SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
ALASKA • CALIFORNIA • COLORADO • FLORIDA • MISSOURI • OREGON • WASHINGTON

400 N. 34TH STREET, SUITE 100
P.O. BOX 300303
SEATTLE, WASHINGTON 98103
206•632•8020 FAX 206•695•6777

TRANSMITTAL

TO	Mr. Daniel E. Johnson	DATE	June 18, 2010
COMPANY	U.S. Army Corps of Engineers, Seattle District	PHONE	
ADDRESS	P.O. Box 3755	FAX	
	Seattle, Washington 98134-2385	JOB NO.	21-1-21199-002
SUBJECT	**Final Geotechnical and Hydrogeologic Report, USACE Task Order No. 002 for Contract No. W912DW-09-D-1005**		

THE FOLLOWING ITEMS ARE TRANSMITTED:

DATE	NO. COPIES	DESCRIPTION
06/18/2010	ORIGINAL + 4 COPIES BOUND; PDF ON CD	SKAGIT RIVER LEVEE GENERAL INVESTIGATION, GEOTECHNICAL AND HYDROGEOLOGIC DATA AND LIQUEFACTION EVALUATION REPORT, SKAGIT COUNTY, WASHINGTON

- [x] Per your request
- [ ] For your approval
- [x] For your information
- [x] For your files
- [ ] For your review
- [ ] For your action
- [ ] Return with comments
- [ ] Other

By: Brian S. Reznick, P.E. c:

Title: Principal Engineer

Skagit River Levee General Investigation
Geotechnical and Hydrogeologic Data and
Liquefaction Evaluation Report
Skagit County, Washington

June 18, 2010

Submitted To:
Mr. Daniel E. Johnson
U.S. Army Corps of Engineers, Seattle District
P.O. Box 3755
Seattle, WA 98134-2385

By:
Shannon & Wilson, Inc.
400 N 34th Street, Suite 100
Seattle, Washington 98103

21-1-21199-002

TABLE OF CONTENTS

FIGURES

APPENDICES

SKAGIT RIVER LEVEE GENERAL INVESTIGATION GEOTECHNICAL AND HYDROGEOLOGIC DATA AND LIQUEFACTION EVALUATION REPORT SKAGIT COUNTY, WASHINGTON

1.0 INTRODUCTION

The Skagit River Levee General Investigation study is part of an effort by the Seattle District U.S. Army Corps of Engineers (USACE) to identify available levee information and to research different measures for flood reduction along the Skagit River levee alignments. This geotechnical and hydrogeologic report presents the results of our recent field exploration program, field testing, laboratory testing, and liquefaction evaluation for the study.

Notice to proceed with this study was provided by the USACE under Task Order No. 002. Our services were performed in general accordance with Contract No. W912DW-09-D-1005 and the corresponding Statement of Work for Task 4.

2.0 SITE AND SCOPE DESCRIPTION

Approximately 100 miles of the Skagit River flow through Skagit County, splitting into two distributaries, the North Fork Skagit River and South Fork Skagit River, before discharging into Skagit Bay. Major cities along the river include Sedro-Woolley, Burlington, and Mount Vernon. The community of Fir Island is located between the two distributaries. Most of the levees along the Skagit River are located downstream of Sedro-Woolley, occupying the lower 30 miles of river. Levee maintenance is divided between municipalities and dike districts along this stretch of river. Figure 1 shows the project vicinity map.

Our scope of services for this part of the study were to evaluate the hydrogeologic and geotechnical properties of the existing levee and underlying soil at eight levee locations near Mount Vernon and Fir Island. The eight locations were selected to evaluate subsurface conditions at known seepage areas along the levee and are based on several conversations with the USACE; Skagit County; and Dike Districts 1, 3, 17, and 22. Our services included:

- Coordinating, drilling, and sampling 16 borings to evaluate subsurface soil and groundwater conditions at eight levee locations.
- Installing monitoring wells and dataloggers in the borings to measure and record groundwater levels.

- Reviewing field logs and soil samples.
- Performing hydraulic conductivity testing in the wells.
- Performing laboratory index, strength, consolidation, and hydraulic conductivity tests on select soil samples.
- Performing liquefaction potential calculations.
- Producing a report to present our findings.

3.0 PREVIOUS STUDY

Shannon & Wilson recently conducted a review of the available levee and geotechnical and geologic site information collected by the Seattle District USACE in the study area. Our findings are summarized in a report titled, "Draft General Investigation Report, Skagit River Basin Levees, Skagit County," dated August 26, 2009. The USACE authorized the study as a first step in identifying construction opportunities for flood reduction along the levee alignments. The information gathered for the report was used in part to select the boring locations for this study.

4.0 SUBSURFACE EXPLORATIONS

We explored the subsurface conditions at eight levee locations by drilling and sampling 16 paired soil borings. Each boring pair consists of one boring drilled on the levee to about 60 to 65 feet below ground surface (bgs) and one boring drilled on the landward side of the levee to about 40 to 50 feet bgs. A groundwater observation well was installed in each boring. Boring names are designated by dike district, location number within that district, and the boring position (either levee or landward). For example, "DD1-1 Levee" was drilled in Dike District 1, Location 1, on the levee. The approximate boring locations are shown in Figure 2 and based on global positioning system (GPS) data. The GPS equipment used has an accuracy of approximately 3 meters. The boring logs are included in Appendix A.

4.1 Drilling Methods

Shannon & Wilson subcontracted with Holocene Drilling, Inc. to drill and sample the soil borings using a Mobile B-61 truck-mounted drill rig and mud rotary drilling methods. Drilling took place between October 8 and 23, 2009. Water mixed with Revert (an organic polymer thickening agent) was pumped from a tank at the ground surface, down the center of the drill rods and out a tri-cone bit, up the annulus of the hole, and back into the tank. The circulation of drilling fluid removes the drill cuttings from the hole and carries them to the surface where they are screened and removed from the recirculating mud. The Revert helps to stabilize the borehole, reducing caving or collapsing during drilling and sampling.

4.2 Soil Testing and Sampling

In general, soil testing and sampling was conducted at 2.5-foot intervals to 20 feet bgs and 5-foot intervals thereafter. Samples were obtained by removing the drill rods, attaching a sampler to the end of the rods, and lowering the sampler to the bottom of the hole. A Shannon & Wilson representative visually classified the retrieved samples, compiled a field log of each boring, and returned the samples to our laboratory in Seattle, Washington. Sample depths and types are shown in the boring logs presented in Figures A-2 through A-17 in Appendix A.

4.2.1 Split-spoon Sampling

Granular and fine-grained disturbed soil samples were obtained by a split-spoon sampler in conjunction with the Standard Penetration Test (SPT) or non-standard penetration sampling. Each recovered soil sample was scraped with a soils knife to remove excess drilling fluid, classified for the boring logs, and sealed in a screw-top plastic jar to preserve moisture. The jars were stored in boxes and returned to our laboratory by our field representative for further analyses and testing.

SPTs were performed in general accordance with ASTM International (ASTM) Designation: D 1586, Standard Test Method for Penetration Test and Split-barrel Sampling of Soils (ASTM, 2009). The SPT consists of a 2-inch outside-diameter (O.D.), 1.375-inch inside-diameter (I.D.), split-spoon sampler driven 18 inches into the bottom of the borehole with a 140-pound hammer free falling 30 inches. The number of blows required to cause the last 12 inches of penetration is termed the Standard Penetration Resistance (N-value). Generally, whenever 50 or more blows are required for 6 inches or less of penetration, the test is terminated and the number of blows and corresponding penetration recorded. The N-values are plotted on the boring logs presented in Appendix A. These values provide an empirical means by which to evaluate the relative density of granular soil and the relative consistency (stiffness) of cohesive soils. The relative density or consistency as it is related to the SPT N-value is shown in Figure A-1. The 2-inch-O.D. split spoon can collect sample volumes up to 26.7 cubic inches.

Non-standard penetration sampling consisted of a 3-inch O.D., 2.4-inch I.D. split-spoon sampler driven 18 inches into the bottom of the borehole with a 140-pound hammer free falling 30 inches. This sampling technique was used to obtain larger granular sample volumes for laboratory hydraulic conductivity testing. The 3-inch-O.D. split spoon can collect sample volumes up to 81.4 cubic inches. Similar to the SPT, the number of blows required to cause the last 12 inches of penetration was recorded and plotted on the boring logs presented in Appendix A.

The penetration resistance values recorded using the SPT are not the same as those recorded using the non-standard sampler. The specific energy imparted to the sample is a function of hammer type, hammer efficiency, hammer weight, hammer drop height, drill rod length and diameter, and sampler size. Published correction factors (Youd and Idriss, 1997) for hammer efficiency, overburden pressure, borehole diameter, rod length, and sampling method can be used to normalize the measured penetration resistances for both the SPT and non-standard sampler. The boring logs in Appendix A present the recorded penetration resistance values observed in the field at the time of drilling and have not been normalized. The word "nonstandard" is plotted next to the penetration resistance value where the 3-inch-O.D sampler was used.

4.2.2 Thin-walled Tube Sampling

At select locations, we obtained relatively undisturbed samples using a 36-inch-long, 3-inch O.D., thin-walled, steel tube sampler (Shelby tube). The direct-push sampling method was used in general accordance with ASTM Designation: D 1587, Standard Practice for Thin-walled Tube Geotechnical Sampling of Soils. In the direct-push method, the Shelby tube is connected to a sampling head that is attached to the drill rods. The tube is pushed by the hydraulic rams of the drill rig into the soil below the bottom of a drill hole and then retracted to retrieve the sample. Shelby tubes are generally used in soft to stiff, fine-grained soils, although occasionally they are used in stiffer soil.

The tube samples were removed from the drill stem, examined from the ends of the tube, and then carefully sealed using plastic lids and tape to preserve the moisture content. These samples were stored in an upright position and transported to the Shannon & Wilson laboratory by our field representative for further analyses and testing. Each tube sample was stored in an upright position, in a temperature- and humidity-controlled environment, in the laboratory. In the lab, each sample was pushed out of the tube in the same direction it entered the tube onto a continuously supported tray. The soil sample was classified and logged, then cut into appropriate lengths for additional testing. Each piece saved was triple-wrapped in plastic wrap to reduce moisture loss and marked for identification. The wrapped samples were stored in a humidity- and temperature-controlled environment until testing.

4.3 Field Soil Classification

Soil classification for this project was based on ASTM Designation: D 2488, Standard Recommended Practice for Description of Soils (Visual-Manual Procedure). The Unified Soil Classification System (USCS), as summarized in Figure A-1 of Appendix A, was used to classify the material encountered.

4.4 Observation Well Installation

Holocene Drilling, Inc. installed monitoring wells in the 16 soil borings. A Shannon & Wilson representative selected well depths based on soil and groundwater conditions and observed the well installation. Each well consists of a 2-inch-I.D., minimum 0.154-inch-thick, Schedule 40 polyvinyl chloride (PVC) casing that extends from the ground surface to a 10-foot-long PVC screen located at the bottom of the well. The well screen slots are 0.01 inch wide (No. 10 slot). Each casing section is 10 feet in length and threaded together at the joints. An end cap is threaded to the bottom of the slotted section. Excess casing is sawed off before installing the well. The screened portion of the well is backfilled with a filter pack consisting of 10-20 Colorado silica sand, extending 1 to 2 feet above the top of the well screen. Above and below the filter pack, the borehole is backfilled with bentonite. The top of each well is secured with a water- and vapor-tight, rubber-ringed locking cap. The wells are completed flush to grade with steel monuments. Specific as-built details for each well are included on the corresponding boring logs found in Appendix A.

Well screen locations were selected to estimate in situ permeability in the levee and foundation soil, and for long-term site-specific groundwater monitoring that could be compared with the gauged river elevations. In general, well screens were installed at depths ranging between 12 and 28 feet bgs. The well screens installed in borings on the levee were placed in the levee fill. The wells installed on the landward side of the levee were screened in relatively pervious alluvium that generally was encountered beneath 10 to 20 feet of less pervious overbank deposits.

5.0 GEOLOGY

5.1 Geologic Setting

The Skagit River flows from the Cascade Mountains to a broad lowland delta along the eastern margin of the Puget Lowland Basin. Pleistocene (approximately 2 million to 10,000 years ago) glacial and Holocene (past 10,000 years) river processes have largely shaped topography and surface geology along the river.

Geologists generally agree that during the Pleistocene, continental ice sheets advanced from Canada at least six times. Thick glacial and nonglacial sediments were deposited during and between the repeated glacial advances across the Puget Lowland basin. During the Holocene, the Skagit River built a broad, delta alluvial plain from Blanchard Mountain to the north, Fidalgo Island to the west, and Milltown to the south. Delta deposits include interbedded channel deposits (Ha[cd]), gravelly channel deposits (Ha[g]), and overbank deposits (Ha[ob]). Near the river outlet, fine-grained sediment is deposited in the Skagit River estuary (He), an area influenced by tidal action. Within the last 100 years humans have modified the delta, including construction of flood control levees, built with local and imported fill (Hf).

5.2 Geologic Units

Geologic units were developed to group the complex sediment and soil types encountered in the project borings. The geologic unit descriptions are described herein and are shown on the boring logs presented in Figures A-2 through A-17 in Appendix A. Summary plots of laboratory grain size analyses are presented by geologic unit in Figures C-29 through C-33 in Appendix C.

5.2.1 Levee Fill (Hf)

The borings drilled on the levees encountered 9 to 17 feet of fill soil with variable properties. Most of the levee fill encountered in our borings consists of very loose to medium dense, silty, fine sand to fine sandy silt that is similar in composition to the native underlying overbank and channel deposits. The fill material is generally massive with scattered clayey pockets and a trace of organics. Based on the similarity in grain size distribution between the fill and underlying native undisturbed soils, we believe that most of the levee fill soil was locally derived. However, borings DD3-1 Levee, DD22-1 Levee, DD22-2 Levee, and DD17-1 Levee encountered medium dense, slightly clayey, gravelly, silty sand; stiff to very stiff, silty clay; and medium dense, slightly sandy gravel layers within the upper 5 to 7 feet of the levee. This mixture of gravel, clay, and sand may indicate that imported material was added to the levees at these locations. Iron-oxide staining within the fill soil provides local evidence of intermittent groundwater presence within the levee, either from rain or groundwater.

5.2.2 Channel Deposits (Ha[cd])

Under normal flow conditions, the Skagit River deposits silt, sand, and gravel within its banks. The channel deposits encountered in the borings consist of very loose to medium dense, trace to slightly gravelly, trace of silt to silty, fine to medium sand. The borings encountered channel deposit layers ranging from 4 to nearly 40 feet thick. Channel deposits generally underlie, and are interbedded with, overbank and gravelly channel deposits. Iron-oxide-stained layers indicate the presence of intermittent groundwater. Scattered wood and organic debris were encountered within these deposits.

5.2.3 Gravelly Channel Deposits (Ha[g])

During high flows, the Skagit River transports and deposits gravel within its banks. The gravel may be derived from local glacial deposits or transported downstream from the Cascade Mountains. Gravelly channel deposits encountered in the borings consist of loose to medium dense, trace to slightly silty, sandy gravel to gravelly sand. The borings encountered gravelly channel deposit layers ranging from 5 to about 25 feet thick. Iron-oxide-stained layers indicate the presence of intermittent groundwater. Scattered wood and organic fragments were encountered within these layers.

5.2.4 Overbank Deposits (Ha[ob])

Overbank sediment is deposited when the Skagit River floods beyond its bank, spreading sediment-laden water over the low-relief delta plain and depositing sediment in a low-energy environment. Overbank deposits are typically laminated, very loose to loose sand and soft to stiff silt with varying amounts of clay. The overbank deposits encountered in the borings range from about 5 to 17 feet thick and commonly overlie Ha(g) and Ha(cd). Iron-oxide-stained layers indicate the presence of intermittent groundwater. Borings encountered up to 2.5-foot-thick intact wood, and scattered wood and organic fragments.

5.2.5 Estuary Deposits (He)

The North Fork and South Fork Skagit Rivers drain into Skagit Bay where fresh river water mingles with the salt water of Puget Sound. The estuary deposits encountered in our borings consist of loose to medium dense, silty, fine to medium sand with trace amounts of clay. Through time, the fine-grained sediments deposited in a quiet estuary were gradually buried by coarser alluvial sediment as the river mouth moved forward into Skagit Bay. These deposits are distinguished from the other alluvial deposits by the presence of scattered to numerous shell fragments.

6.0 HYDROGEOLOGIC STUDIES

Following the completion of drilling and well installation, the observation wells were developed, tested, and monitored to provide hydrogeologic data for future analyses. The data loggers remain active and can be used for future services.

6.1 Observation Well Development

Each observation well was developed to remove sediment and drilling fluid from the casing and filter pack, and to improve the hydraulic connection between the well screen and the adjacent subsurface soils. Well development occurred between October 27 and November 4, 2009 taking around 2 to 4 hours per well, depending on site conditions. To develop each well, a Shannon & Wilson representative surged and pumped groundwater in the well with a check valve-type inertial pump (Waterra). The Waterra pump is connected to clean, high-density polyethylene (HDPE) tubing with a plastic check valve. A surge block is attached to the check valve to facilitate the movement of water back and forth through the well screen during the development process. Between approximately 50 and 70 gallons were purged at each of the landward well locations. At the time of development, levee wells did not have groundwater present. Therefore, approximately 20 gallons of tap water were added to each of the levee wells to flush drilling fluid out of the filter pack. The added water was then surged and pumped in the same method as the groundwater well development on the landward side borings. Between 8 and 16 gallons were removed from each of the levee wells. Development continued until the field representative did not observe sediment in the discharge water.

Additional well development occurred in the levee wells between February 22 and March 10, 2010. The additional well development was performed after Shannon & Wilson observed that the in situ hydraulic conductivity test results for the levee fill were lower than that which would be expected based on soil classification and grain size distributions. The discrepancy was attributed to the drilling mud (Revert), which did not break down in zones above the water table. The Revert remained in the soil surrounding the wells, reducing the hydraulic connection between the wells and the surrounding formation. A dilute bleach solution was used to break down the drilling fluid additive in accordance with the Revert manufacturer's recommendations. Dilute bleach water was left in the wells overnight (once per levee well) to allow the bleach solution to permeate the formation and break down the Revert mud that had infiltrated into the formation. Next, each levee well was redeveloped four additional times by adding bleach solution to the wells and then surging and pumping out the water. The process was repeated until the rate of water infiltrating into the well had increased to a consistent rate.

6.2 In Situ Hydraulic Conductivity Testing

A Shannon & Wilson representative performed either slug tests or falling-head percolation tests in levee and landward observation wells. The slug tests and falling-head percolation tests provide an in situ means of estimating the horizontal hydraulic conductivity of saturated sediments surrounding the screened zone of a well. Slug tests and falling-head percolation tests have a small radius of influence. As such, they do not provide data regarding large-scale aquifer properties, aquifer geometry, or boundary conditions affecting groundwater flow. Pumping tests are necessary to provide data related to large-sale aquifer properties.

6.2.1 Slug Testing – Landward Borings

Single-well field hydraulic conductivity tests (slug tests) were performed in borings drilled on the landward side of the levees where groundwater was present at the time of testing (Table B-1). Slug testing consists of rapidly raising or lowering the water level within an observation well and measuring the recovery of the water level over time to the static level. Raising the water level is achieved by lowering a slug (a sealed, sand-filled, PVC pipe) below the static water level to displace water within the well casing. This procedure is termed a "falling head test" because the water level falls with time back to the static level. Lowering the water level is achieved by quickly removing the slug from the well. This is termed a "rising head test" because the water level rises back to the static level after the slug is removed. A Shannon & Wilson representative performed multiple rising- and falling-head tests as part of the slug testing at each location.

Water level data during the slug tests were recorded using a Levellogger brand data logger/ pressure transducer system, which was placed at the bottom of the well.

6.2.2 Slug Test Results

The wells in the landward side borings are generally screened in native, undisturbed alluvium of channel and gravelly channel deposits. Plots for the slug tests performed at each well are included in Appendix B. Data obtained from the slug tests were plotted as semi-log plots of change in head (water-level change) versus time (Figures B-1 through B-16).

Regression lines fit to the slug test data in each plot were used to calculate hydraulic conductivity in general accordance with the Bouwer and Rice (1976 and 1989) methods.

The hydraulic conductivity slug test data results range from values of approximately 6×10^{-3} centimeters per second (cm/sec) to 2×10^{-2} cm/sec, as shown in Table B-1. During our in situ testing, groundwater level measurements were collected every 0.5 second, which may not fully capture rapid head changes during the early portion of tests made in rapidly permeable soil. Therefore, hydraulic conductivity results in Table B-1 may be on the low end of the soil conductivity range. In our experience, slug testing methods may not be sufficient to estimate hydraulic conductivity faster than approximately 2×10^{-2} cm/sec because rapid groundwater level recovery cannot be adequately measured. Because the results of the slug tests are within an order of magnitude of measurement limitations, some results could provide low estimates of the soil hydraulic conductivity. Designers should pick appropriate values for hydraulic conductivity, which may differ from test data range. Alternative testing methods, such as a pumping test, should be considered to estimate the hydraulic conductivity in the more pervious alluvium sands.

6.2.3 Falling Head Percolation Testing – Levee Borings

A Shannon & Wilson representative performed falling head percolation tests in eight observation wells located on the existing levees. Prior to testing, groundwater was not present in the wells. A falling-head percolation test consists of injecting water into the well until a steady state is achieved; i.e., the flow rate into the well and the water level inside the well reach constant values, followed by the cessation of water flow into the well and the subsequent "falling" of the water level as water percolates into the formation from the well. Evaluation of falling-head percolation test data provides an estimate of hydraulic conductivity for soils above the groundwater table.

To prepare for the falling-head percolation test, a constant water level was maintained above the well screen for approximately 30 minutes to saturate the soil in the surrounding formation. This saturation phase is performed so the test results can represent the saturated hydraulic conductivity. Water level data during the falling-head percolation tests were recorded using a Levellogger brand data logger/pressure transducer system, which was placed at the bottom of the well.

The original percolation tests performed on the levee wells were not considered representative of the soil conditions because the drilling fluid additive had not broken down, thus reducing the hydraulic conductivity of the soil surrounding the wells. As described previously, the wells were redeveloped and then retested. The falling-head percolation tests performed in the Levee wells after redevelopment are included in Table B-2.

6.2.4 Falling Head Percolation Test Results

The wells in the levee borings are screened in levee fill materials. These soils generally have low permeability. Data obtained from the falling-head percolation tests were plotted as semi-log plots of change in head (water-level change) versus time (Figures B-17 through B-24). A regression line was fit to the test data for the plot. The falling-head percolation test data were analyzed using the Bouwer and Rice solution (Bouwer and Rice 1976 and 1989) to estimate the soil hydraulic conductivity.

Evaluation of falling head percolation test data for DD17-2 Levee indicated a hydraulic conductivity value of approximately 1×10^{-4} cm/sec, as shown in Table B-2. Based on our interpretation of the grain-size analysis and our review of soil samples for DD17-2 Levee, it is our opinion that the estimated hydraulic conductivity is representative of the levee soil near the well screen. The remaining seven levee boring percolation tests showed hydraulic conductivity ranging from approximately 3×10^{-7} to 8×10^{-6} cm/sec, which is in the lower range of the anticipated hydraulic conductivity values based on soil type, grain size distribution, and our experience with similar soil conditions. In our opinion, these values may not be representative of the soil type tested because of one or more conditions, including:

- Partial saturation resulting in multi-phase flow in the soil,
- Capillary effects,
- Complicated flow conditions during testing (flow is not radial, but a combination of radial and vertical),
- Local heterogeneities in the soil, and
- Plugging of pore space with drilling fluid.

Table B-2 and Figures B-17 through B-24 present the percolation test results.

6.3 Groundwater Monitoring

At each landward and levee boring location, a Levellogger brand data logger/pressure transducer system was placed at the bottom of the well screen and programmed to record the groundwater level hourly. In the landward borings, the data logger/pressure transducer records groundwater fluctuations in the well; in the levee borings the data logger/pressure transducer records groundwater fluctuations if groundwater enters the well screen in the levee. Data from the months of November and December 2009 were downloaded on December 29, 2009, and are included in the plots B-25 through B-39. Boring DD17-2 Landward had a programming error and data was not recovered from the data logger/pressure transducer, and therefore excluded from this report.

After the data logger/pressure transducers were downloaded, the data logger/pressure transducers were reset and returned to the wells and are continuing to record groundwater information.

Plots of hourly groundwater readings are presented in Figures B-25 though B-39. The plots show that data logger/pressure transducers recorded seepage into the well screens at locations DD3-1 Levee, DD17-3 Levee, and DD22-2 Levee. In the landward borings, wells DD1-2 Landward, DD22-1 Landward, and DD22-2 Landward show intermittent negative depths to water, which we interpret to indicate that the water pressures in the screened zone of soils are above the ground surface. Groundwater levels above the ground surface can only be recorded in wells with the tightly sealed caps, otherwise leakage of water from the well will reduce the recorded pressure and the measurements may not be representative of the actual groundwater conditions. Groundwater monitoring in the landward borings shows groundwater levels ranging from 2 feet above the top of the well casing to 15 feet below the top of the well casing.

7.0 GEOTECHNICAL LABORATORY TESTING

Geotechnical laboratory tests were performed on soil samples retrieved from the borings. The laboratory testing program included tests to classify soil samples and to provide data for future engineering studies.

Visual classification was performed on all retrieved samples. Index testing, including water content determinations, grain size distributions, and Atterberg Limits, were completed on select samples. Consolidated-undrained triaxial compression tests and one-dimensional consolidation soil strength tests were completed on select relatively undisturbed samples. Hydraulic conductivity tests were completed on relatively undisturbed samples and remolded disturbed samples.

The following sections describe the laboratory test procedures. The laboratory test results are presented as Table C-1 and Figures C-1 through C-54 in Appendix C.

7.1 Soil Index Tests

7.1.1 Visual Classification

Soil samples retrieved from the borings were visually classified in the laboratory using a system based on ASTM 2487, Standard Test Method for Classification of Soil for Engineering Purposes, and/or ASTM D 2488, Standard Recommended Practice for Description of Soils (Visual-Manual Procedure) (ASTM, 2009). These ASTM standards use the USCS and are described in Figure A-1. Visual classifications were checked using index testing as discussed in the next sections.

7.1.2 Water Content Determination

The water content of the retrieved samples was determined in general accordance with ASTM D 2216, Standard Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures (ASTM, 2009). Comparison of the water content of a soil with its index properties can be useful in characterizing soil unit weight, consistency, compressibility, and strength. The water content is shown graphically on each of the boring logs presented in Appendix A.

7.1.3 Atterberg Limits Tests

Soil plasticity was determined by performing Atterberg Limits tests on select fine-grained samples. The tests were performed in general accordance with ASTM D 4318, Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils (ASTM, 2009). The Atterberg Limits include Liquid Limit (LL), Plastic Limit (PL), and Plasticity Index (PI = LL - PL). They are generally used to assist in classifying soils, to indicate soil consistency (when compared with natural water content), and to provide correlation with soil properties including compressibility and strength. The results are shown graphically on the boring logs presented in Appendix A, and plotted on plasticity charts presented in Appendix C, Figures C-1 to C-11. The plasticity charts provide USCS group symbols, sample descriptions, and water contents. An Atterberg Limits plot for the overbank deposits geologic unit is also presented in Appendix C, Figure C-12.

7.1.4 Grain Size Distribution Analyses

Grain-size distribution analyses on select samples were performed in general accordance with ASTM D 422, Standard Test Method for Particle-Size Analysis of Soils (ASTM, 2009). The clay fraction of select samples was estimated by performing a hydrometer test. Grain size distribution is used to assist in classifying soil and to provide correlation with soil properties, including permeability, liquefaction potential, capillary action, and sensitivity to moisture. Results of these analyses are presented as gradation curves in Appendix C, Figures C-13 to C-28. Each gradation sheet provides the USCS group symbol, the sample description, and water content. Grain-size plots are also presented by geologic unit in Appendix C, Figures C-29 to C-33.

7.2 Soil Strength Tests

7.2.1 One-dimensional Consolidation Tests

One-dimensional consolidation tests were performed on two relatively undisturbed samples in general accordance with ASTM D 2435, Standard Test Methods for One-Dimensional Consolidation Properties of Soils Using Incremental Loading (ASTM, 2009). The samples were incrementally loaded in a fixed-ring consolidometer. During each load increment, the change in sample height with time was recorded. Each load increment approximately doubled the previous load, to a preselected maximum consolidation pressure. The samples were inundated with distilled water after the first load increment. Drainage was allowed from both the top and bottom of the sample. An intermediate unload-reload cycle was performed when the consolidation pressure from a particular load increment was greater than the estimated in situ vertical stress for the sample. Upon reaching the maximum test load, the sample was unloaded in steps of about one-fourth the previous load.

A summary of the test results is presented in Appendix C, Figures C-34 and C-35. Specimen data is included in the data sheets.

7.2.2 Consolidated-undrained Triaxial Compression Test

Multi-staged consolidated-undrained triaxial compression tests with pore pressure measurements were performed on three relatively undisturbed samples in general accordance with ASTM D 4767, Test Method for Consolidated-Undrained Triaxial Compression Test on Cohesive Soil (ASTM, 2009). Prior to consolidation and shearing, each sample was saturated using back pressure. The degree of saturation was estimated by measuring the pore pressure coefficient B. A displacement-controlled testing machine was used to perform the test.

Each sample was sheared three times. Effective confining (or consolidating) pressures were generally applied as one-half the estimated in situ stress, the estimated in situ stress, and twice the estimated in situ stress. Initial consolidation of the sample was performed incrementally by doubling the effective confining pressure until the desired value was reached. During each stage, the sample was strained to produce a peak shear stress ratio, or to achieve a maximum 5 percent strain, whichever occurred first. At that point, the sample was released from its deviator stress and re-consolidated to the next higher confining pressure before the next shearing stage. Ductile behavior was observed for each sample during each stage of the test.

A summary of the test results is presented in Appendix C, Figures C-36 to C-38. Specimen data are included in the data sheets.

7.3 Hydraulic Conductivity Testing

7.3.1 Methodology

Hydraulic conductivity testing was performed on nine relatively undisturbed samples and seven reconstituted disturbed samples in general accordance with ASTM D 5084, Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter (ASTM, 2009). Relatively undisturbed sample tests and reconstituted sample tests are identified in Table C-1. Samples for hydraulic conductivity testing were trimmed to a cylinder that is enclosed in a membrane and mounted in a permeameter cell. A porous stone is mounted on the base and top cap and the cell is filled with water and pressurized. The sample is saturated using back pressure and a small gradient through the sample to remove water carrying dissolved air and then consolidated to a preselected effective confining pressure. After the sample is saturated and consolidated, a preselected gradient is placed on the sample and the volume of flow into the base and out the top of the sample is recorded versus time.

7.3.2 Results

Results of the hydraulic conductivity tests for vertical hydraulic conductivity are presented in Figures C-39 through C-54 and summarized in Table C-1. Estimated vertical hydraulic conductivity ranges from about 4×10^{-7} to 1×10^{-3} cm/sec. Generally, the soils used in the hydraulic conductivity testing consist of silty sand to sandy silt overbank, estuarine, and channel deposits. Test results reflect heterogeneities, including organic casts and clasts, and fine-grained laminations, which influence the flow of water through the soil. In some cases, the hydraulic conductivity results from the testing are different than we would anticipate from the soil description.

We used the Hazen (1892), and Alyamini and Sen (1993), methods to estimate hydraulic conductivity based on grain size distribution analyses of the same or similar samples, and compared those results to our laboratory hydraulic conductivity testing. The grain size-based hydraulic conductivity estimates range from approximately $6x10^{-8}$ to $1x10^{-2}$ cm/sec, with most soil samples falling between $5x10^{-6}$ and $5x10^{-4}$ cm/sec. With the exception of samples DD3-1 Landward at 40 feet, DD17-2 Landward at 7.5 feet, and DD17-3 Landward at 5.9 feet, the laboratory hydraulic conductivity tests and grain size-based estimates were similar. The estimated hydraulic conductivity values from these three tests were considerably slower than the values estimated from the grain size distribution, and may not be representative of the naturally deposited soil conditions. In the case of DD3-1 Landward, laboratory testing was done on a remolded, soil sample. The difference in estimated hydraulic conductivity for samples DD17-2 Landward and DD17-3 Landward likely reflects the difference between horizontal and vertical hydraulic conductivity, which can differ by more than an order of magnitude for fine-grained soil. Soil sample collection methods that disturb the soils, especially fine-grained soil, may also affect hydraulic conductivity testing results.

We recommend careful consideration of the soil information, including laboratory testing and soil descriptions, when selecting hydraulic conductivity values for engineering analyses, rather than relying solely on the hydraulic conductivity test results. The saturation of a soil can have a large influence on the hydraulic conductivity. Caution should also be taken when estimating hydraulic conductivity using grain size distribution, especially for fine-grained soil (Mitchell 1993). Mitchell states that grain size-based methods of estimating hydraulic conductivity are inadequate for clays, and describes numerous factors that affect hydraulic conductivity of fine-grained soil, including soil fabric at the micro, mini, and macro scales. The fabric is affected by depositional mode, compaction methods, water content during compaction, past depositional environmental changes, and numerous other factors that need to be considered.

8.0 RECOMMENDED SOIL PROPERTIES

Based on our in situ and laboratory test results, review of soil descriptions, and experience with similar soil units, we recommend the following range of hydraulic conductivity values be used for concept-level design and analyses:

Geologic Unit	Estimated Hydraulic Conductivity, k (cm/sec)
Levee fill and Overbank deposits	$1x10^{-6}$ to $1x10^{-3}$
Channel deposits	$1x10^{-3}$ to $1x10^{-2}$
Gravelly channel deposits	$1x10^{-3}$ to $1x10^{-1}$

Note:
cm/sec = centimeters per second

Two consolidation and three strength tests were performed on overbank deposit samples collected from varying depths and at different levee locations. The overbank material tested was deposited during different life cycles of the river and likely had differing site conditions throughout its history. The following range of soil properties was interpolated based on our laboratory test results and could be used for concept-level design and analyses:

Geologic Unit	Compression Index, Cc	Recompression Index, Cr
Overbank deposits	0.28 to 0.43	0.019 to 0.023

Geologic Unit	Effective Friction (degrees)	Effective Cohesion (psf)	Total Friction (degrees)	Total Cohesion (psf)
Overbank deposits	33 to 37	0	15 to 24	0 to 600

Note:
psf = pounds per square foot

We recommend careful consideration of the soil information, including laboratory testing and soil descriptions, when selecting soil property values for engineering analyses.

9.0 LIQUEFACTION

9.1 Analysis Approach

We evaluated the liquefaction potential at the eight levee locations using the empirical procedures outlined in NCEER (Youd and Idriss, 1997), and the subsequent alternative procedures and updates by:

- Youd and others (2001)
- Seed and others (2003)
- Idriss and Boulanger (2006)

For an empirical liquefaction evaluation, the SPT blow count (N-value) is correlated to the liquefaction resistance of the soil (expressed as cyclic resistance ratio). The soil resistance is compared to the earthquake-induced loading (expressed as cyclic stress ratio), and a corresponding factor of safety (FS) against liquefaction is estimated.

The estimated fines content for a granular soil and the Atterberg Limits plasticity index for a cohesive soil were used as a basis for estimating the soil liquefaction resistance. Where laboratory tests were not available, we estimated the fines content based on nearby samples and the boring log soil descriptions. Fines content and Atterberg Limits tested for the 16 borings used in our evaluation are provided in Appendix C and shown graphically on the boring logs in Appendix A.

For the borings drilled landward of the levee, we assumed a groundwater elevation consistent with the November 2009 well readings. Wells installed in the levees were dry during the November 2009 readings; therefore, groundwater was assumed at an elevation consistent with the nearby landward wells.

During the subsurface explorations, some samples were obtained using a non-standard split spoon sampler in borings DD3-1 Levee, DD17-1 Levee, DD17-2 Levee, DD17-3 Levee, DD22-1 Landward, DD22-1 Levee, and DD22-2 Levee. For these samples, we applied a conversion factor (Burmister, 1948) to the measured blow count to estimate the SPT value for the liquefaction analyses.

An auto-hammer was used during the split spoon sampling. Holocene Drilling, Inc. reported that their hammer energy efficiency is 83 percent. We used this hammer efficiency value for our liquefaction analyses.

9.2 Ground Motions

Earthquake loading for three design ground motion levels is specified in ER 1110-2-1806 (1995). The three ground motion levels are defined as follows:

- Operating Basis Earthquake (OBE) – Earthquake ground motions with a 50 percent probability of exceedence during the service life of the structure (based on a 100-year service life, the OBE corresponds to a return period of 144 years).
- Maximum Design Earthquake (MDE) – The maximum earthquake ground motion for which the structure is designed or evaluated.

- Maximum Credible Earthquake (MCE) – The greatest earthquake that can reasonably be generated by a specific source.

The MDE and MCE have not been selected by the USACE for the sites. Therefore, we analyzed the OBE ground motion level and an alternate ground motion level that has a 5 percent probability of exceedence in 50 years. These two ground motions correspond to an average return period of 144 and 975 years, respectively.

The soft rock peak ground accelerations (PGA) and corresponding approximate characteristic moment magnitudes (M_w) were obtained from the U.S. Geological Survey 2008 National Seismic Hazard Mapping Project (Peterson and others, 2008) ground motion hazard deaggregation. The soil PGA was estimated by applying an amplification factor based on Stewart and others (2003). The magnitude, rock PGA, amplification factor, and soil PGA for the two ground motion levels are summarized in the following table:

Earthquake Parameter	Ground Motion Level	
	144-year (OBE)	975-year
M_w*	6.6	6.6
PGA_{rock}*	0.13	0.33
Amplification Factor*	1.5	1.1
PGA_{soil}	0.20	0.36

* The approximate characteristic moment magnitudes, soft rock peak ground acceleration (PGA), and Amplification Factors are preliminary and should be revised when the maximum design earthquake and maximum credible earthquake ground motions levels have been selected for the design at each site.
OBE = operating basis earthquake

9.3 Results

The FSs against liquefaction versus depth was calculated at each boring for the 144-year (OBE) and the 975-year ground motion levels. Plots of FS versus depth are provided in Appendix D. The approximate locations of the borings are shown in Figure 2.

The estimated FSs against liquefaction for the OBE ground motion level are less than 1 in scattered zones within the borings. The zones of potential liquefaction range in thickness from a few feet to 15 feet. For the 975-year ground motion level, our calculations show the FS against liquefaction is typically less than 1 from the groundwater surface to the depth of our explorations.

The potential effects of an estimated FS less than 1 include a reduction in soil shear strength, potential embankment instability or lateral spreading, and settlement.

10.0 LIMITATIONS

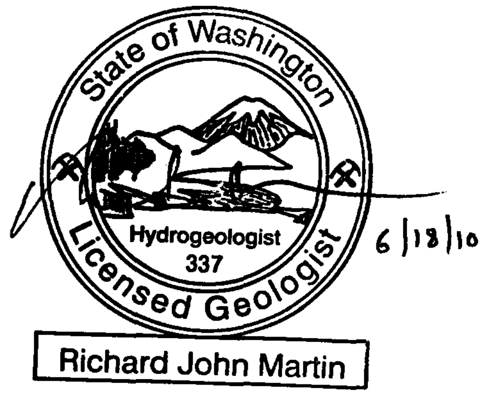
The purpose of this report is to present the results obtained from the subsurface exploration program, in situ and laboratory testing, and our interpretation of the subsurface conditions at the eight distinct locations drilled along the Skagit River levee system. The analyses and conclusions contained in this report are based on site conditions as they existed during our site visits and explorations. It should be understood that the results and interpretations presented in this draft report may be different along the levee alignment from those disclosed in the explorations and not representative of the subsurface conditions. Additional subsurface information, interpretation, and analyses in agreement with USACE standards are needed for future design and construction. If subsurface conditions different from those described in this report are observed or appear to be present during future studies or construction, we should be advised at once so that we can review these conditions and reconsider our conclusions, where necessary.

This report was prepared for the exclusive use of the USACE. It should be made available to stakeholders such as Skagit County and the dike districts, and to future contractors working at or near the levees for information on factual data only, and not as a warranty of subsurface conditions, such as those interpreted from the boring logs and discussions of subsurface conditions included in this report. Unanticipated soil and groundwater conditions are commonly encountered and cannot be fully determined merely by taking soil samples from a limited number of borings.

Within the limitations of the scope, schedule, and budget, the interpretations, analyses, and conclusions presented in this report were prepared in accordance with generally accepted geotechnical and hydrogeological engineering principals and practices in this area at the time this report was prepared. We make no other warranty, either express or implied.

The scope of our services did not include any environmental assessment or evaluation of hazardous or toxic materials in the soil, surface water, groundwater, or air on or below or around the site. Shannon & Wilson, Inc. has qualified personnel to assist you with these services should they be necessary. We have prepared the document, "Important Information About Your Geotechnical/Environmental Report," in Appendix E to assist you and others in understanding the use and limitations of our report.

SHANNON & WILSON, INC.



Brian S. Reznick, P.E.
Principal Engineer

Richard J. Martin, L.H.G.
Senior Associate

Geotechnical items related to subsurface characterization, soil engineering properties, and liquefaction analyses and results were prepared under the direct supervision of Brian S. Reznick, P.E.

Hydrogeologic items related to groundwater testing, analyses, and results were prepared under the direct supervision of Richard J. Martin, L.H.G.

JKN:CIJ:KES:BSR: RJM:CAR:WTL/bsr

8.0 REFERENCES

Alyamani, Mahmoud S., and Sen, Zekai., 1993, Determination of hydraulic conductivity from complete grain-size distribution curves: Groundwater, 31.4, p. 551-555.

ASTM International, 2009, Annual book of standards, construction, v. 4.08, soil and rock (I): D 420 - D 5876: West Conshohocken, Penn., ASTM International, 1 v.

Bouwer, Herman; and Rice, R.C., 1976, A slug test for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells: Water Resources Research, v. 12, no. 3, June, p. 423-428.

Bouwer, Herman; and Rice, R.C., 1989, The Bouwer and Rice slug test – an update: Ground Water, v. 27, no. 3, May-June, p. 304-309.

Burmister, D.M., 1948, Principles and techniques of soil identifications: National Research Council (U.S.) Highway Research Board, Proceedings of the Annual Meeting,1949, p. 402-433.

Department of the Army, United States Army Corps of Engineers, 1995, Engineering and Design: Earthquake Design and Evaluation for Civil Works Projects, ER 110-2-1806, July 31.

