160', σ_c'= 46 psi, CSR = 0.353

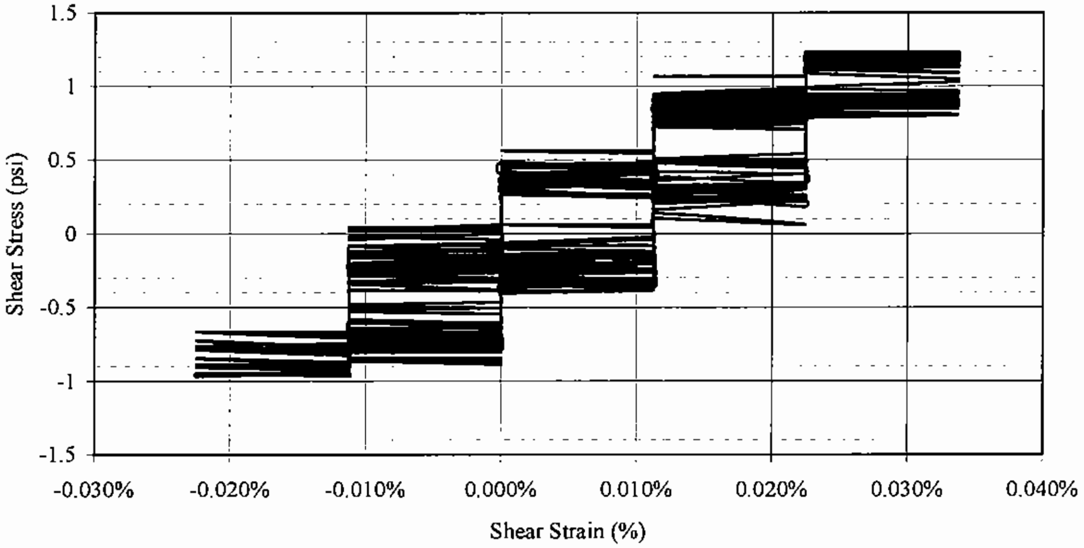


Boring SD-122, Sample No. S-36
Static Stress Control Test
Sample Depth = 160 ', σ_c'=46 psi



Test 2
Boring SD-122, Sample No. S-36

Boring SD-122, Sample No. S-36
Modulus Reduction Test, Loading No. 1,
Sample Depth 161 ft., σ_c' = 47.2 psi, CSR = 0.023



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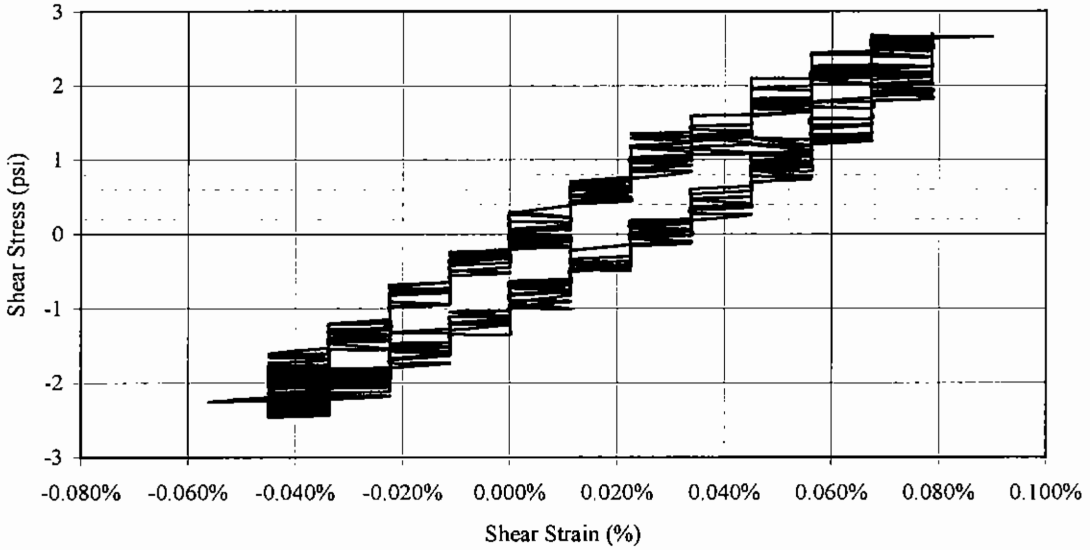
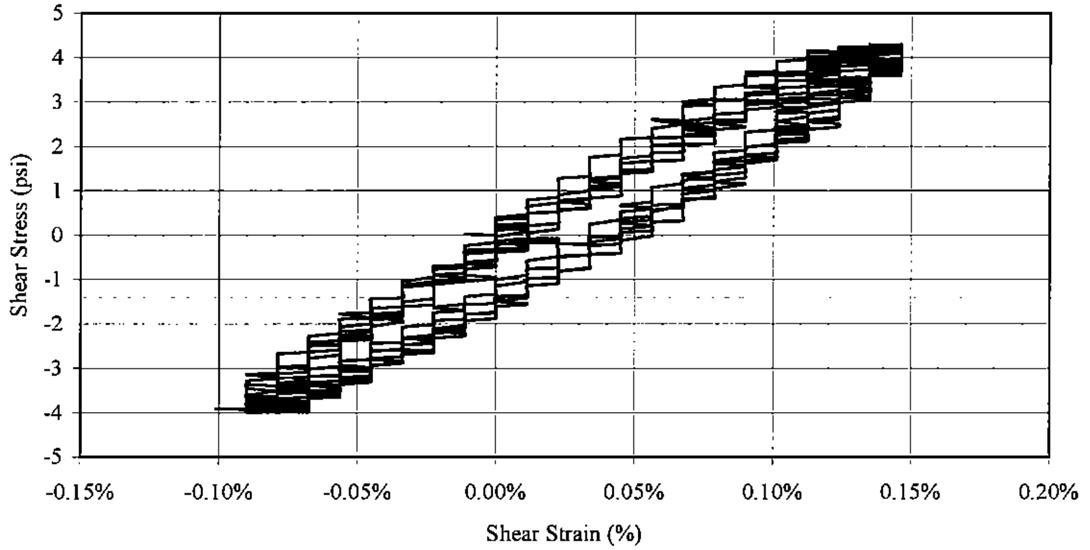
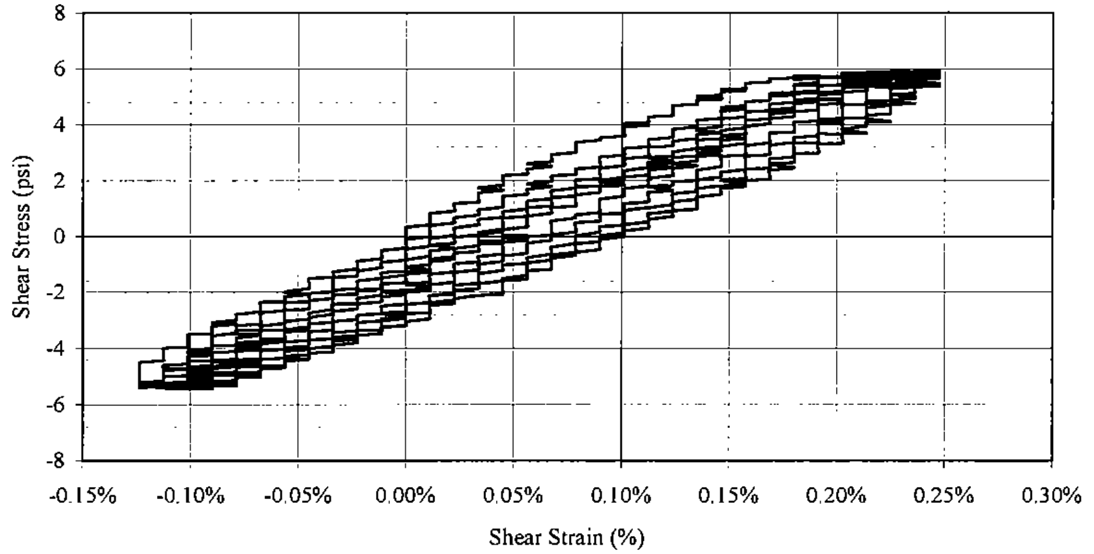
Modulus Reduction Test, Loading No. 2,
Sample Depth 161 ft., σ_c' = 47.2 psi, CSR = 0.055



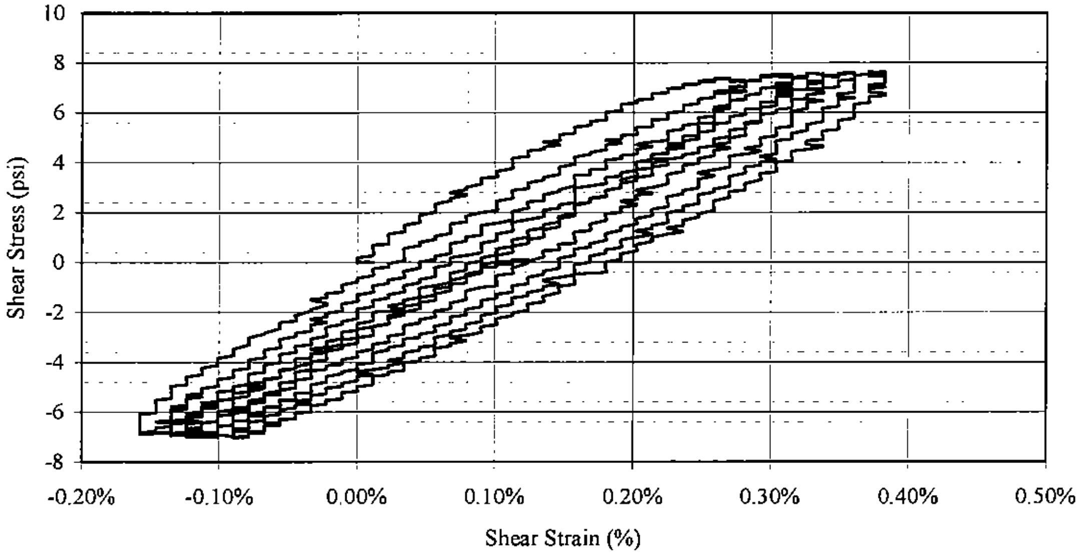


Boring SD-122, Sample No. S-36
Modulus Reduction Test, Loading No. 3,
Sample Depth 161 ft., σ_c' = 47.2 psi, CSR = 0.088

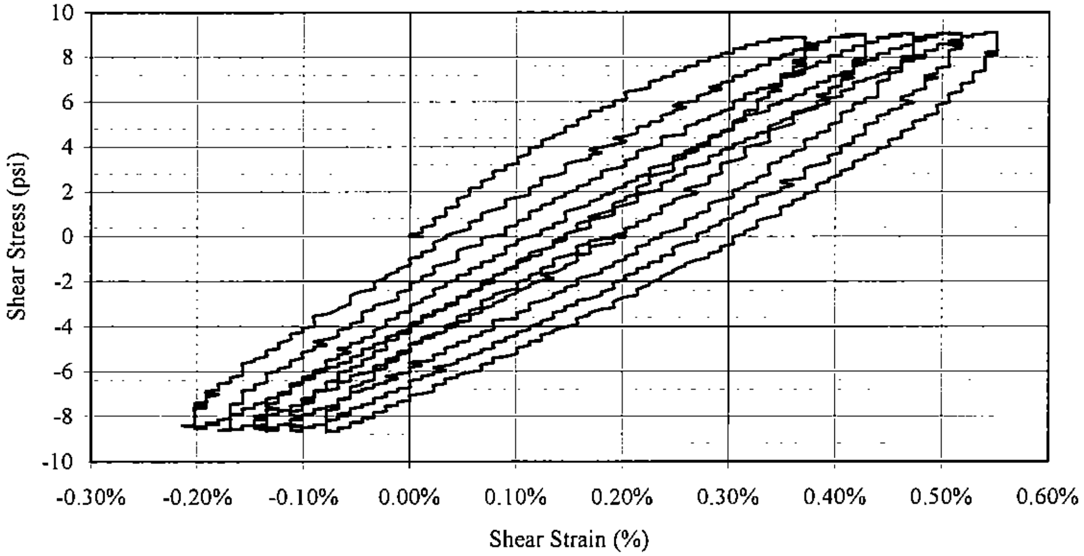


Boring SD-122, Sample No. S-36
Modulus Reduction Test, Loading No. 4,
Sample Depth 161 ft., σ_c'= 47.2 psi, CSR = 0.121

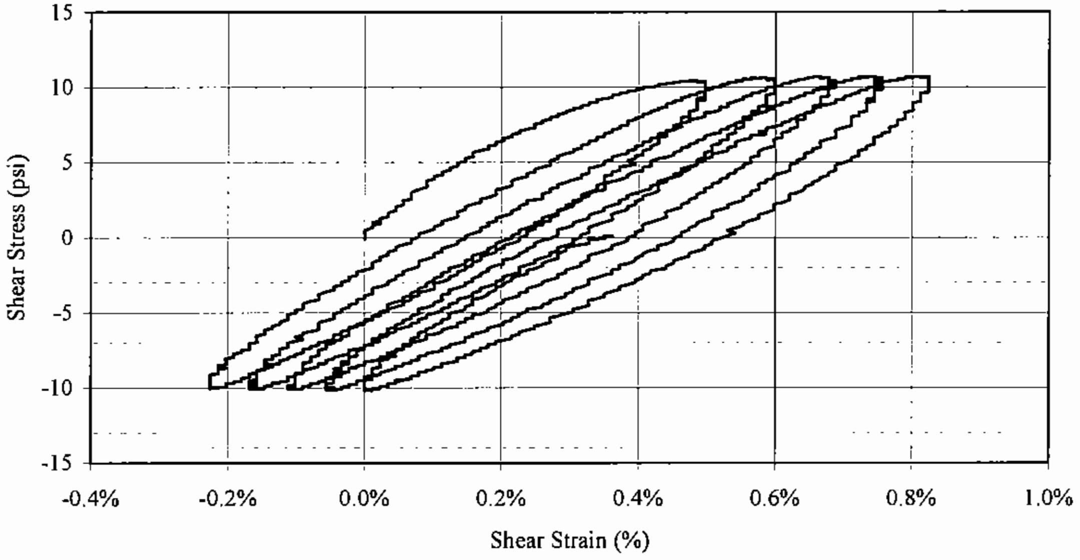
Boring SD-122, Sample No. S-36
Modulus Reduction Test, Loading No. 5,
Sample Depth 161 ft., σ_c'= 47.2 psi, CSR = 0.155



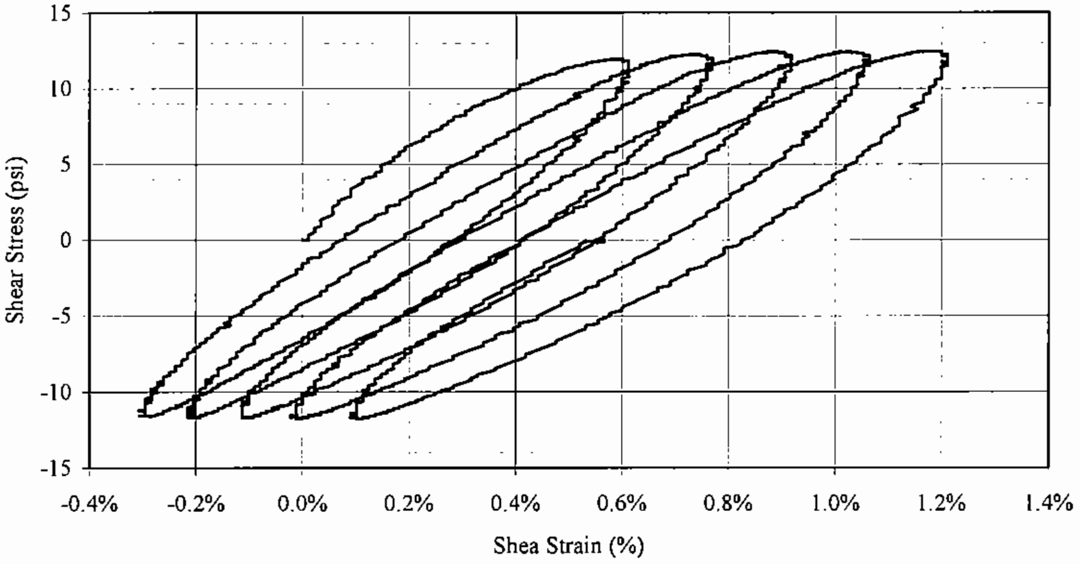
Boring SD-122, Sample No. S-36
Modulus Reduction Test, Loading No. 6,
Sample Depth 161 ft., σ_c'= 47.2 psi, CSR = 0.189



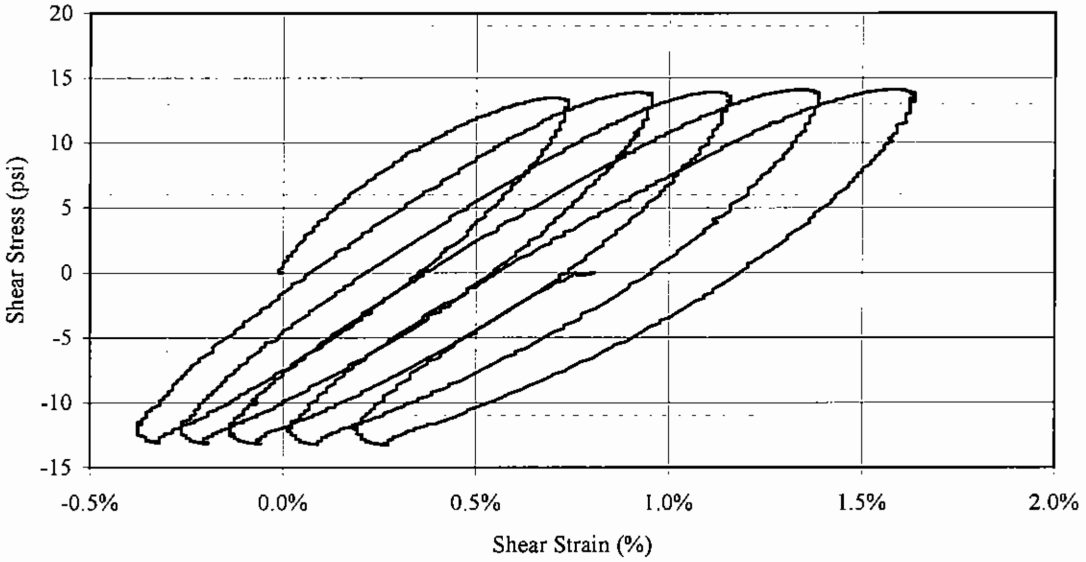
Boring SD-122, Sample No. S-36
Modulus Reduction Test, Loading No. 7,
Sample Depth 161 ft., σ_c'= 47.2 psi, CSR = 0.221



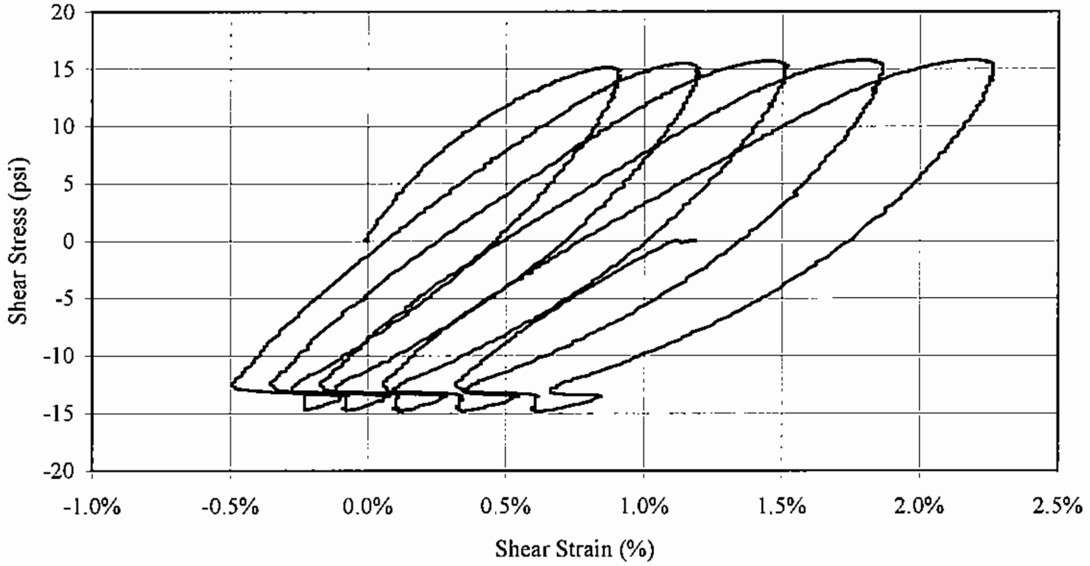
Boring SD-122, Sample No. S-36
Modulus Reduction Test, Loading No. 8,
Sample Depth 161 ft., σ_c'= 47.2 psi, CSR = 0.256