Hazen, A., 1892, Some physical properties of sands and gravels: Mass. State Board of Health, Annual Report 1892, p. 539-556.

Idriss, I.M.; and Boulanger, R.W., 2006, Semi-empirical procedures for evaluating liquefaction potential during earthquakes: Proceedings of the 11th ICSDEE & 3rd ICEGE, January 2004.

Mitchell, James K., 1993, Fundamentals of soil behavior, (2nd ed.): N.Y., Wiley, section 12.5 hydraulic conductivity, p. 234-246.

Petersen, M.D.; Frankel, A.D.; Harmsen, S.C.; and others, 2008, Documentation for the 2008 update of the national seismic hazard maps: U.S. Geological Survey Open File Report 08–1128, available at http://pubs.usgs.gov/of/2008/1128.

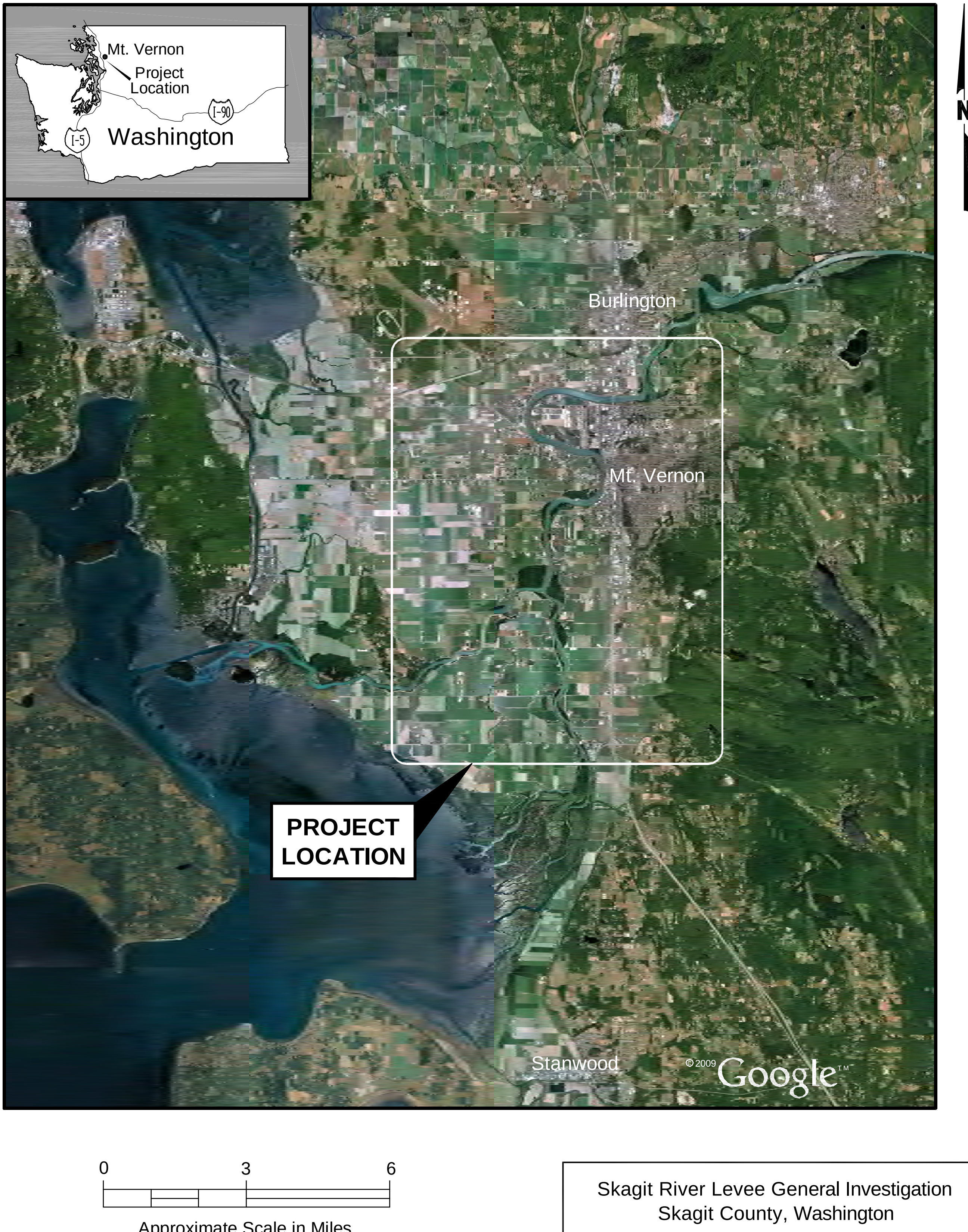
Seed, R.B. and others, 2003, Recent advances in soil liquefaction engineering: A unified and consistent framework in Proceedings, 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queen Mary, Long Beach, California, April 30.

Shannon & Wilson, Inc., 2009, Draft General Investigation Report, Skagit River Basin Levees, Skagit County, Washington: Report prepared by Shannon & Wilson, Inc., Seattle, Wash., 21-1-21199-001, for U.S. Army Corps of Engineer, 1 v., August 26.

Stewart, J.P.; Liu, A.H.; and Choi, Y., 2003, Amplification factors for spectral acceleration in tectonically active regions: Bulletin of the Seismological Society of America, v. 93, no. 1, p. 332-352.

Youd, T.L.; and Idriss, I.M., 1997, Proceedings of the NCEER workshop on evaluation of liquefaction resistance of soils: Buffalo, N.Y., National Center for Earthquake Engineering Research, Technical Report no. NCEER-97-0022.

Youd, L.T.; Idriss, I.M.; Andrus, Ronald D.; and others; 2001, Liquefaction resistance of soils: Summary report from the 1996 NCEER and 1998 NCEER/NSF workshops on Evaluation of Liquefaction Resistance of Soils in Journal of Geotechnical and Environmental Engineering, New York, American Society of Civil Engineers, v. 127, no. 10, October, p. 817-833.



NOTE

Map adapted from aerial imagery provided by Google Earth Pro, reproduced by permission granted by Google Earth ™ Mapping Service.

Skagit River Levee General Investigation Skagit County, Washington	
VICINITY MAP	
June 2010	21-1-21199-002
SHANNON & WILSON, INC. Geotechnical and Environmental Consultants	**FIG. 1**

Filename: J:\211\21199-002\21-1-21199-002 Fig 1.dwg Date: 06-01-2010 Login: lr

LEGEND

Approximate Boring Location

City Boundary

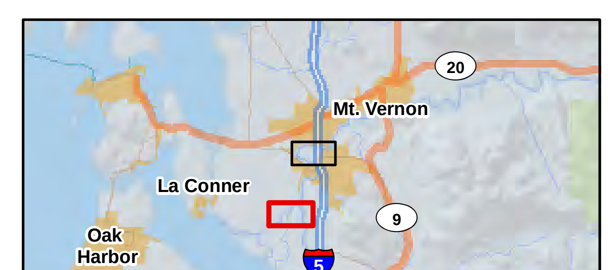
Levees

NOTE

Data provided by General Design Memorandum Levee Improvements Vol. 2 of 2 July 1979,the City of Burlington.

N
W E
S

0 500 1,000 2,000 Feet



Skagit River Levee General Investigation
Skagit County, Washington

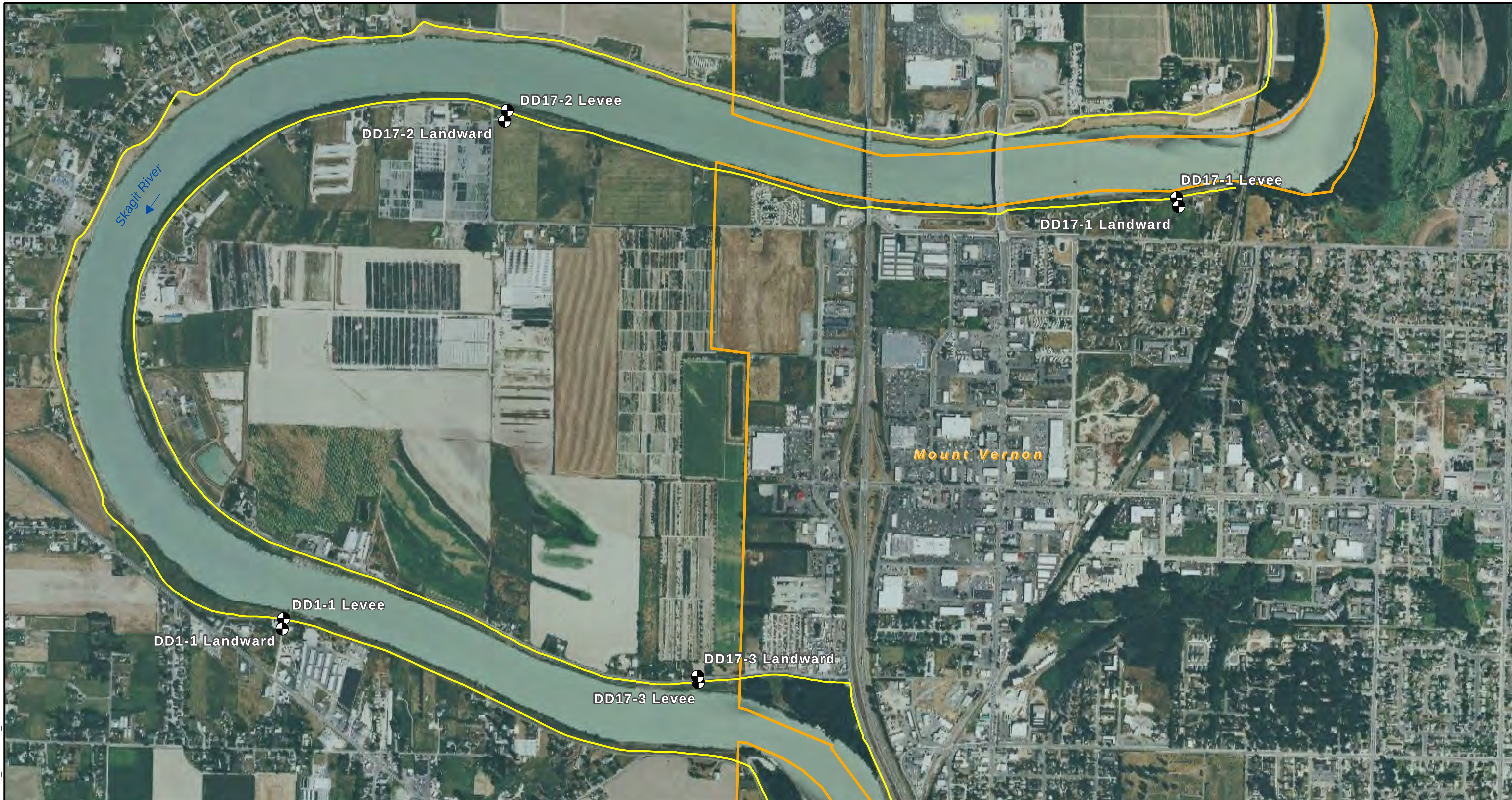
SITE AND EXPLORATION PLAN

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 2
Sheet 1 of 2

Filename: T:\Project\21-1\21199_Skagit River\Av_mxd\SITE_PLAN.mxd Date: 1/28/2010 ATJ



LEGEND

Approximate Boring Location

City Boundary

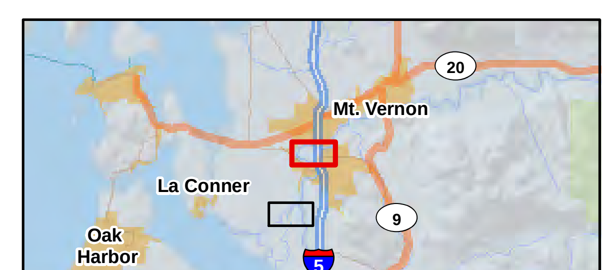
Levees

NOTE

Data provided by General Design Memorandum Levee Improvements Vol. 2 of 2 July 1979,the City of Burlington.

N S E W

0 500 1,000 2,000 Feet



Skagit River Levee General Investigation
Skagit County, Washington

SITE AND EXPLORATION PLAN

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 2
Sheet 2 of 2

Filename: T:\Project\21-1\21199_Skagit River\Av_mxd\SITE_PLAN.mxd Date: 1/28/2010 ATJ

APPENDIX A

BORING LOGS

APPENDIX A

BORING LOGS

TABLE OF CONTENTS

FIGURES

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
WOH	Weight of hammer
WOR	Weight of drill rods
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	

Skagit River Levee General Investigation
Skagit County, Washington

SOIL CLASSIFICATION AND LOG KEY

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

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

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.

Skagit River Levee General Investigation
Skagit County, Washington

SOIL CLASSIFICATION AND LOG KEY

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-1
Sheet 2 of 2

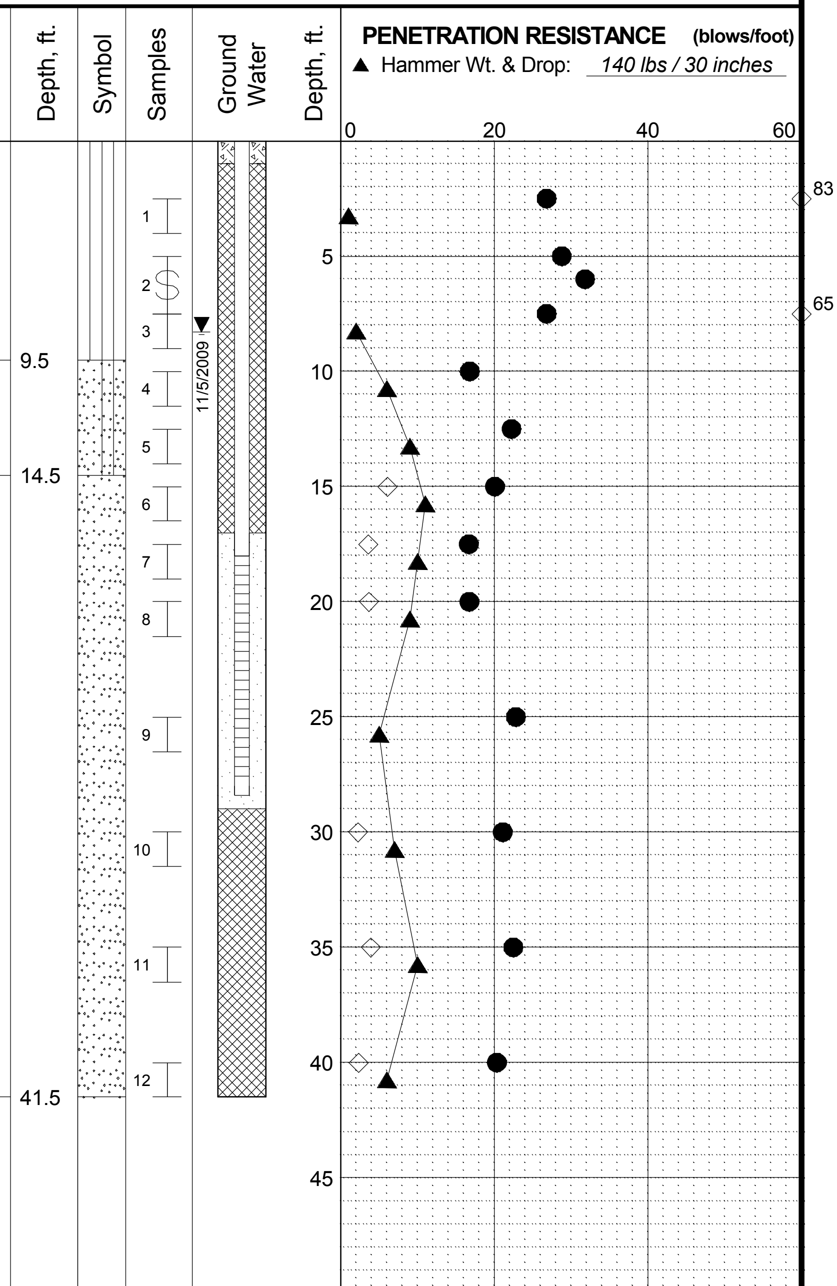
BORING CLASS2 21-21199.GPJ SWNEW.GDT 6/1/10

Total Depth:	41.5 ft.	Northing:	~ 525,847 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	5 in.
Top Elevation:	~	Easting:	~ 1,268,352 ft.	Drilling Company:	Holocene Drilling	Rod Diam.:	NWJ
Vert. Datum:		Station:	~	Drill Rig Equipment:	B-61 Mobile Truck	Hammer Type:	Automatic
Horiz. Datum:	NAD83	Offset:	~	Other Comments:			

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.
Very loose, brown, fine sandy SILT to silty, fine SAND; moist; trace of fine roots, laminated; (Ha[ob]) ML/SM.	
Interbedded, loose, brown and gray, slightly silty, fine to medium SAND and silty, fine SAND; moist to wet; (Ha[cd]) SP-SM/SM.	9.5
Loose to medium dense, gray, trace of silt to slightly silty, slightly fine gravelly to fine gravelly, fine to medium SAND; wet; (Ha[cd]) SP/SP-SM.	14.5
BOTTOM OF BORING COMPLETED 10/16/2009	41.5



LEGEND

- * Sample Not Recovered
- Standard Penetration Test
- 3" O.D. Thin-Walled Tube
- 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. 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. USCS designation is based on visual-manual classification and selected lab testing.

Skagit River Levee General Investigation
Skagit County, Washington

LOG OF BORING DD1-1 Landward

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-2

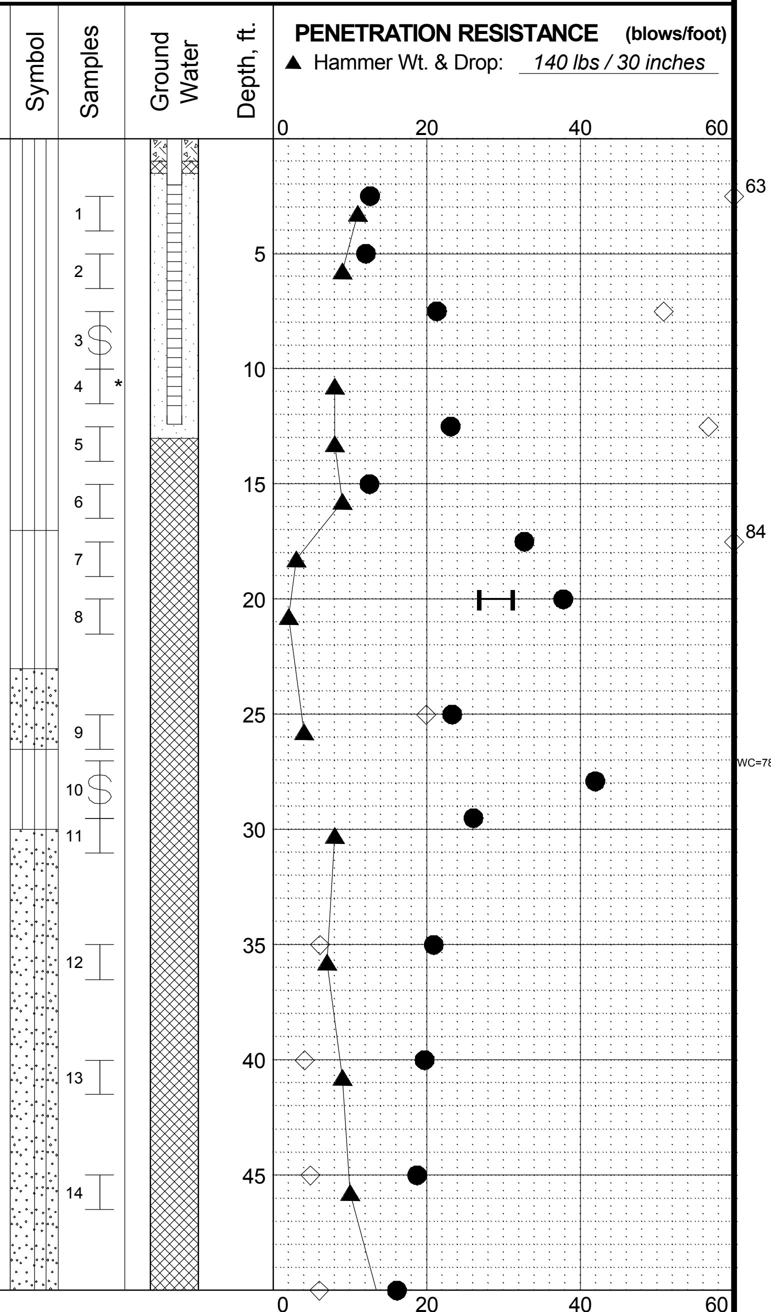
MASTER_LOG_E 21-21199.GPJ SHAN_WIL.GDT 6/1/10 Log: EVP Rev: JKN Typ: CLP

Total Depth:	61.5 ft.	Northing:	~ 525,954 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	5 in.
Top Elevation:	~	Easting:	~ 1,268,368 ft.	Drilling Company:	Holocene Drilling	Rod Diam.:	NWJ
Vert. Datum:		Station:	~	Drill Rig Equipment:	B-61 Mobile Truck	Hammer Type:	Automatic
Horiz. Datum:	NAD83	Offset:	~	Other Comments:			

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.
Loose to medium dense, brown, fine sandy SILT; moist; trace of organics; (Hf) ML.	
Soft, brown, trace to slightly clayey, trace of fine sand to slightly fine sandy SILT; moist to wet; scattered roots; (Ha[ob]) ML.	17.0
Loose, gray, silty, fine to medium SAND; wet; scattered silty, fine sand seams, iron-oxide staining; (Ha[ob]) SM.	23.0
Interbedded, loose, gray-brown, slightly fine sandy to fine sandy SILT, silty, fine SAND, and medium stiff, organic SILT; wet; 1/2-inch silty clay seam and 7-inch-thick wood fragment; (Ha[ob]) ML/SM/OL.	26.5
Loose to medium dense, gray, trace to slightly fine gravelly, trace to slightly silty SAND; wet; (Ha[cd]) SP-SM/SP.	30.0



CONTINUED NEXT SHEET

LEGEND

- * Sample Not Recovered
- Standard Penetration Test
- 3" O.D. Thin-Walled Tube
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout

◇ % 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. 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. USCS designation is based on visual-manual classification and selected lab testing.

Skagit River Levee General Investigation
Skagit County, Washington

LOG OF BORING DD1-1 Levee

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-3
Sheet 1 of 2

Total Depth:	61.5 ft.	Northing:	~ 525,954 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	5 in.
Top Elevation:	~	Easting:	~ 1,268,368 ft.	Drilling Company:	Holocene Drilling	Rod Diam.:	NWJ
Vert. Datum:		Station:	~	Drill Rig Equipment:	B-61 Mobile Truck	Hammer Type:	Automatic
Horiz. Datum:	NAD83	Offset:	~	Other Comments:			

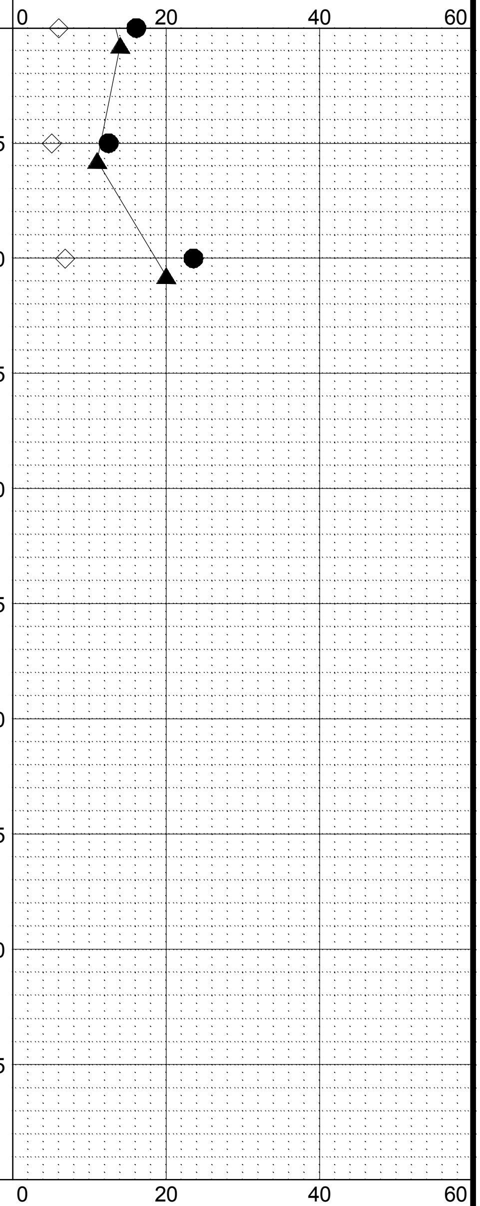
SOIL DESCRIPTION

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.	Samples
		15
Medium dense, gray, slightly silty, fine gravelly SAND; wet; (Ha[g]) SW-SM.	53.0	16
Medium dense, gray, slightly silty, fine to medium SAND; wet; (Ha[cd]) SP-SM.	58.0	17
BOTTOM OF BORING COMPLETED 10/16/2009	61.5	

PENETRATION RESISTANCE (blows/foot)

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



LEGEND

- * Sample Not Recovered
- Standard Penetration Test
- 3" O.D. Thin-Walled Tube
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout

◇ % 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. 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. USCS designation is based on visual-manual classification and selected lab testing.

Skagit River Levee General Investigation
Skagit County, Washington

LOG OF BORING DD1-1 Levee

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-3
Sheet 2 of 2

MASTER_LOG_E 21-21199.GPJ SHAN_WIL.GDT 6/1/10 Log: EVP Rev: JKN Typ: CLP

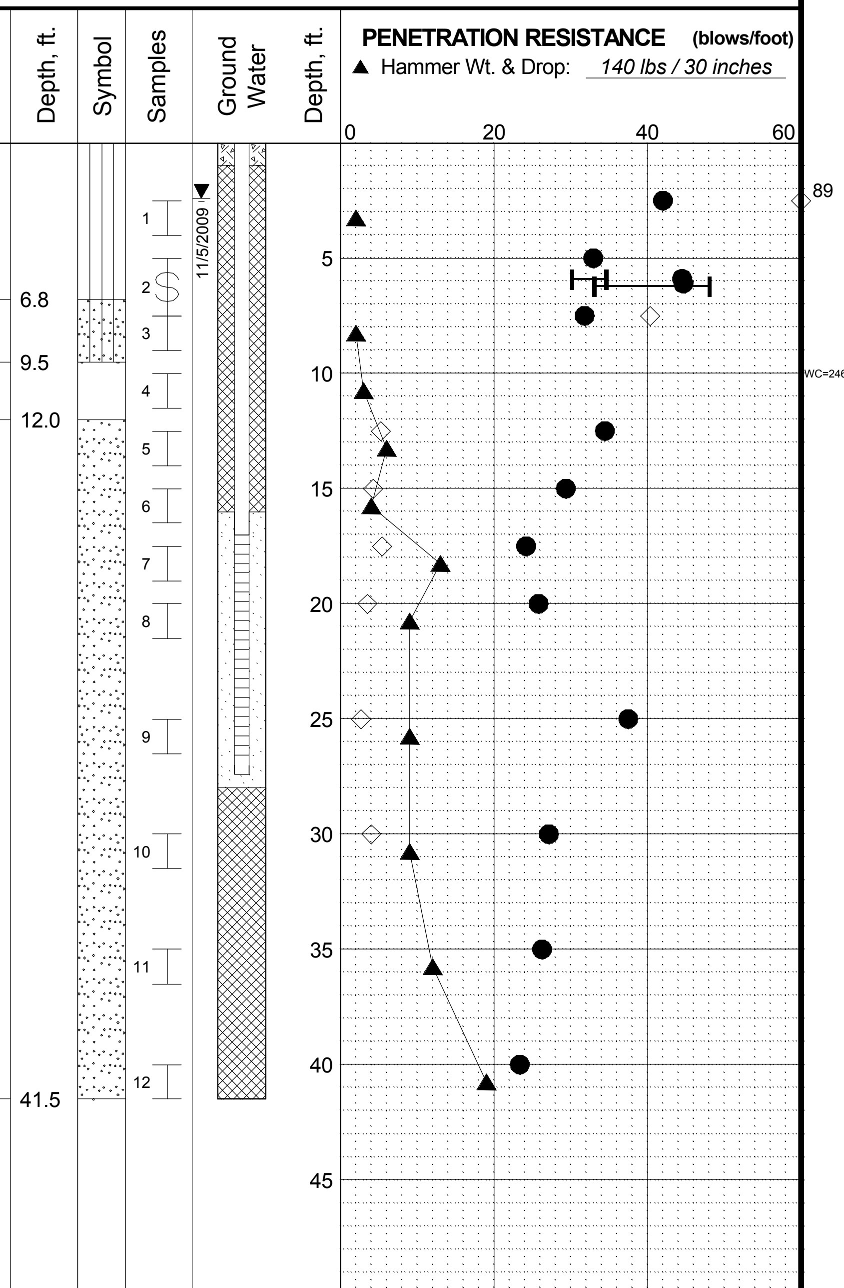
Total Depth:	41.5 ft.	Northing:	~ 508,726 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	5 in.
Top Elevation:	~	Easting:	~ 1,263,857 ft.	Drilling Company:	Holocene Drilling	Rod Diam.:	NWJ
Vert. Datum:		Station:	~	Drill Rig Equipment:	BK-81 Truck	Hammer Type:	Automatic
Horiz. Datum:	NAD83	Offset:	~	Other Comments:			

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.
Soft, brown, trace to slightly clayey, slightly fine sandy SILT; moist; scattered roots, iron-oxide staining; (Ha[ob]) ML.	6.8
Very loose, brown, silty, fine SAND; wet; scattered roots, trace of iron-oxide staining; (Ha[ob]) SM.	9.5
Soft, brown WOOD; moist; horizontal grain; (WOOD).	12.0
Loose to medium dense, gray, trace to slightly silty, fine medium SAND; wet; trace to scattered wood fragments, scattered mica flakes; (Ha[cd]) SP/SP-SM.	41.5

BOTTOM OF BORING
COMPLETED 10/19/2009



LEGEND

- * Sample Not Recovered
- Standard Penetration Test
- 3" O.D. Thin-Walled Tube
- 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. 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. USCS designation is based on visual-manual classification and selected lab testing.

Skagit River Levee General Investigation
Skagit County, Washington

LOG OF BORING DD1-2 Landward

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-4

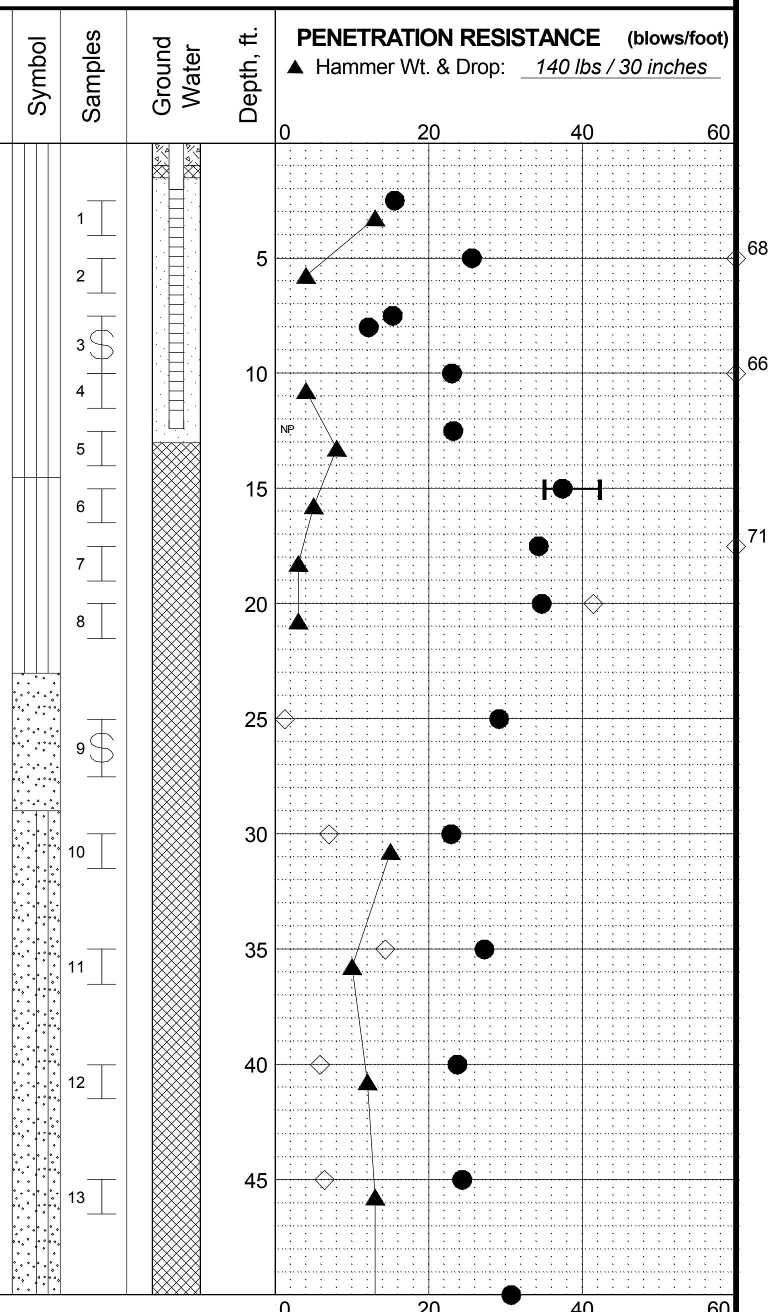
Total Depth:	61.5 ft.	Northing:	~ 508,713 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	5 in.
Top Elevation:	~	Easting:	~ 1,263,901 ft.	Drilling Company:	Holocene Drilling	Rod Diam.:	NWJ
Vert. Datum:		Station:	~	Drill Rig Equipment:	BK-81 Truck	Hammer Type:	Automatic
Horiz. Datum:	NAD83	Offset:	~	Other Comments:			

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.
Loose to medium dense, brown, fine sandy SILT; moist; trace of organics, locally trace of clay, local slightly silty sand zones; (Hf) ML. - Iron-oxide-stained seams below 12 feet.	14.5
Interbedded, very loose to loose and soft to medium stiff, brown, fine sandy SILT, slightly fine sandy SILT, trace of clay, and silty, fine SAND; moist; scattered organics and wood, trace of iron-oxide-stained seams; (Ha[ob]) ML/SM.	23.0
Gray, fine SAND, trace of silt; wet; stratified; (Ha[cd]) SP.	29.0
Loose to medium dense, gray, slightly silty to silty, fine to medium SAND; wet; trace of organics, locally trace of fine gravel; (Ha[cd]) SP-SM/SM. - Scattered wood fragments at 35 feet.	

CONTINUED NEXT SHEET



LEGEND

- * Sample Not Recovered
- Standard Penetration Test
- 3" O.D. Thin-Walled Tube
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout

◇ % 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. 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. USCS designation is based on visual-manual classification and selected lab testing.

Skagit River Levee General Investigation
Skagit County, Washington

LOG OF BORING DD1-2 Levee

June 2010 — 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-5
Sheet 1 of 2

MASTER_LOG_E 21-21199.GPJ SHAN_WIL.GDT 6/1/10 Log: EVP Rev: JKN Typ: LKN

Total Depth:	*61.5 ft.*	Northing:	*~ 508,713 ft.*	Drilling Method:	*Mud Rotary*	Hole Diam.:	*5 in.*
Top Elevation:	*~*	Easting:	*~ 1,263,901 ft.*	Drilling Company:	*Holocene Drilling*	Rod Diam.:	*NWJ*
Vert. Datum:		Station:	*~*	Drill Rig Equipment:	*BK-81 Truck*	Hammer Type:	*Automatic*
Horiz. Datum:	*NAD83*	Offset:	*~*	Other Comments:			

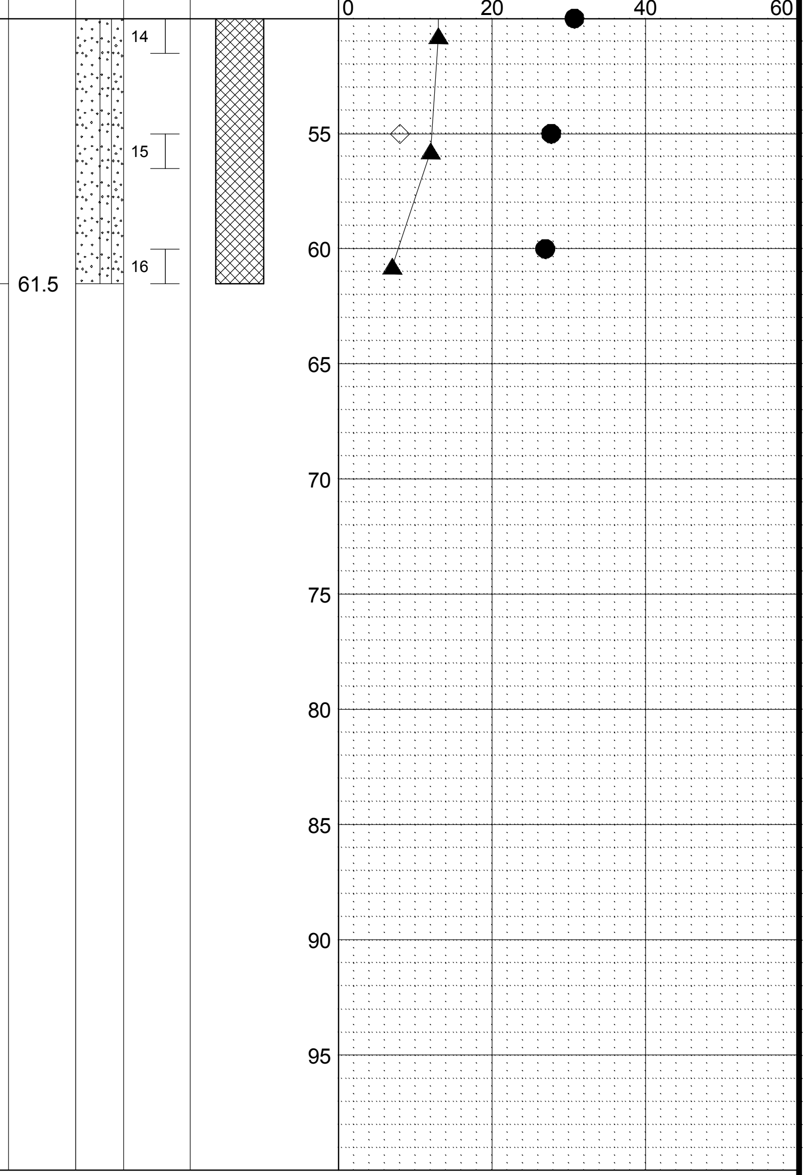
SOIL DESCRIPTION

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 10/20/2009

LEGEND

* Sample Not Recovered
Standard Penetration Test
3" O.D. Thin-Walled Tube

Piezometer Screen and Sand Filter
Bentonite-Cement Grout
Bentonite Chips/Pellets
Bentonite Grout

◇ % 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. 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. USCS designation is based on visual-manual classification and selected lab testing.

Skagit River Levee General Investigation
Skagit County, Washington

LOG OF BORING DD1-2 Levee

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-5
Sheet 2 of 2

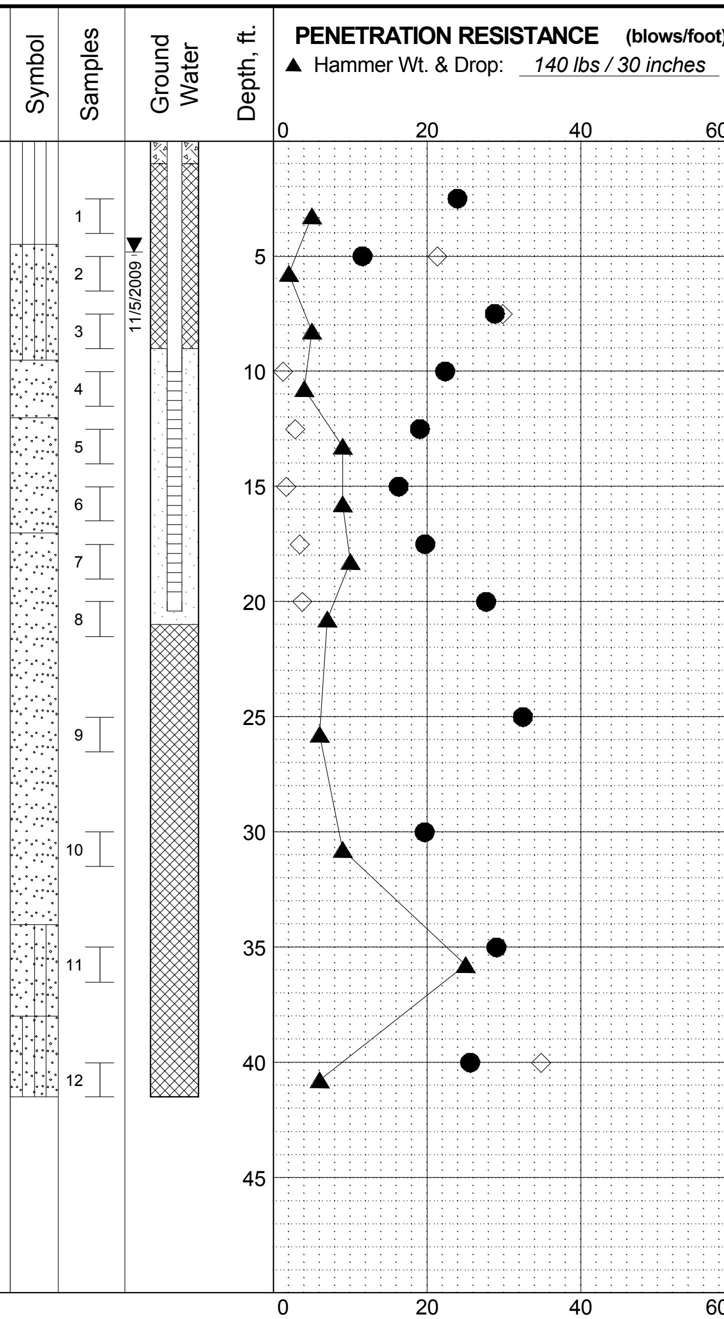
Total Depth:	41.5 ft.	Northing:	~ 507,123 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	5 in.
Top Elevation:	~	Easting:	~ 1,269,522 ft.	Drilling Company:	Holocene Drilling	Rod Diam.:	NWJ
Vert. Datum:		Station:	~	Drill Rig Equipment:	BK-81 Truck	Hammer Type:	Automatic
Horiz. Datum:	NAD83	Offset:	~	Other Comments:			

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.
Loose, brown, slightly fine sandy SILT; moist; scattered organics; (Topsoil) ML.	4.5
Very loose to loose, brown and gray, silty, fine SAND; wet; (Ha[ob]) SM.	9.5
Loose, gray SAND, trace of silt and fine gravel; wet; (Ha[cd]) SP.	12.0
Loose, gray, fine gravelly SAND, trace of silt; wet; (Ha[g]) SP.	17.0
Loose, gray, trace to slightly fine gravelly SAND, trace of silt; wet; local slightly silty layers at 25 feet; (Ha[cd]) SP.	34.0
Medium dense, gray, slightly silty, fine SAND, trace of fine gravel; wet; scattered shell fragments; (He) SP-SM.	38.0
Loose, gray, silty, fine to medium SAND, trace of clay; wet; trace of shell fragments; (He) SM.	41.5

BOTTOM OF BORING
COMPLETED 10/20/2009



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. 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. USCS designation is based on visual-manual classification and selected lab testing.