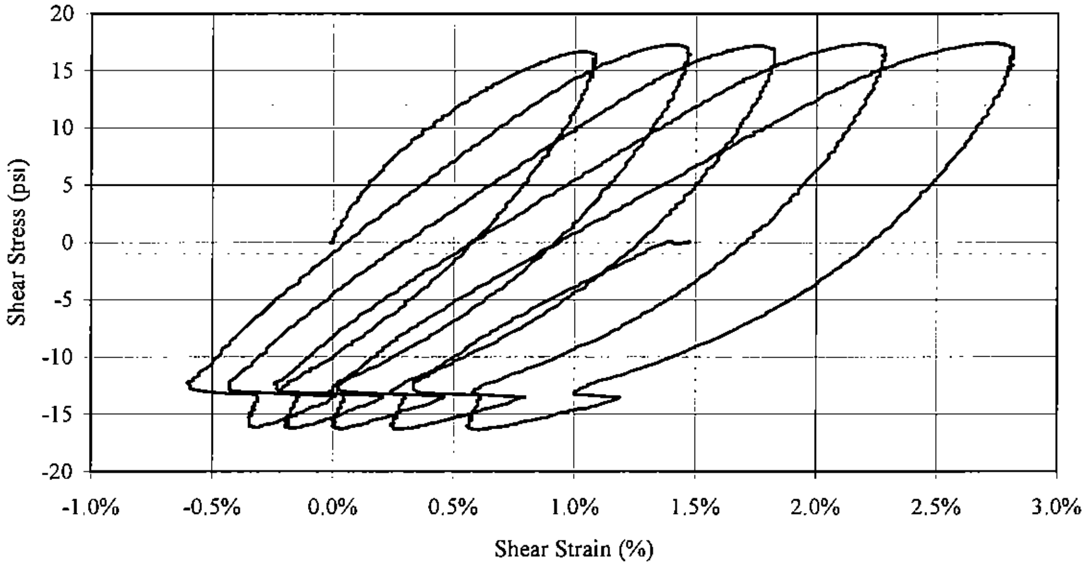
Boring SD-122, Sample No. S-36
Modulus Reduction Test, Loading No. 9,
Sample Depth 161 ft., σ_c'= 47.2 psi, CSR = 0.289



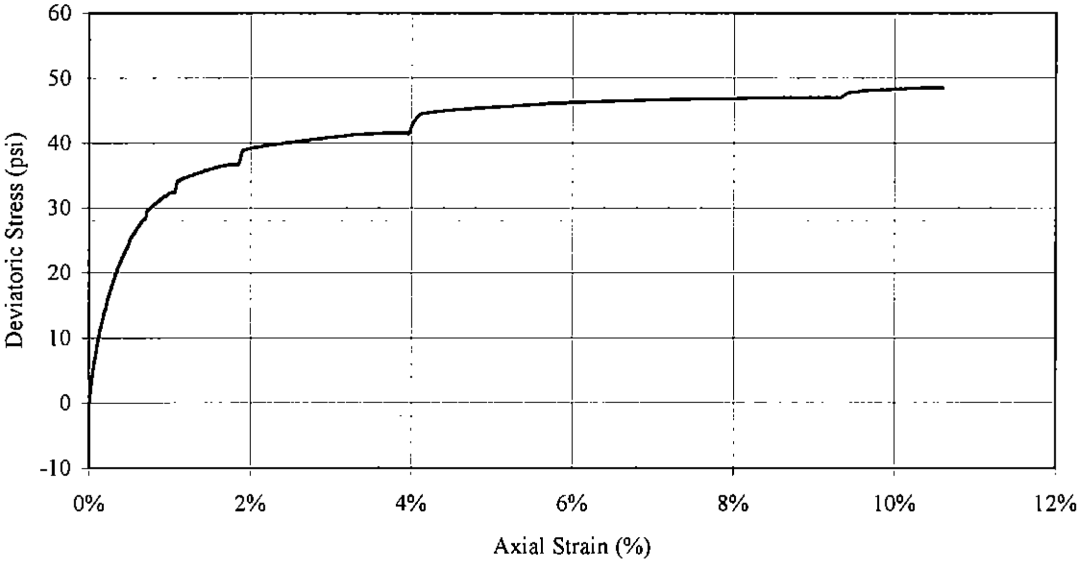
Boring SD-122, Sample No. S-36
Modulus Reduction Test, Loading No. 10,
Sample Depth 161 ft., σ_c'= 47.2 psi, CSR =0.323



Boring SD-122, Sample No. S-36
Modulus Reduction Test, Loading No. 11,
Sample Depth161 ft., σ_c'= 47.2 psi, CSR = 0.355



Boring SD-122, Sample No. S-36
Static Stress Control Test
Sample Depth =161 ft., σ_c'= 47.2 psi