Skagit River Levee General Investigation
Skagit County, Washington

LOG OF BORING DD3-1 Landward

June 2010 | 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

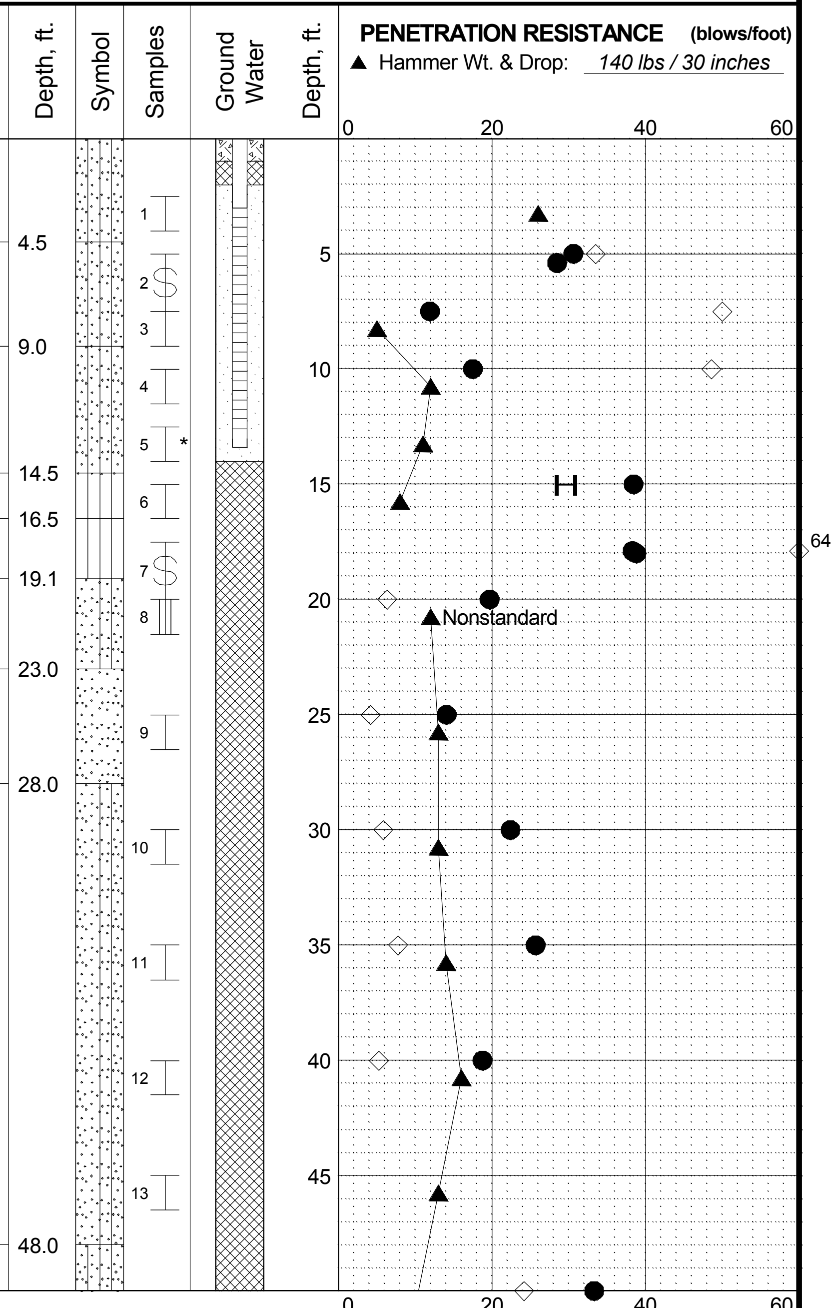
FIG. A-6

Total Depth:	61.5 ft.	Northing:	~ 507,134 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	5 in.
Top Elevation:	~	Easting:	~ 1,269,453 ft.	Drilling Company:	Holocene Drilling	Rod Diam.:	NWJ
Vert. Datum:		Station:	~	Drill Rig Equipment:	BK-81 Truck	Hammer Type:	Automatic
Horiz. Datum:	NAD83	Offset:	~	Other Comments:			

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.
Medium dense, gray, slightly clayey, slightly gravelly, silty SAND; moist; scattered roots; (Hf) SM.	
Loose, brown, silty, fine SAND to fine sandy SILT, trace of fine gravel; moist; trace of organics; (Hf) SM/ML.	4.5
Medium dense, gray-brown, silty, fine SAND; moist; scattered fine sandy silt seams; (Hf) SM.	9.0
Medium stiff, brown, slightly clayey SILT, trace of fine sand; wet; faint iron-oxide mottles; (Ha[ob]) ML.	14.5
	16.5
Gray and orange, fine sandy SILT grading to silty, fine SAND; wet; iron-oxide mottling, stratified, trace of fine roots; (Ha[ob]) ML/SM.	19.1
Medium dense, gray, slightly silty SAND, trace of fine gravel; wet; (Ha[cd]) SP-SM.	23.0
Medium dense, gray, fine gravelly SAND, trace of silt; wet; (Ha[g]) SP.	
Medium dense, gray, trace of fine gravel to slightly fine gravelly, slightly silty SAND; wet; (Ha[cd]) SP-SM/SW-SM.	28.0
	48.0



CONTINUED NEXT SHEET

LEGEND

- * Sample Not Recovered
- Standard Penetration Test
- 3" O.D. Thin-Walled Tube
- 3" O.D. Split Spoon Sample
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout

◇ % 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. 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. USCS designation is based on visual-manual classification and selected lab testing.

Skagit River Levee General Investigation
Skagit County, Washington

LOG OF BORING DD3-1 Levee

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-7
Sheet 1 of 2

MASTER_LOG_E 21-21199.GPJ SHAN_WIL.GDT 6/1/10 Log: EVP Rev: JKN Typ: LKN

Total Depth:	*61.5 ft.*	Northing:	*~ 507,134 ft.*	Drilling Method:	*Mud Rotary*	Hole Diam.:	*5 in.*
Top Elevation:	*~*	Easting:	*~ 1,269,453 ft.*	Drilling Company:	*Holocene Drilling*	Rod Diam.:	*NWJ*
Vert. Datum:		Station:	*~*	Drill Rig Equipment:	*BK-81 Truck*	Hammer Type:	*Automatic*
Horiz. Datum:	*NAD83*	Offset:	*~*	Other Comments:			

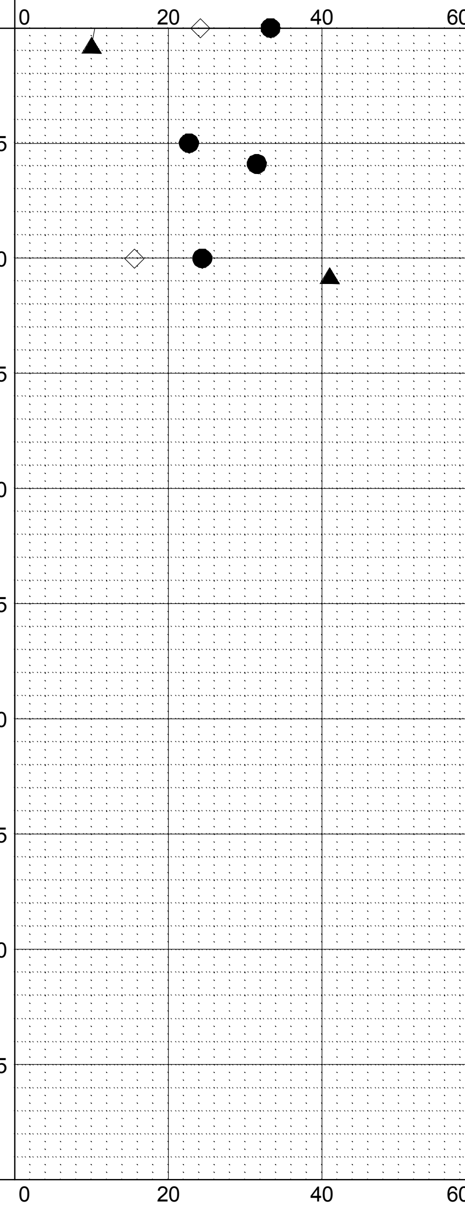
SOIL DESCRIPTION

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.	Samples
Medium dense, gray, silty, fine to medium SAND; wet; trace of shells and organics; (He) SM.	53.0	14
Gray, trace of silt to slightly silty, fine to medium SAND; wet; trace of shell fragments, scattered coarse wood fragments; (Ha[cd]/He) SP-SM/SP.	59.0	15
Dense, gray, silty, fine to medium SAND; wet; (Ha[cd]) SM.	61.5	16

BOTTOM OF BORING
COMPLETED 10/21/2009

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



LEGEND

- * Sample Not Recovered
- Standard Penetration Test
- 3" O.D. Thin-Walled Tube
- 3" O.D. Split Spoon Sample
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout

◇ % 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. 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. USCS designation is based on visual-manual classification and selected lab testing.

Skagit River Levee General Investigation
Skagit County, Washington

LOG OF BORING DD3-1 Levee

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-7
Sheet 2 of 2

MASTER_LOG_E 21-21199.GPJ SHAN_WIL.GDT 6/17/10 Log: EVP Rev: JKN Typ: LKN

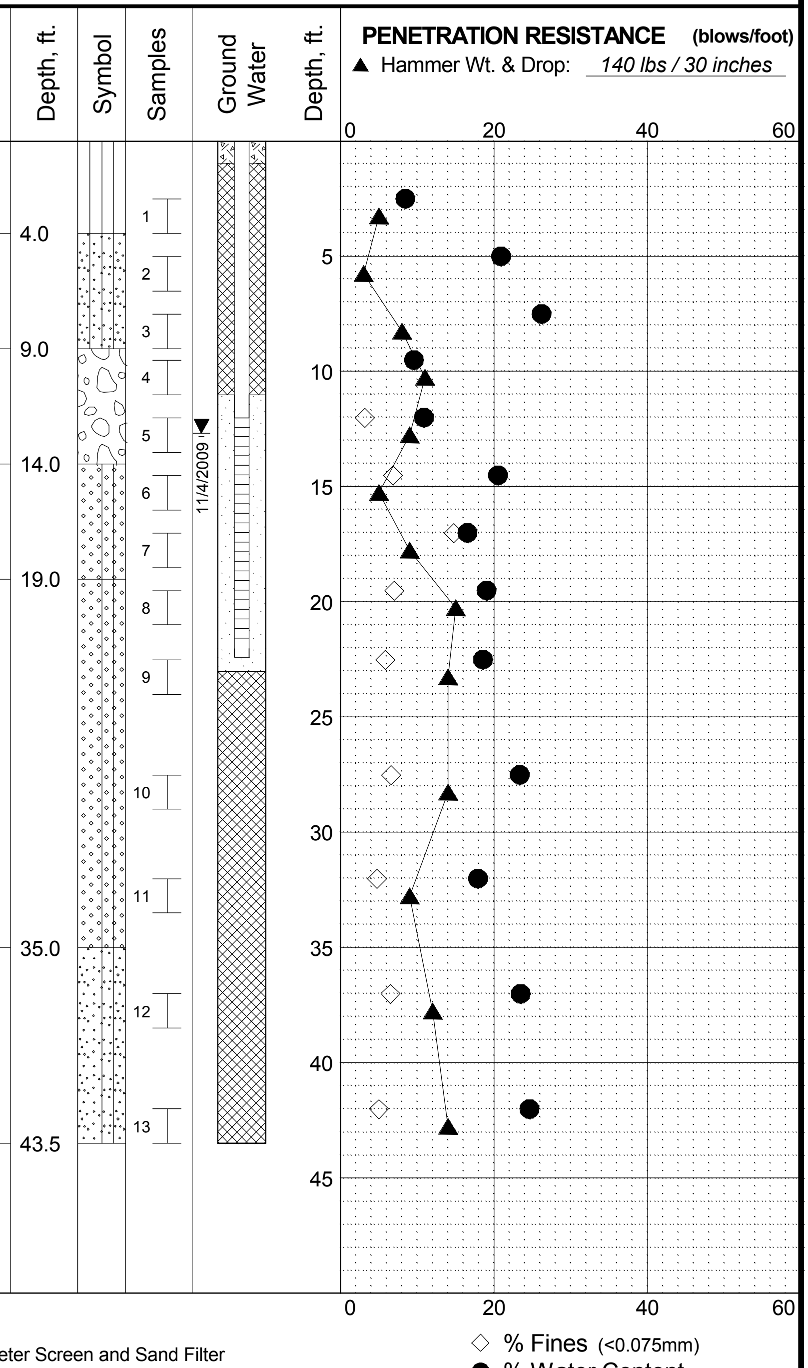
Total Depth:	43.5 ft.	Northing:	~ 530,262 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	5 in.
Top Elevation:	~	Easting:	~ 1,277,725 ft.	Drilling Company:	Holocene Drilling	Rod Diam.:	NWJ
Vert. Datum:		Station:	~	Drill Rig Equipment:	B-61 Mobile Truck	Hammer Type:	Automatic
Horiz. Datum:	NAD83	Offset:	~	Other Comments:			

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.
Loose, brown, slightly fine sandy SILT; moist; trace of fine roots; (Ha[ob]) ML.	4.0
Very loose to loose, brown, silty, fine SAND; moist; scattered iron-oxide-stained seams; (Ha[cd]) SM.	9.0
Loose to medium dense, brown, sandy, fine GRAVEL, trace of silt to gravelly SAND, trace of silt; wet; strong iron-oxide staining below 12 feet, rounded to subrounded gravel; (Ha[g]) GP/SW.	14.0
Loose, gray, slightly silty, slightly fine gravelly SAND to silty SAND, trace of fine gravel; wet; scattered silty sand seams, scattered iron-oxide-stained and dark brown layers below 17 feet, trace of organics; (Ha[cd]) SW-SM/SM.	19.0
Loose to medium dense, gray, trace to slightly silty, trace of fine gravel to fine gravelly SAND; wet; (Ha[cd]) SW-SM/SP.	35.0
Medium dense, gray, slightly silty, fine to medium SAND, trace of fine gravel; wet; (Ha[cd]) SP-SM.	43.5

BOTTOM OF BORING
COMPLETED 10/9/2009



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. 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. USCS designation is based on visual-manual classification and selected lab testing.

Skagit River Levee General Investigation
Skagit County, Washington

LOG OF BORING DD17-1 Landward

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-8

Log: EVP Rev: JKN Typ: CLP

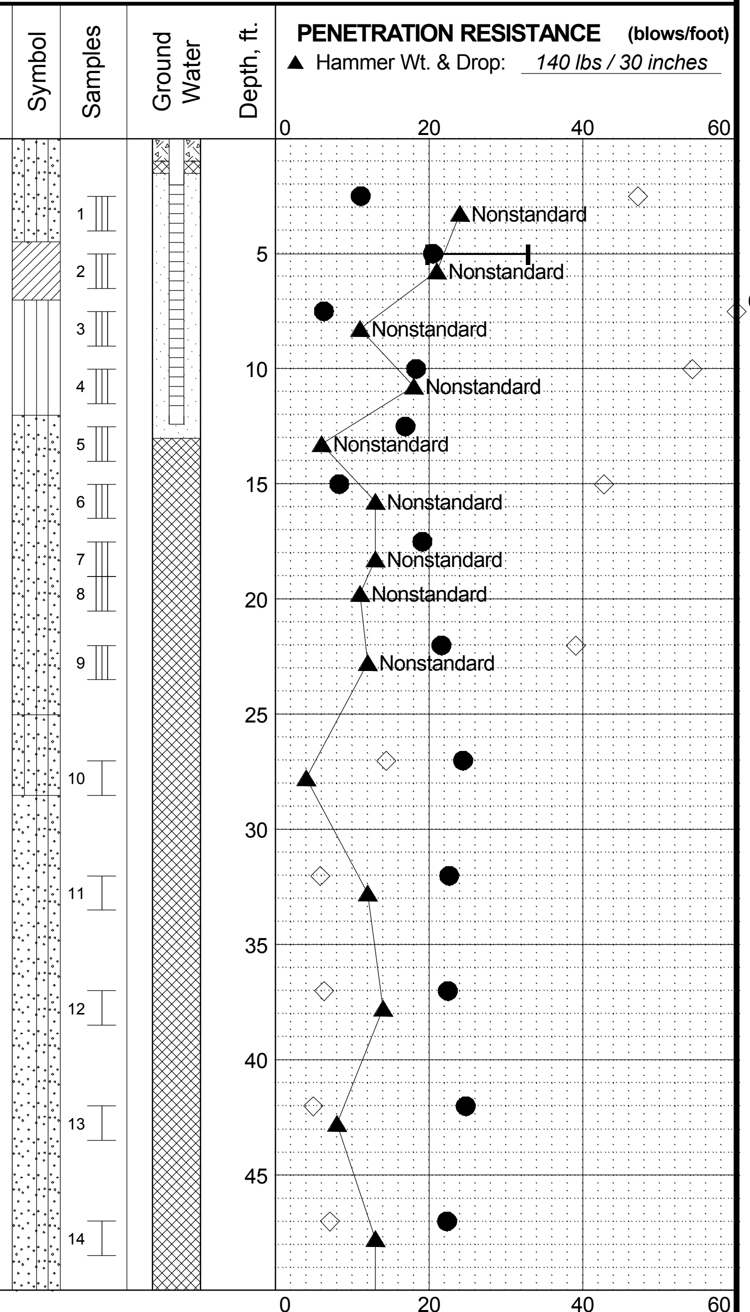
MASTER_LOG_E 21-21199.GPJ SHAN_WIL.GDT 6/1/10

Total Depth:	*63.5 ft.*	Northing:	*~ 530,351 ft.*	Drilling Method:	*Mud Rotary*	Hole Diam.:	*5 in.*
Top Elevation:	*~*	Easting:	*~ 1,277,702 ft.*	Drilling Company:	*Holocene Drilling*	Rod Diam.:	*NWJ*
Vert. Datum:		Station:	*~*	Drill Rig Equipment:	*B-61 Mobile Truck*	Hammer Type:	*Automatic*
Horiz. Datum:	*NAD83*	Offset:	*~*	Other Comments:			

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.
Medium dense, brown, slightly clayey, fine gravelly, silty SAND; moist; iron-oxide mottles, trace of fine roots; (Hf) SM.	4.5
Very stiff, brown, silty CLAY, trace of sand and gravel and medium dense, fine sandy SILT; moist; trace of organics; (Hf) CL/ML.	7.0
Medium dense, brown, fine sandy SILT; moist; scattered slightly fine sandy to fine sandy silt layers; (Hf) ML.	12.0
Loose to medium dense, brown and gray, silty, fine SAND, trace of fine gravel; moist; (Ha[ob]) SM.	25.0
Loose, brown, silty, fine to medium SAND; moist; (Ha[cd]) SM.	28.5
Loose to medium dense, gray, trace of silt to slightly silty, fine to medium SAND, trace of fine gravel; wet; (Ha[cd]) SP-SM/SP/SW-SM. - Slightly silty sand layer at 47 feet.	



CONTINUED NEXT SHEET

LEGEND

- * Sample Not Recovered
- 3" O.D. Split Spoon Sample
- Standard Penetration Test
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout

◇ % 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. 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. USCS designation is based on visual-manual classification and selected lab testing.

Skagit River Levee General Investigation
Skagit County, Washington

LOG OF BORING DD17-1 Levee

June 2010 — 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-9
Sheet 1 of 2

Total Depth:	*63.5 ft.*	Northing:	*~ 530,351 ft.*	Drilling Method:	*Mud Rotary*	Hole Diam.:	*5 in.*
Top Elevation:	*~*	Easting:	*~ 1,277,702 ft.*	Drilling Company:	*Holocene Drilling*	Rod Diam.:	*NWJ*
Vert. Datum:		Station:	*~*	Drill Rig Equipment:	*B-61 Mobile Truck*	Hammer Type:	*Automatic*
Horiz. Datum:	*NAD83*	Offset:	*~*	Other Comments:			

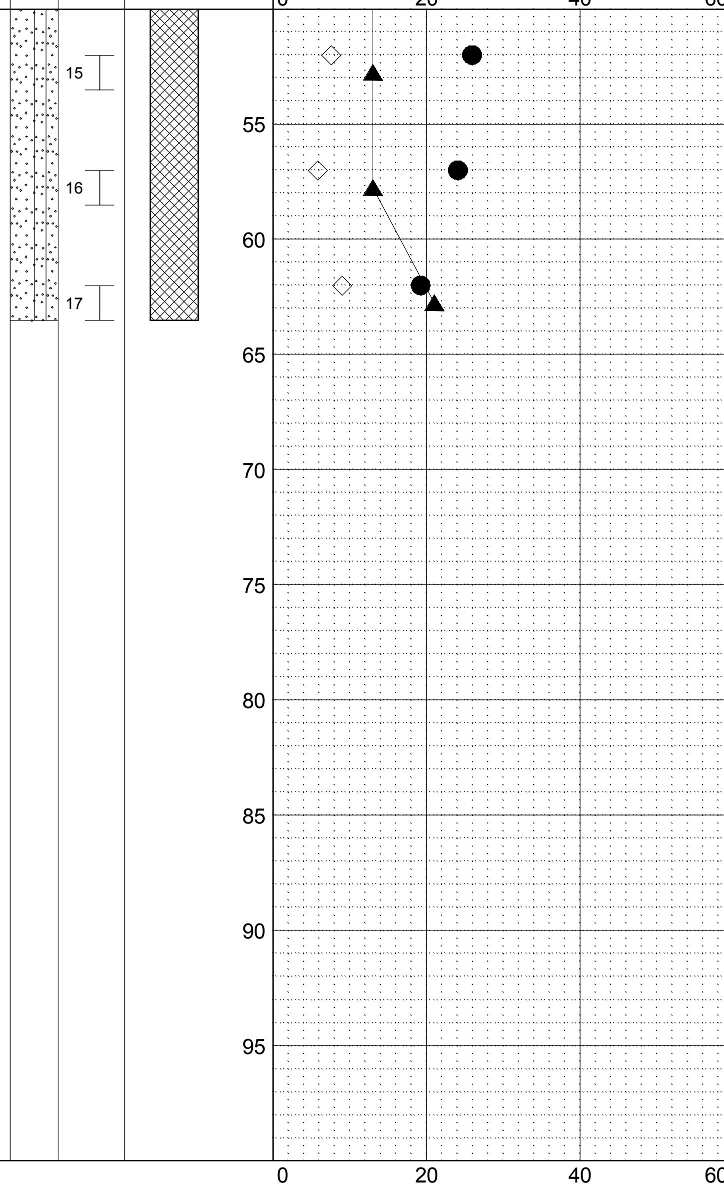
SOIL DESCRIPTION

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*



63.5

BOTTOM OF BORING
COMPLETED 10/9/2009

LEGEND

- * Sample Not Recovered
- 3" O.D. Split Spoon Sample
- Standard Penetration Test
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout

◇ % 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. 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. USCS designation is based on visual-manual classification and selected lab testing.

Skagit River Levee General Investigation
Skagit County, Washington

LOG OF BORING DD17-1 Levee

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-9
Sheet 2 of 2

Log: EVP Rev: JKN Typ: CLP

MASTER LOG E 21-21199.GPJ SHAN WIL.GDT 6/1/10

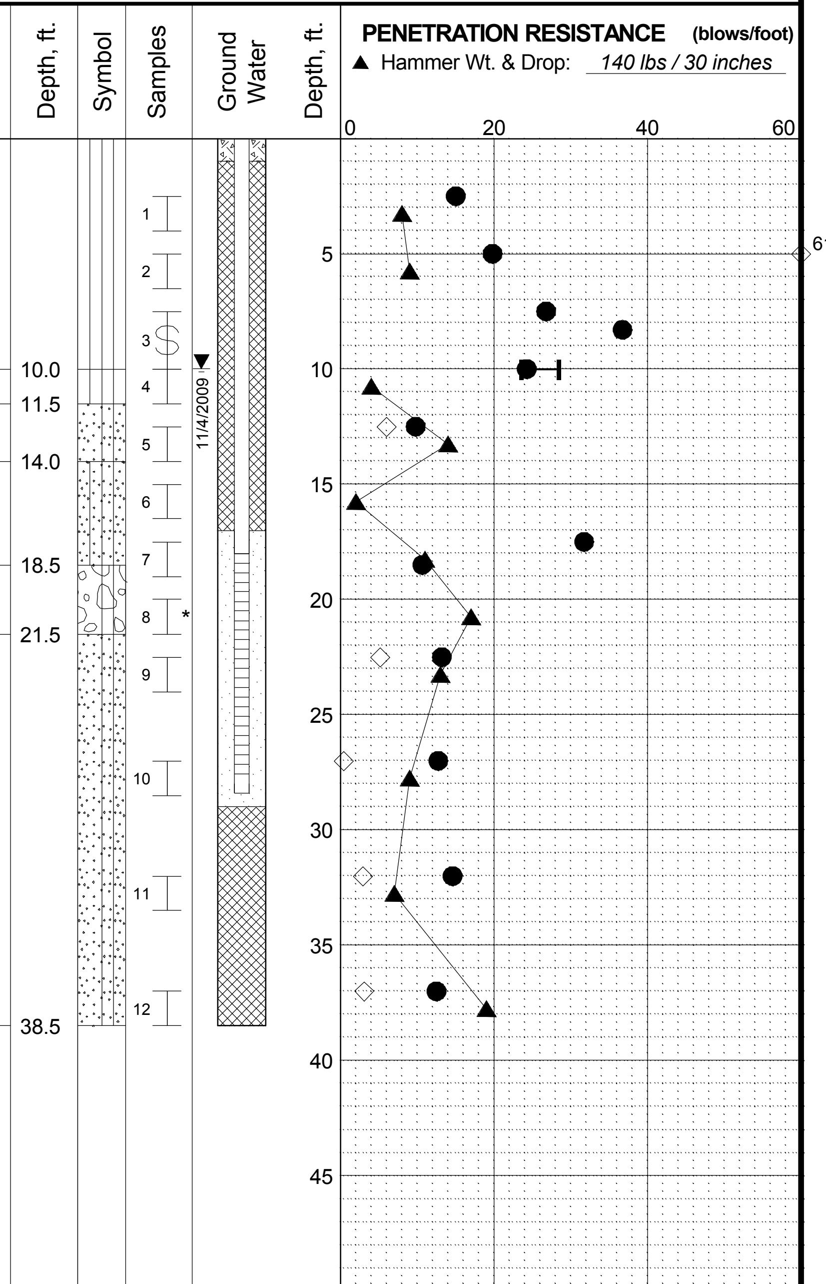
Total Depth:	38.5 ft.	Northing:	~ 531,266 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	5 in.
Top Elevation:	~	Easting:	~ 1,270,707 ft.	Drilling Company:	Holocene Drilling	Rod Diam.:	NWJ
Vert. Datum:		Station:	~	Drill Rig Equipment:	B-61 Mobile Truck	Hammer Type:	Automatic
Horiz. Datum:	NAD83	Offset:	~	Other Comments:			

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.
Loose, mottled brown and gray, fine sandy SILT, trace of clay; moist; scattered iron-oxide staining, slightly fine gravelly sand layer at 9.1 feet; (Ha[ob]) ML.	10.0
Soft, brown, slightly clayey, fine sandy SILT; wet; trace of organics; (Ha[ob]) ML.	11.5
Medium dense, brown, slightly silty, fine gravelly SAND; moist; scattered silt pockets; (Ha[cd]) SP-SM.	14.0
Very loose to medium dense, brown and gray, silty, fine SAND to slightly fine sandy SILT, trace of clay; wet; (Ha[ob]) SM/ML.	18.5
Medium dense, gray-brown, slightly silty, sandy GRAVEL; wet; scattered silty, fine sand seams; (Ha[g]) GP-GM.	21.5
Loose to medium dense, gray, trace of silt to slightly silty, fine gravelly SAND and sandy GRAVEL, trace of silt; wet; (Ha[g]) SP-SM/GW/SP.	38.5

BOTTOM OF BORING
COMPLETED 10/9/2009



Log: EVP Rev: JKN Typ: CLP

MASTER_LOG_E 21-21199.GPJ SHAN_WIL.GDT 6/1/10

LEGEND

- * Sample Not Recovered
- Standard Penetration Test
- 3" O.D. Thin-Walled Tube
- 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. 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. USCS designation is based on visual-manual classification and selected lab testing.

Skagit River Levee General Investigation
Skagit County, Washington

LOG OF BORING DD17-2 Landward

June 2010 | 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

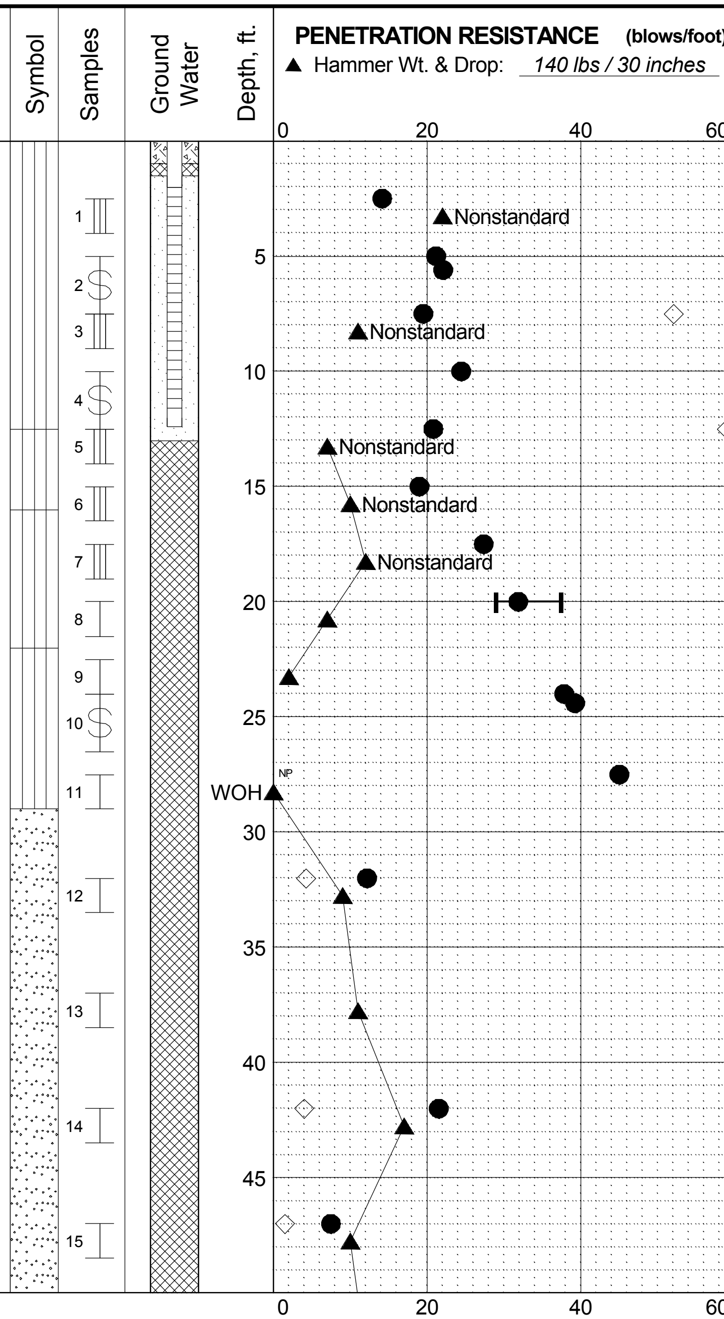
FIG. A-10

Total Depth:	63.5 ft.	Northing:	~ 531,153 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	5 in.
Top Elevation:	~	Easting:	~ 1,270,679 ft.	Drilling Company:	Holocene Drilling	Rod Diam.:	JWJ
Vert. Datum:		Station:	~	Drill Rig Equipment:	B-61 Mobile Truck	Hammer Type:	Automatic
Horiz. Datum:	NAD83	Offset:	~	Other Comments:			

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.
Medium dense, brown and gray, fine sandy SILT to silty, fine SAND; moist; slightly gravelly above 7.5 feet, locally trace of clay, trace of organics, trace of slightly clayey silt pockets; (Hf) ML/SM.	
Loose, brown, fine sandy SILT; moist; trace of iron-oxide staining; (Ha[ob]) ML.	12.5
Medium stiff to stiff, brown, trace to slightly clayey, trace to slightly fine sandy SILT; moist; faintly laminated, trace of roots, scattered iron-oxide stains, silty fine sand seams above 20 feet; (Ha[ob]) ML.	16.0
Very soft, gray, trace to slightly fine sandy SILT, trace of clay; wet; scattered silty fine sand seams and layers; (Ha[ob]) ML.	22.0
Loose to medium dense, gray, gravelly SAND, trace of silt to sandy GRAVEL, trace of silt; wet; locally trace of wood fragments; (Ha[g]) SP/GW.	29.0



CONTINUED NEXT SHEET

LEGEND

- * Sample Not Recovered
- 3" O.D. Split Spoon Sample
- 3" O.D. Thin-Walled Tube
- Standard Penetration Test
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout

◇ % 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. 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. USCS designation is based on visual-manual classification and selected lab testing.

Skagit River Levee General Investigation
Skagit County, Washington

LOG OF BORING DD17-2 Levee

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-11
Sheet 1 of 2

Total Depth:	*63.5 ft.*	Northing:	*~ 531,153 ft.*	Drilling Method:	*Mud Rotary*	Hole Diam.:	*5 in.*
Top Elevation:	*~*	Easting:	*~ 1,270,679 ft.*	Drilling Company:	*Holocene Drilling*	Rod Diam.:	*JWJ*
Vert. Datum:		Station:	*~*	Drill Rig Equipment:	*B-61 Mobile Truck*	Hammer Type:	*Automatic*
Horiz. Datum:	*NAD83*	Offset:	*~*	Other Comments:			

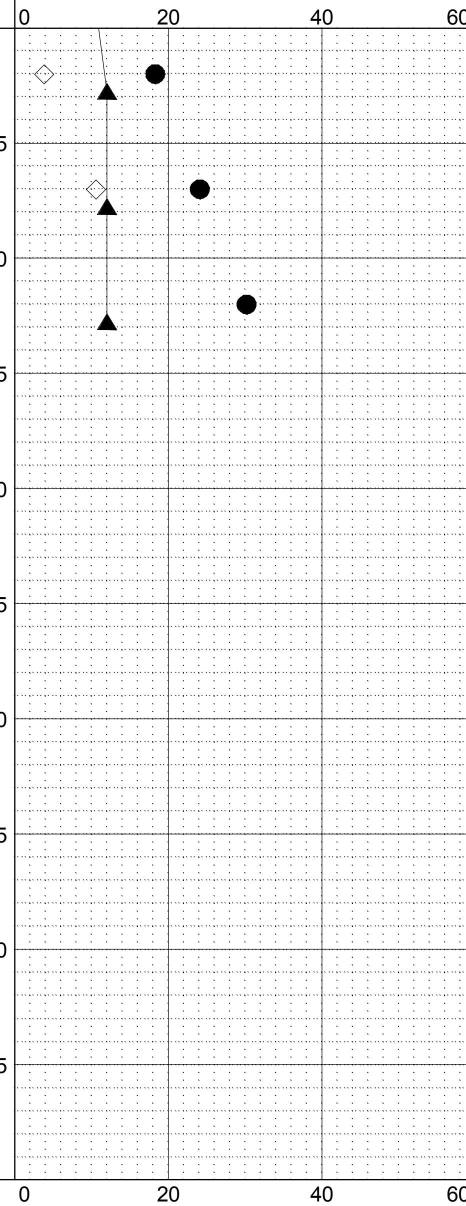
SOIL DESCRIPTION

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.	Samples
		16
Medium dense, gray, slightly silty SAND, trace of fine gravel; wet; (Ha[cd]) SW-SM.	53.5	17, 18
BOTTOM OF BORING COMPLETED 10/13/2009	63.5	

PENETRATION RESISTANCE (blows/foot)

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



LEGEND

* Sample Not Recovered
3" O.D. Split Spoon Sample
3" O.D. Thin-Walled Tube
Standard Penetration Test
Piezometer Screen and Sand Filter
Bentonite-Cement Grout
Bentonite Chips/Pellets
Bentonite Grout

◇ % 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. 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. USCS designation is based on visual-manual classification and selected lab testing.

Skagit River Levee General Investigation
Skagit County, Washington

LOG OF BORING DD17-2 Levee

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-11
Sheet 2 of 2

Total Depth:	*51.5 ft.*	Northing:	*~ 525,350 ft.*	Drilling Method:	*Mud Rotary*	Hole Diam.:	*5 in.*
Top Elevation:	*~*	Easting:	*~ 1,272,695 ft.*	Drilling Company:	*Holocene Drilling*	Rod Diam.:	*NWJ*
Vert. Datum:		Station:	*~*	Drill Rig Equipment:	*B-61 Mobile Truck*	Hammer Type:	*Automatic*
Horiz. Datum:	*NAD83*	Offset:	*~*	Other Comments:			

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.

Interbedded, very loose to loose, brown and gray, fine sandy SILT to slightly silty and silty, fine SAND; moist; iron-oxide-stained seams, laminated, slightly clayey silt layers above 5 feet; (Ha[ob]) ML/SM/SP-SM.

14.5

Loose, orange-brown, slightly silty, fine to medium SAND, trace of fine gravel; wet; iron-oxide-stained; (Ha[cd]) SP-SM.

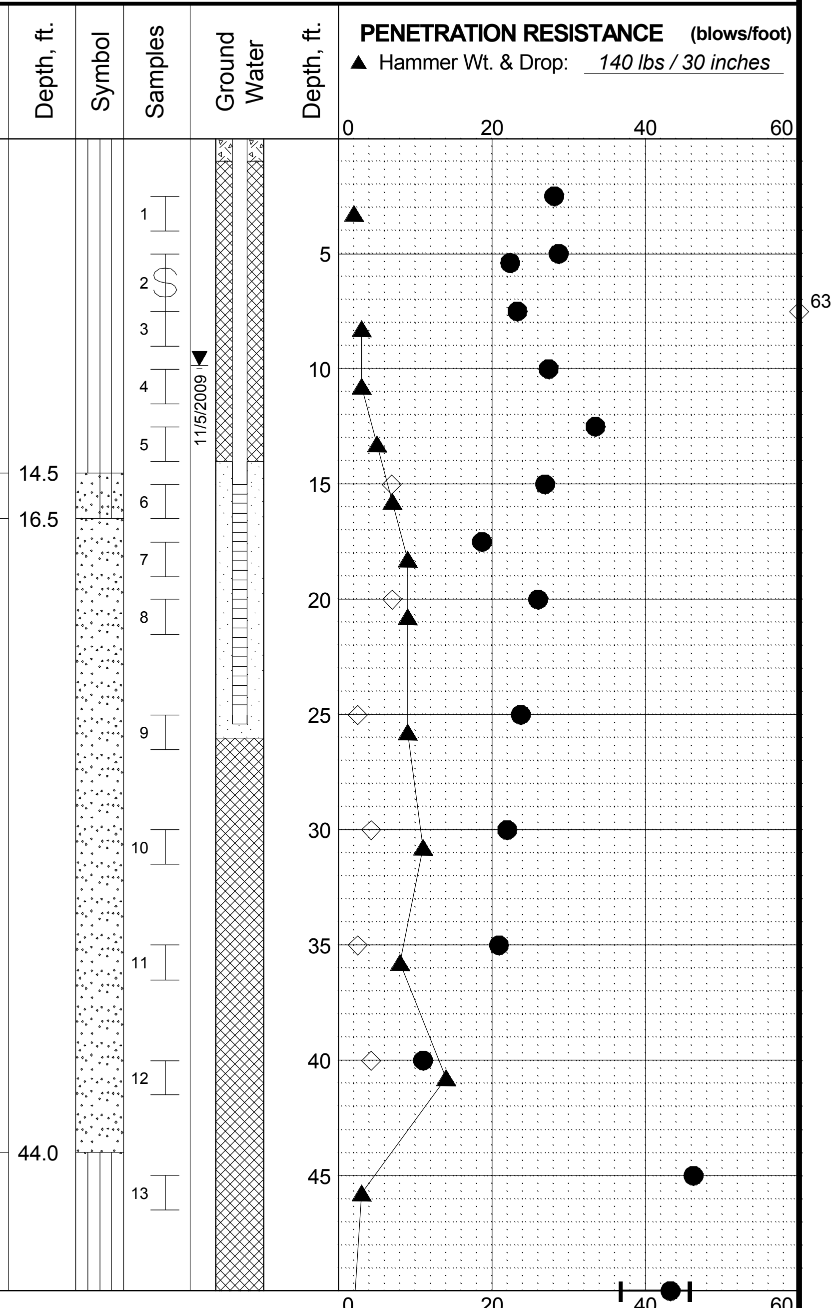
16.5

Loose to medium dense, gray, trace of silt to slightly silty, trace of gravel to gravelly SAND; wet; (Ha[cd]) SP/SW-SM.

44.0

Soft, gray, slightly clayey to clayey SILT; wet; scattered wood fragments and scattered to numerous organics; (Ha[ob]) ML.

CONTINUED NEXT SHEET



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

LEGEND

- * Sample Not Recovered
- Standard Penetration Test
- 3" O.D. Thin-Walled Tube
- 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. 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. USCS designation is based on visual-manual classification and selected lab testing.