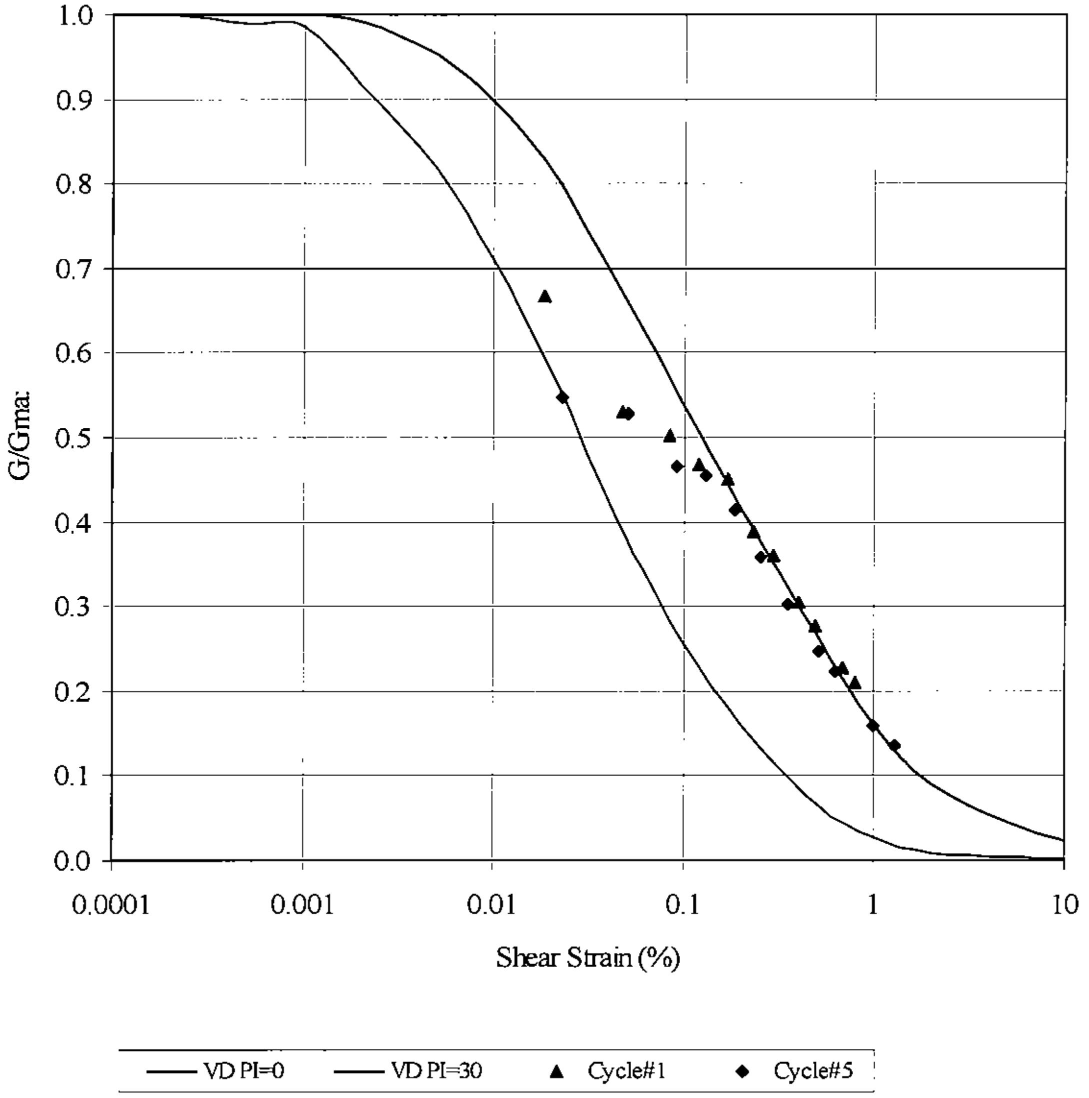


Appendix B

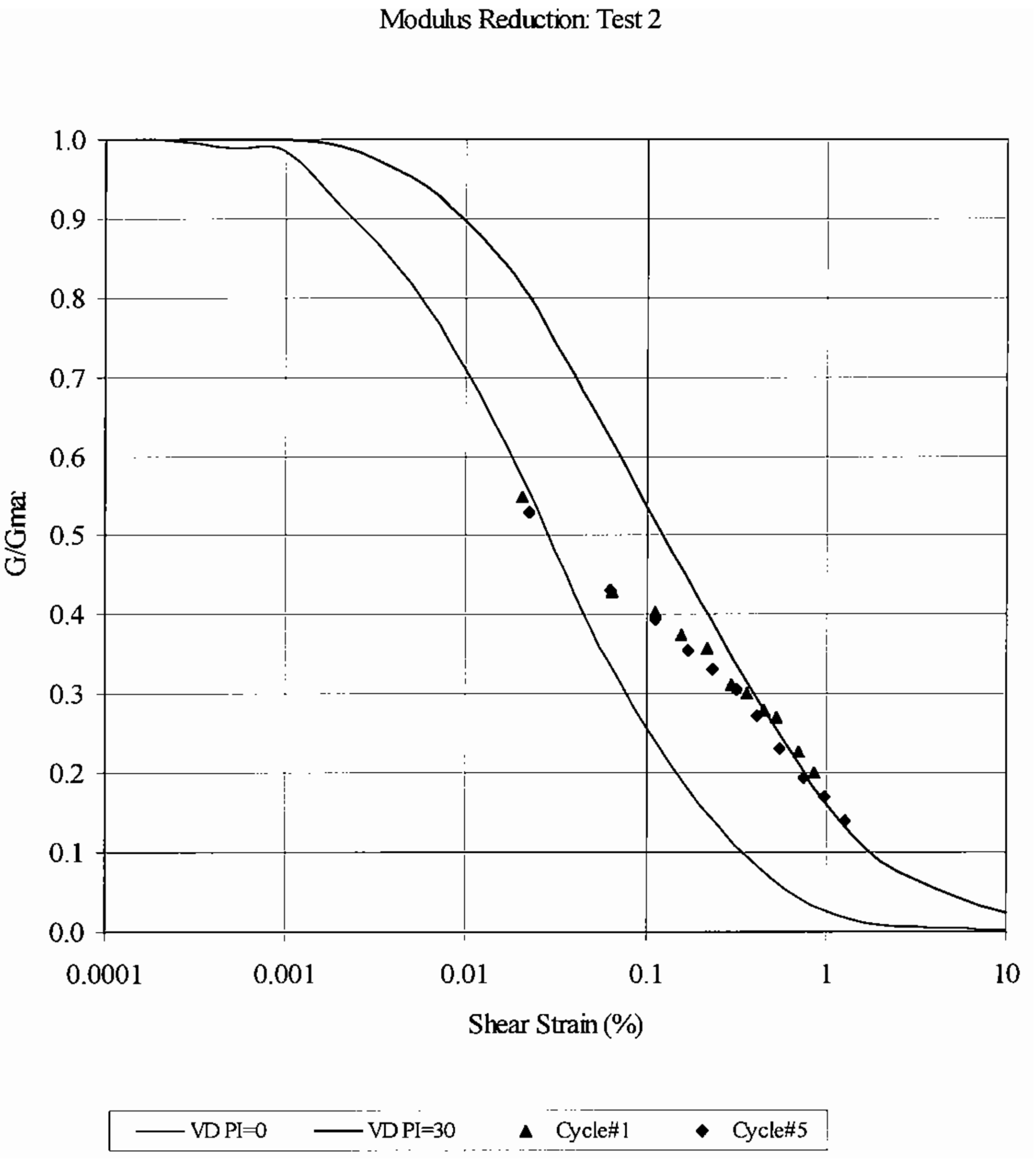
Variation of Soil Modulus with Cyclic Shear Strain

Test 1
Boring SD-122, Sample No. S-36

Modulus Reduction: Test 1

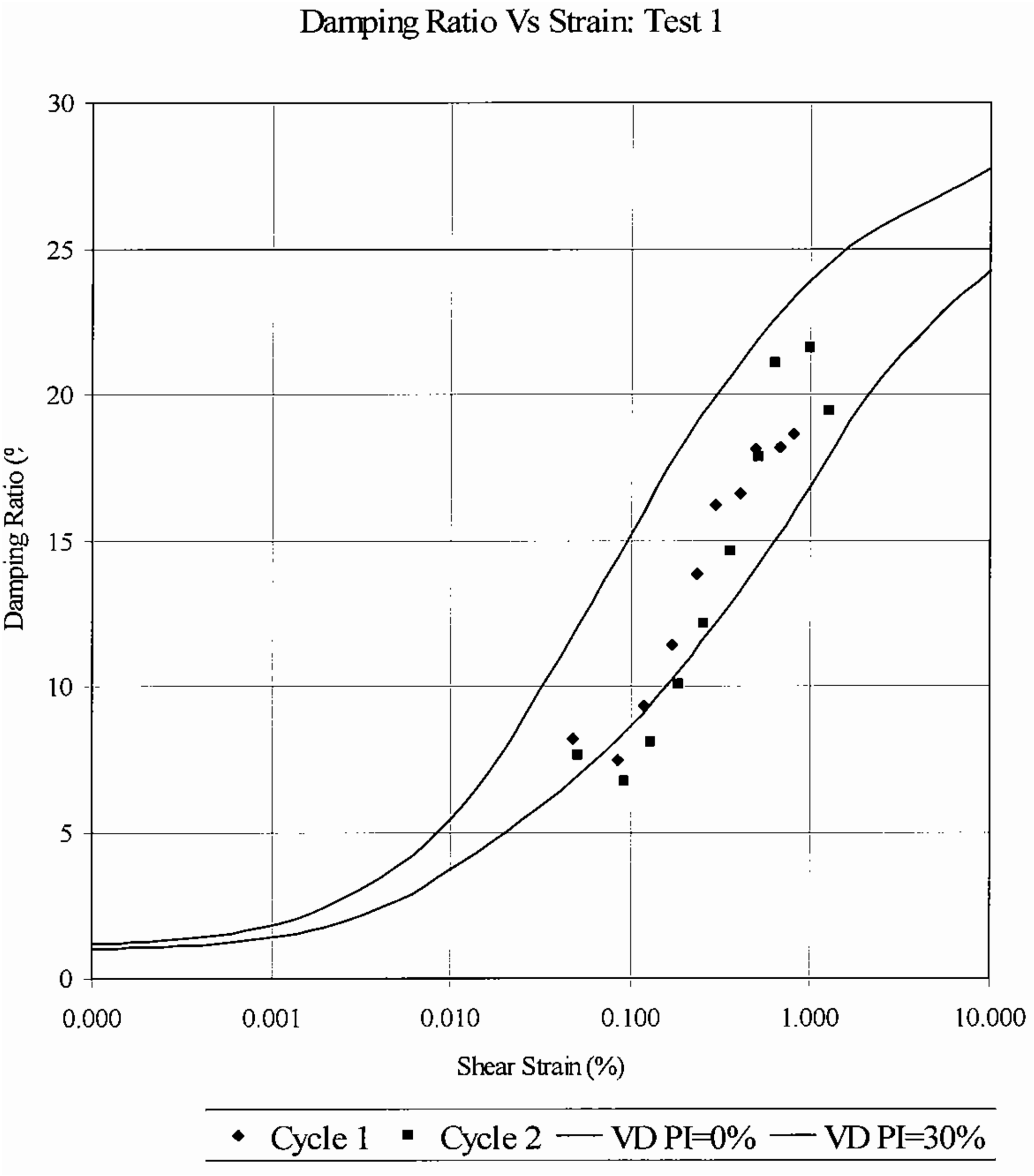


Test 2
Boring SD-122, Sample No. S-36

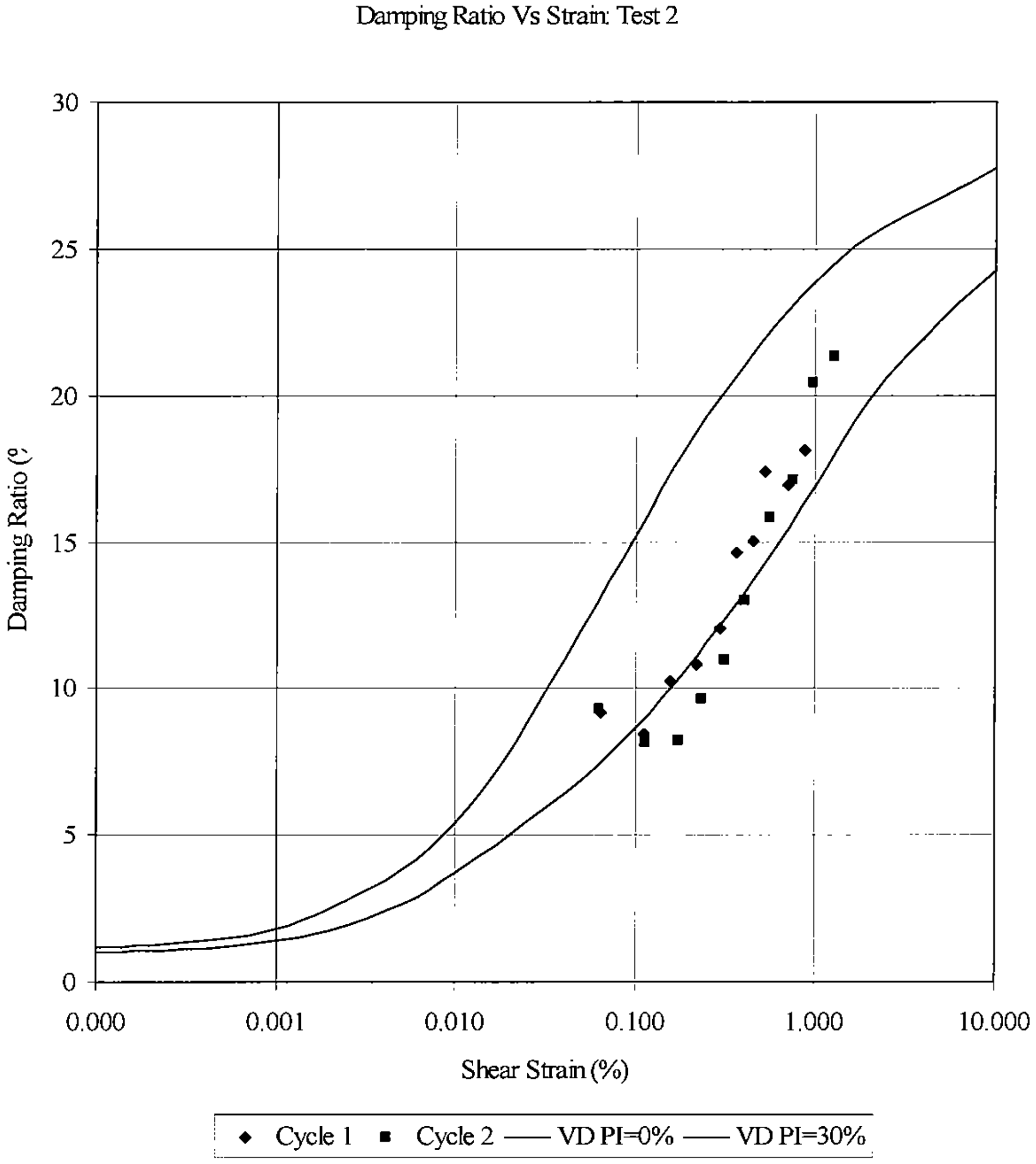

Modulus Reduction: Test 2
G/Gmax
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.0001
0.001
0.01
0.1
1
10
Shear Strain (%)
VD PI=0
VD PI=30
▲ Cycle#1
◆ Cycle#5

Appendix C
Variation of Damping Ratio with Cyclic Shear Strain

Test 1
Boring SD-122, Sample No. S-36


Damping Ratio Vs Strain: Test 1
30
25
20
15
10
5
0
Damping Ratio (º
0.000
0.001
0.010
0.100
1.000
10.000
Shear Strain (%)
◆ Cycle 1
■ Cycle 2
— VD PI=0%
— VD PI=30%

Test 2
Boring SD-122, Sample No. S-36


Damping Ratio Vs Strain: Test 2
30
25
20
15
10
5
0
Damping Ratio (°
0.000
0.001
0.010
0.100
1.000
10.000
Shear Strain (%)
◆ Cycle 1
■ Cycle 2
VD PI=0%
VD PI=30%

D.2 SEATTLE MONORAIL PROJECT GEOTECHNICAL CHARACTERIZATION REPORT EXCERPTS

CONTENTS

- Geology Text Excerpt

The following description of Seattle geology is excerpted from the SMP GCR Addendum No. 110-5 (Shannon & Wilson, 2004e). The "project alignment" and "project corridor" mentioned below refer to the formerly proposed SMP alignment. Detailed descriptions of geologic units from the SMP GCR were not included below if those units were not encountered in the vicinity of the array.

"An understanding of the geologic history and the depositional processes that produced the soil stratigraphy in the project area is useful for understanding the engineering characteristics and predicted behavior of the deposits encountered along the project alignment. In addition, this information can be used to make stratigraphic correlation between borings. It also provides a framework for anticipating subsurface conditions that may not have been disclosed directly by the exploration program, but may be reasonably expected based on past local project experience with similar geologic units."

D.2.1 Regional Geology

"The Puget Sound area has been subjected to six or more major glaciations during the Pleistocene Epoch (2 million years ago to about 10,000 years ago). The ice sheet of each glaciation overrode and compacted underlying soils to a very dense or hard state (overconsolidated). During the most recent ice coverage of the central Puget Lowland (Vashon Stade of Fraser Glaciation), the thickness of ice is estimated to have been about 3,000 feet in the alignment area. The last ice covering the alignment area receded about 13,500 years ago, leaving a landscape sculpted into a series of north-south-trending ridges and valleys. These deep valleys were commonly, partially, or completely filled with recessional glacial deposits and recent Holocene deposits. As the last ice sheet retreated, sea level changed as a result of isostatic readjustment of the land and rising water levels from the melting of the ice worldwide. At times during the last recession, sea level was considerably different from the present sea level.

Tectonically, the Puget Lowland is located in the fore arc of the Cascadia Subduction Zone. The tectonics and seismicity of the region are the result of the relative northeastward subduction of the Juan de Fuca Plate beneath the North American Plate. North-south compression is being accommodated primarily beneath the Puget Lowland by a series of west- and northwest-trending thrust faults that extend to depths of about 12 miles. The nearest potentially active fault to the project is the Seattle Fault, a collective term for a series of four or more east-west-trending south-dipping fault splays, beneath Seattle. Recent geologic evidence indicates that ground surface rupture from movement on this fault zone occurred as recently as 1,100 years before present. One or more of these splays likely cross the southern portion of the alignment. Refer to the

Seismic Ground Motion Study (SGMS), February 2004[b], prepared by Shannon & Wilson, Inc. for more information regarding the tectonic setting of the Puget Sound region, fault locations, fault activity, and seismicity."

D.2.2 Geologic Unit Descriptions

"Based on the soils encountered in the subsurface exploration program and on exploration logs completed by others in the project vicinity, the following is a stratigraphic outline for the Holocene and Pleistocene geologic history (youngest to oldest) along the project corridor:

- Holocene (not glacially consolidated, nonglacial)
  - Fill (Hf)
  - Landslide Debris (Hls)
  - Alluvium (Ha)
  - Estuarine (He)
  - Peat Deposits (Hp)
  - Beach Deposits (Hb)
  - Lacustrine Deposits (Lake) (Hl)
  - Reworked Glacial Deposits (Hrw)
- Vashon (glacial)
  - Not Glacially Consolidated Sediments
    - Recessional Outwash (Qvro)
    - Recessional Lacustrine Deposits (Qvrl)
    - Ice-Contact Deposits (Qvri)
    - Ablation Till (Qvat)
  - Glacially Consolidated Sediments
    - Lodgement Till (Qvt)
    - Glacial Till-Like Deposits (Qvd)
    - Advance Outwash (Qva)
    - Glaciolacustrine Deposits (Qvgl)
- Pre-Vashon (glacially consolidated, nonglacial, deposited during interglacial periods)
  - Fluvial Deposits (Qpnf)
  - Lacustrine Deposits (Qpnl)
  - Peat Deposits (Qpnp)
  - Landslide Deposits (Qpls)

- Pre-Vashon (glacial)
  - Outwash (Qpgo)
  - Glaciolacustrine Deposits (Qpgl)
  - Till (Qpgt)
  - Till-Like Deposits (Qpgd)
  - Glaciomarine Drift (Qpgm)

Soil strata have been delineated according to geologic unit. Geologic units were defined based on depositional environment and general geologic characteristics. The geologic nomenclature used for the project and corresponding general soil characteristics are described on Figure 4 and in the text below. These geologic units are interpretive and based on our opinion of the grouping of complex sediments and soil types into units appropriate for the project."

D.2.2.1 Holocene (Nonglacial) Units

"The Holocene soils (Hf, Hls, Ha, He, Hp, Hb, Hl, and Hrw) have all been deposited since the retreat of the last glacial ice sheet and have not been glacially overridden. The properties of these soils are often quite variable.

Fill (Hf) has widely variable properties, depending on the material used as fill and whether the fill was placed in an engineered or nonengineered fashion. Most of the fill encountered along the alignment consists of loose to dense granular material, such as silty sand. Some of this fill may have been hydraulically placed. Gravel, cobbles, and boulders are common in this unit, particularly in nonengineered fill. About 50 percent of cobbles and boulders that were encountered during explorations for this project were encountered within the fill soils. Fill soils were identified from the presence of irregular clasts of one soil type within soil of another type, or from the presence of debris such as fragments of glass, asphalt, concrete, wood, sawdust, or coal. In general, the presence of debris may be more frequent in areas where historical fill placement occurred during the settlement of Seattle, such as the SODO and Interbay areas. These soils also show zones of iron-oxide staining. Because drilling typically took place along streets or sidewalks, some of the fill encountered may represent backfill material for utility trenches or fill placed during the original grading of the street."

"Alluvium (Ha) is primarily present in the SODO area and extends to significant depths. Ha soils are also present locally in the West Seattle, Downtown, and Interbay Segments. This deposit generally consists of loose to medium dense sand, sandy silt, and silty sand with scattered fine gravel. Cobbles and boulders may be anticipated within this unit, but were not encountered in the explorations.

Estuarine deposits (He) are also primarily present in the SODO area, generally interlayered within and underlying the Ha soils. He soils are also present locally in the West Seattle, Downtown, and Interbay Segments. This deposit generally consists of loose to medium dense silt and sandy silt to very soft to stiff, clayey silt to silty clay. Interbeds of organic-rich soils exist within this unit."

"Beach deposits (Hb) were encountered along the West Seattle, SODO, Interbay, and Ballard Crossing Segments. These deposits are generally located near the base of the Holocene units. They generally consist of sand and gravel and may also contain scattered cobbles and locally cohesive fines. In places, Hb deposits extend to considerable depths as a result of sea level and shoreline position changes since the last glaciation. Scattered to abundant shell fragments and wood debris were observed in these soils."

"Reworked glacial deposits (Hrw) were encountered in the SODO area. These deposits are generally located near the base of the Holocene units and may be a mixture of more than one soil type. This unit is commonly associated with Hb deposits overlying glacially overridden soils. Scattered cobbles and boulders may be found in Hrw deposits; however, none were encountered in the explorations."

D.2.2.2 Quaternary Vashon Units

"The recessional-type deposits (Qvro, Qvrl, Qvri, and Qvat) were deposited during the wasting of the glacial ice and, therefore, were not overridden by the Vashon ice sheet. The rest of the Vashon sediments (Qvt, Qvd, Qva, and Qvgl) are older and were overridden by the advancing Vashon glacier after deposition. Generally, these deposits are very dense or hard and overconsolidated."

"Recessional lacustrine deposits (Qvrl) consist of dense to very dense, silty, fine sand and soft to hard, silty clay to clayey silt. The clayey sediments are generally of low plasticity. Qvrl deposits were encountered below the West Seattle, SODO, and Ballard Crossing Segments. Cobbles and boulders, if present, are most likely to exist at the contact with the underlying sediments."