Skagit River Levee General Investigation
Skagit County, Washington

LOG OF BORING DD17-3 Landward

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-12
Sheet 1 of 2

Log: EVP Rev: JKN Typ: CLP

MASTER_LOG_E 21-21199.GPJ SHAN_WIL.GDT 6/1/10

Total Depth:	51.5 ft.	Northing:	~ 525,350 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	5 in.
Top Elevation:	~	Easting:	~ 1,272,695 ft.	Drilling Company:	Holocene Drilling	Rod Diam.:	NWJ
Vert. Datum:		Station:	~	Drill Rig Equipment:	B-61 Mobile Truck	Hammer Type:	Automatic
Horiz. Datum:	NAD83	Offset:	~	Other Comments:			

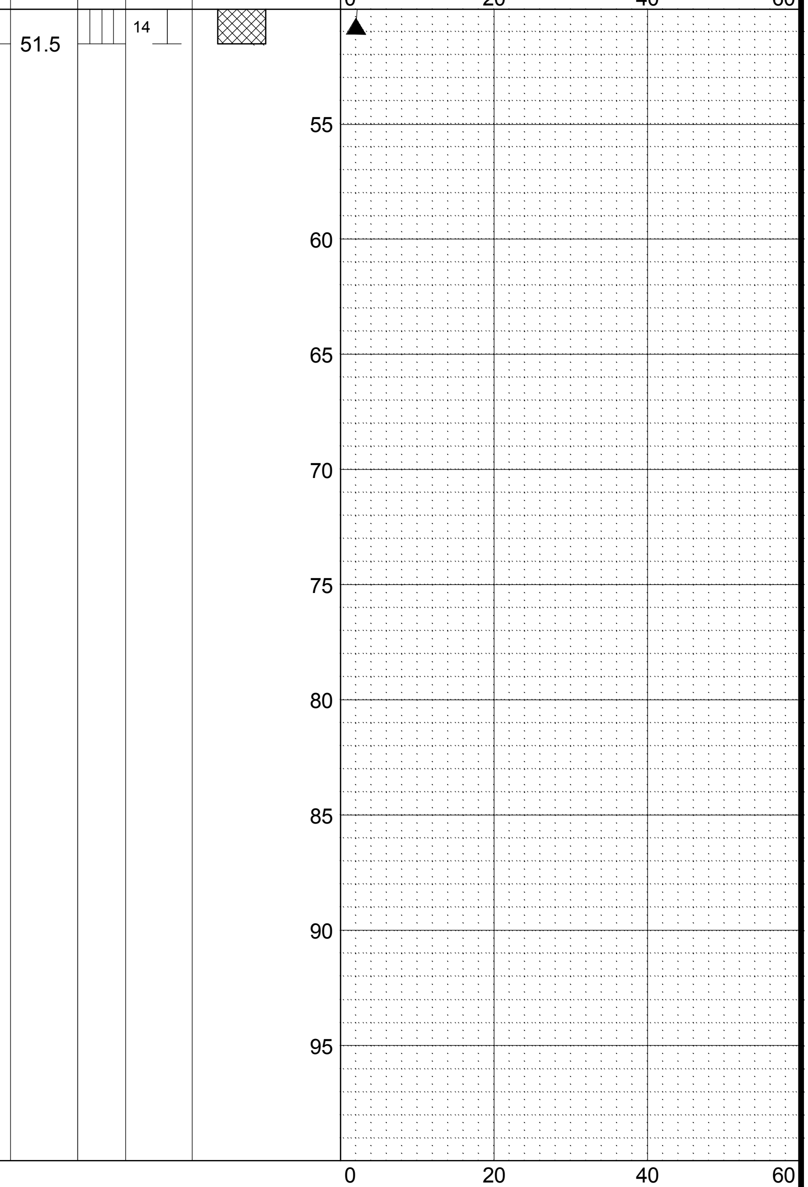
SOIL DESCRIPTION

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 10/15/2009

LEGEND

* Sample Not Recovered
Standard Penetration Test
3" O.D. Thin-Walled Tube

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. 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. USCS designation is based on visual-manual classification and selected lab testing.

Skagit River Levee General Investigation
Skagit County, Washington

LOG OF BORING DD17-3 Landward

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

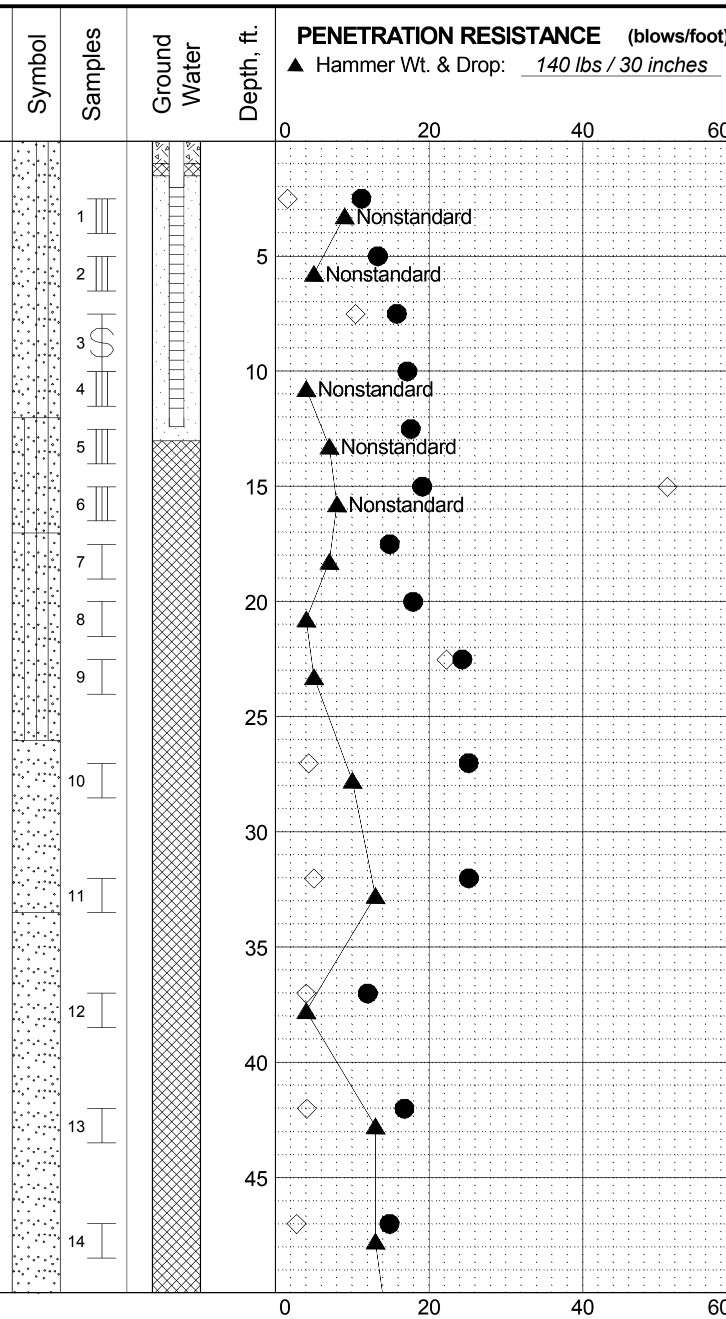
FIG. A-12
Sheet 2 of 2

Total Depth:	66 ft.	Northing:	~ 525,290 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	5 in.
Top Elevation:	~	Easting:	~ 1,272,702 ft.	Drilling Company:	Holocene Drilling	Rod Diam.:	NWJ
Vert. Datum:		Station:	~	Drill Rig Equipment:	B-61 Mobile Truck	Hammer Type:	Automatic
Horiz. Datum:	NAD83	Offset:	~	Other Comments:			

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.
Loose, brown, trace to slightly silty, fine SAND; moist; locally trace of gravel, trace of organics, scattered silty clay clasts above 5 feet, scattered fine sandy silt layers below 10 feet; (Hf) SP-SM/SP.	12.0
Loose, gray-brown, silty, fine SAND to fine sandy SILT; moist; laminated, faint iron-oxide-stained seams, scattered fine sandy silt layers below 15 feet; (Ha[ob]) SM/ML.	17.0
Loose, gray, silty, fine SAND; moist; (Ha[ob]) SM.	26.0
Medium dense, gray, trace to slightly silty, trace to slightly fine gravelly, fine to medium SAND; wet; (Ha[cd]) SP/SP-SM.	33.5
Loose to medium dense, gravelly SAND, trace of silt and sandy GRAVEL, trace of silt; wet; (Ha[g]) SP/GW/SW.	



CONTINUED NEXT SHEET

LEGEND

- * Sample Not Recovered
- 3" O.D. Split Spoon Sample
- 3" O.D. Thin-Walled Tube
- Standard Penetration Test
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout

◇ % 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. 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. USCS designation is based on visual-manual classification and selected lab testing.

Skagit River Levee General Investigation
Skagit County, Washington

LOG OF BORING DD17-3 Levee

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-13
Sheet 1 of 2

Total Depth:	*66 ft.*	Northing:	*~ 525,290 ft.*	Drilling Method:	*Mud Rotary*	Hole Diam.:	*5 in.*
Top Elevation:	*~*	Easting:	*~ 1,272,702 ft.*	Drilling Company:	*Holocene Drilling*	Rod Diam.:	*NWJ*
Vert. Datum:		Station:	*~*	Drill Rig Equipment:	*B-61 Mobile Truck*	Hammer Type:	*Automatic*
Horiz. Datum:	*NAD83*	Offset:	*~*	Other Comments:			

SOIL DESCRIPTION

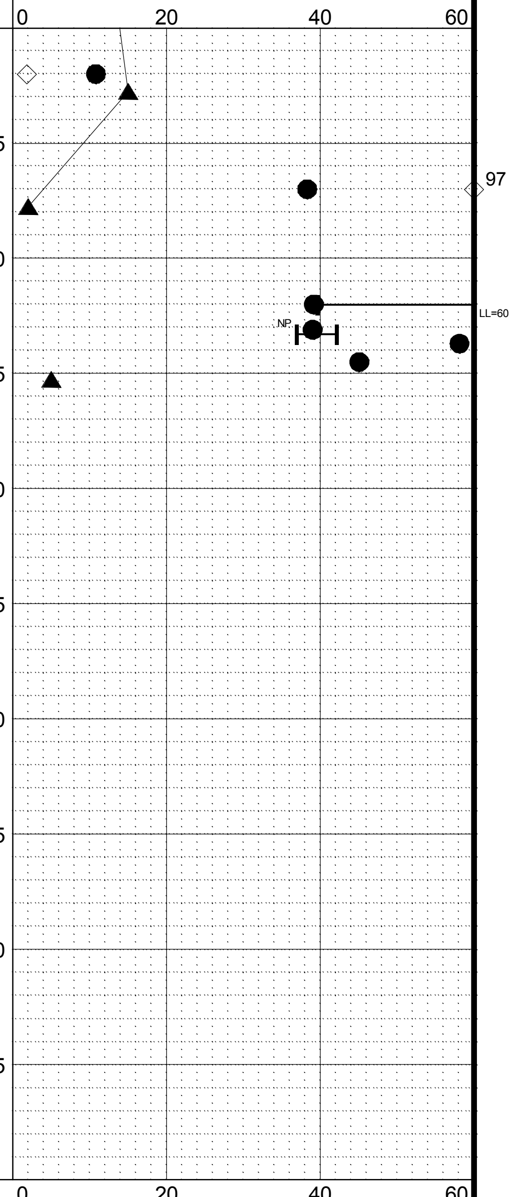
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples
		15
Soft to medium stiff, gray, slightly clayey to clayey SILT, trace of fine sand and SILT; wet; trace to scattered organics; (Ha[ob]) ML.	55.0	16, 17, 18
BOTTOM OF BORING COMPLETED 10/14/2009	66.0	

Symbol | Samples | Ground Water | Depth, ft.

PENETRATION RESISTANCE **(blows/foot)**

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



LEGEND

* Sample Not Recovered
3" O.D. Split Spoon Sample
3" O.D. Thin-Walled Tube
Standard Penetration Test
Piezometer Screen and Sand Filter
Bentonite-Cement Grout
Bentonite Chips/Pellets
Bentonite Grout

◇ % 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. 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. USCS designation is based on visual-manual classification and selected lab testing.

Skagit River Levee General Investigation
Skagit County, Washington

LOG OF BORING DD17-3 Levee

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-13
Sheet 2 of 2

MASTER_LOG_E 21-21199.GPJ SHAN_WIL.GDT 6/1/10 Log: EVP Rev: JKN Typ: CLP

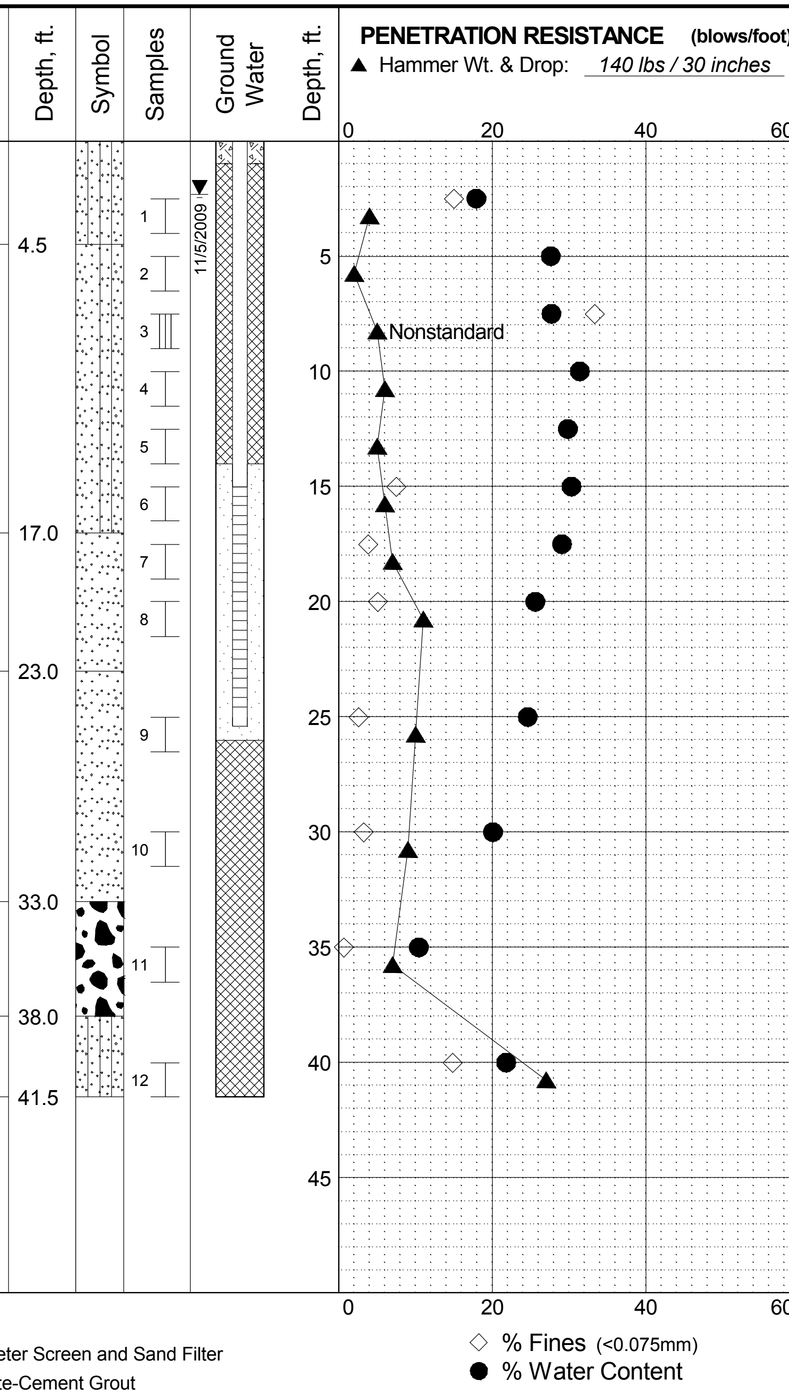
Total Depth: *41.5 ft.*	Northing: *~ 504,871 ft.*	Drilling Method:	*Mud Rotary*	Hole Diam.:	*5 in.*
Top Elevation: *~*	Easting: *~ 1,268,661 ft.*	Drilling Company:	*Holocene Drilling*	Rod Diam.:	*NWJ*
Vert. Datum:	Station: *~*	Drill Rig Equipment:	*BK-81 Truck*	Hammer Type:	*Automatic*
Horiz. Datum: *NAD83*	Offset: *~*	Other Comments:			

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.
Loose, gray-brown, silty, fine SAND; moist; scattered roots; (Ha[ob]) SM.	4.5
Very loose to loose, gray, slightly silty to silty, fine to medium SAND; wet; trace of organics, moist above 7 feet; (Ha[cd]) SP-SM/SM.	17.0
Loose to medium dense, gray, trace to slightly silty, fine to medium SAND; wet; (Ha[cd]) SP/SP-SM.	23.0
Loose, gray, trace to slightly gravelly SAND, trace of silt; wet; (Ha[cd]) SP.	33.0
Loose, gray, sandy GRAVEL, trace of silt; wet; (Ha[g]) GW.	38.0
Medium dense, gray, silty, fine to medium SAND; wet; numerous shell fragments; (He) SM.	41.5

BOTTOM OF BORING
COMPLETED 10/21/2009



LEGEND

- * Sample Not Recovered
- Standard Penetration Test
- 3" O.D. Split Spoon Sample
- 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. 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. USCS designation is based on visual-manual classification and selected lab testing.

Skagit River Levee General Investigation
Skagit County, Washington

LOG OF BORING DD22-1 Landward

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-14

Total Depth:	*61.5 ft.*	Northing:	*~ 504,876 ft.*	Drilling Method:	*Mud Rotary*	Hole Diam.:	*5 in.*
Top Elevation:	*~*	Easting:	*~ 1,268,717 ft.*	Drilling Company:	*Holocene Drilling*	Rod Diam.:	*NWJ*
Vert. Datum:		Station:	*~*	Drill Rig Equipment:	*BK-81 Truck*	Hammer Type:	*Automatic*
Horiz. Datum:	*NAD83*	Offset:	*~*	Other Comments:			

SOIL DESCRIPTION

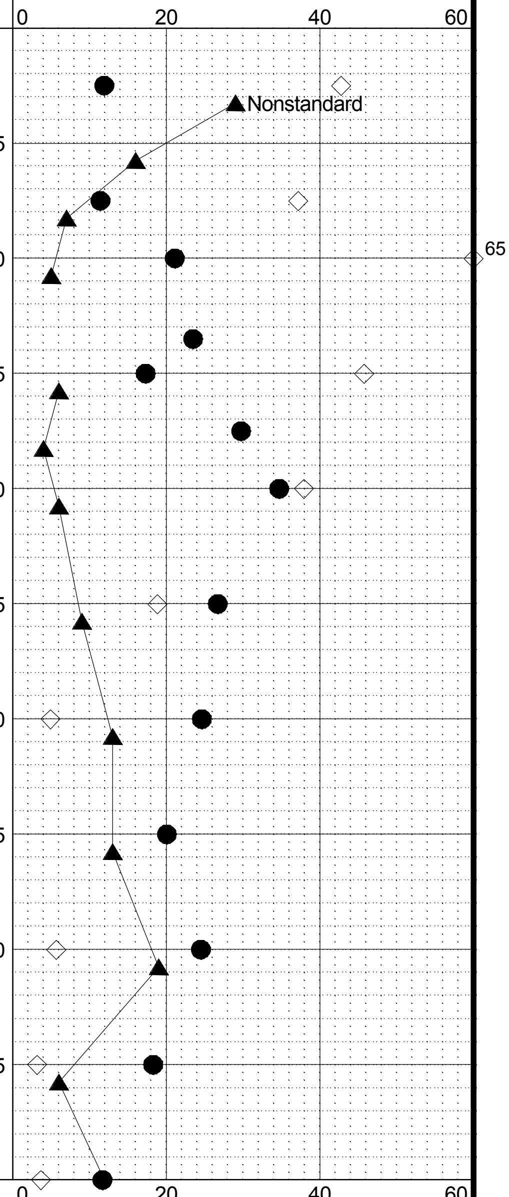
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples
Medium dense, brown, slightly clayey, gravelly, silty SAND; moist; (Hf) SM.		1
Medium dense, gray-brown, silty, sandy GRAVEL, trace of clay; moist; scattered slightly clayey pockets; (Hf) GM.	4.5	2
Loose, gray-brown, silty, fine SAND; wet; (Hf) SM.	7.0	3
Loose, brown, fine sandy SILT to silty, fine SAND; moist; clayey silt pockets, intermixed, scattered roots above 13 feet; (Hf) ML/SM.	9.5	4, 5
Loose, gray-brown, silty, fine SAND; moist; laminated, iron-oxide-stained seams, scattered silt layers; (Ha[ob]) SM.	15.0	6, 7
Loose, gray-brown, silty, fine SAND; wet; strongly iron-oxide-stained layers; (Ha[ob]) SM.	19.5	8
Loose, gray, silty, fine to medium SAND; wet; (Ha[ob]) SM.	23.0	9
Medium dense, gray, trace to slightly silty, fine to medium SAND, trace of fine gravel; wet; (Ha[cd]) SP/SP-SM.	28.0	10, 11, 12
Loose to medium dense, gray, fine gravelly SAND, trace of silt; wet; (Ha[g]) SP/SW.	43.0	13

CONTINUED NEXT SHEET

PENETRATION RESISTANCE (blows/foot)

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



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

LEGEND

- * Sample Not Recovered
- 3" O.D. Split Spoon Sample
- Standard Penetration Test
- 3" O.D. Thin-Walled Tube
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
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. USCS designation is based on visual-manual classification and selected lab testing.

Skagit River Levee General Investigation
Skagit County, Washington

LOG OF BORING DD22-1 Levee

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-15
Sheet 1 of 2

Log: EVP Rev: JKN Typ: LKN

MASTER_LOG_E 21-21199.GPJ SHAN_WIL.GDT 6/1/10

Total Depth:	61.5 ft.	Northing:	~ 504,876 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	5 in.
Top Elevation:	~	Easting:	~ 1,268,717 ft.	Drilling Company:	Holocene Drilling	Rod Diam.:	NWJ
Vert. Datum:		Station:	~	Drill Rig Equipment:	BK-81 Truck	Hammer Type:	Automatic
Horiz. Datum:	NAD83	Offset:	~	Other Comments:			

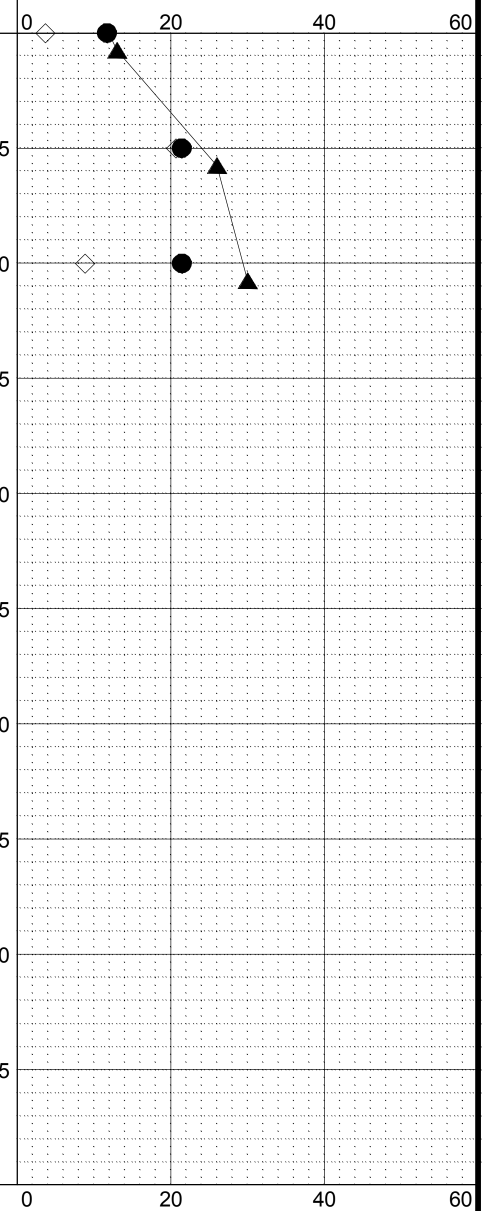
SOIL DESCRIPTION

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.	Samples
		14
Medium dense, gray, silty, fine to medium SAND, trace of clay; wet; scattered shell fragments; (He) SM.	53.0	15
Medium dense, gray, slightly silty, fine to medium SAND; wet; trace of shell fragments; (He) SP-SM.	58.0	16
BOTTOM OF BORING COMPLETED 10/22/2009	61.5	

PENETRATION RESISTANCE (blows/foot)

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



LEGEND

- * Sample Not Recovered
- 3" O.D. Split Spoon Sample
- Standard Penetration Test
- 3" O.D. Thin-Walled Tube
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
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. USCS designation is based on visual-manual classification and selected lab testing.

Skagit River Levee General Investigation
Skagit County, Washington

LOG OF BORING DD22-1 Levee

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-15
Sheet 2 of 2

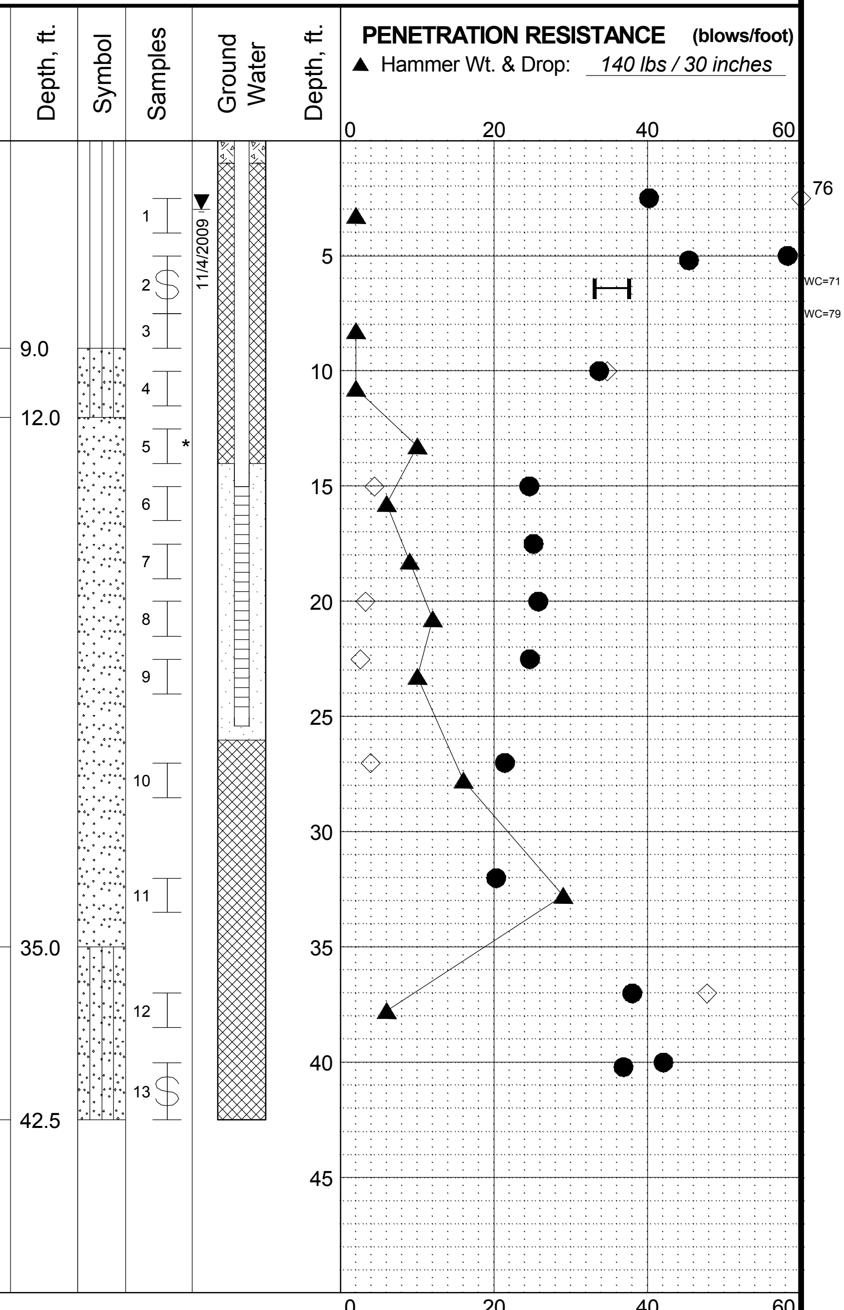
Total Depth:	42.5 ft.	Northing:	~ 502,793 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	5 in.
Top Elevation:	~	Easting:	~ 1,259,501 ft.	Drilling Company:	Holocene Drilling	Rod Diam.:	NWJ
Vert. Datum:		Station:	~	Drill Rig Equipment:	BK-81 Truck	Hammer Type:	Automatic
Horiz. Datum:	NAD83	Offset:	~	Other Comments:			

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.
Very loose, gray and brown, slightly fine sandy to fine sandy SILT, trace of clay to soft, slightly clayey SILT; wet; scattered iron-oxide-stained seams, peat seam at 5.9 feet, numerous wood fragments and coarse organics below 6 feet, laminated; (Ha[ob]) ML.	9.0
Very loose, gray, silty, fine SAND; wet; laminated, scattered organics; (Ha[ob]) SM.	12.0
Loose to medium dense, gray, fine to medium SAND, trace of silt and fine gravel; wet; trace of organics; (Ha[cd]) SP.	35.0
Loose, gray, silty, fine SAND to fine sandy SILT; wet; scattered fine organics, laminated, scattered slightly clayey to clayey seams, slightly silty, fine sand below 41.5 feet; (Ha[ob]) SM/ML.	42.5

BOTTOM OF BORING
COMPLETED 10/22/2009



LEGEND

- * Sample Not Recovered
- Standard Penetration Test
- 3" O.D. Thin-Walled Tube
- 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. 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. USCS designation is based on visual-manual classification and selected lab testing.

Skagit River Levee General Investigation
Skagit County, Washington

LOG OF BORING DD22-2 Landward

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-16

MASTER_LOG_E 21-21199.GPJ SHAN_WIL.GDT 6/1/10 Log: EVP Rev: JKN Typ: LKN

Total Depth:	61.5 ft.	Northing:	~ 502,860 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	5 in.
Top Elevation:	~	Easting:	~ 1,259,493 ft.	Drilling Company:	Holocene Drilling	Rod Diam.:	NWJ
Vert. Datum:		Station:	~	Drill Rig Equipment:	BK-81 Truck	Hammer Type:	Automatic
Horiz. Datum:	NAD83	Offset:	~	Other Comments:			

SOIL DESCRIPTION

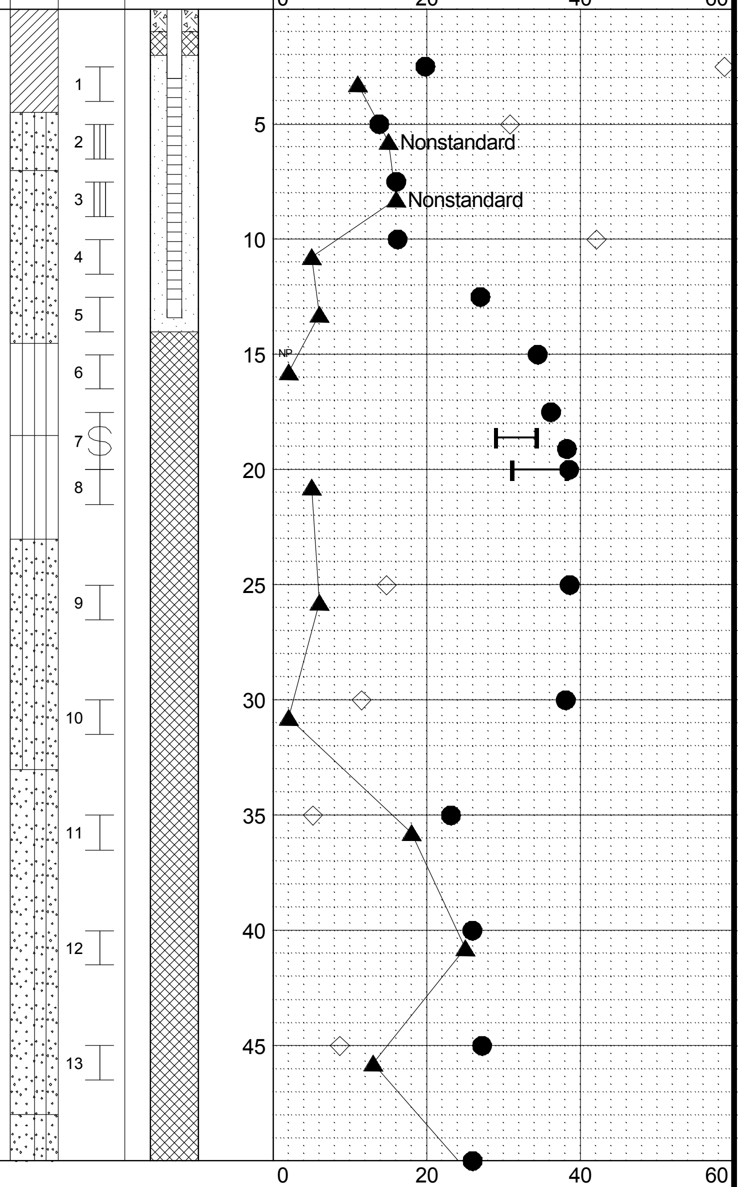
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples
Stiff, brown and gray, slightly fine gravelly, sandy, silty CLAY; moist; trace of iron-oxide-stained pockets, scattered clayey sand pockets, trace of roots; (Hf) CL.	4.5	1
Medium dense, brown, fine gravelly, silty SAND; moist; intermixed, locally trace of clay, trace of iron-oxide stains; (Hf) SM.	7.0	2
Loose to medium dense, brown, silty, fine SAND; moist; fine sandy silt layers below 12 feet, locally trace of gravel; (Hf) SM.	14.5	3, 4, 5
Soft, brown, slightly fine sandy SILT; wet; trace of organics, scattered silty, fine sand seams and layers, trace of iron-oxide staining; (Ha[ob]) ML.	18.5	6
Medium stiff, gray, clayey SILT, trace of fine sand; wet; trace of organics, laminated, iron-oxide-stained seams, scattered dark brown, organic-rich partings, scattered slightly fine sandy silt seams; (Ha[ob]) ML.	23.0	7, 8
Very loose to loose, gray, slightly silty to silty, fine to medium SAND; wet; numerous organics, scattered wood fragments; (Ha[cd]) SM/SP-SM.	33.0	9, 10
Medium dense, gray, slightly silty SAND, trace of fine gravel; wet; (Ha[cd]) SP-SM. - Scattered large wood fragments and silty clay seams at 45 feet.	48.0	11, 12, 13

CONTINUED NEXT SHEET

PENETRATION RESISTANCE (blows/foot)

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



LEGEND

- * Sample Not Recovered
- Standard Penetration Test
- 3" O.D. Split Spoon Sample
- 3" O.D. Thin-Walled Tube
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout

◇ % 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. 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. USCS designation is based on visual-manual classification and selected lab testing.

Skagit River Levee General Investigation
Skagit County, Washington

LOG OF BORING DD22-2 Levee

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-17
Sheet 1 of 2

Total Depth:	61.5 ft.	Northing:	~ 502,860 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	5 in.
Top Elevation:	~	Easting:	~ 1,259,493 ft.	Drilling Company:	Holocene Drilling	Rod Diam.:	NWJ
Vert. Datum:		Station:	~	Drill Rig Equipment:	BK-81 Truck	Hammer Type:	Automatic
Horiz. Datum:	NAD83	Offset:	~	Other Comments:			

SOIL DESCRIPTION

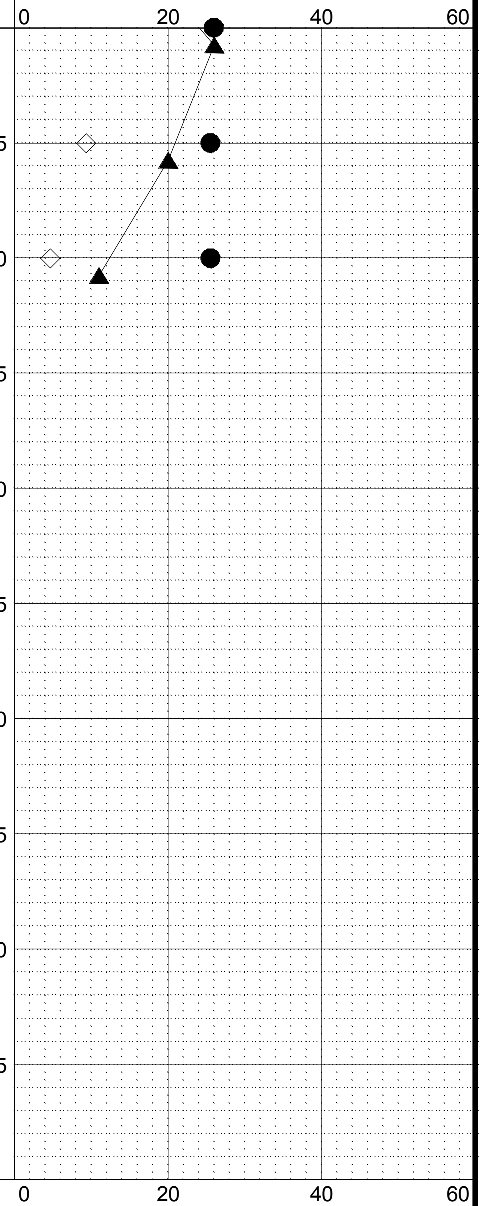
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples
Medium dense, gray, trace to slightly silty, fine to medium SAND; wet; (Ha[cd]) SP-SM/SP.		14
		15
- Trace of wood fragments at 60 feet.		16
BOTTOM OF BORING COMPLETED 10/23/2009	61.5	

Symbol | Ground Water | Depth, ft.

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

3" O.D. Split Spoon Sample

3" O.D. Thin-Walled Tube

Piezometer Screen and Sand Filter

Bentonite-Cement Grout

Bentonite Chips/Pellets

Bentonite Grout

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
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. USCS designation is based on visual-manual classification and selected lab testing.

Skagit River Levee General Investigation
Skagit County, Washington

LOG OF BORING DD22-2 Levee

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-17
Sheet 2 of 2

MASTER_LOG_E 21-21199.GPJ SHAN_WIL.GDT 6/1/10 Log: EVP Rev: JKN Typ: LKN

APPENDIX B

HYDROGEOLOGIC FIELD TEST RESULTS

APPENDIX B

HYDROGEOLOGIC FIELD TEST RESULTS

TABLE OF CONTENTS

TABLES

FIGURES

FIGURES (cont.)

Monitoring Well Designation	Date Tested	Slug Test Type and Number	Hydraulic Conductivity K (ft/day)	Hydraulic Conductivity K (cm/sec)
DD1-1Landward	11/5/09	Falling Head Test 1	35	1.2E-02
	11/5/09	Falling Head Test 2	18	6.5E-03
	11/5/09	Falling Head Test 3	25	8.8E-03
	11/5/09	Rising Head Test 1	24	8.3E-03
	11/5/09	Rising Head Test 2	15	5.3E-03
	11/5/09	Rising Head Test 3	72	2.5E-02
		Geomean	**27**	**9.6E-03**
DD1-2Landward	11/5/09	Falling Head Test 1	20	7.2E-03
	11/5/09	Falling Head Test 2	31	1.1E-02
	11/5/09	Falling Head Test 3	32	1.1E-02
	11/5/09	Rising Head Test 1	42	1.5E-02
	11/5/09	Rising Head Test 2	33	1.2E-02
	11/5/09	Rising Head Test 3	29	1.0E-02
		Geomean	**30**	**1.1E-02**
DD3-1Landward	11/5/09	Falling Head Test 1	30	1.1E-02
	11/5/09	Falling Head Test 2	27	9.6E-03
	11/5/09	Falling Head Test 3	35	1.2E-02
	11/5/09	Rising Head Test 1	28	9.9E-03
	11/5/09	Rising Head Test 2	33	1.2E-02
	11/5/09	Rising Head Test 3	45	1.6E-02
		Geomean	**33**	**1.1E-02**
DD17-1Landward	11/4/09	Falling Head Test 1	14	4.8E-03
	11/4/09	Falling Head Test 2	8	2.7E-03
	11/4/09	Falling Head Test 3	10	3.6E-03
	11/4/09	Rising Head Test 1	50	1.8E-02
	11/4/09	Rising Head Test 2	14	4.8E-03
	11/4/09	Rising Head Test 3	41	1.5E-02
		Geomean	**18**	**6.2E-03**
DD17-2Landward	11/4/09	Falling Head Test 1	27	9.5E-03
	11/4/09	Falling Head Test 2	25	8.7E-03
	11/4/09	Falling Head Test 3	27	9.5E-03
	11/4/09	Rising Head Test 1	25	9.0E-03
	11/4/09	Rising Head Test 2	21	7.4E-03
	11/4/09	Rising Head Test 3	28	1.0E-02
		Geomean	**25**	**9.0E-03**

Monitoring Well Designation	Date Tested	Slug Test Type and Number	Hydraulic Conductivity K (ft/day)	Hydraulic Conductivity K (cm/sec)
DD17-3Landward	11/5/09	Falling Head Test 1	55	2.0E-02
	11/5/09	Falling Head Test 2	58	2.0E-02
	11/5/09	Falling Head Test 3	70	2.5E-02
	11/5/09	Rising Head Test 1	62	2.2E-02
	11/5/09	Rising Head Test 2	57	2.0E-02
	11/5/09	Rising Head Test 3	55	1.9E-02
		Geomean	**59**	**2.1E-02**
DD22-1Landward	11/5/09	Falling Head Test 1	29	1.0E-02
	11/5/09	Falling Head Test 2	29	1.0E-02
	11/5/09	Falling Head Test 3	26	9.1E-03
	11/5/09	Rising Head Test 1	25	8.7E-03
	11/5/09	Rising Head Test 2	27	9.4E-03
	11/5/09	Rising Head Test 3	26	9.3E-03
		Geomean	**27**	**9.5E-03**
DD22-2Landward	11/5/09	Falling Head Test 1	29	1.0E-02
	11/5/09	Falling Head Test 2	27	9.4E-03
	11/5/09	Falling Head Test 3	34	1.2E-02
	11/5/09	Rising Head Test 1	36	1.3E-02
	11/5/09	Rising Head Test 2	30	1.0E-02
	11/5/09	Rising Head Test 3	30	1.1E-02
		Geomean	**31**	**1.1E-02**

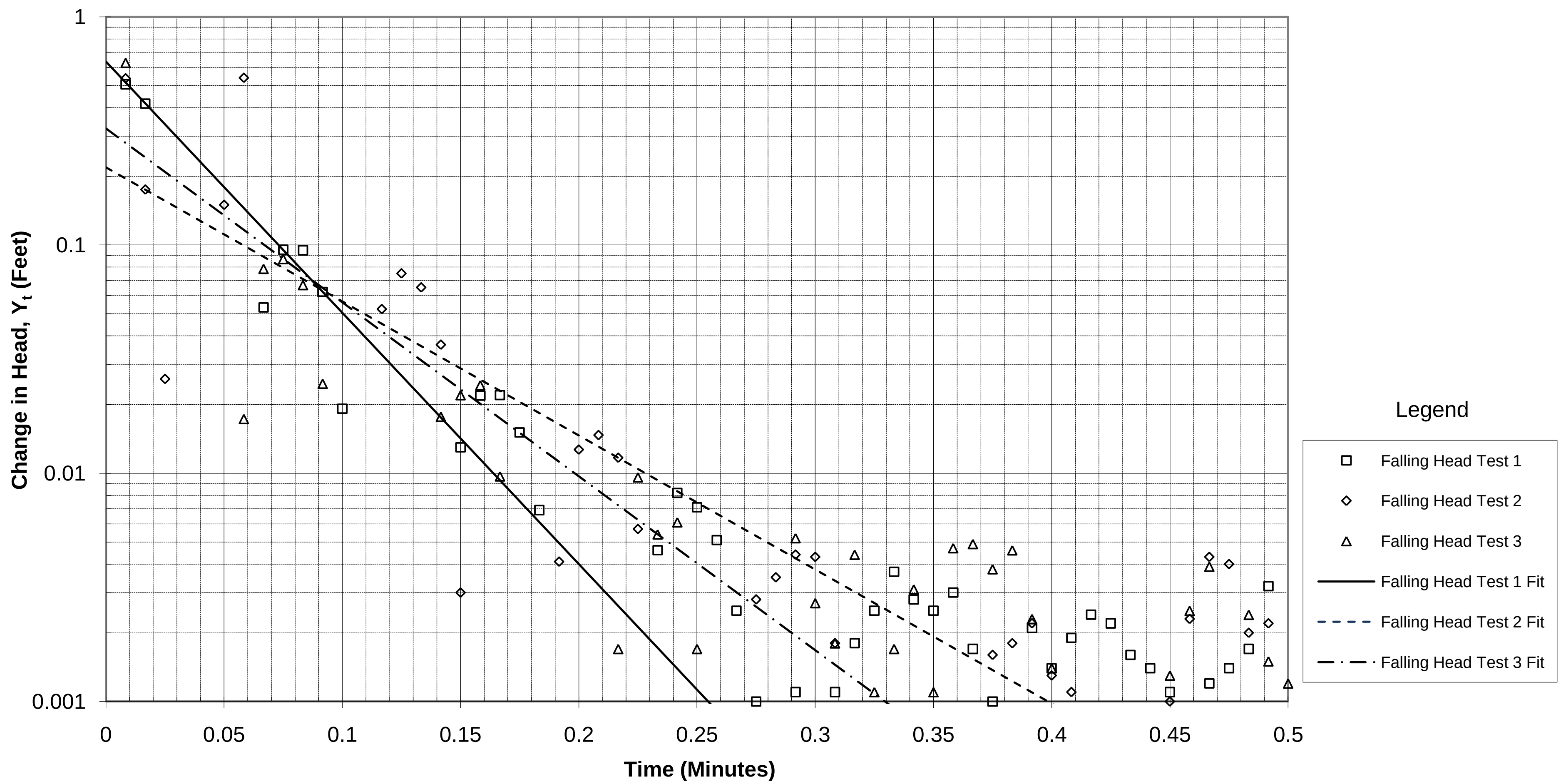
ft/day = feet per day

cm/sec = centimeters per second

A geometric mean (geomean) is the n-th root of the product of n numbers. Unlike an arithmetic mean, it tends to dampen the effect of very high or low values, which might bias the mean if an arithmetic mean were calculated.

Monitoring Well Designation	**Date Tested**	**Fit Line Number**	**Hydraulic Conductivity**	**Hydraulic Conductivity**
Symbol (unit)			K (ft/day)	K (cm/sec)
DD1-1Levee	3/11/10	Falling Head Test 1	0.00	2.60E-07
	3/12/10	Falling Head Test 2	0.00	9.17E-08
		Geomean	**0.00**	**1.54E-07**
DD1-2Levee	3/11/10	Falling Head Test 1	0.00	6.96E-07
	3/12/10	Falling Head Test 2	0.00	7.89E-08
		Geomean	**0.00**	**2.34E-07**
DD3-1Levee	3/11/10	Falling Head Test 1	0.01	2.53E-06
	3/12/10	Falling Head Test 2	0.00	4.00E-07
		Geomean	**0.00**	**1.01E-06**
DD17-1Levee	3/11/10	Falling Head Test 1	0.00	2.32E-07
	3/12/10	Falling Head Test 2	0.00	1.26E-07
		Geomean	**0.00**	**1.71E-07**
DD17-2Levee	12/29/09	Fit line 1	0.32	**1.08E-04**
	12/29/09	Fit line 2	0.27	**9.50E-05**
		Geomean	**0.30**	**1.06E-04**
DD17-3Levee	3/11/10	Falling Head Test 1	0.02	7.79E-06
	3/12/10	Falling Head Test 2	0.03	9.72E-06
		Geomean	**0.02**	**8.70E-06**
DD22-1Levee	3/11/10	Falling Head Test 1	0.00	6.32E-07
	3/12/10	Falling Head Test 2	0.00	2.17E-07
	3/12/10	Falling Head Test 2 Fit 2	0.00	5.02E-07
		Geomean	**0.00**	**3.70E-07**
DD22-2Levee	3/11/10	Falling Head Test 1	0.00	1.03E-06
	3/12/10	Falling Head Test 2	0.00	4.91E-07
		Geomean	**0.00**	**7.10E-07**

ft/day = feet per day
cm/sec = centimeters per second
A geometric mean (geomean) is the n-th root of the product of n numbers. Unlike an arithmetic mean, it tends to dampen the effect of very high or low values, which might bias the mean if an arithmetic mean were calculated.



Skagit River Levee General Investigation
Skagit County, Washington

FALLING HEAD SLUG TESTS
OBSERVATION WELL DD1-1Landward

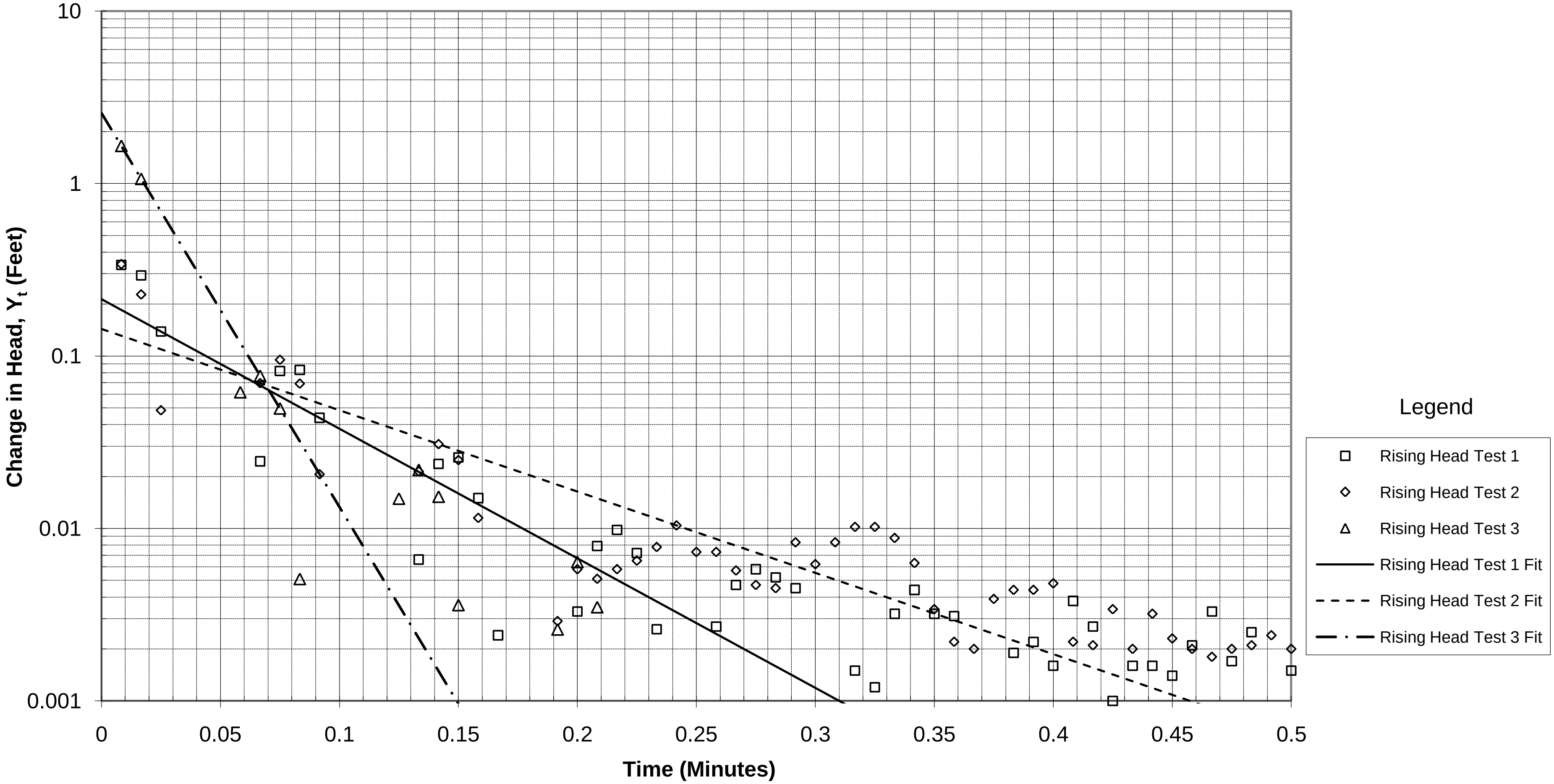
June 2010

21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-1

FIG. B-1



Skagit River Levee General Investigation
Skagit County, Washington

RISING HEAD SLUG TESTS
OBSERVATION WELL DD1-1Landward

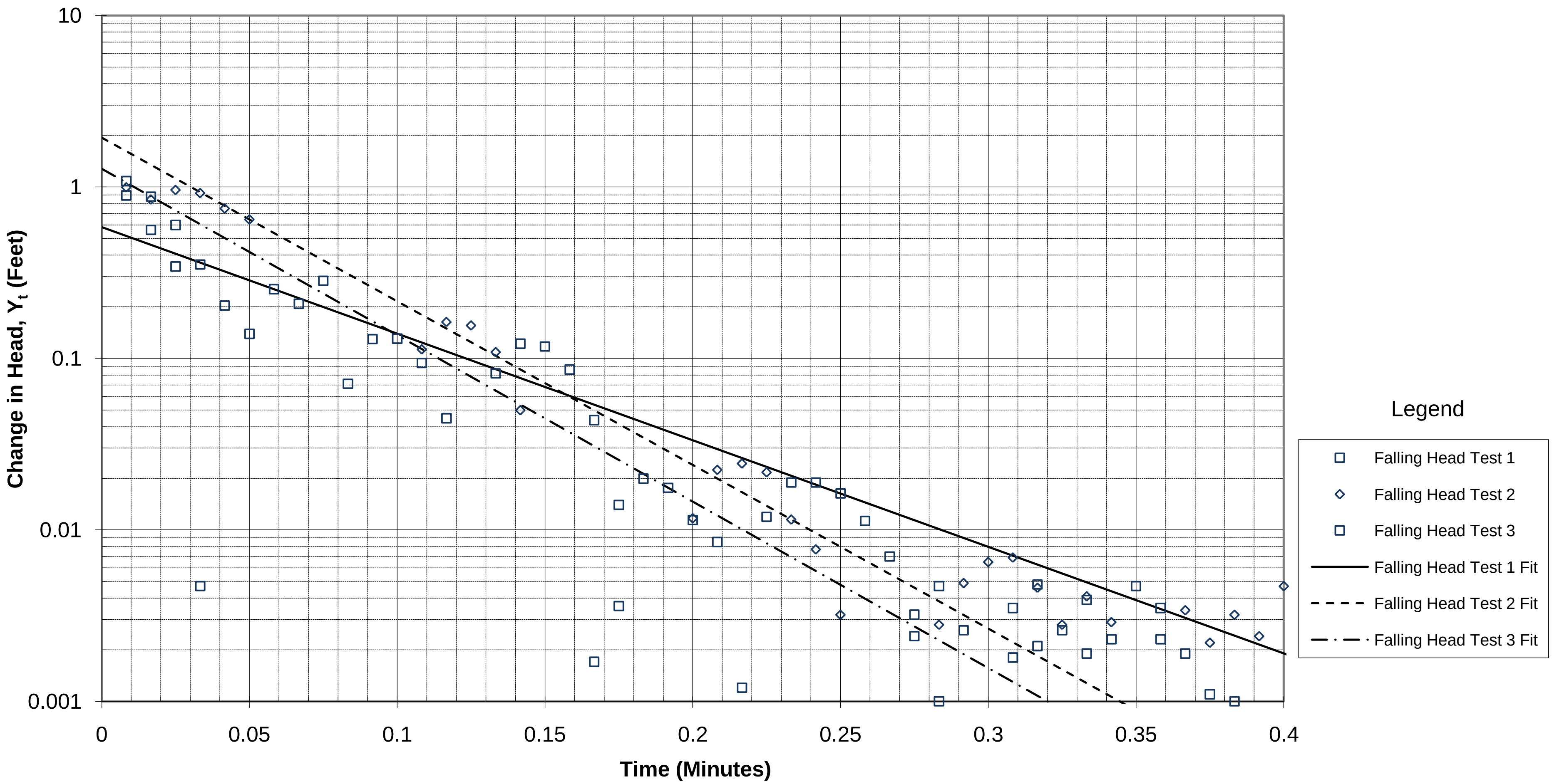
June 2010

21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-2

FIG. B-2



Skagit River Levee General Investigation
Skagit County, Washington

FALLING HEAD SLUG TESTS
OBSERVATION WELL DD1-2Landward

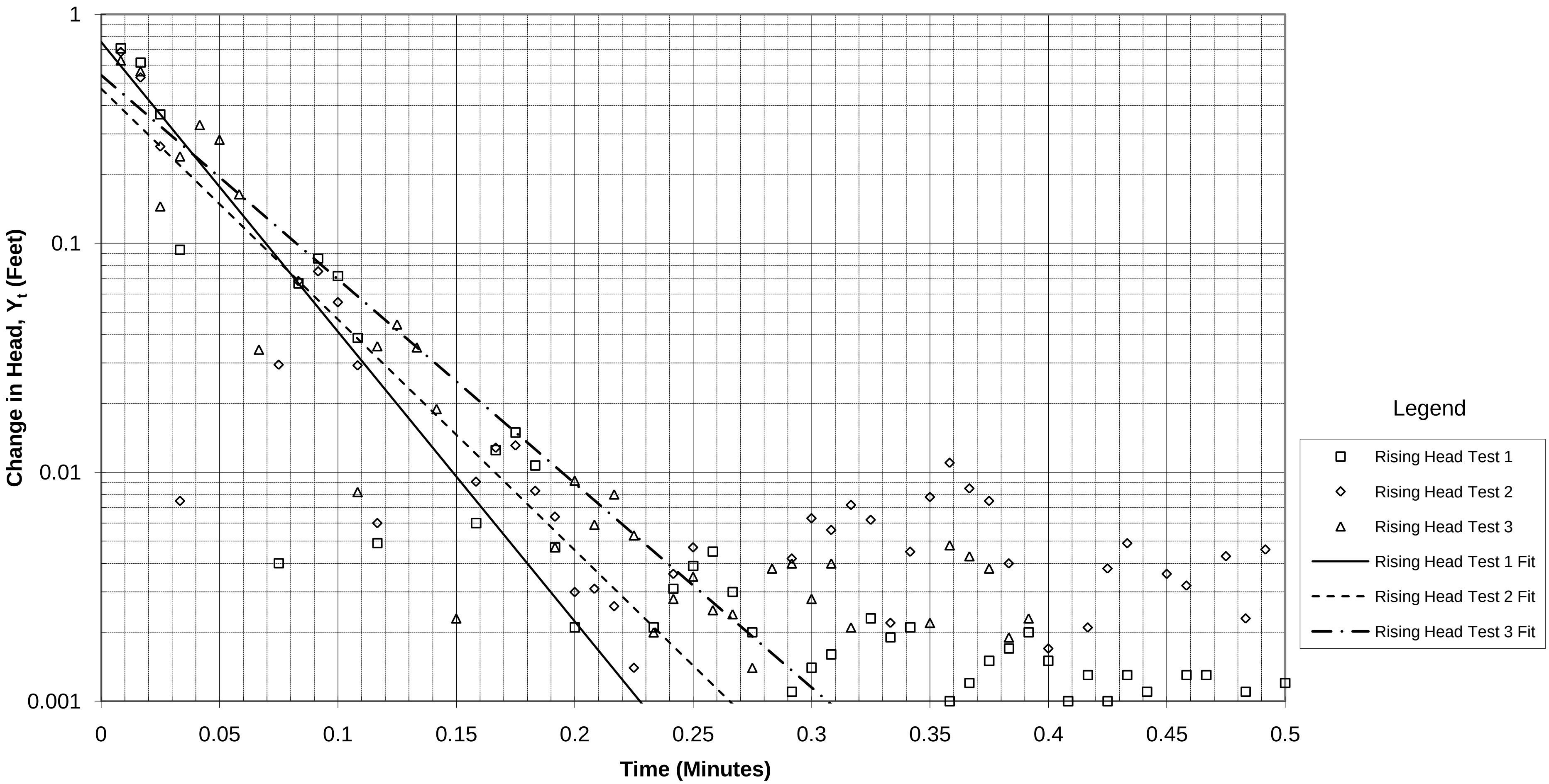
June 2010

21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-3

FIG. B-3



Skagit River Levee General Investigation
Skagit County, Washington

RISING HEAD SLUG TESTS
OBSERVATION WELL DD1-2Landward

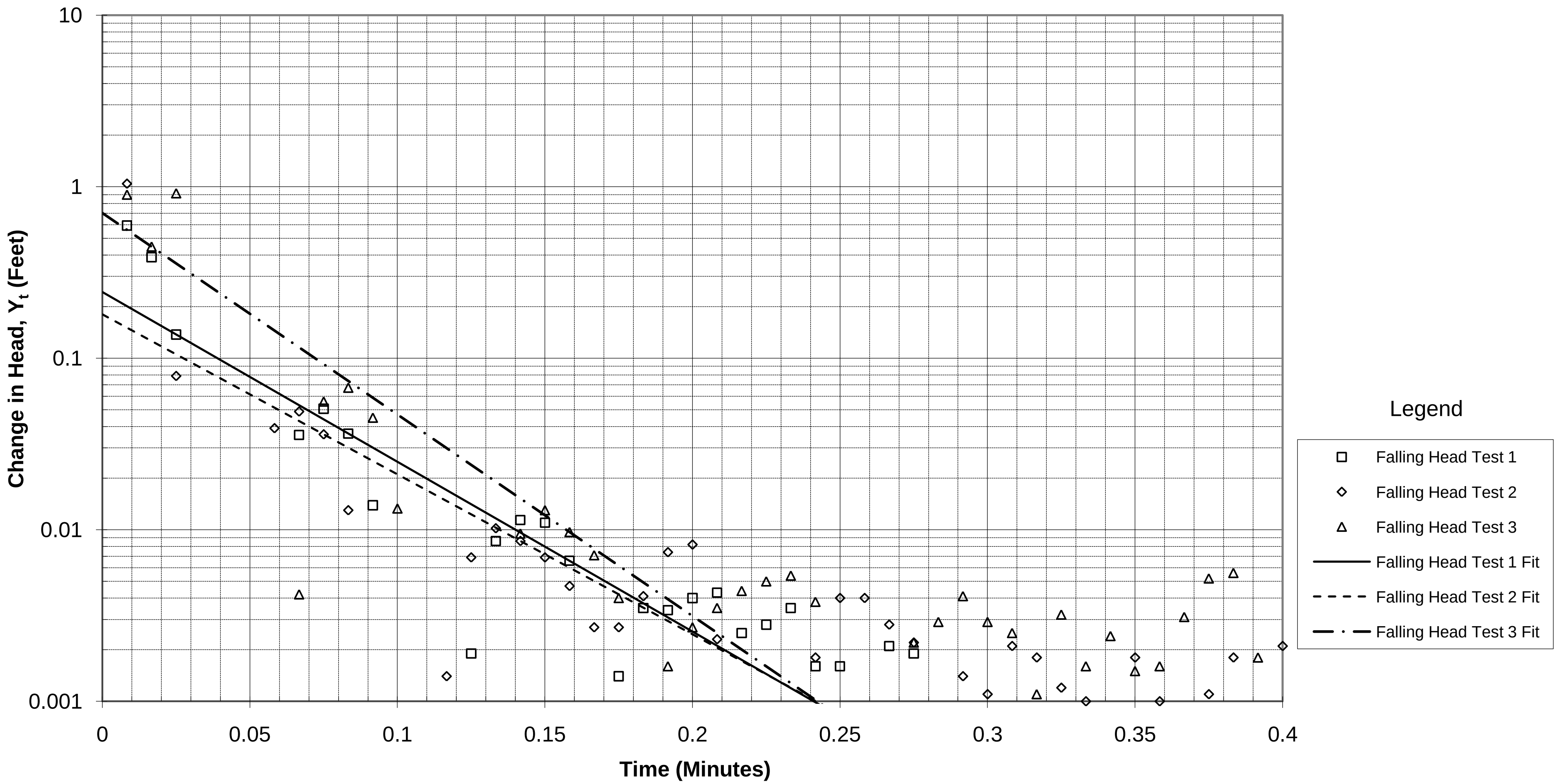
June 2010

21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-4

FIG. B-4



Skagit River Levee General Investigation
Skagit County, Washington

FALLING HEAD SLUG TESTS
OBSERVATION WELL DD3-1Landward

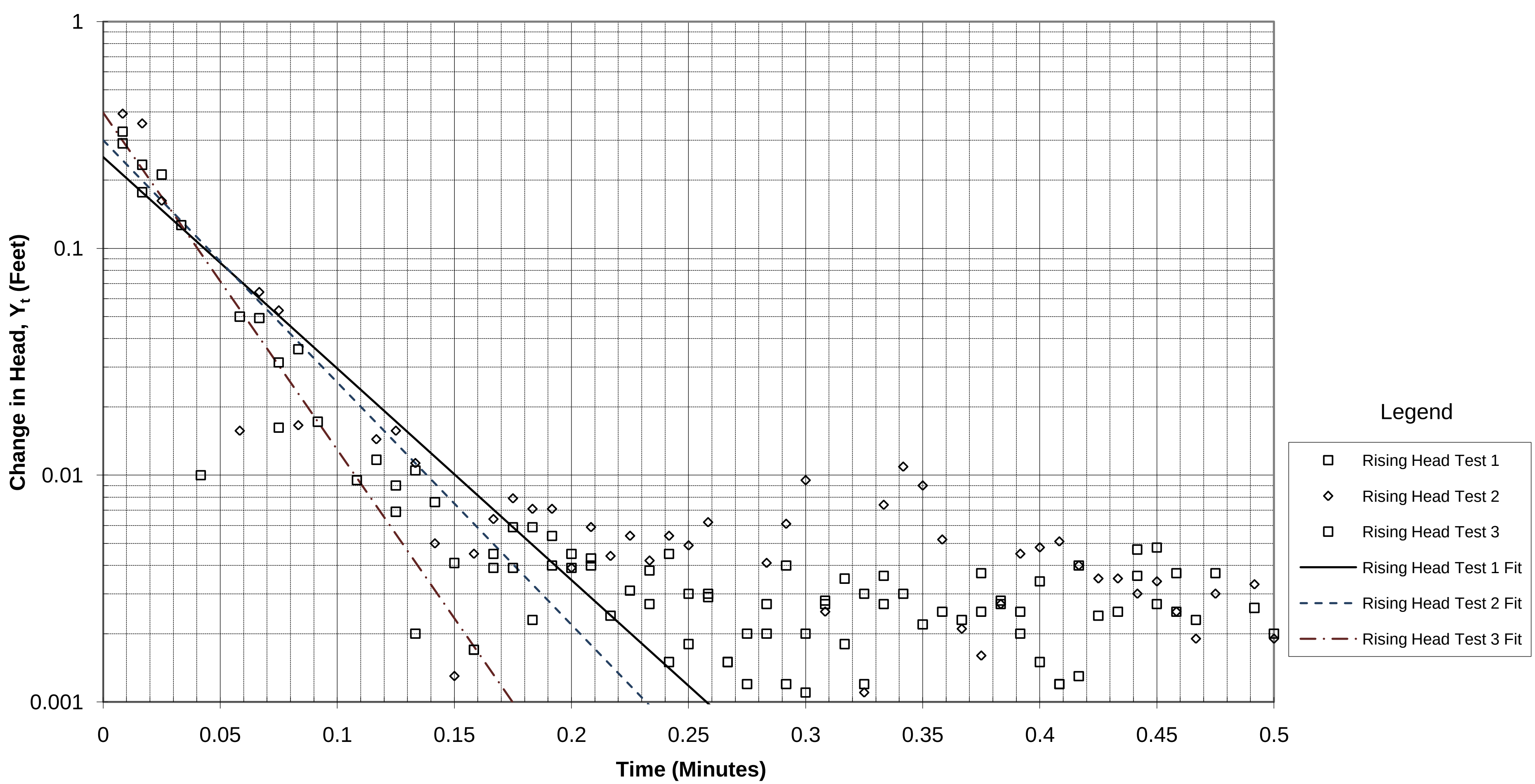
June 2010

21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-5

FIG. B-5



Skagit River Levee General Investigation
Skagit County, Washington

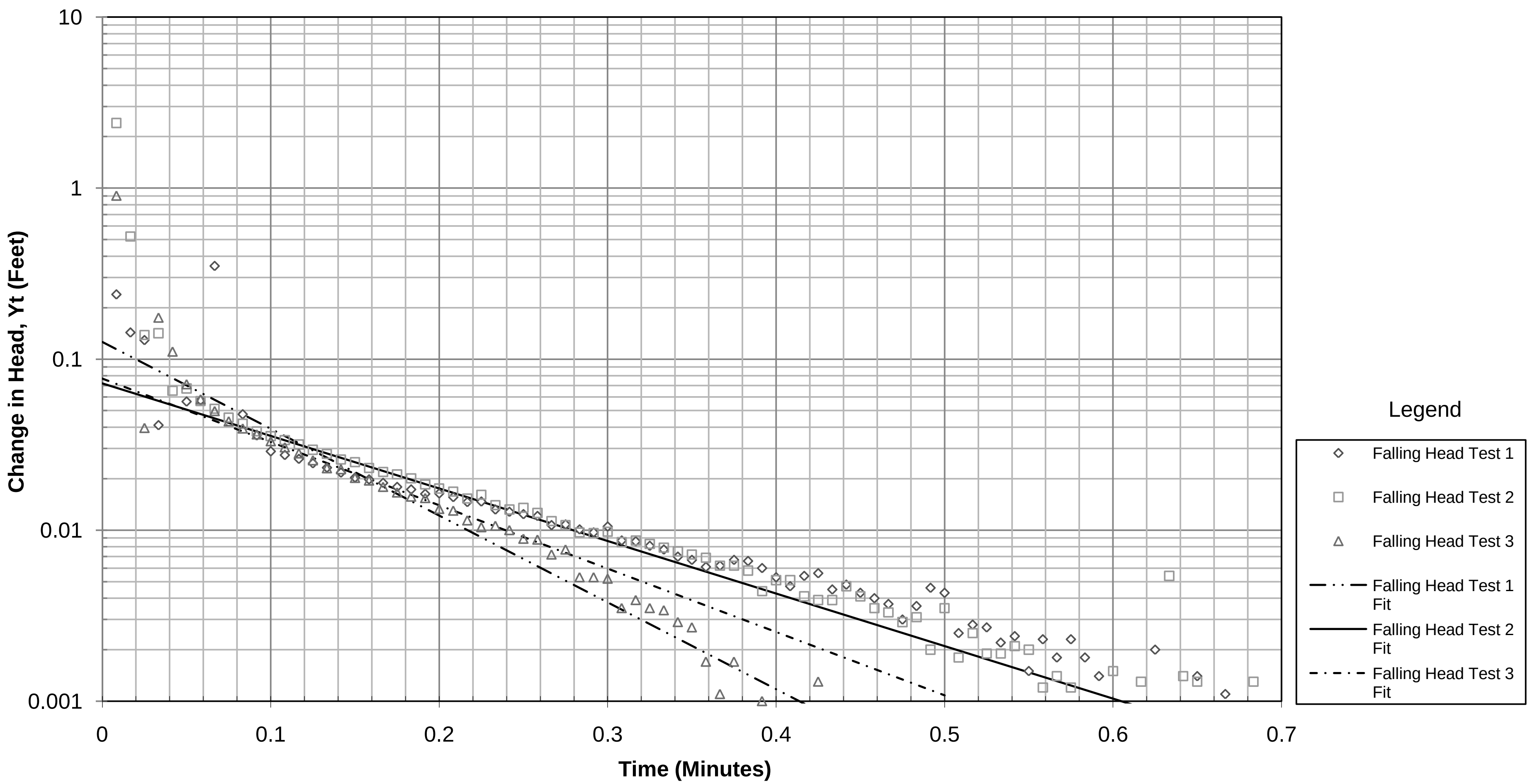
RISING HEAD SLUG TESTS
OBSERVATION WELL DD3-1Landward

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-6

FIG. B-6



Skagit River Levee General Investigation
Skagit County, Washington

FALLING HEAD SLUG TESTS
OBSERVATION WELL DD17-1Landward

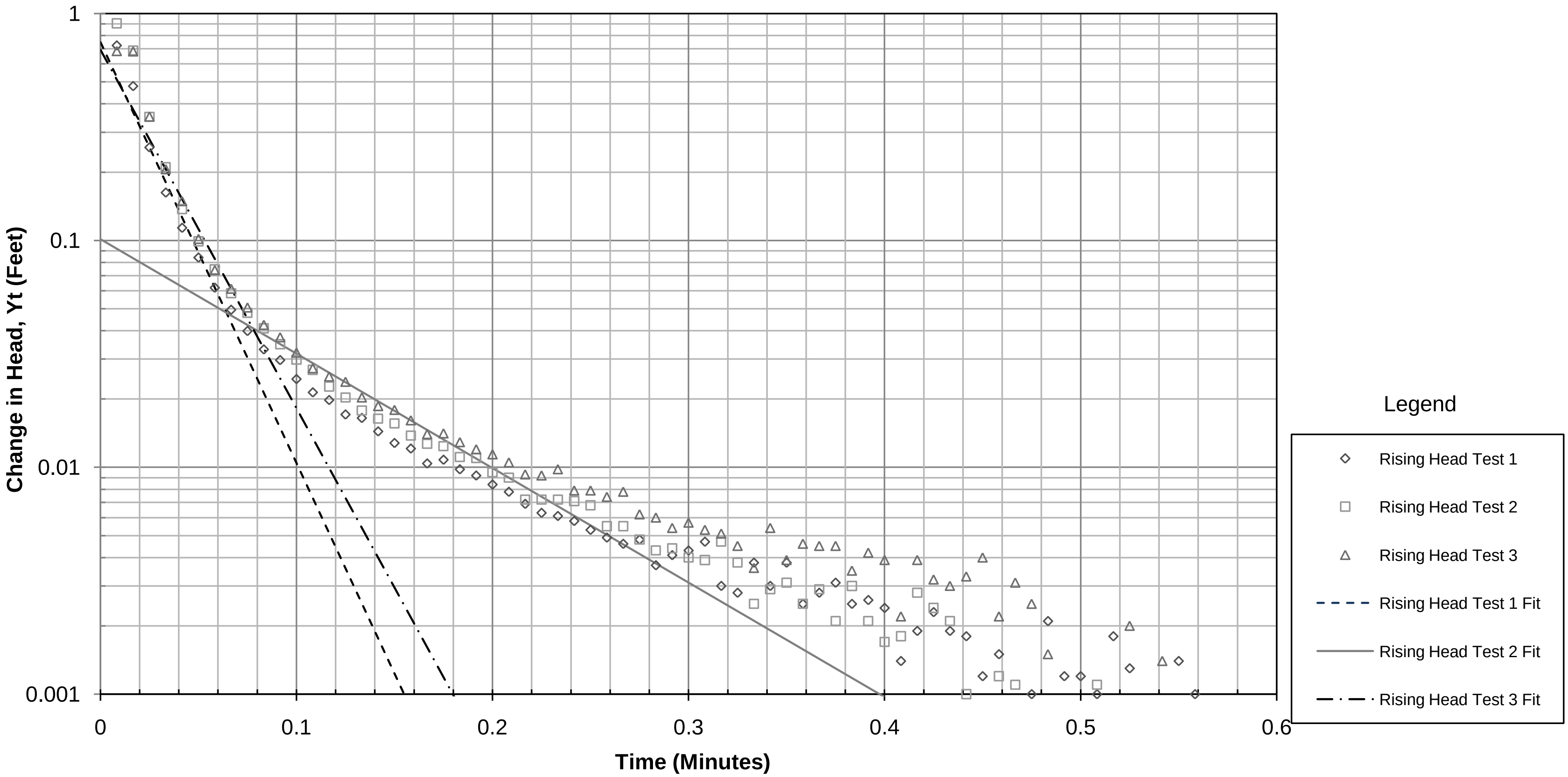
June 2010

21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-7

FIG. B-7



Skagit River Levee General Investigation
Skagit County, Washington

RISING HEAD SLUG TESTS
OBSERVATION WELL DD17-1Landward

June 2010

21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-8

FIG. B-8

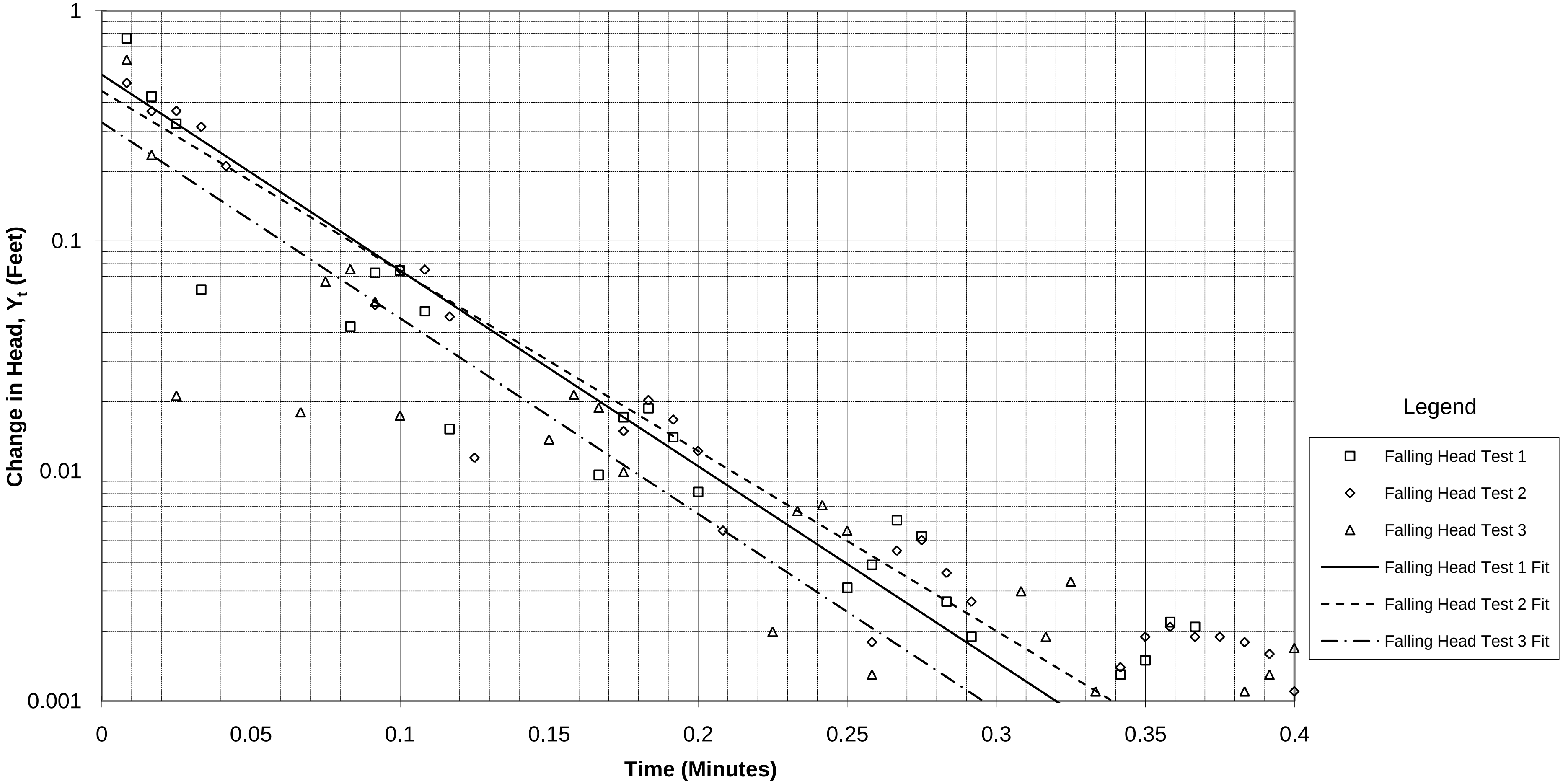


FIG. B-9

Skagit River Levee General Investigation
Skagit County, Washington

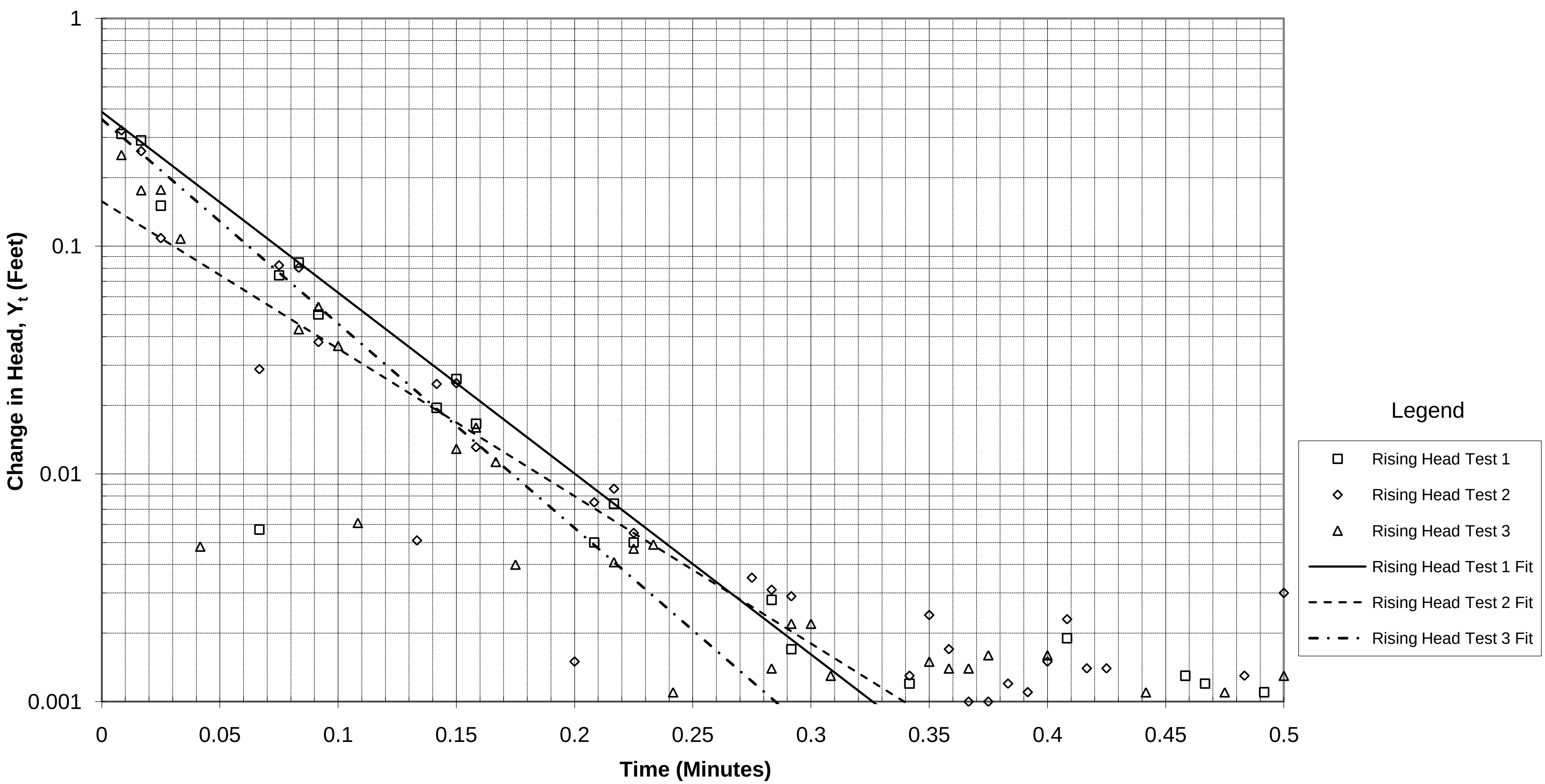
FALLING HEAD SLUG TESTS
OBSERVATION WELL DD17-2Landward