D.2.2.3 Quaternary Pre-Vashon Nonglacial (Interglacial) Units

"During the time period between two glaciations (interglacial), sediments (Qpnf, Qpnl, Qpnp, and Qpls) were deposited by nonglacial processes. These sediments commonly contain organic material and may have more discontinuous distribution because of the nature of the depositional processes. These sediments have been overridden by one or more glaciations and are generally very dense or hard. Qpnl and Qpnp would not likely contain boulders, based on their depositional environments. However, these sediments may have been deposited on top of an erosional surface on pre-existing glacial or nonglacial sediments. As such, Qpnl and Qpnp nonglacial soils may contain relict cobbles and boulders along the erosional surface at the base of the unit. Qpnf and Qpls may contain cobbles and boulders due to their inherent depositional environments."

D.2.2.4 Quaternary Pre-Vashon Glacial Units

"The following units (Qpgo, Qpgl, Qpgt, Qpgd, and Qpgm) represent sediments deposited by glacial processes during one of the several glacial episodes prior to the Vashon glaciation. All pre-Vashon soils have been glacially consolidated and are generally very dense or very stiff to hard. All of these units, except Qpgm, have Vashon equivalents because, generally, the same processes took place during each of the glacial episodes. As such, the differentiation of Vashon from pre-Vashon sediments was largely accomplished through stratigraphic position.

Outwash (Qpgo) was encountered in most areas along the alignment. These deposits typically consist of very dense, clean to silty, fine or fine to medium sand with a trace of coarse sand and fine gravel. This unit contains scattered cobbles and boulders. These sediments are very similar to Qva and Qpnf and were differentiated from them by the lack of organics or from stratigraphy.

Glaciolacustrine deposits (Qpgl) consist of very stiff to hard, silty clay and, to a lesser extent, clayey silt with scattered beds of silt and silty, fine sand. Qpgl includes both low- and high-plasticity clay but is generally of higher plasticity than Qvgl soil. Qpgl soils are commonly laminated to bedded but can also be massive (lacking bedding). The Qpgl soils sometimes exhibit scattered to abundant sheared and slickensided zones. These features are more commonly found in darker gray clays with higher plasticity. Qpgl soils were encountered below most of the alignment segments, except the Ballard Segment, where the glacial stratigraphy is predominantly Vashon age. Ice-rafted gravel, cobbles, and boulders (dropstones) may be encountered within this unit.

Till (Qpgt) was encountered in the SODO and Interbay Segments. Where encountered, Qpgt soils were similar to Qvt soils and consisted of very dense, gravelly, silty sand to silty, gravelly sand with nonplastic to low plasticity fines. Along the alignment, Qpgt soils are commonly gradational with Qpgm. Cobbles and boulders are common in this unit."

"Glaciomarine drift (Qpgm) generally consists of poorly graded granular material with a clayey matrix (a clayey diamict). Qpgm has a grain size distribution similar to till (Qvt and Qpgt). Qpgm soils may vary considerably, from very dense, gravelly, silty sand with a trace of clay, to silty, clayey sand and hard, silty clay with small amounts of sand and gravel. Cobbles and boulders are common in this unit. Qpgm was encountered along the West Seattle, SODO, and Downtown Segments and commonly grades into and contains layers of Qpgl."

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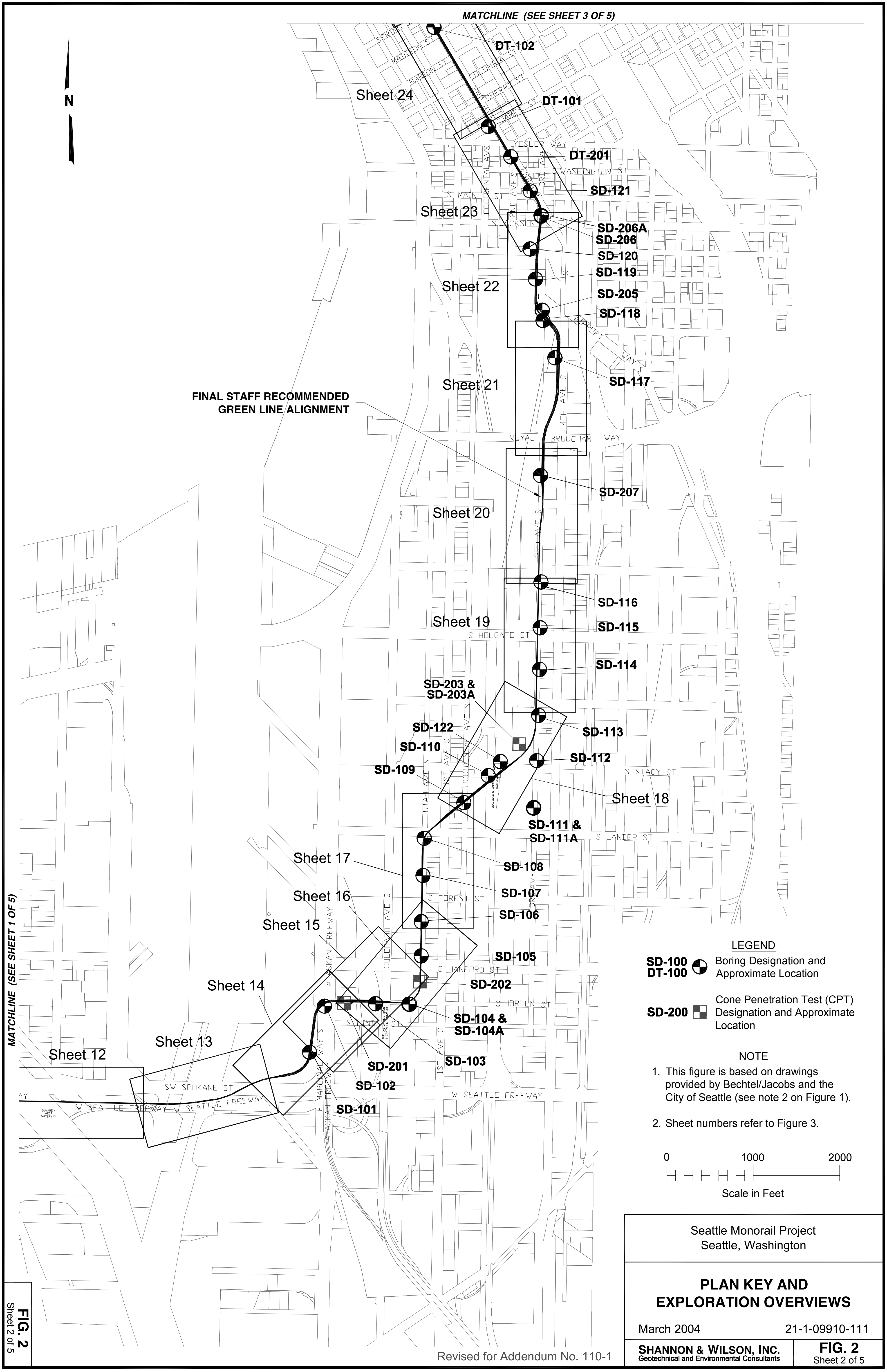


LEGEND

SD-100 DT-100	◕	Boring Designation and Approximate Location
SD-200	▚	Cone Penetration Test (CPT) Designation and Approximate Location

NOTE

1. This figure is based on drawings provided by Bechtel/Jacobs and the City of Seattle (see note 2 on Figure 1).
2. Sheet numbers refer to Figure 3.

0 1000 2000

Scale in Feet

Seattle Monorail Project
Seattle, Washington

PLAN KEY AND EXPLORATION OVERVIEWS

March 2004 21-1-09910-111

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 2
Sheet 2 of 5

Revised for Addendum No. 110-1

LEGEND

◐	**SD-100**	Project Boring Designation and Surveyed Location
🟥	**SD-200**	Cone Penetration Test (CPT) Designation and Approximate Location
●	187-1260	Research Boring Designation and Approximate Location
═ , ═		Final Staff Recommended Alignment for Green Line
∼ 230 ∼		Topographic Contours With Elevation in Feet

NOTES

1. This figure is based on drawings and aerial photographs provided by Bechtel/Jacobs and the City of Seattle. The alignment and stations were compiled from the following .dwg files received 3-4-04: gl01-00-plan-J, gl02-00-plan-J, gl03-00-plan-J, gl04-00-plan-J, gl05-00-plan-J, gl06-00-plan-J and the following .dwg files received 2-25-04: gl01-00-plan-J_nucor, GL01_cCN, and GL01_cLS.
2. Vertical datum: NAVD88.

0 100 200

Scale in Feet

STATIONING RANGE

360+00 to 375+00

Revised for Addendum No. 110-1

Seattle Monorail Project
Seattle, Washington

SITE AND EXPLORATION PLAN

March 2004 21-1-09910-111

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 3
Sheet 18 of 51

File: I:\Drafting\211\09910-001 \plans\21-1-09910 Plans.dwg Date: 04-02-2004 Author: LR

GEOLOGIC UNIT EXPLANATION

NON OVERRIDDEN

HOLOCENE DEPOSITS

Hf	FILL: Fill placed by humans, both engineered and nonengineered. Various materials, including debris; cobbles and boulders may be common; commonly dense or stiff if engineered, but very loose to dense or very soft to stiff if nonengineered.
Hls	LANDSLIDE DEPOSITS: Deposits of landslides, normally at and adjacent to the toe of slopes. Disturbed, heterogeneous mixture of one or more soil types; may contain wood and other organics; loose or soft, with random dense or hard pockets.
Ha	ALLUVIUM: River or creek deposits, normally associated with historical streams, including deltaic and overbank deposits. Sand, silty Sand, gravelly Sand; very loose to very dense.
Hp	PEAT DEPOSITS: Depression fillings of organic materials. Peat, peaty Silt, organic Silt; very soft to medium stiff.
He	ESTUARINE DEPOSITS: Fine-grained sediments deposited in brackish water associated with rivers and streams located along the present and former Puget Sound shoreline. Clayey Silt, silty Clay, Silt, and fine Sand; organics and shell fragments common; very soft to very stiff or very loose to medium dense.
Hl	LAKE DEPOSITS: Depression fillings of fine-grained soils. Sandy Silt, Silt, clayey Silt, silty Clay; commonly with scattered organics; very soft to stiff or very loose to medium dense.
Hb	BEACH DEPOSITS: Deposits along present and former shorelines of Puget Sound and tributary river mouths. Silty Sand, sandy Gravel, gravelly Sand, wood and shell debris common; loose to dense.
Hrw	REWORKED GLACIAL DEPOSITS: Glacially deposited soils that have been reworked by fluvial or wave action. Sand, silty Sand, gravelly Sand; lies on top of glacially overridden soils; loose to dense.