June 2010

21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-9



Skagit River Levee General Investigation
Skagit County, Washington

RISING HEAD SLUG TESTS
OBSERVATION WELL DD17-2Landward

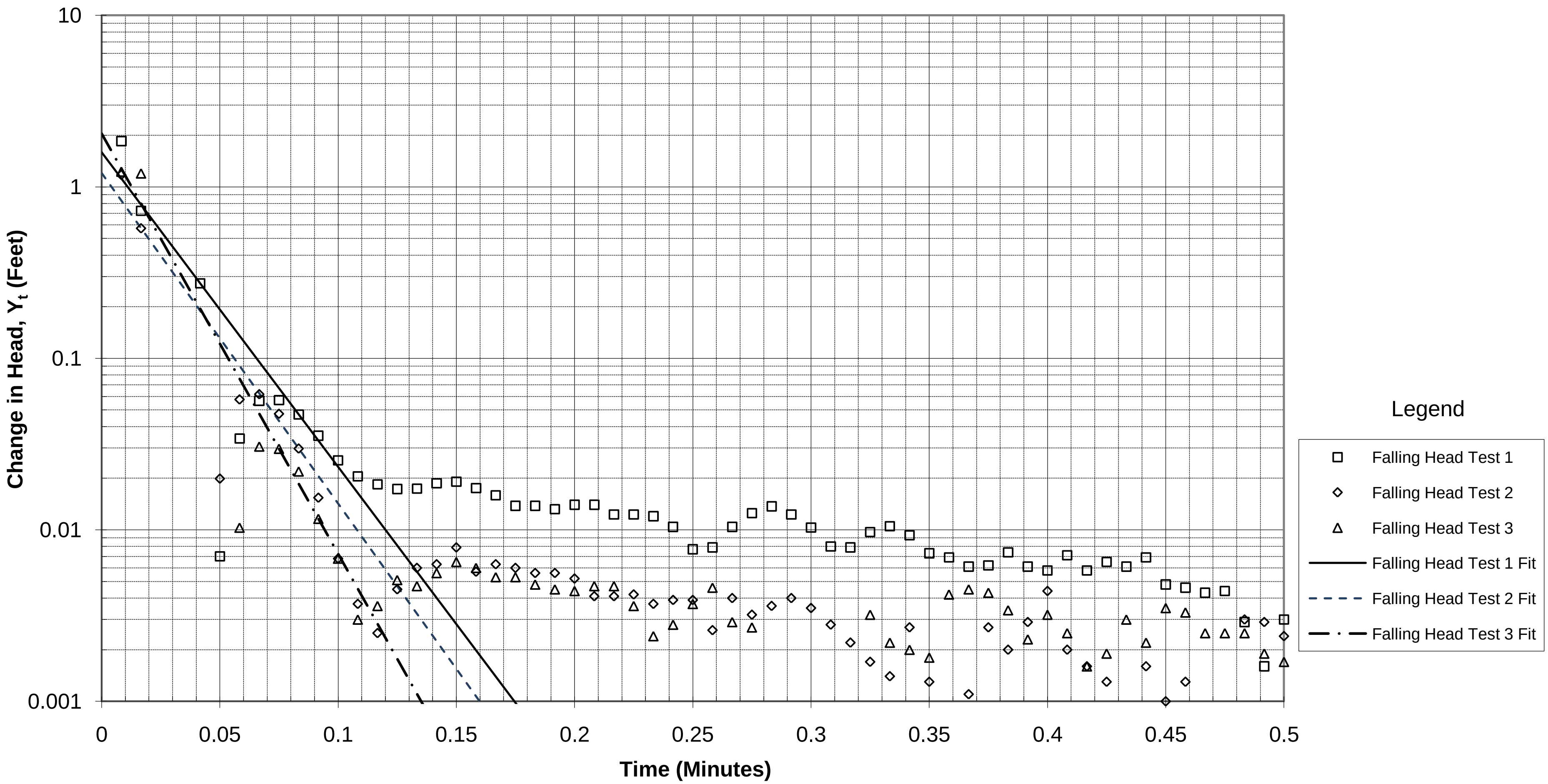
June 2010

21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-10

FIG. B-10



Skagit River Levee General Investigation
Skagit County, Washington

FALLING HEAD SLUG TESTS
OBSERVATION WELL DD17-3Landward

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-11

FIG. B-11

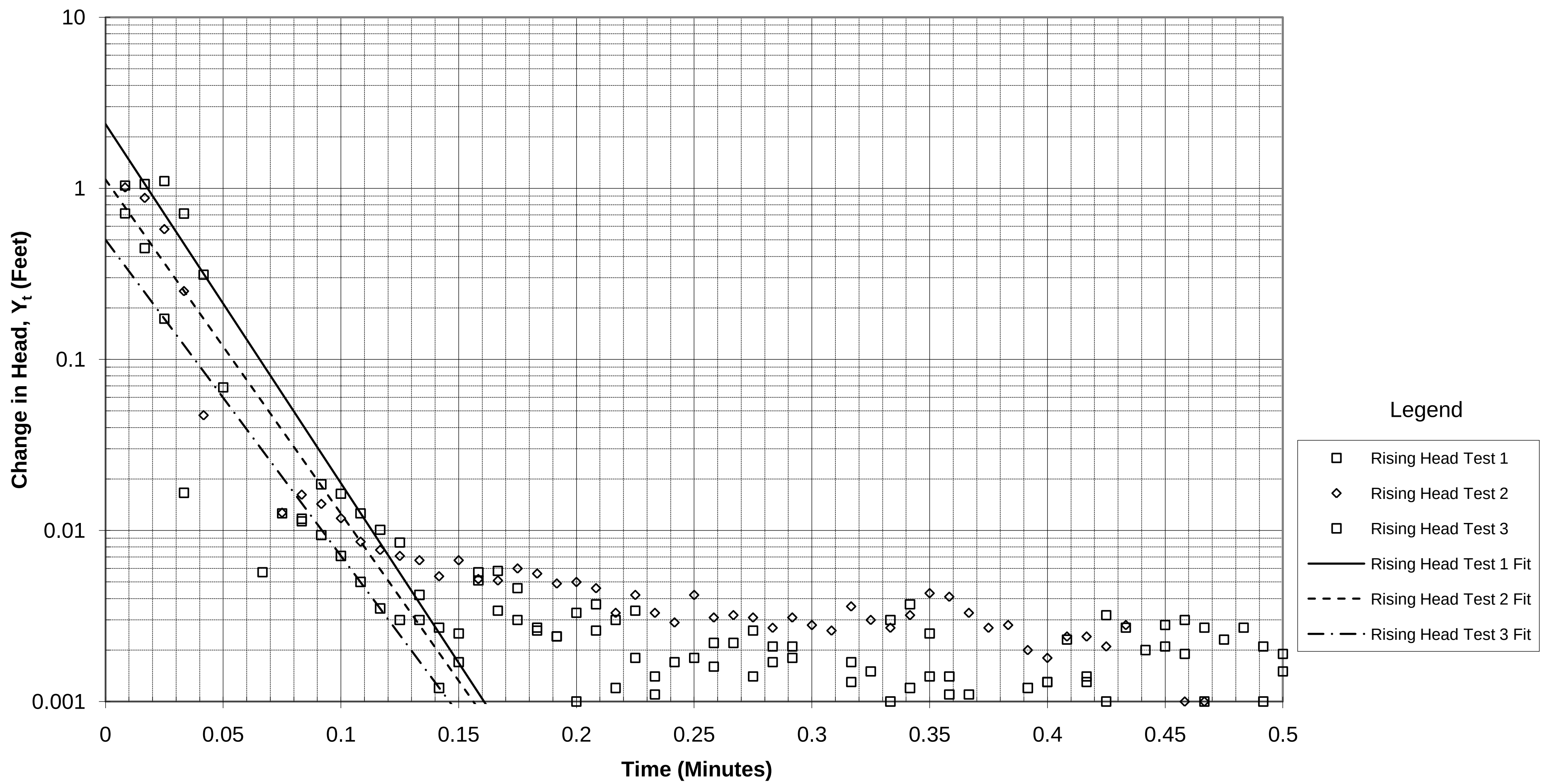


FIG. B-12

Skagit River Levee General Investigation
Skagit County, Washington

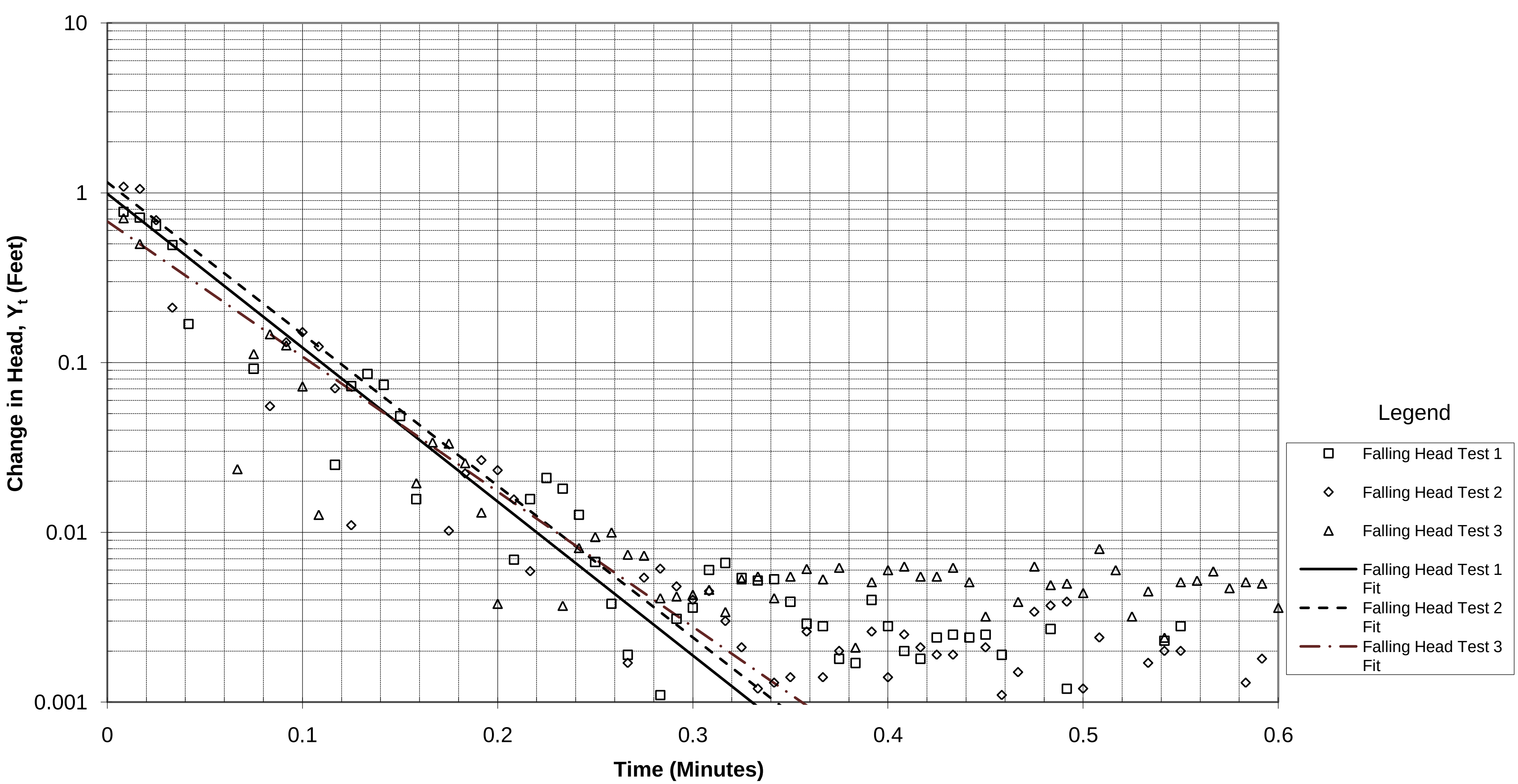
RISING HEAD SLUG TESTS
OBSERVATION WELL DD17-3Landward

June 2010

21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-12



Skagit River Levee General Investigation
Skagit County, Washington

FALLING HEAD SLUG TESTS
OBSERVATION WELL DD22-1Landward

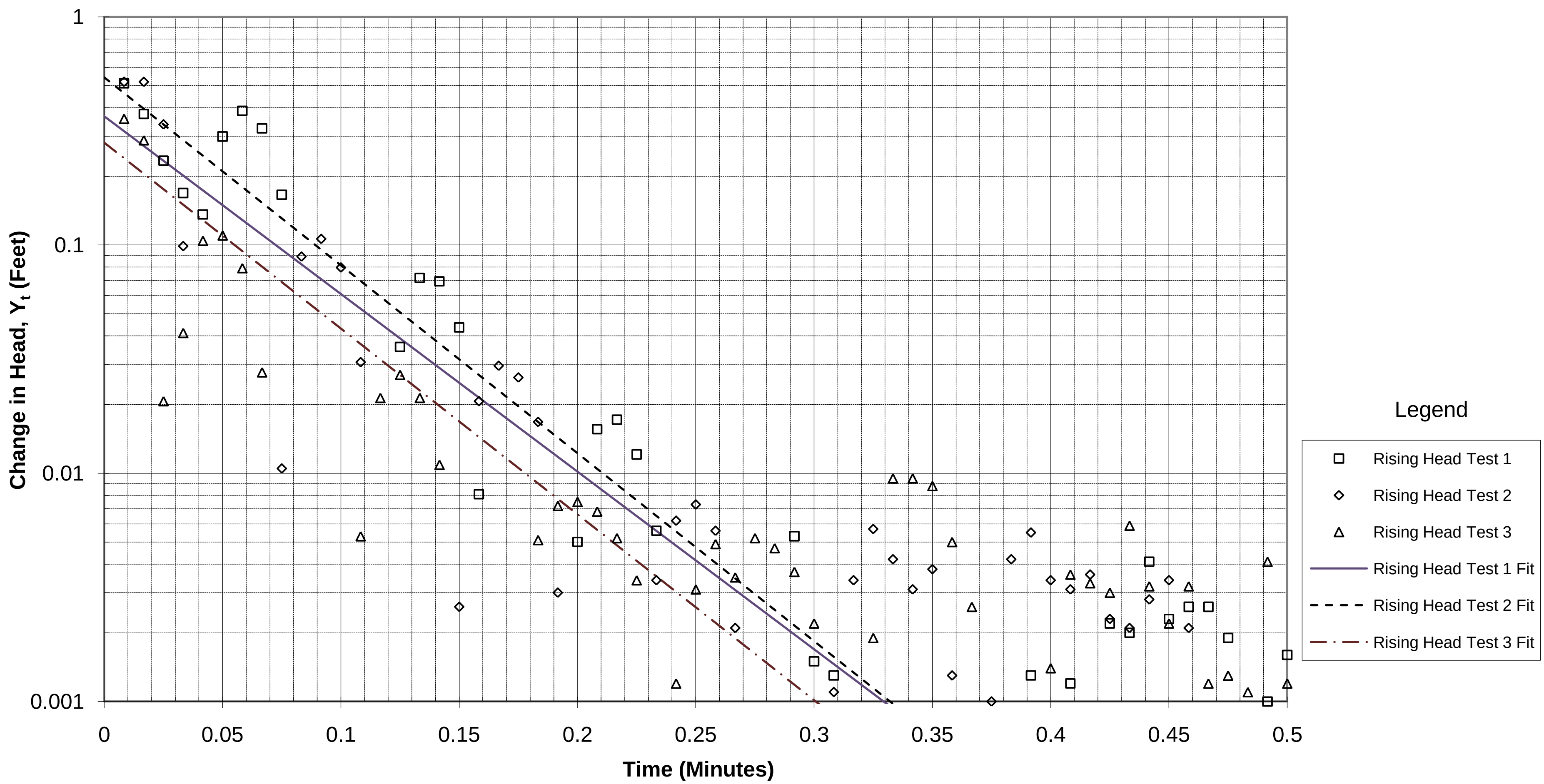
June 2010

21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-13

FIG. B-13



Skagit River Levee General Investigation
Skagit County, Washington

RISING HEAD SLUG TESTS
OBSERVATION WELL DD22-1Landward

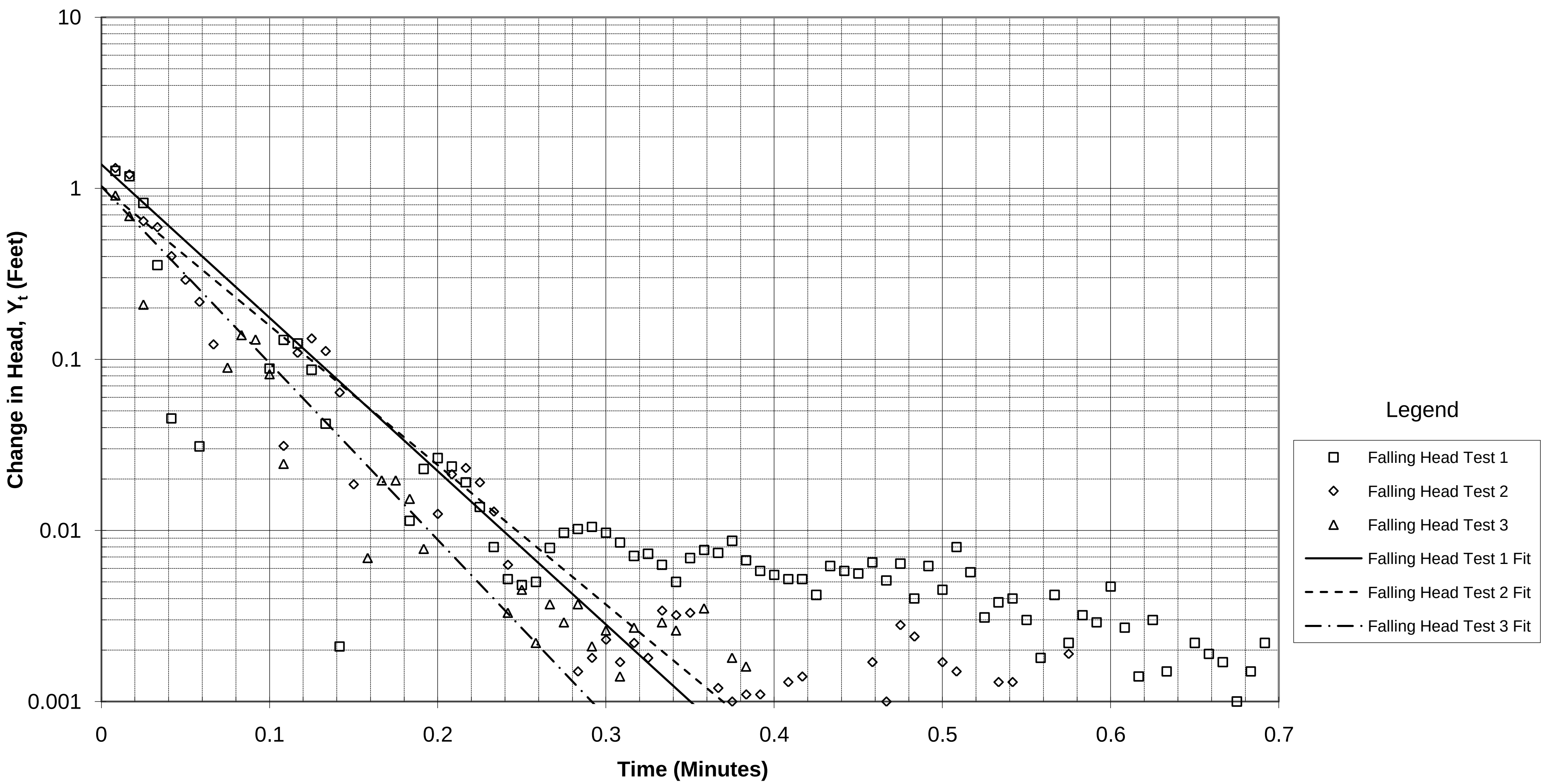
June 2010

21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-14

FIG. B-14



Skagit River Levee General Investigation
Skagit County, Washington

FALLING HEAD SLUG TESTS
OBSERVATION WELL DD22-2Landward

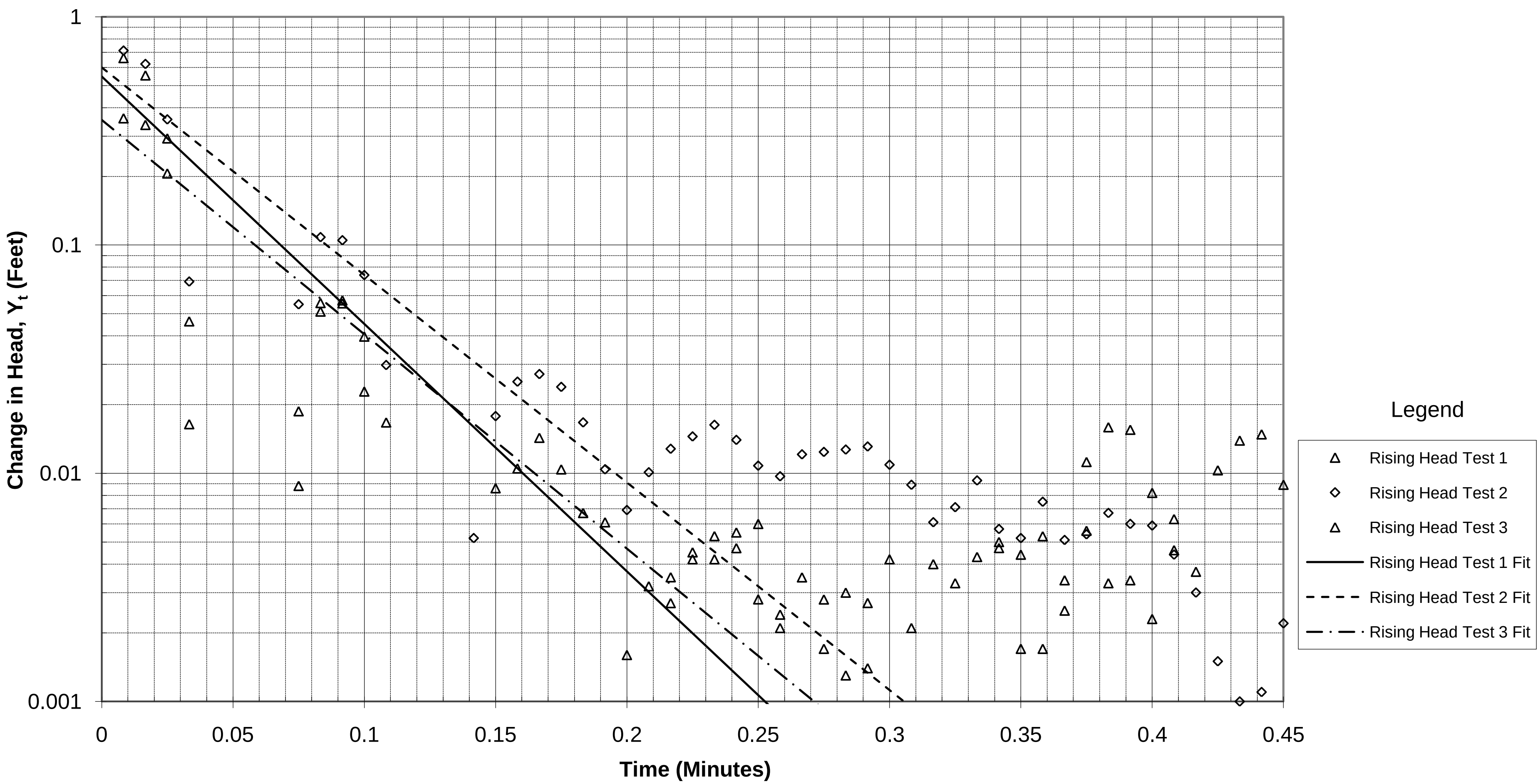
June 2010

21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-15

FIG. B-15



Skagit River Levee General Investigation
Skagit County, Washington

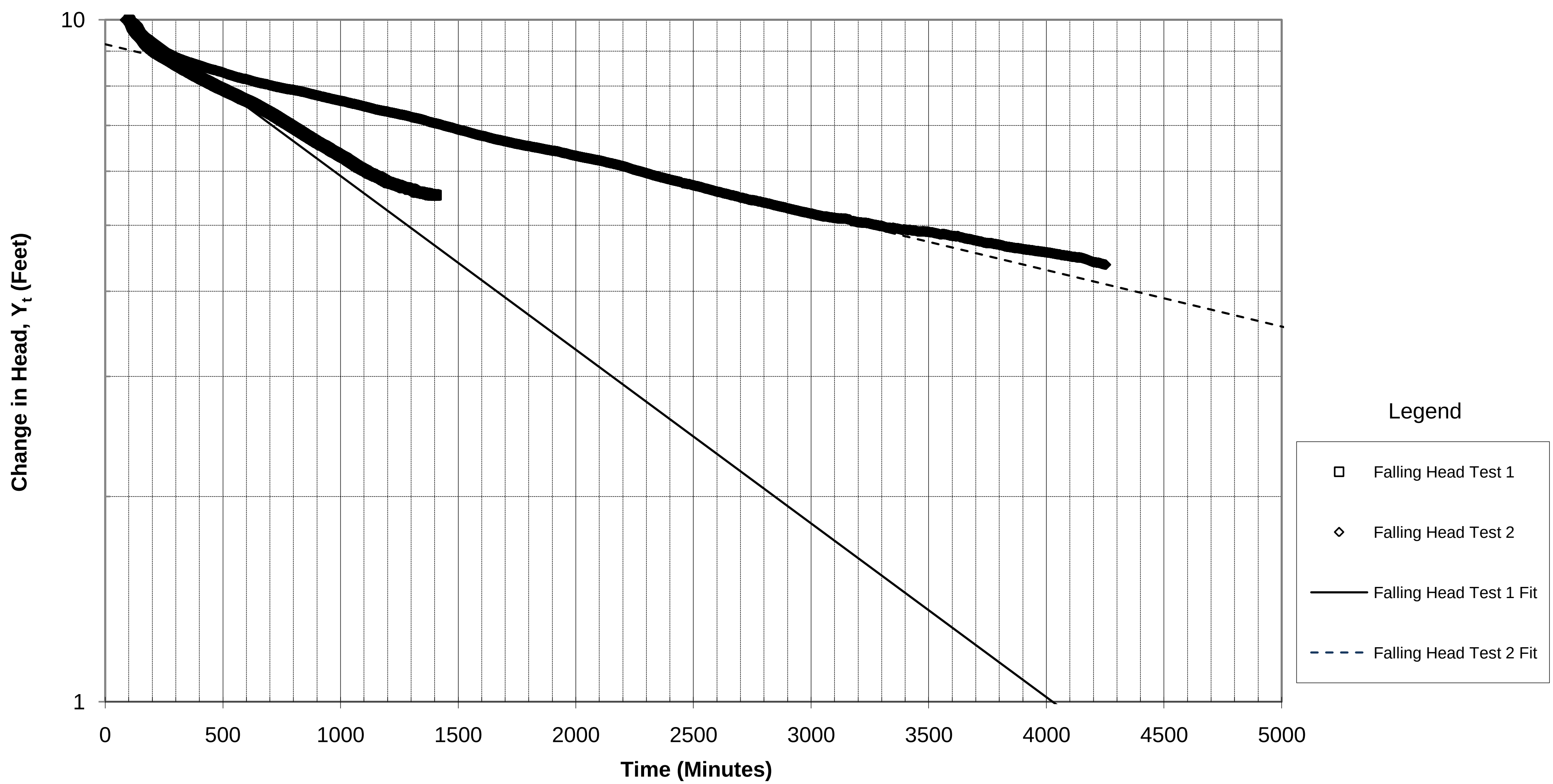
RISING HEAD SLUG TESTS
OBSERVATION WELL DD22-2Landward