QUATERNARY VASHON DEPOSITS

Qvro	RECESSIONAL OUTWASH DEPOSITS: Glaciofluvial sediment deposited as glacial ice retreated. Clean to silty Sand, gravelly Sand, sandy Gravel; cobbles and boulders common; loose to very dense.
Qvrl	RECESSIONAL LACUSTRINE DEPOSITS: Glaciolacustrine sediment deposited as glacial ice retreated. Fine Sand, Silt, and Clay; dense to very dense, soft to hard.
Qvri	ICE-CONTACT DEPOSITS: Heterogeneous soils deposited against or adjacent to ice during the wasting of glacial ice; commonly reworked. Stratified to irregular bodies of Gravel, Sand, Silt, and Clay; loose to dense.
Qvat	ABLATION TILL: Heterogeneous soils deposited during the wasting of glacial ice; generally not reworked. Gravelly silty Sand, silty gravelly Sand, with some clay; cobbles and boulders common; loose to very dense or soft to hard.

GLACIALLY OVERRIDDEN

QUATERNARY VASHON DEPOSITS

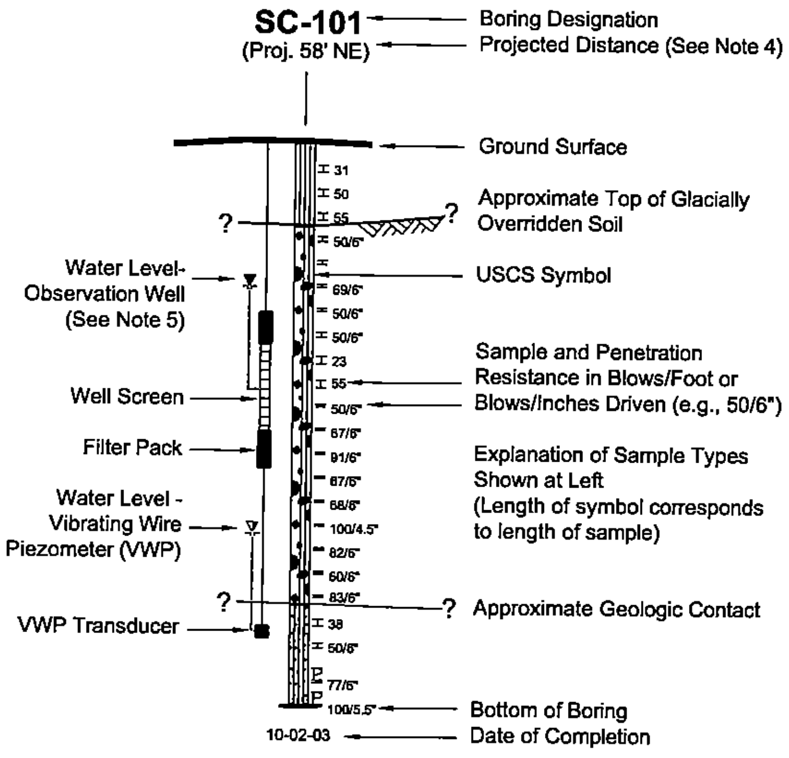
Qvt	TILL: Lodgment till laid down along the base of glacial ice. Gravelly silty Sand, silty gravelly Sand ("hardpan"); cobbles and boulders common; very dense.
Qvd	TILL-LIKE DEPOSITS (DIAMICT): Glacial deposit intermediate between till and outwash; subglacially reworked. Silty gravelly Sand, silty Sand, sandy Gravel; highly variable over short distances; cobbles and boulders common; dense to very dense.
Qva	ADVANCE OUTWASH: Glaciofluvial sediment deposited as the glacial ice advanced through the Puget Lowland. Clean to silty Sand, gravelly Sand, sandy Gravel; dense to very dense.
Qvgl	GLACIOLACUSTRINE DEPOSITS: Fine-grained glacial flour deposited in proglacial lake in Puget Lowland. Silty clay, Clayey Silt, with interbeds of Silt and fine Sand; locally laminated; scattered organic fragments locally; hard or dense to very dense.

QUATERNARY PRE-VASHON DEPOSITS

Qpnf	FLUVIAL DEPOSITS: Alluvial deposits of rivers and creeks. Clean to silty Sand, gravelly Sand, sandy Gravel; very dense.
Qpnl	LACUSTRINE DEPOSITS: Fine-grained lake deposits in depressions, large and small. Fine sandy Silt, silty fine Sand, clayey Silt; scattered to abundant fine organics; dense to very dense or very stiff to hard.
Qpnp	PEAT DEPOSITS: Depression fillings of organic materials. Peat, peaty Silt, organic Silt; hard.
Qpls	LANDSLIDE DEPOSITS: Heterogeneous deposits of landslide debris. Chaotic mixture of silt, sand, clay, and gravel; may contain wood and other organics; hard or very dense.
Qpgo	OUTWASH: Glaciofluvial sediment deposited as the glacial ice advanced or retreated through the Puget Lowland. Clean to silty Sand, gravelly Sand, sandy Gravel; very dense.
Qpgl	GLACIOLACUSTRINE DEPOSITS: Fine-grained glacial flour deposited in proglacial lake in Puget Lowland. Silty Clay, clayey Silt, with interbeds of Silt and fine Sand; very stiff to hard or very dense.
Qpgt	TILL: Lodgment till laid down along the base of glacial ice. Gravelly silty Sand, silty gravelly Sand ("hardpan"); cobbles and boulders common; very dense.
Qpgd	TILL-LIKE DEPOSITS (DIAMICT): Glacial deposit intermediate between till and outwash; subglacially reworked. Silty gravelly Sand, silty Sand, sandy Gravel; highly variable over short distance; cobbles and boulders common; very dense.
Qpgm	GLACIOMARINE DEPOSITS: Till-like deposit with clayey matrix deposited in proglacial lake by icebergs, floating ice, or gravity currents. Variable mixture of Clay, Silt, Sand, and Gravel; scattered shells locally; cobbles and boulders common; very dense or hard.

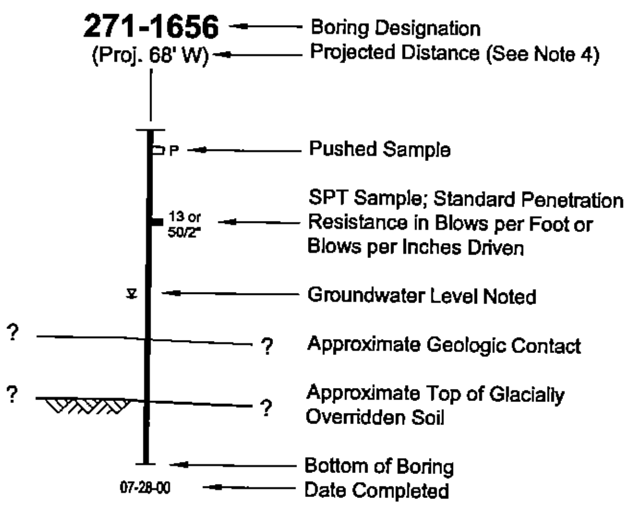
PROFILE LEGEND

PROJECT BORING

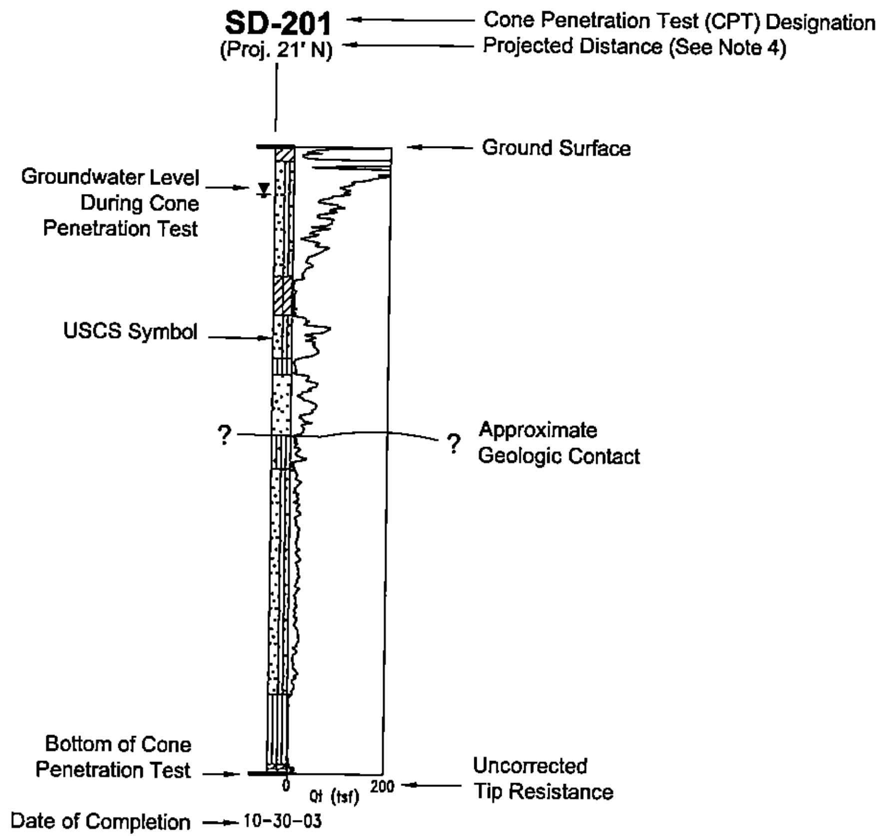


PREVIOUS BORING

(By Shannon & Wilson or others)



PROJECT CONE PENETRATION TEST



NOTES

1. Ground surface shown was constructed from digital elevation data provided by Bechtel/Jacobs and the City of Seattle.
2. Elevation Datum: North American Vertical Datum of 1988 (NAVD88).
3. Subsurface conditions shown are generalized from soils encountered in project borings and from logs of borings previously completed for other projects along the alignment. Variations between the profile and actual conditions may exist.
4. Projections are taken from the southbound track alignment in areas where two tracks are present.
5. See Data Report for groundwater fluctuations.
6. The description of each geologic unit includes only general information regarding the environment of deposition and basic soil characteristics. See text of report for additional discussion of geologic units.