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-16

FIG. B-16



Skagit River Levee General Investigation
Skagit County, Washington

FALLING HEAD PERCOLATION TESTS
OBSERVATION WELL DD1-1Levee

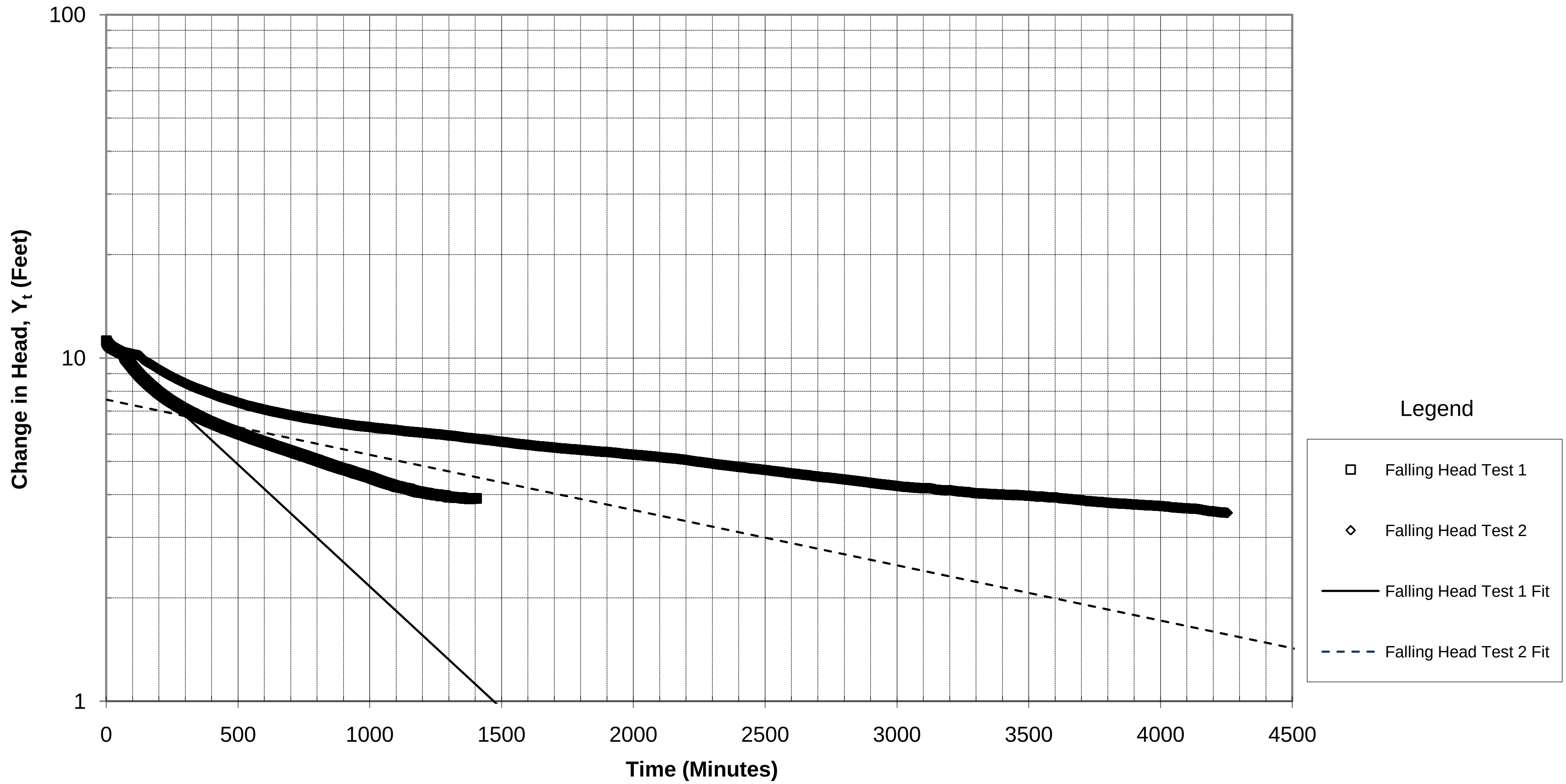
June 2010

21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-17

FIG. B-17



Skagit River Levee General Investigation
Skagit County, Washington

FALLING HEAD PERCOLATION TESTS
OBSERVATION WELL DD1-2Levee

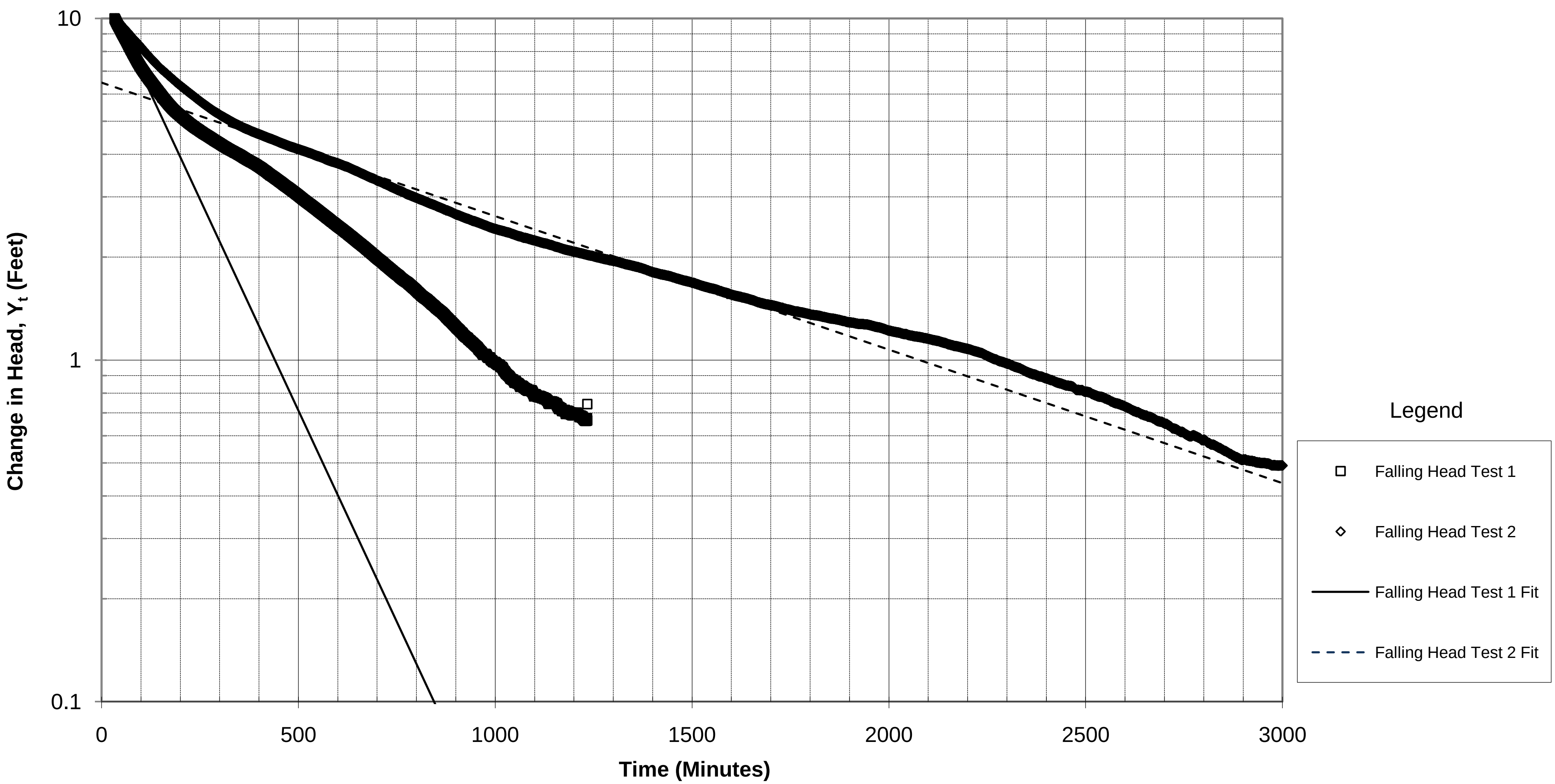
June 2010

21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-18

FIG. B-18



Skagit River Levee General Investigation
Skagit County, Washington

FALLING HEAD PERCOLATION TESTS
OBSERVATION WELL DD3-1Landward

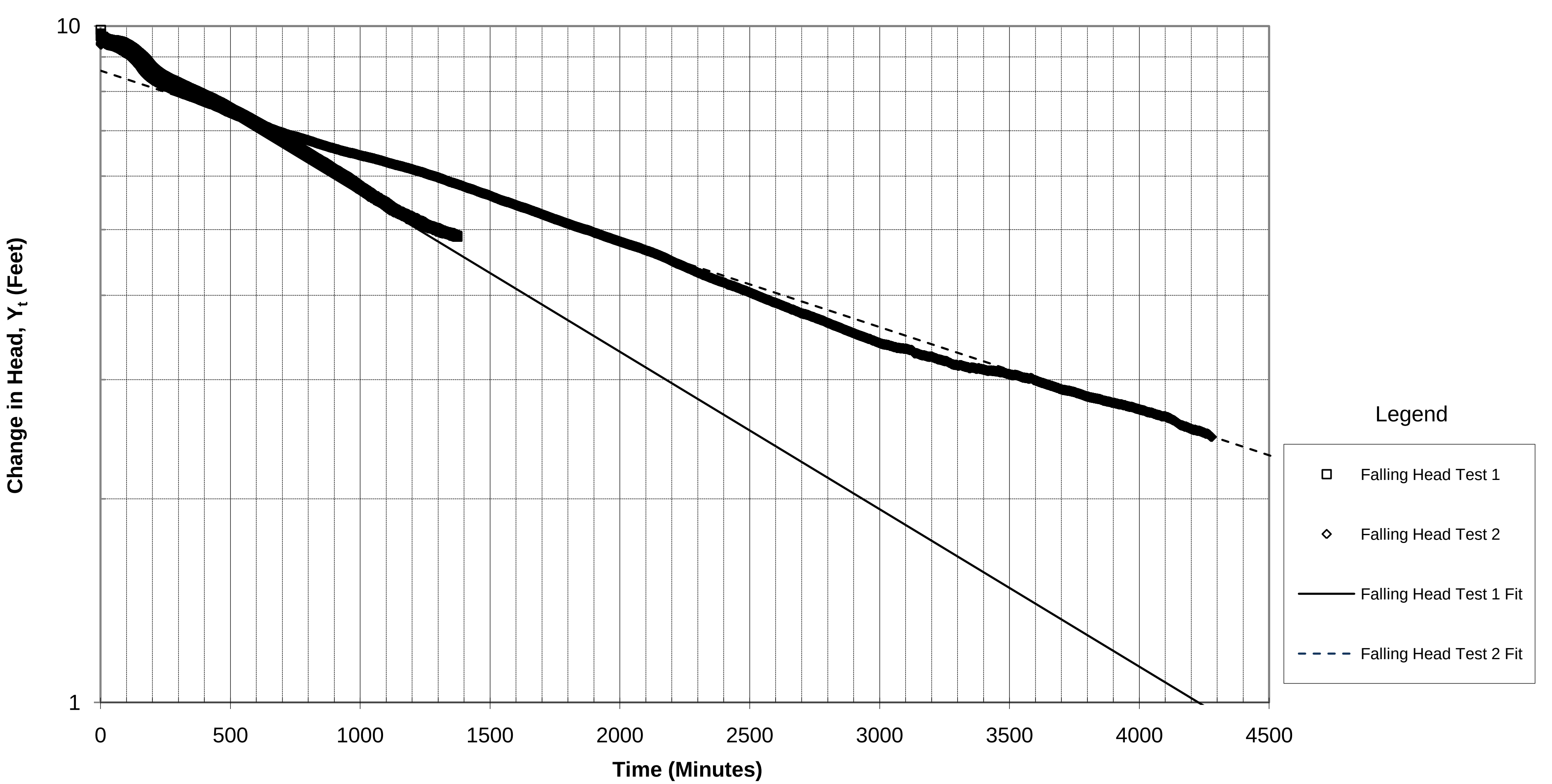
June 2010

21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-19

FIG. B-19



Skagit River Levee General Investigation
Skagit County, Washington

FALLING HEAD PERCOLATION TESTS
OBSERVATION WELL DD17-1Levee

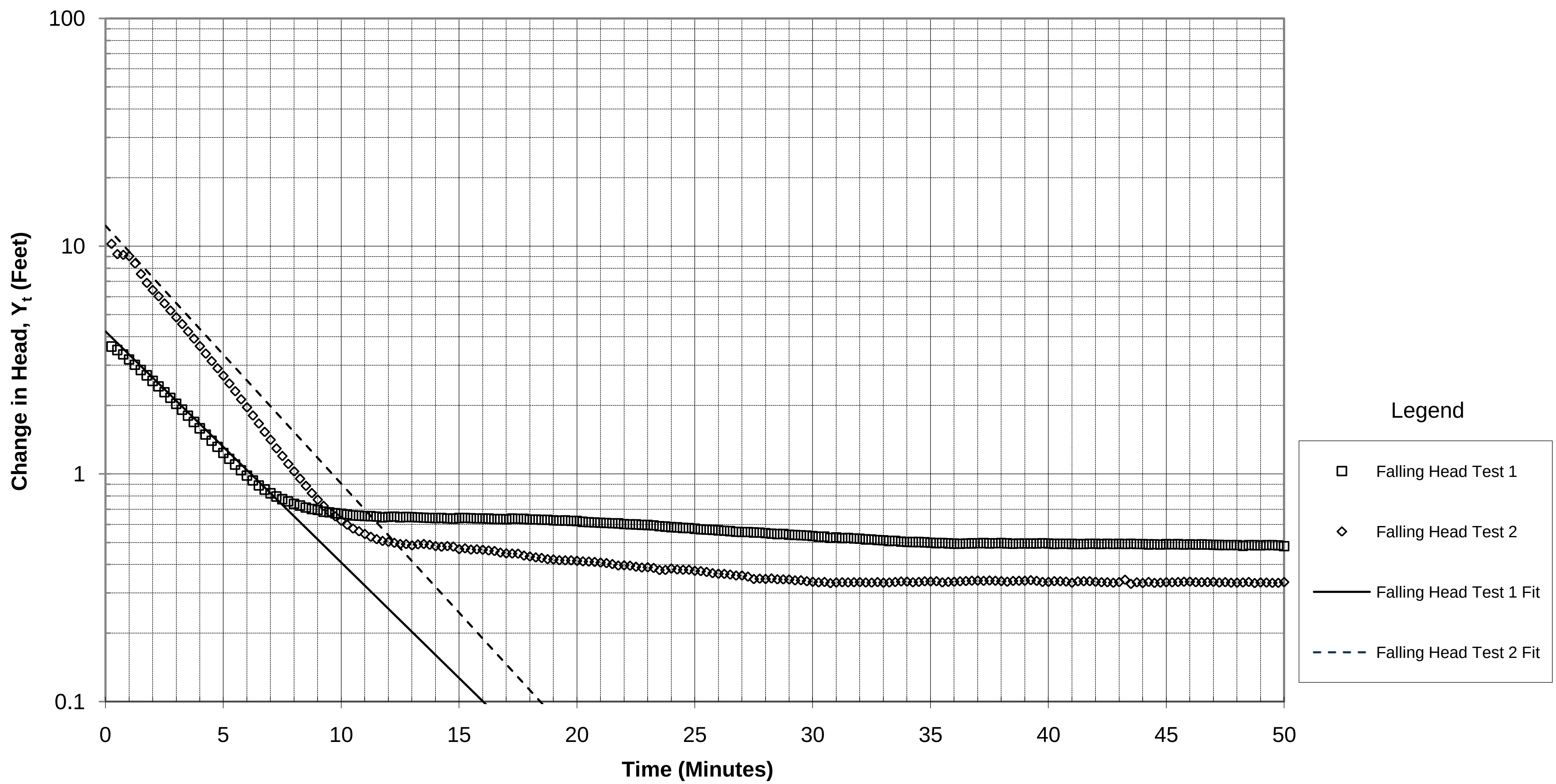
June 2010

21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-20

FIG. B-20



Skagit River Levee General Investigation
Skagit County, Washington

FALLING HEAD PERCOLATION TESTS
OBSERVATION WELL DD17-2Levee

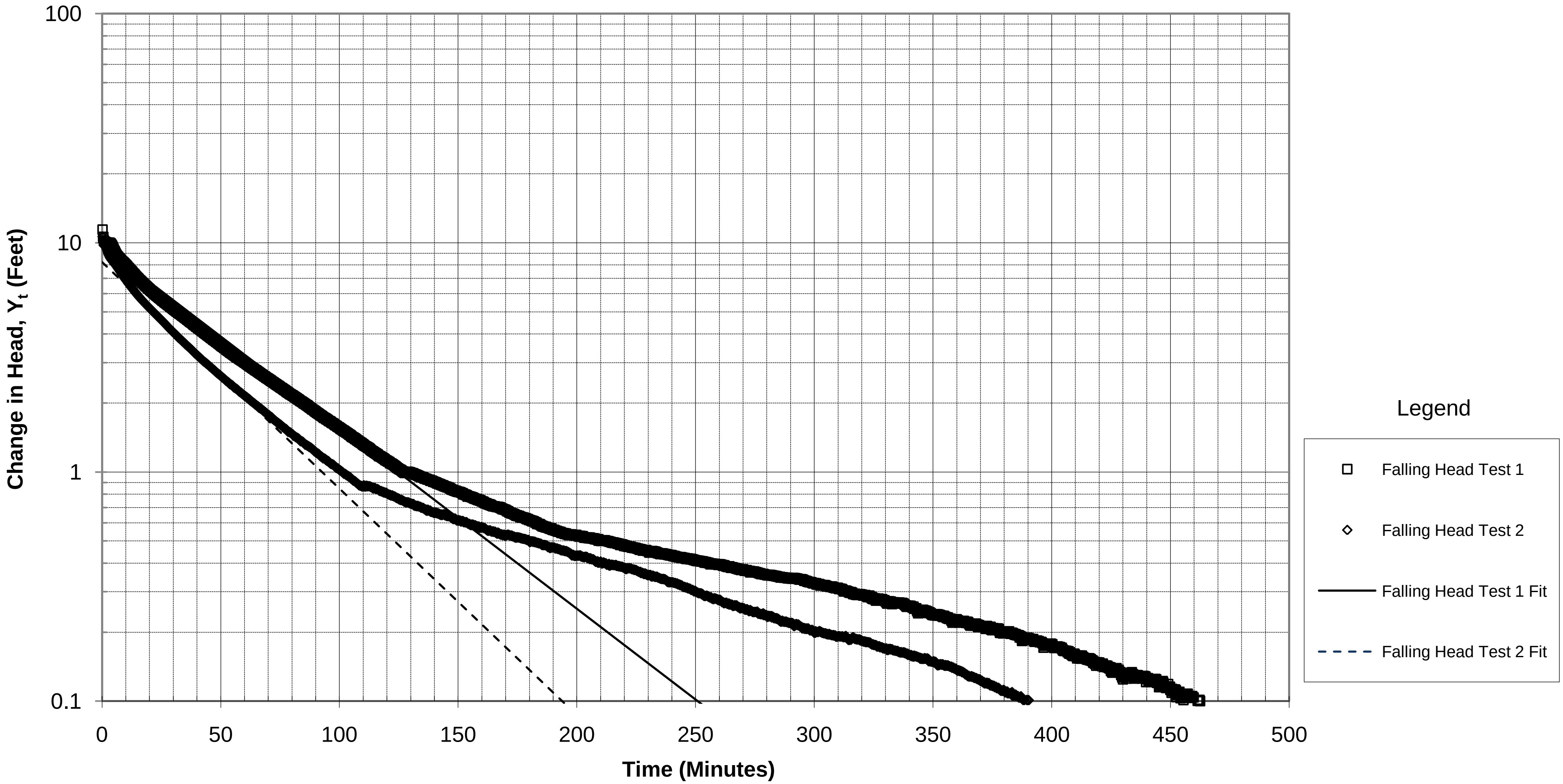
June 2010

21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-21

FIG. B-21



Skagit River Levee General Investigation
Skagit County, Washington

FALLING HEAD PERCOLATIONTESTS
OBSERVATION WELL DD17-3Landward

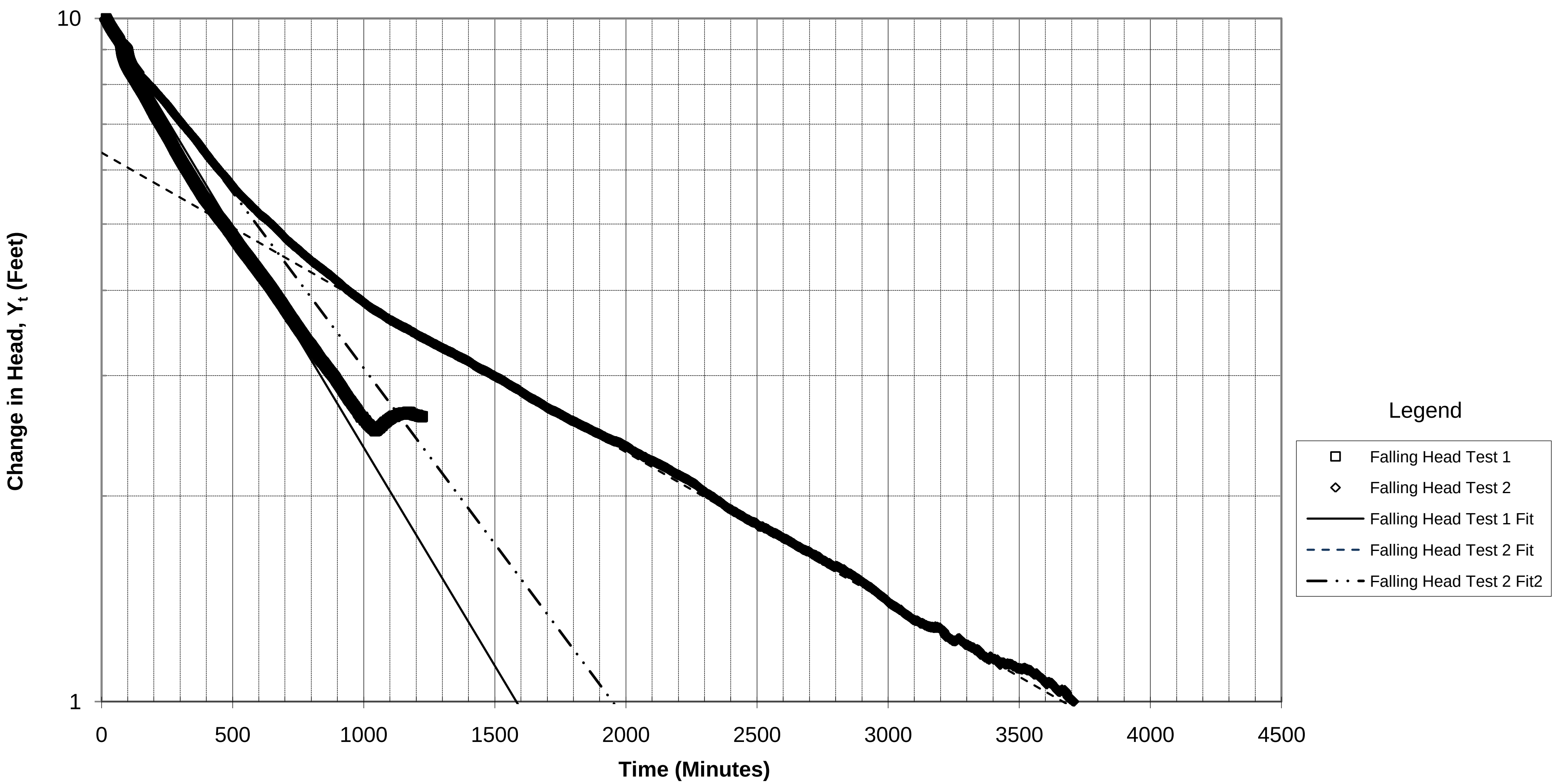
June 2010

21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-22

FIG. B-22



Skagit River Levee General Investigation
Skagit County, Washington

FALLING HEAD PERCOLATION TESTS
OBSERVATION WELL DD22-1Levee

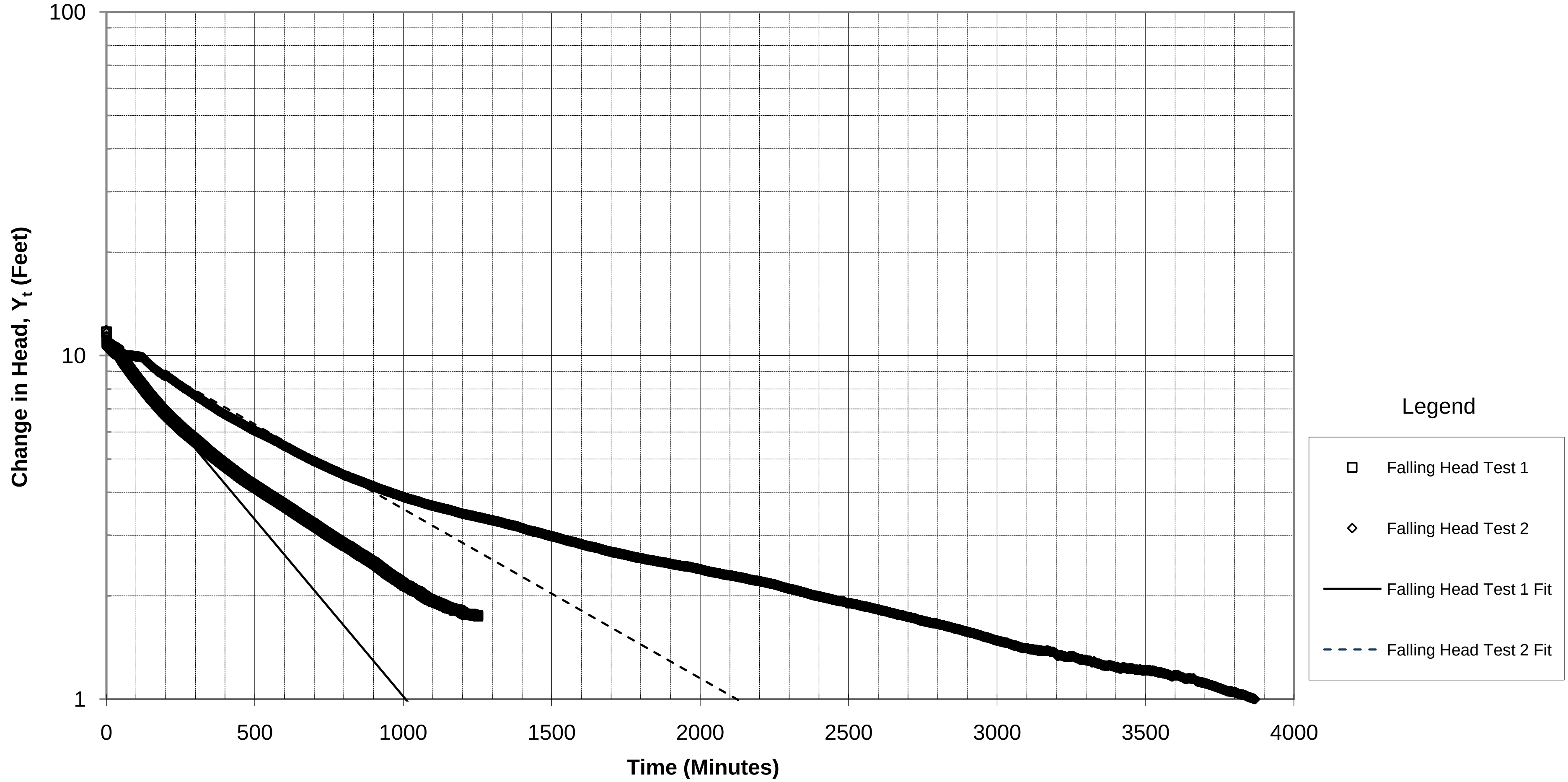
June 2010

21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-23

FIG. B-23



Skagit River Levee General Investigation
Skagit County, Washington

FALLING HEAD PERCOLATION TESTS
OBSERVATION WELL DD22-2Levee

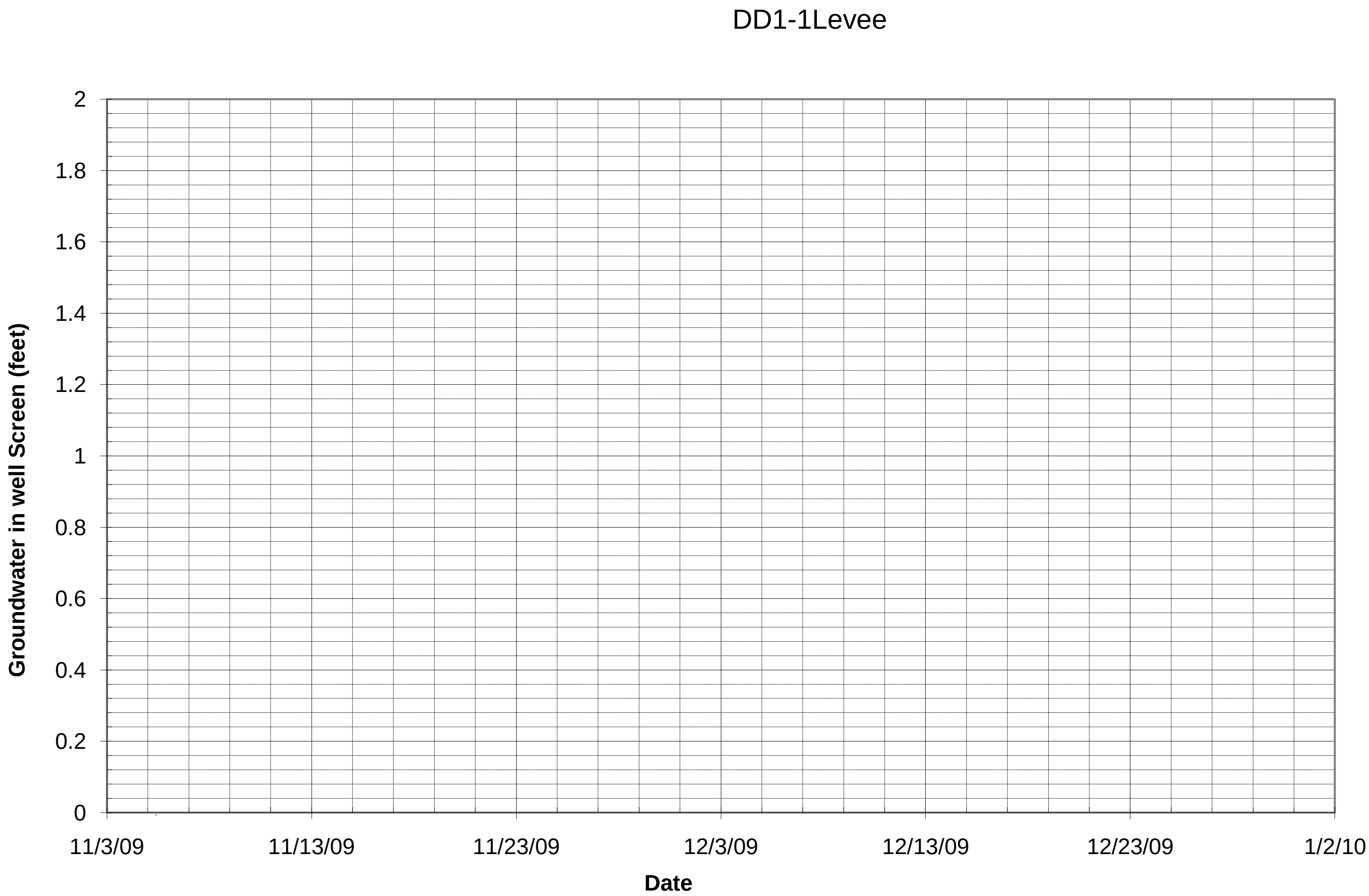
June 2010

21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-24

FIG. B-24



Skagit River Levee General Investigation
Skagit County, Washington

HOURLY GROUNDWATER DATA
(NO WATER IN LEVEE)
DD1-1Levee

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-25

FIG. B-25

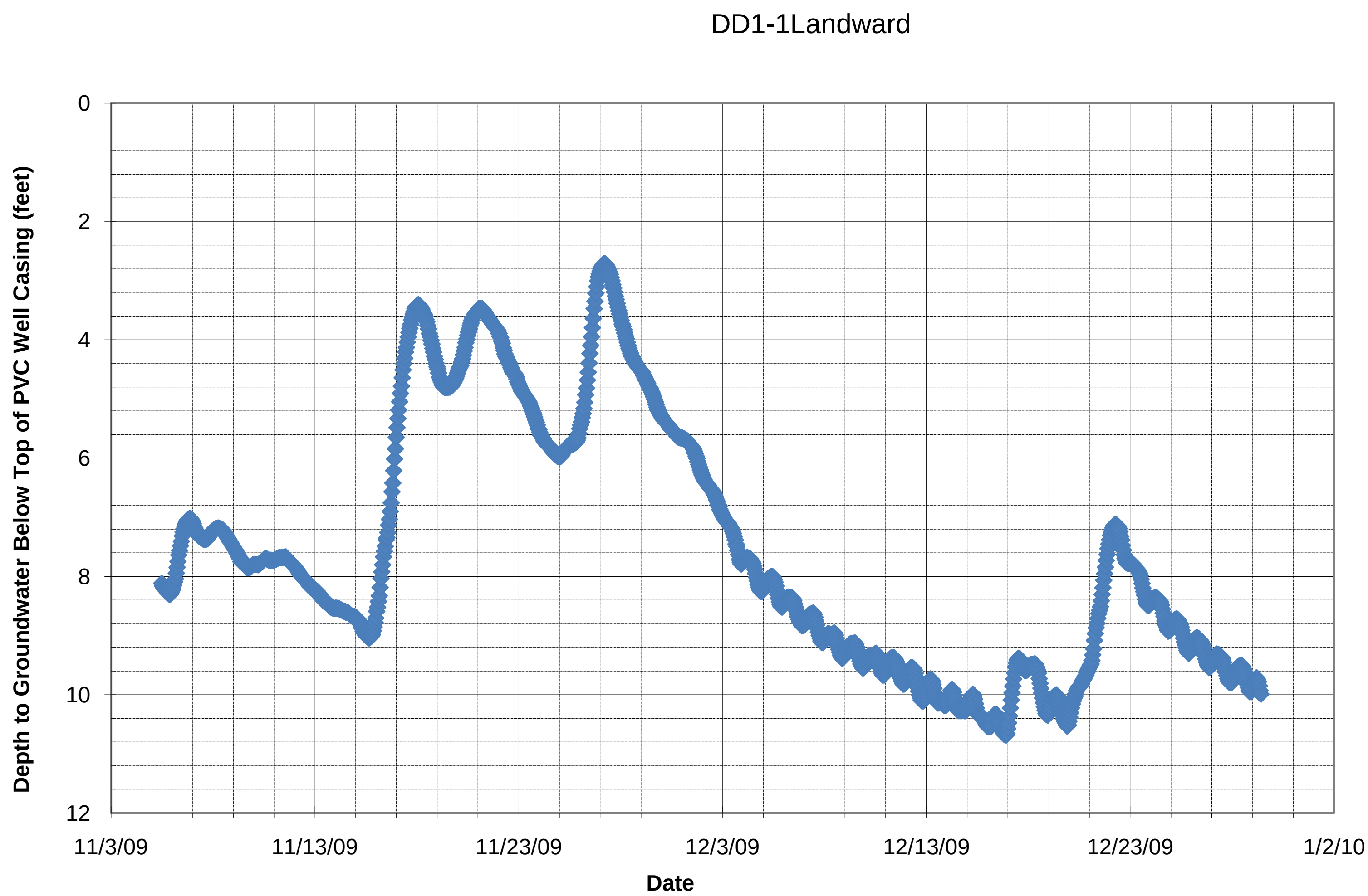


FIG. B-26

Skagit River Levee General Investigation
Skagit County, Washington

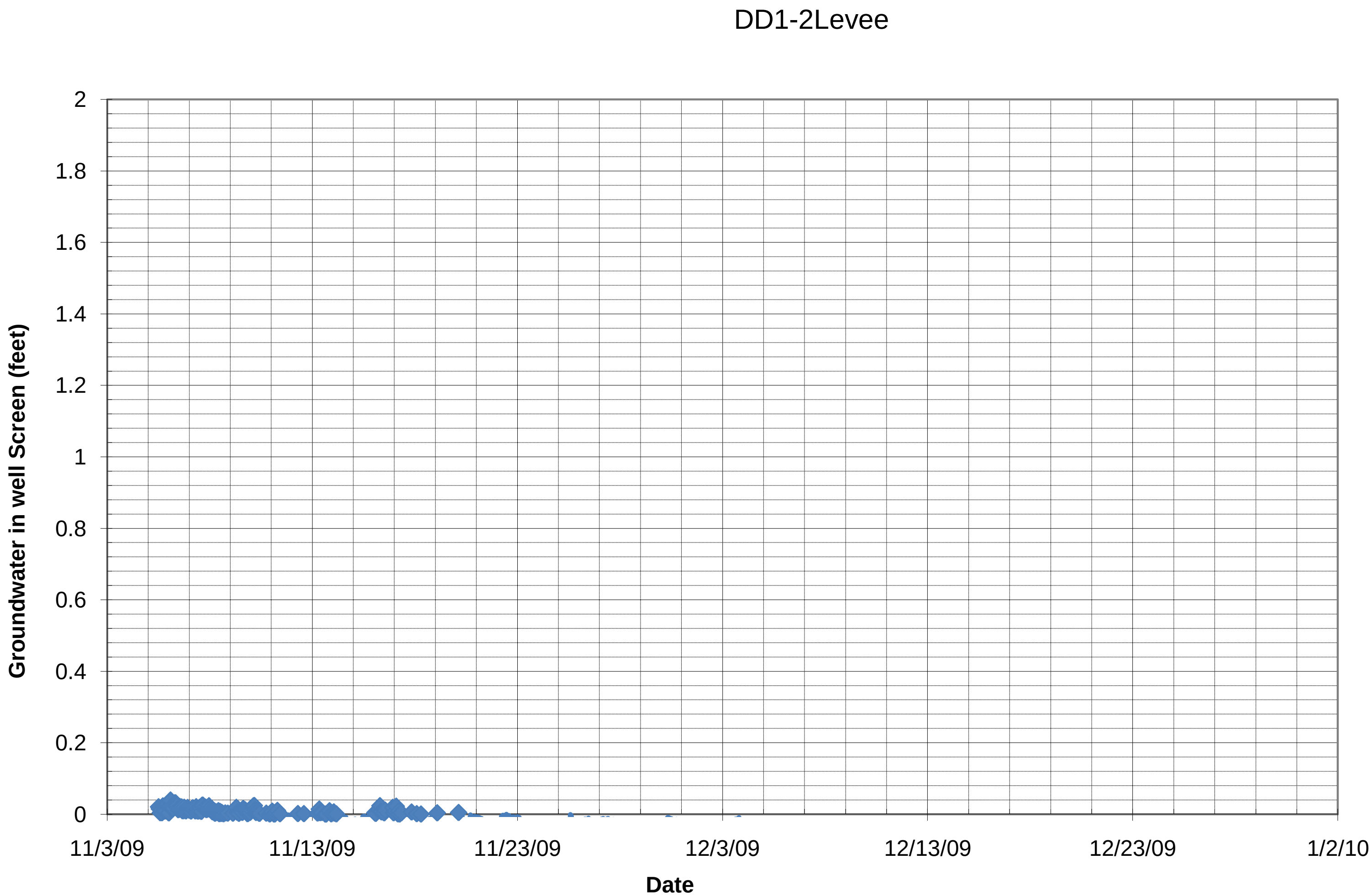
HOURLY GROUNDWATER DATA
DD1-1Landward

June 2010

21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-26



We believe that the groundwater readings in November (less than 0.04 foot of water is detected by the data logger) are from water trapped in the well sump from development

Skagit River Levee General Investigation
Skagit County, Washington

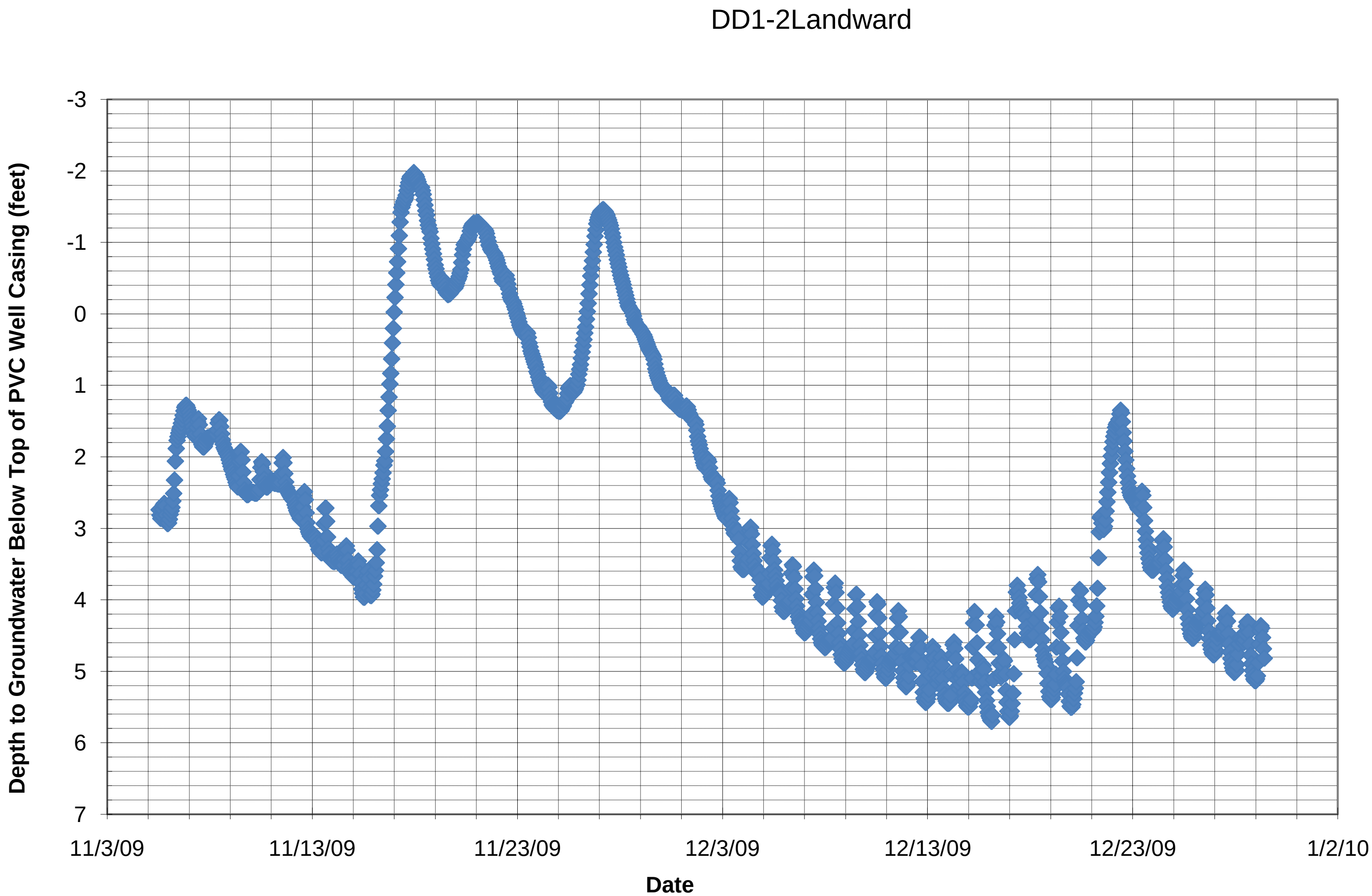
HOURLY GROUNDWATER DATA
(NO WATER IN LEVEE)
DD1-2Levee

June 2010 | 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-27

FIG. B-27



Skagit River Levee General Investigation
Skagit County, Washington

HOURLY GROUNDWATER DATA
DD1-2Landward

June 2010

21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-28

FIG. B-28

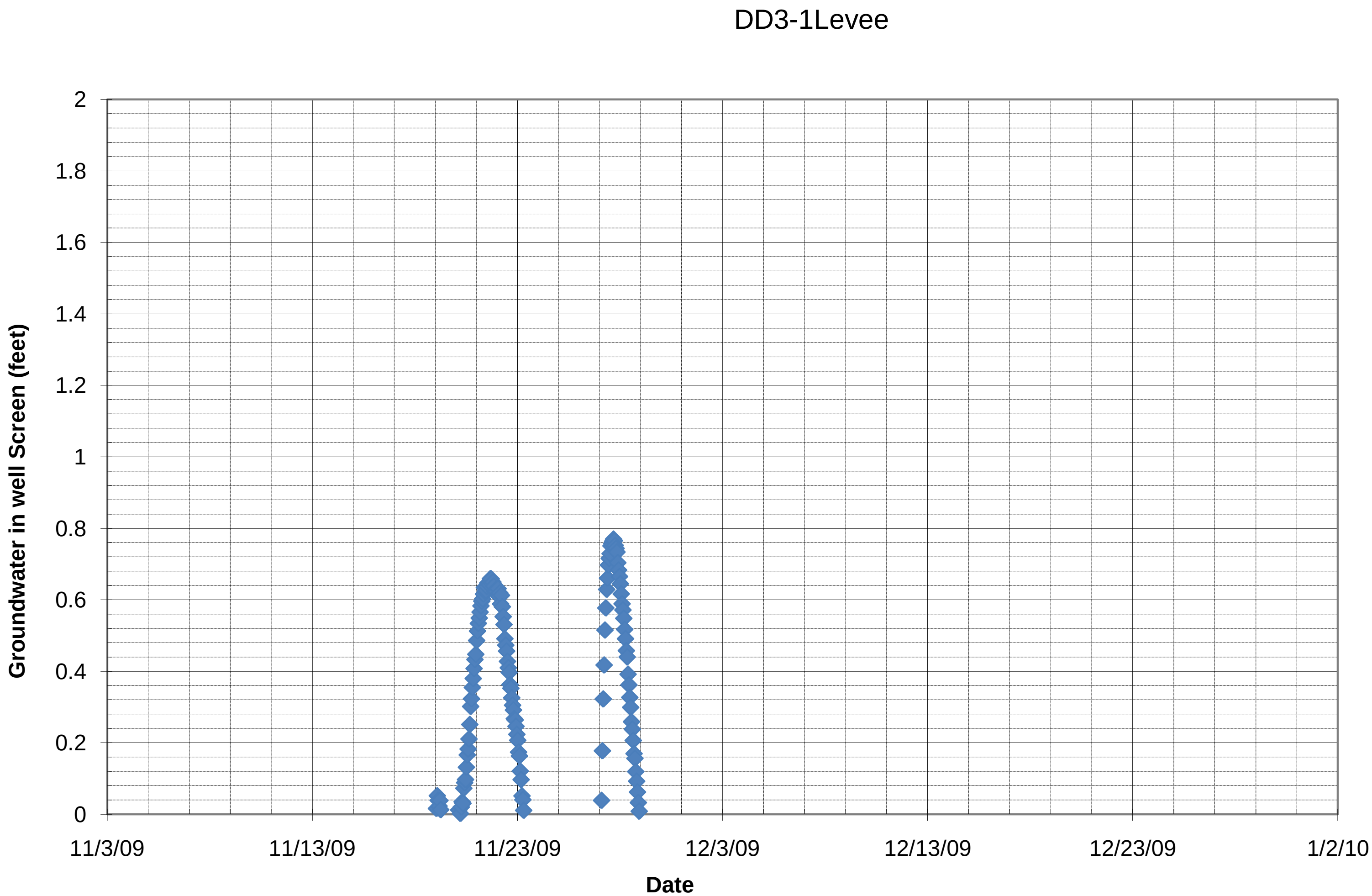


FIG. B-29

Skagit River Levee General Investigation
Skagit County, Washington

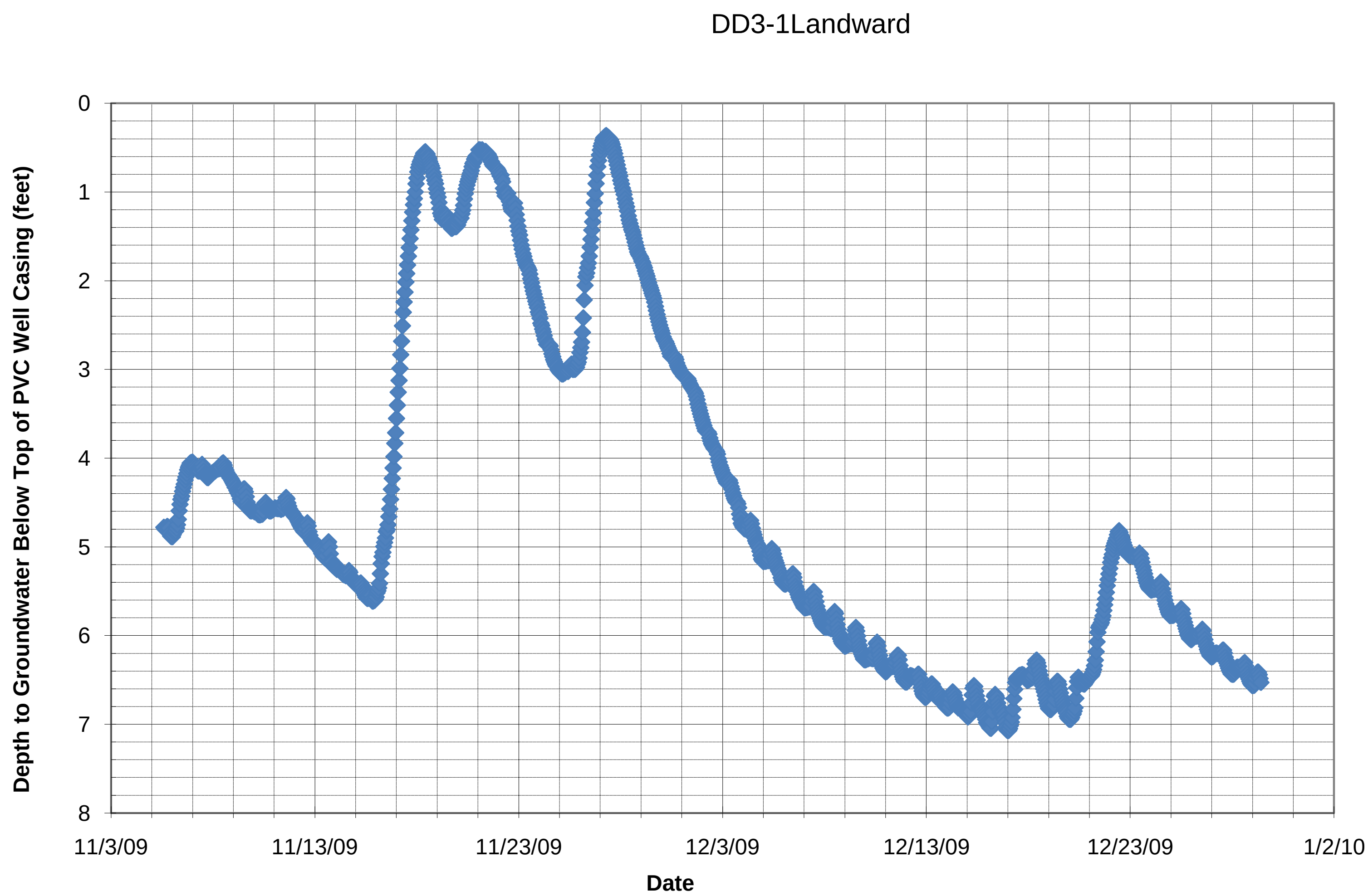
HOURLY GROUNDWATER DATA (WATER SEEPAGE IN LEVEE) DD3-1Levee

June 2010

21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-29



Skagit River Levee General Investigation
Skagit County, Washington

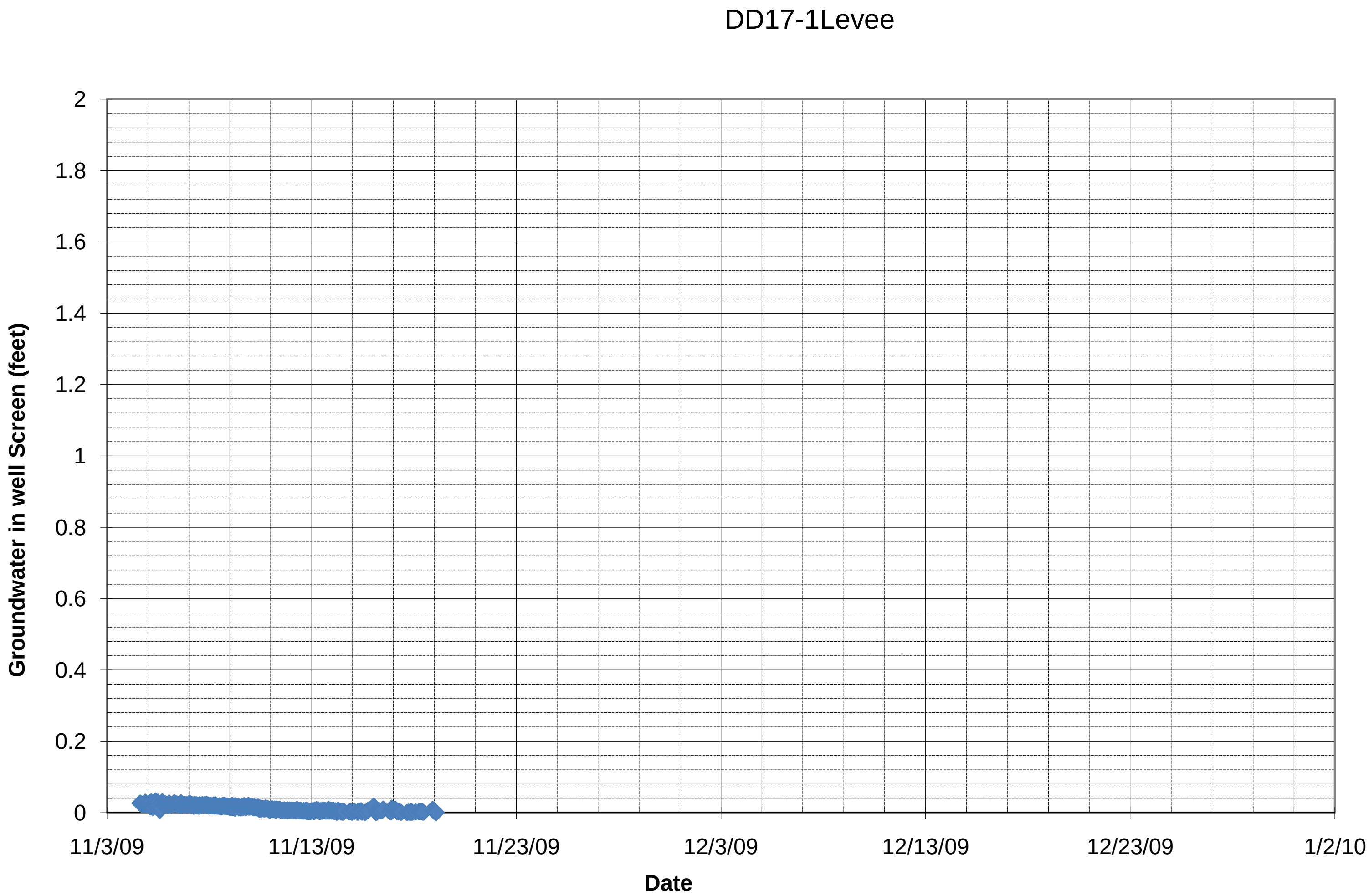
HOURLY GROUNDWATER DATA
DD3-1Landward

June 2010 | 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-30

FIG. B-30



We believe that the groundwater readings in November (less than 0.04 foot of water is detected by the data logger) are from water trapped in the well sump from development

Skagit River Levee General Investigation
Skagit County, Washington

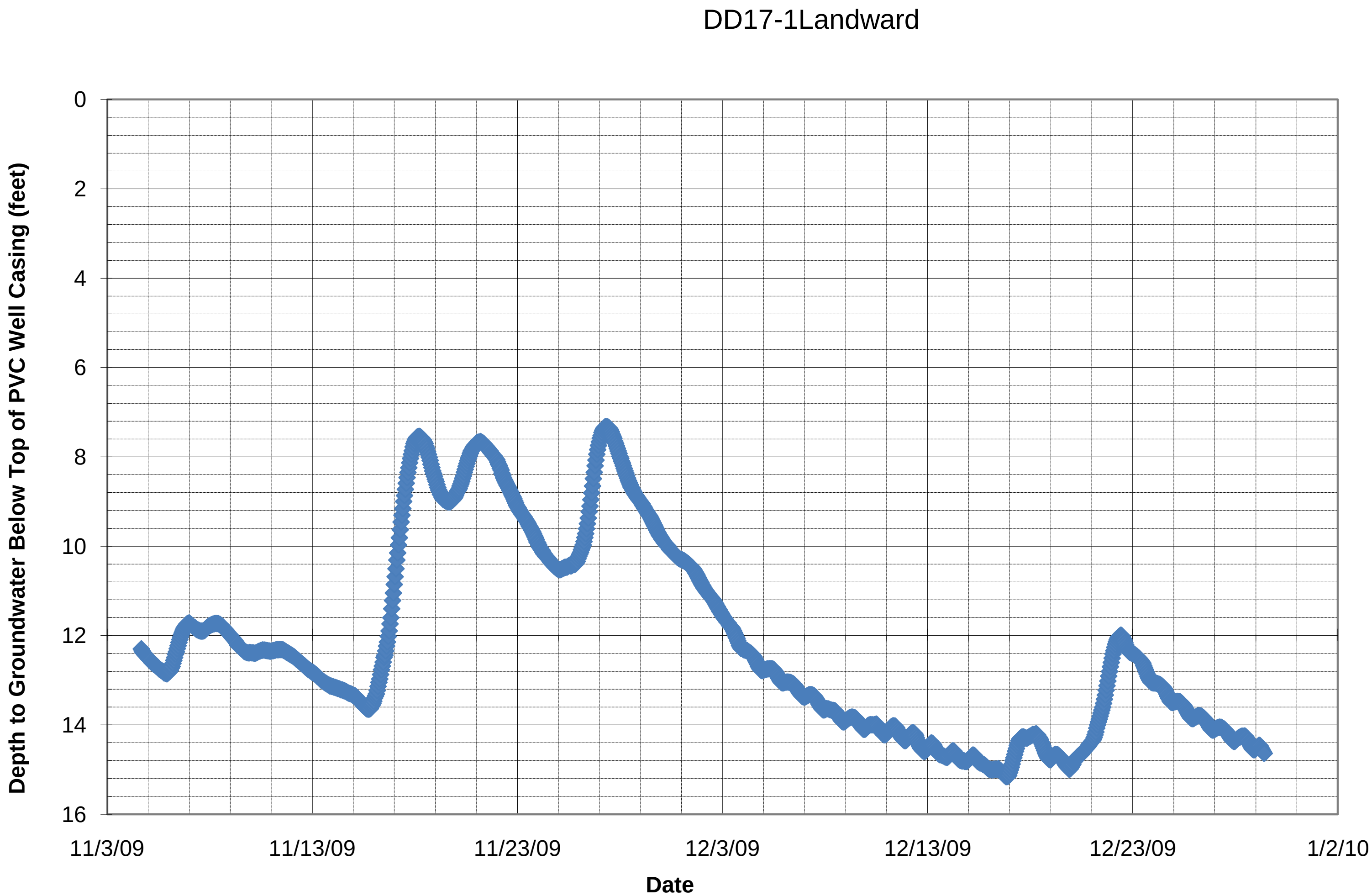
HOURLY GROUNDWATER DATA
(NO WATER IN LEVEE)
DD17-1Levee