Seattle Monorail Project
Seattle, Washington

PROFILE LEGEND AND GEOLOGIC UNIT EXPLANATION

January 2004 21-1-09910-111

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 4

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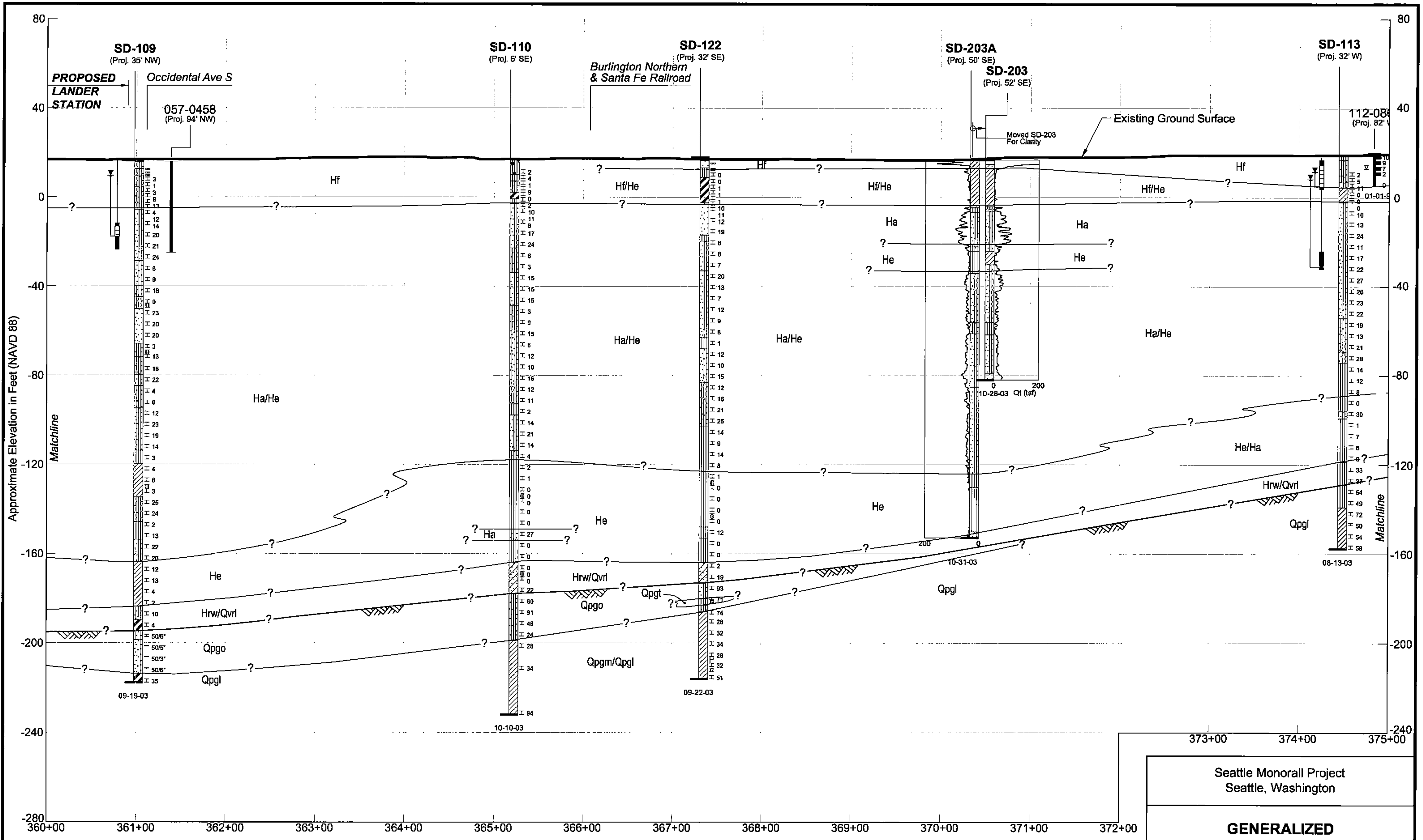

NOTE
See Figure 4 for Legend and Geological Unit Explanation

Seattle Monorail Project
Seattle, Washington

GENERALIZED SUBSURFACE PROFILE

January 2004 21-1-09910-111

SHANNON & WILSON, INC.
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FIG. 5
Sheet 17 of 50

IMPORTANT INFORMATION

Important Information

ABOUT YOUR GEOTECHNICAL/ENVIRONMENTAL REPORT

CONSULTING SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND FOR SPECIFIC CLIENTS.

Consultants prepare reports to meet the specific needs of specific individuals. A report prepared for a civil engineer may not be adequate for a construction contractor or even another civil engineer. Unless indicated otherwise, your consultant prepared your report expressly for you and expressly for the purposes you indicated. No one other than you should apply this report for its intended purpose without first conferring with the consultant. No party should apply this report for any purpose other than that originally contemplated without first conferring with the consultant.

THE CONSULTANT'S REPORT IS BASED ON PROJECT-SPECIFIC FACTORS.

A geotechnical/environmental report is based on a subsurface exploration plan designed to consider a unique set of project-specific factors. Depending on the project, these may include the general nature of the structure and property involved; its size and configuration; its historical use and practice; the location of the structure on the site and its orientation; other improvements such as access roads, parking lots, and underground utilities; and the additional risk created by scope-of-service limitations imposed by the client. To help avoid costly problems, ask the consultant to evaluate how any factors that change subsequent to the date of the report may affect the recommendations. Unless your consultant indicates otherwise, your report should not be used (1) when the nature of the proposed project is changed (for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one, or chemicals are discovered on or near the site); (2) when the size, elevation, or configuration of the proposed project is altered; (3) when the location or orientation of the proposed project is modified; (4) when there is a change of ownership; or (5) for application to an adjacent site. Consultants cannot accept responsibility for problems that may occur if they are not consulted after factors that were considered in the development of the report have changed.

SUBSURFACE CONDITIONS CAN CHANGE.

Subsurface conditions may be affected as a result of natural processes or human activity. Because a geotechnical/environmental report is based on conditions that existed at the time of subsurface exploration, construction decisions should not be based on a report whose adequacy may have been affected by time. Ask the consultant to advise if additional tests are desirable before construction starts; for example, groundwater conditions commonly vary seasonally.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes, or groundwater fluctuations may also affect subsurface conditions and, thus, the continuing adequacy of a geotechnical/environmental report. The consultant should be kept apprised of any such events and should be consulted to determine if additional tests are necessary.

MOST RECOMMENDATIONS ARE PROFESSIONAL JUDGMENTS.

Site exploration and testing identifies actual surface and subsurface conditions only at those points where samples are taken. The data were extrapolated by your consultant, who then applied judgment to render an opinion about overall subsurface conditions. The actual interface between materials may be far more gradual or abrupt than your report indicates. Actual conditions in areas not sampled may differ from those predicted in your report. While nothing can be done to prevent such situations, you and your consultant can work together to help reduce their impacts. Retaining your consultant to observe subsurface construction operations can be particularly beneficial in this respect.

A REPORT'S CONCLUSIONS ARE PRELIMINARY.

The conclusions contained in your consultant's report are preliminary, because they must be based on the assumption that conditions revealed through selective exploratory sampling are indicative of actual conditions throughout a site. Actual subsurface conditions can be discerned only during earthwork; therefore, you should retain your consultant to observe actual conditions and to provide conclusions. Only the consultant who prepared the report is fully familiar with the background information needed to determine whether or not the report's recommendations based on those conclusions are valid and whether or not the contractor is abiding by applicable recommendations. The consultant who developed your report cannot assume responsibility or liability for the adequacy of the report's recommendations if another party is retained to observe construction.

THE CONSULTANT'S REPORT IS SUBJECT TO MISINTERPRETATION.

Costly problems can occur when other design professionals develop their plans based on misinterpretation of a geotechnical/environmental report. To help avoid these problems, the consultant should be retained to work with other project design professionals to explain relevant geotechnical, geological, hydrogeological, and environmental findings, and to review the adequacy of their plans and specifications relative to these issues.

BORING LOGS AND/OR MONITORING WELL DATA SHOULD NOT BE SEPARATED FROM THE REPORT.

Final boring logs developed by the consultant are based upon interpretation of field logs (assembled by site personnel), field test results, and laboratory and/or office evaluation of field samples and data. Only final boring logs and data are customarily included in geotechnical/environmental reports. These final logs should not, under any circumstances, be redrawn for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process.

To reduce the likelihood of boring log or monitoring well misinterpretation, contractors should be given ready access to the complete geotechnical engineering/environmental report prepared or authorized for their use. If access is provided only to the report prepared for you, you should advise contractors of the report's limitations, assuming that a contractor was not one of the specific persons for whom the report was prepared, and that developing construction cost estimates was not one of the specific purposes for which it was prepared. While a contractor may gain important knowledge from a report prepared for another party, the contractor should discuss the report with your consultant and perform the additional or alternative work believed necessary to obtain the data specifically appropriate for construction cost estimating purposes. Some clients hold the mistaken impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes that aggravate them to a disproportionate scale.

READ RESPONSIBILITY CLAUSES CLOSELY.

Because geotechnical/environmental engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against consultants. To help prevent this problem, consultants have developed a number of clauses for use in their contracts, reports, and other documents. These responsibility clauses are not exculpatory clauses designed to transfer the consultant's liabilities to other parties;

rather, they are definitive clauses that identify where the consultant's responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your report, and you are encouraged to read them closely. Your consultant will be pleased to give full and frank answers to your questions.

The preceding paragraphs are based on information provided by the ASFE/Association of Engineering Firms Practicing in the Geosciences, Silver Spring, Maryland