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-31

FIG. B-31



Skagit River Levee General Investigation
Skagit County, Washington

HOURLY GROUNDWATER DATA
DD17-1Landward

June 2010

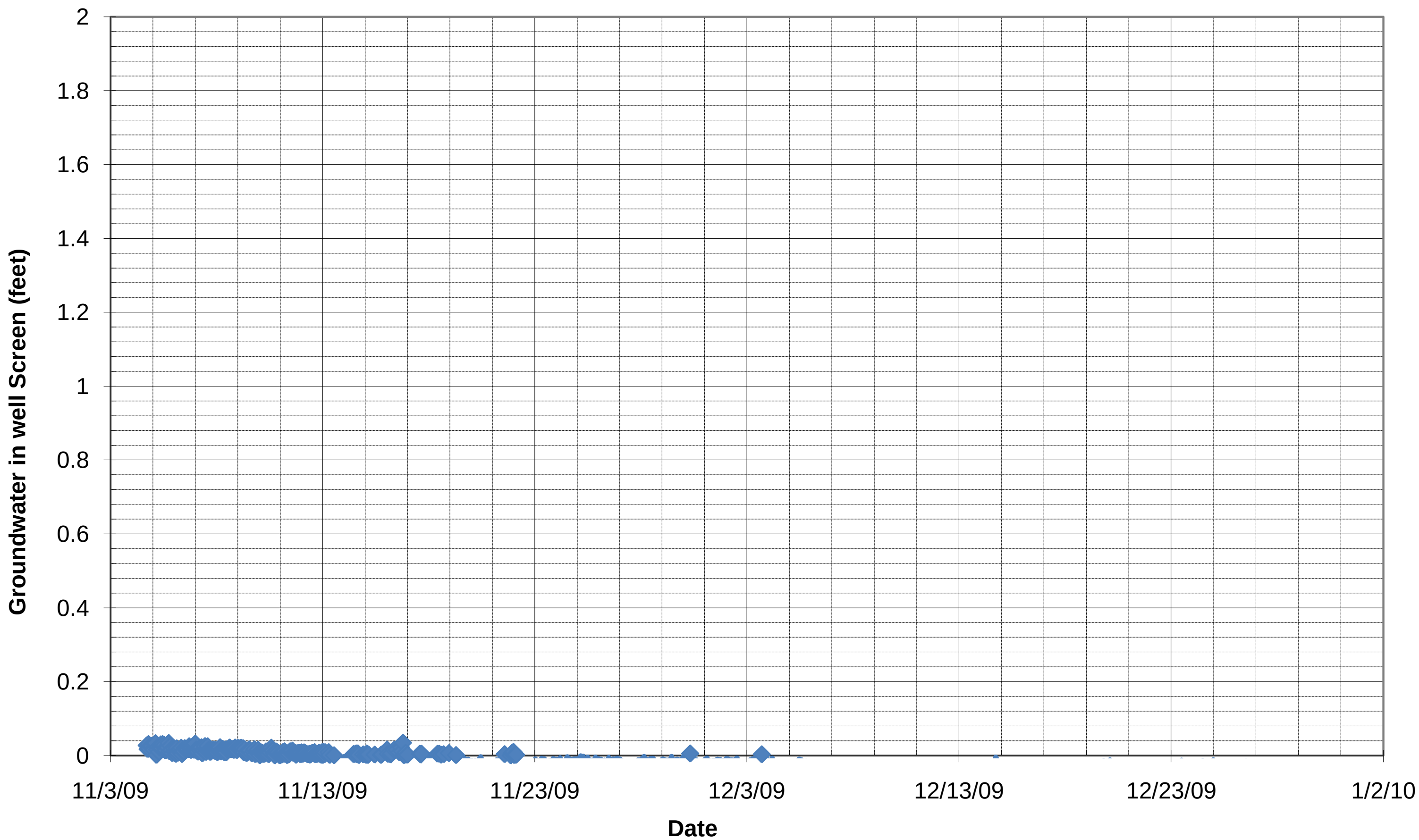
21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-32

FIG. B-32

DD17-2Levee



We believe that the groundwater readings in November (less than 0.04 foot of water is detected by the data logger) are from water trapped in the well sump from development

Skagit River Levee General Investigation
Skagit County, Washington

HOURLY GROUNDWATER DATA
(NO WATER IN LEVEE)
DD17-2Levee

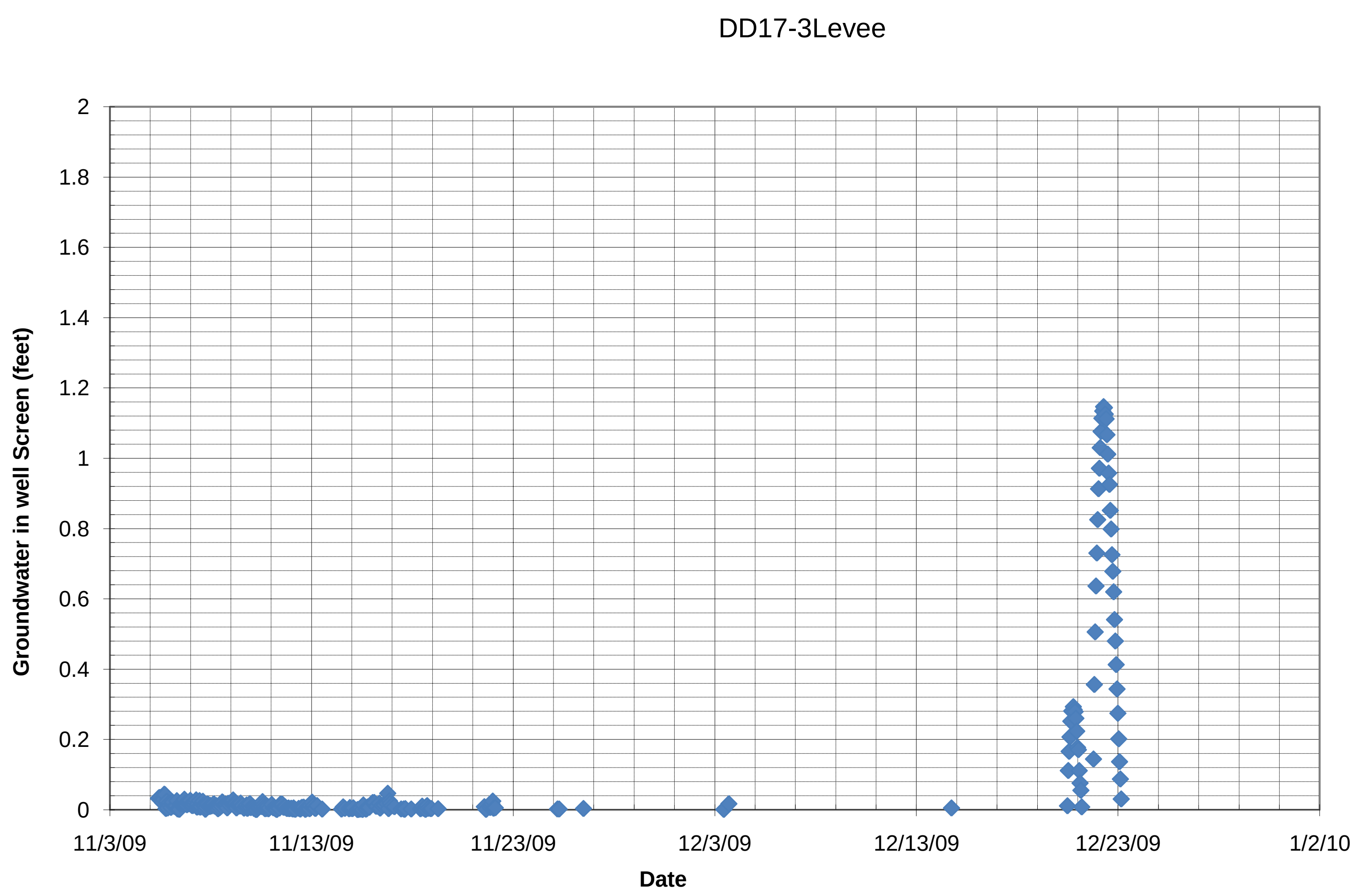
June 2010

21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-33

FIG. B-33



We believe that the groundwater readings in November (less than 0.04 foot of water is detected by the data logger) are from water trapped in the well sump from development

Skagit River Levee General Investigation
Skagit County, Washington

HOURLY GROUNDWATER DATA (WATER SEEPAGE IN LEVEE) DD17-3Levee

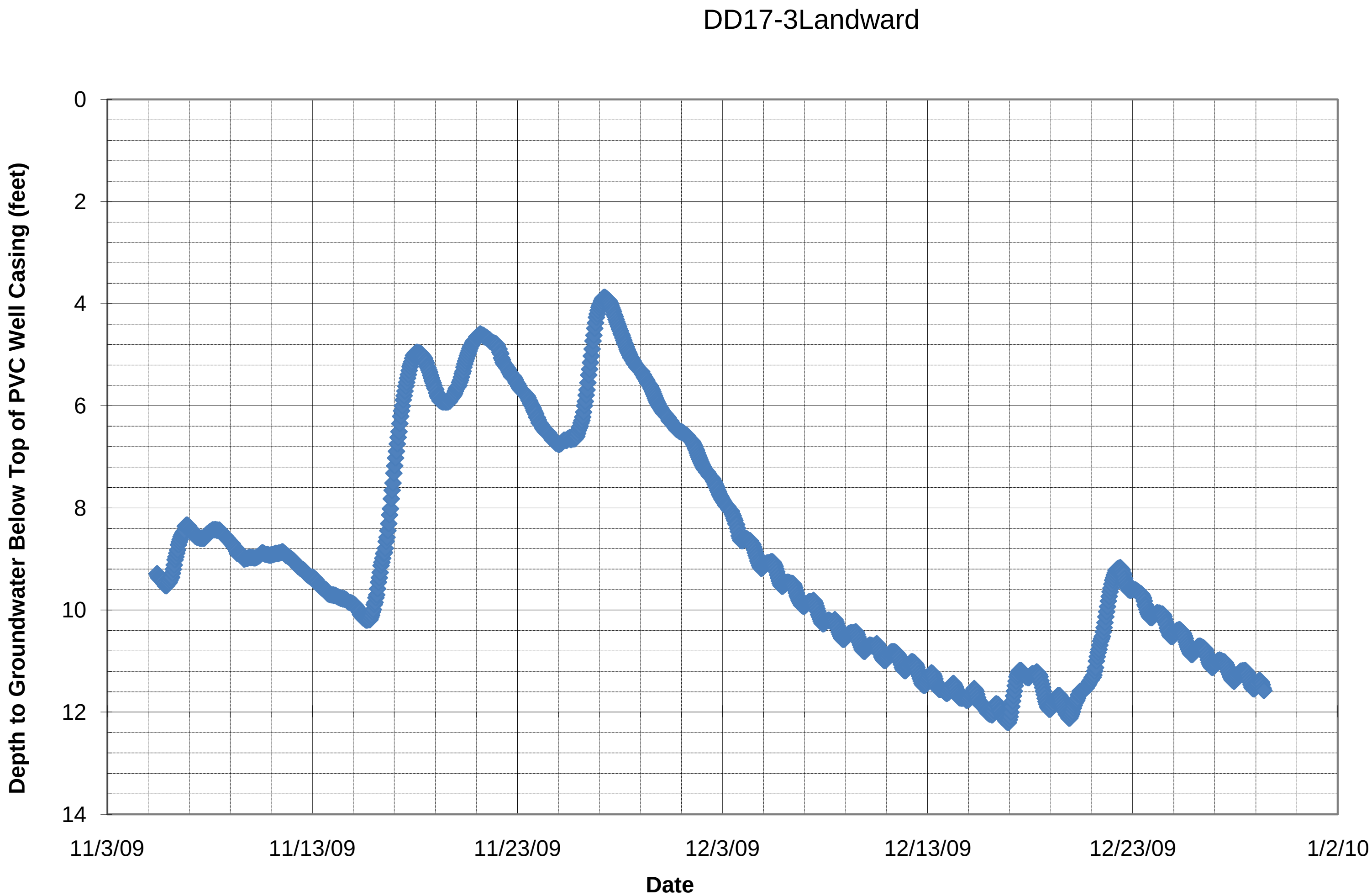
June 2010

21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-34

FIG. B-34



Skagit River Levee General Investigation
Skagit County, Washington

HOURLY GROUNDWATER DATA
DD17-3Landward

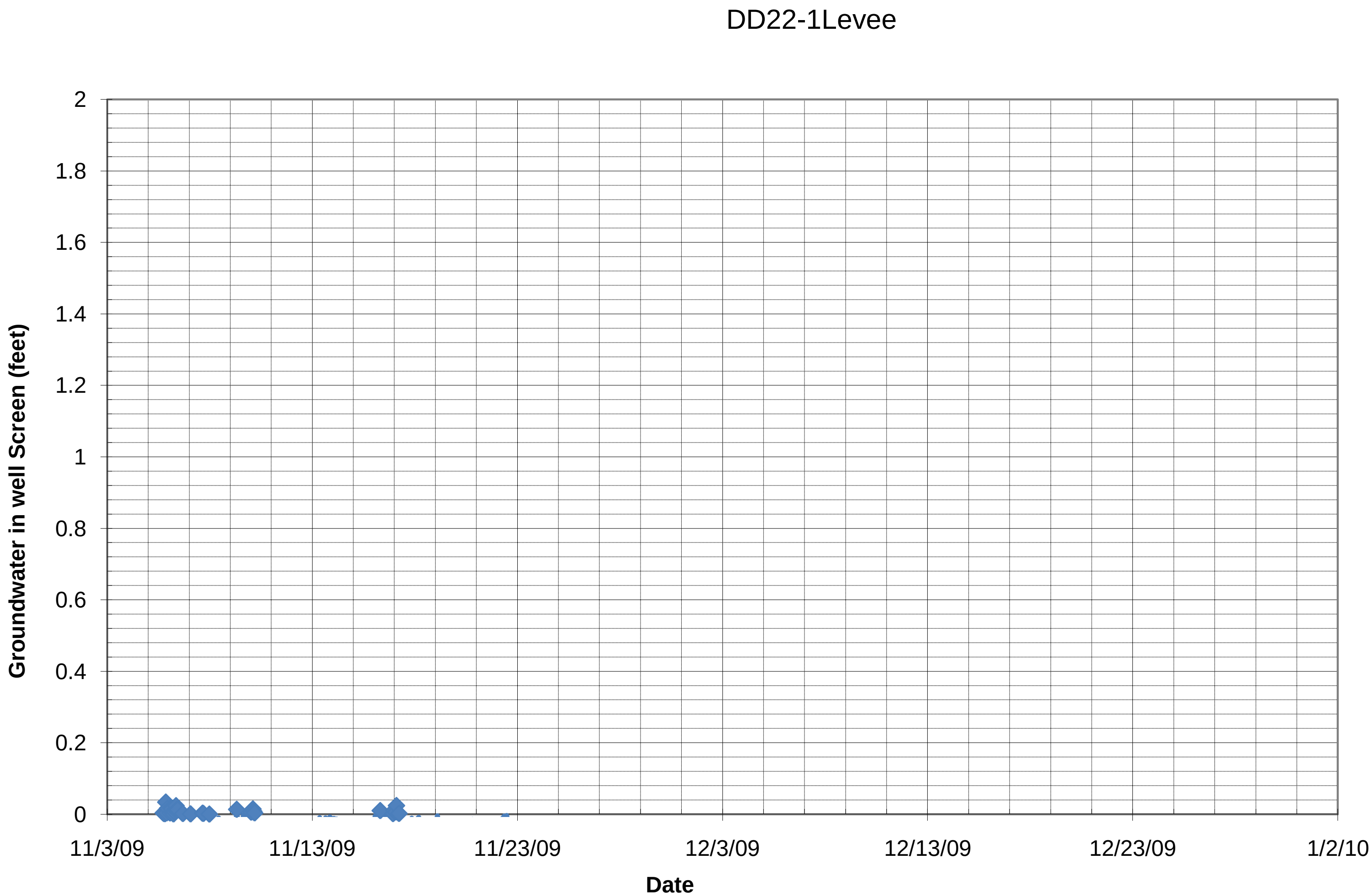
June 2010

21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-35

FIG. B-35



We believe that the groundwater readings in November (less than 0.04 foot of water is detected by the data logger) are from water trapped in the well sump from development

Skagit River Levee General Investigation
Skagit County, Washington

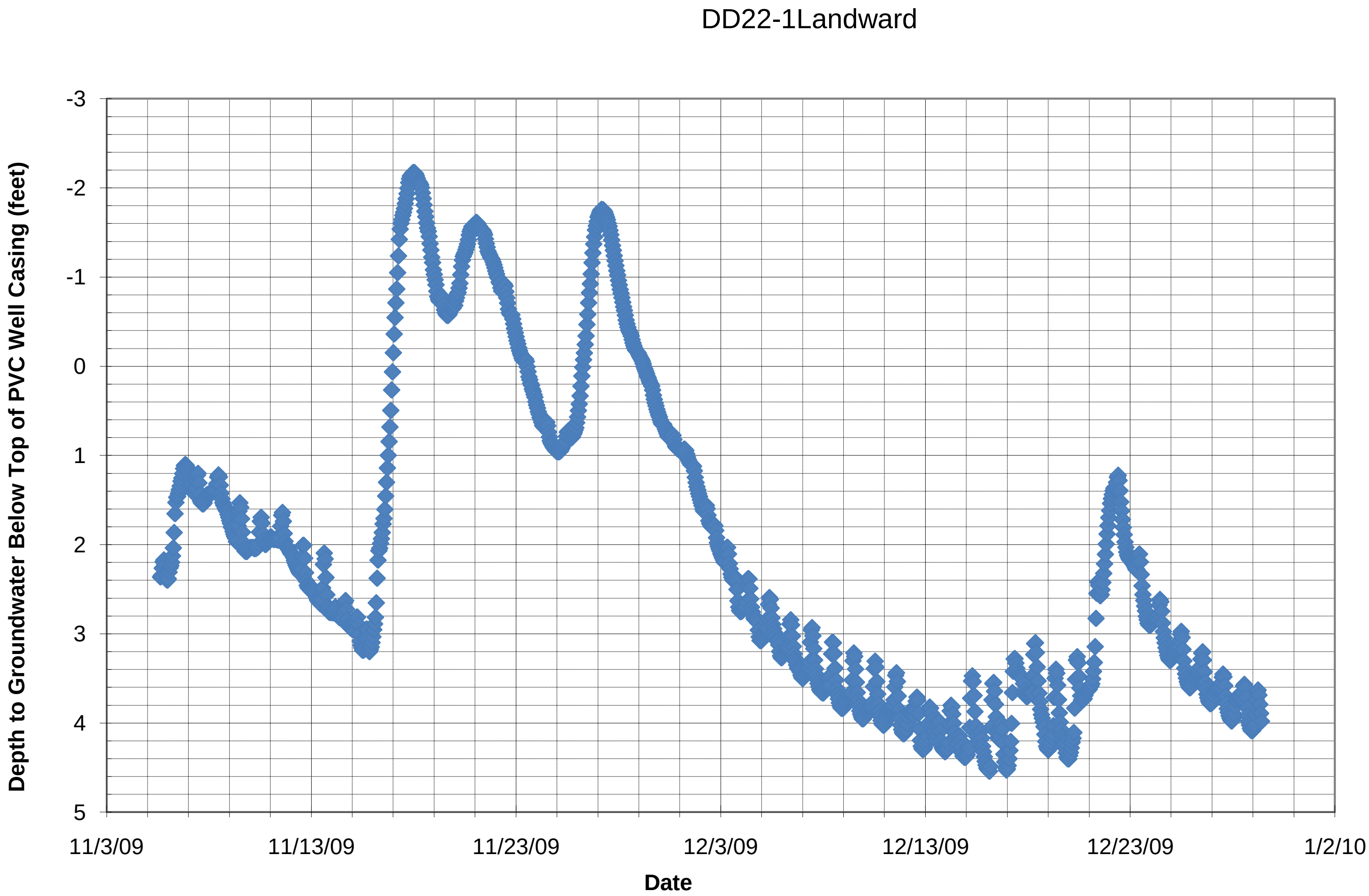
HOURLY GROUNDWATER DATA
(NO WATER IN LEVEE)
DD22-1Levee

June 2010

21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-36



Skagit River Levee General Investigation
Skagit County, Washington

HOURLY GROUNDWATER DATA
DD22-1Landward

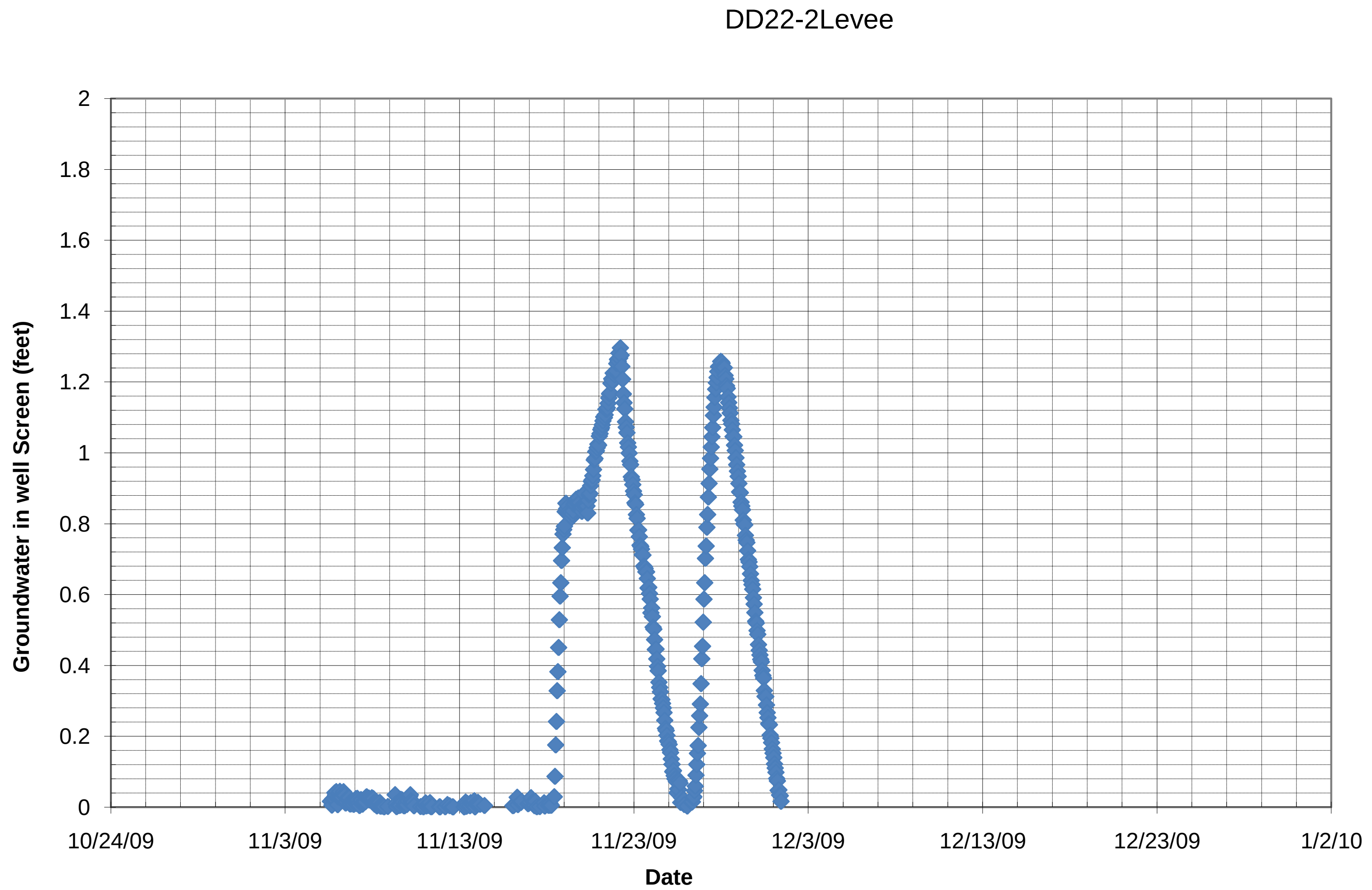
June 2010

21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-37

FIG. B-37



Skagit River Levee General Investigation
Skagit County, Washington

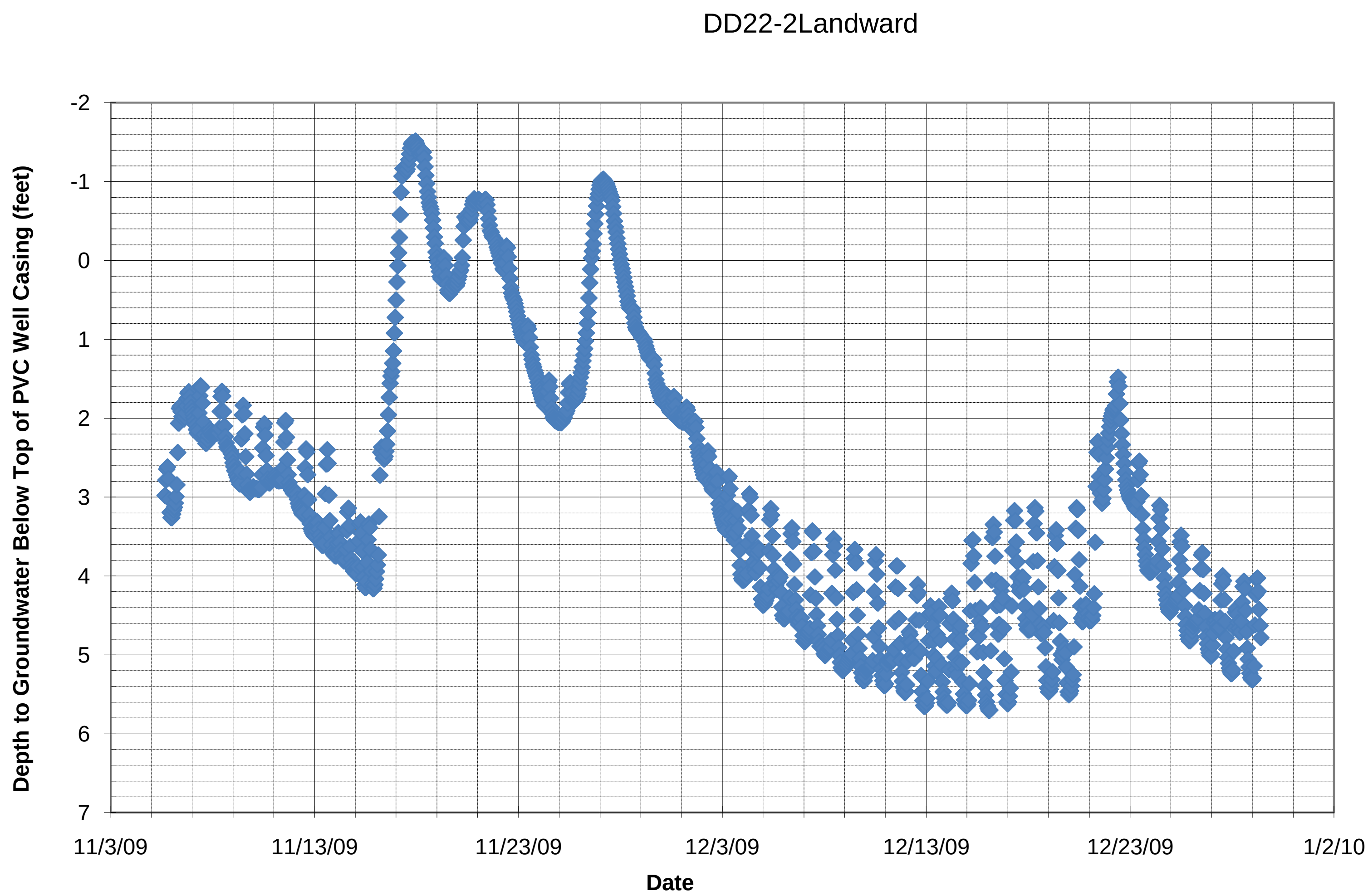
HOURLY GROUNDWATER DATA (WATERSEEPAGE IN LEVEE) DD22-2Levee

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-38

FIG. B-38



Skagit River Levee General Investigation
Skagit County, Washington

HOURLY GROUNDWATER DATA
DD22-2Landward

June 2010 | 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-39

FIG. B-39

APPENDIX C

GEOTECHNICAL LABORATORY TEST RESULTS

APPENDIX C

GEOTECHNICAL LABORATORY TEST RESULTS

TABLE OF CONTENTS

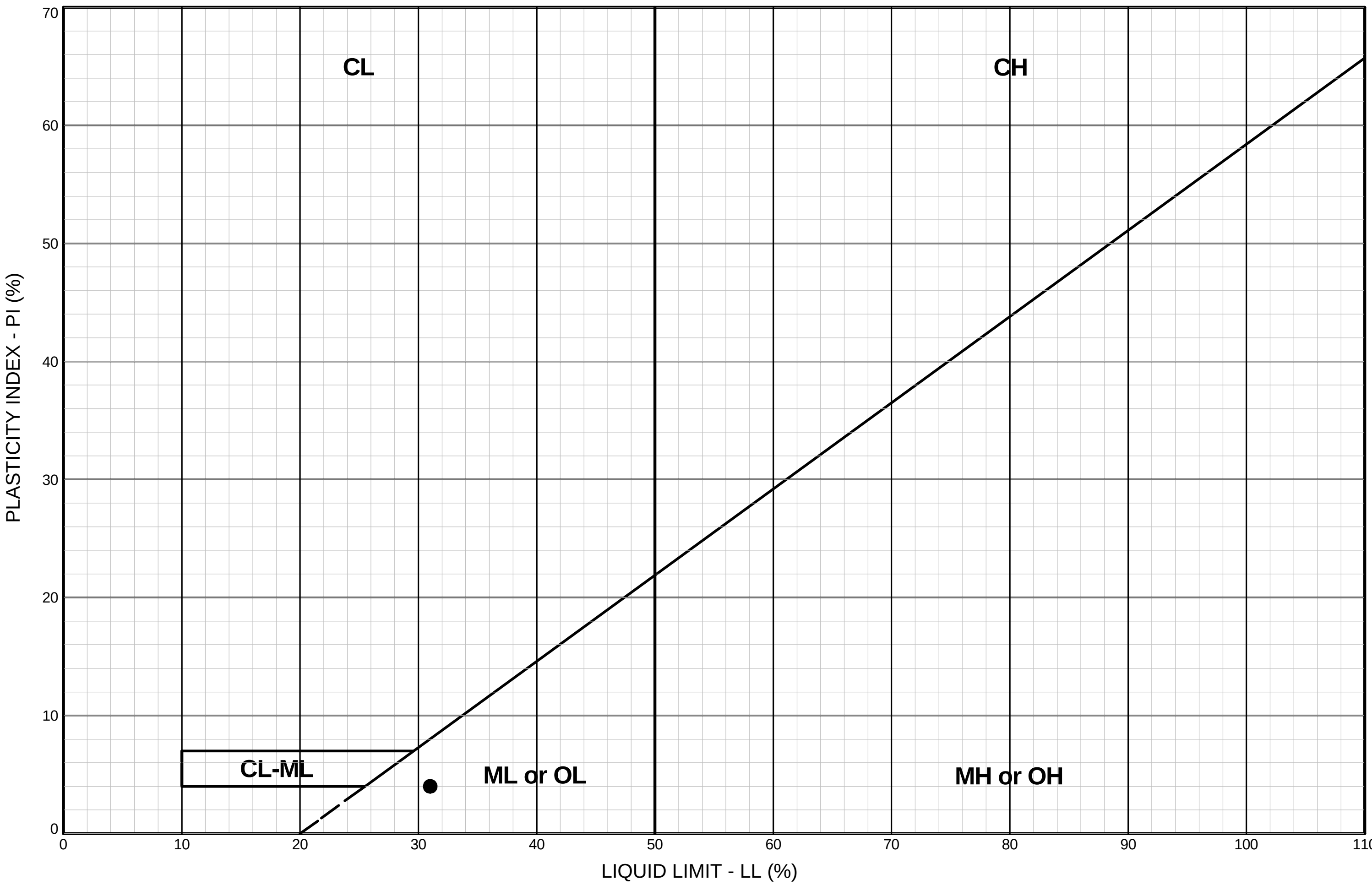
TABLE

FIGURES

FIGURES (cont.)

Table C-1
Summary of Laboratory Permeability Tests

Geologic Designation	Geologic Description	Avg. Hydraulic Conductivity (cm/sec)	Reconstituted Sample (Y/N)	Sample Depth (ft)	Boring Designation	Figure No
Overbank Deposits (Ha[ob])	Very loose, fine sandy SILT to silty fine SAND, trace fine roots, laminated (ML/SM)	7.9×10^{-06}	Yes	5.0 / 7.5	DD1-1 Landward	C-39
Overbank Deposits (Ha[ob])	Loose, interbedded, slightly fine sandy to fine sandy SILT, silty fine SAND, & medium stiff organic SILT, with 1/2-inch silty clay seam and 7-inch wood fragment (ML/SM/OL)	2.0×10^{-05}	No	27.4	DD1-1 Levee	C-40
EstuaryDeposits (He)	Loose, silty, fine to medium SAND, trace of clay, trace of shell fragments (SM)	4.8×10^{-07}	Yes	40.0	DD3-1 Landward	C-41
Overbank Deposits (Ha[ob])	Fine sandy SILT grading to silty fine SAND, trace of fine roots (ML/SM)	2.6×10^{-04}	No	18.1	DD3-1 Levee	C-42
Estuary Deposits (He)	Trace to slightly silty, fine to medium SAND, trace of shell fragments, scattered coarse wood fragments (SP-SM/SP)	1.6×10^{-03}	No	56.1	DD3-1 Levee	C-43
Channel Deposits (Ha[cd])	Very loose to loose, silty fine SAND (SM)	4.1×10^{-05}	Yes	5.0 / 7.5	DD17-1 Landward	C-44
Overbank Deposits (Ha[ob])	Loose to medium dense, silty fine SAND, trace fine gravel (SM)	5.3×10^{-04}	Yes	12.5 / 15.0	DD17-1 Levee	C-45
Overbank Deposits (Ha[ob])	Loose, fine sandy SILT, trace of clay (ML)	3.4×10^{-07}	No	7.5	DD17-2 Landward	C-46
Overbank Deposits (Ha[ob])	Very soft, trace to slightly fine sandy SILT, trace of clay, scattered silty fine sand seams and layers (ML)	1.5×10^{-05}	No	24.5	DD17-2 Levee	C-47
Overbank Deposits (Ha[ob])	Very loose to loose, interbedded, fine sandy SILT to slightly silty and silty, fine SAND (ML/SM/SP-SM)	3.5×10^{-04}	No	5.9	DD17-3- Landward	C-48
Overbank Deposits (Ha[ob])	Loose, silty fine SAND to fine sandy SILT, laminated (SM/ML)	1.9×10^{-04}	Yes	12.5 / 15.0	DD17-3 Levee	C-49
Overbank Deposits (Ha[ob])	Loose, silty fine SAND, scattered roots (SM)	4.8×10^{-04}	Yes	2.5	DD22-1 Landward	C-50
Overbank / Fill (Ha[ob] / Hf)	Loose , fine sandy SILT to silty fine SAND, clayey silt pockets, scatered roots (ML/SM) / Loose silty fine SAND, scattered silt layers (SM)	1.2×10^{-04}	Yes	10.0 / 15.0 / 17.5	DD22-1 Levee	C-51
Overbank Deposits (Ha[ob])	Very loose, slightly fine sandy to fine sandy SILT, trace of clay to soft, slightly clayey SILT (ML)	2.9×10^{-05}	No	5.3	DD22-2 Landward	C-52
Channel Deposits (Ha[cd])	Loose, silty fine SAND to fine sandy SILT, laminated, scattered organics, scattered slightly clayey to clayey seams, slightly silty fine sand (SM/ML)	4.7×10^{-05}	No	41.2	DD22-2 Landward	C-53
Overbank Deposits (Ha[ob])	Medium stiff, clayey SILT, trace of fine sand, scattered organic-rich partings, scattered slightly fine sandy silt seams (ML)	2.2×10^{-04}	No	18.3	DD-22-2 Levee	C-54



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

NOTES

AD Sample air dried before testing
ND Sample not air dried

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	SMPL PREP.
● DD1-1 Levee, S-8	20.0	ML	Brown, slightly fine sandy SILT, trace of clay	31	27	4	37.8		JJM	ARM	ND
											ND
											ND
											ND
											ND
											ND
											ND

Skagit River Levee General Investigation
Skagit County, Washington

PLASTICITY CHART
BORING DD1-1 Levee

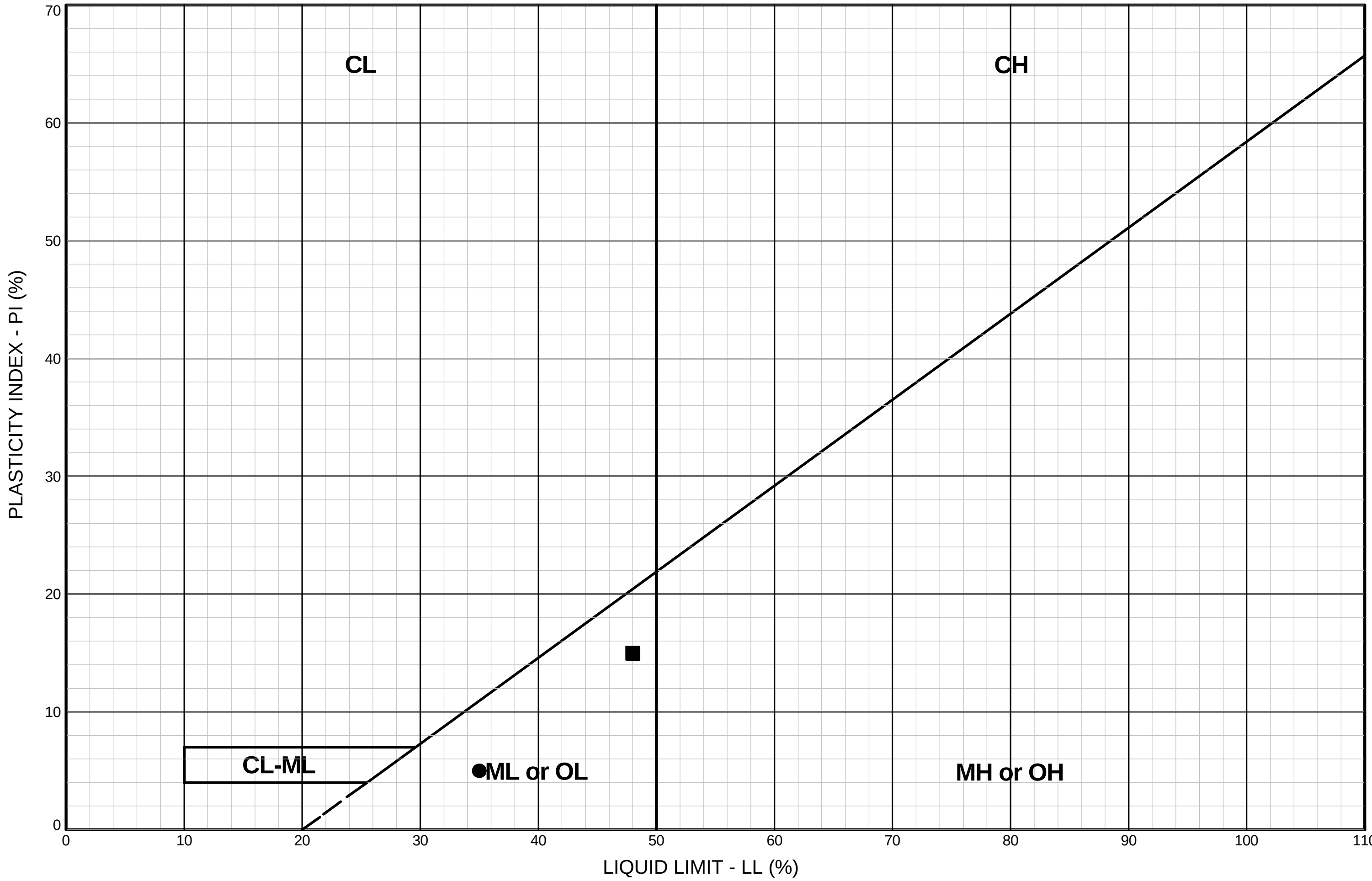
June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-1

AASHTO_ATT_MAIN_LOCAL 21-21199.GPJ SHAN_WIL.GDT 6/1/10

FIG. C-1



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

NOTES

AD Sample air dried before testing
ND Sample not air dried

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	SMPL PREP.
● DD1-2 Landward, S-2	5.9	ML	Gray-brown, slightly clayey SILT, trace of fine sand; scattered roots and organics; iron-oxide staining	35	30	5	44.5		JJM	ARM	ND
■ DD1-2 Landward, S-2	6.2	ML	Gray-brown, slightly clayey SILT; scattered organics	48	33	15			JJM	ARM	ND
											ND
											ND
											ND
											ND
											ND

Skagit River Levee General Investigation
Skagit County, Washington

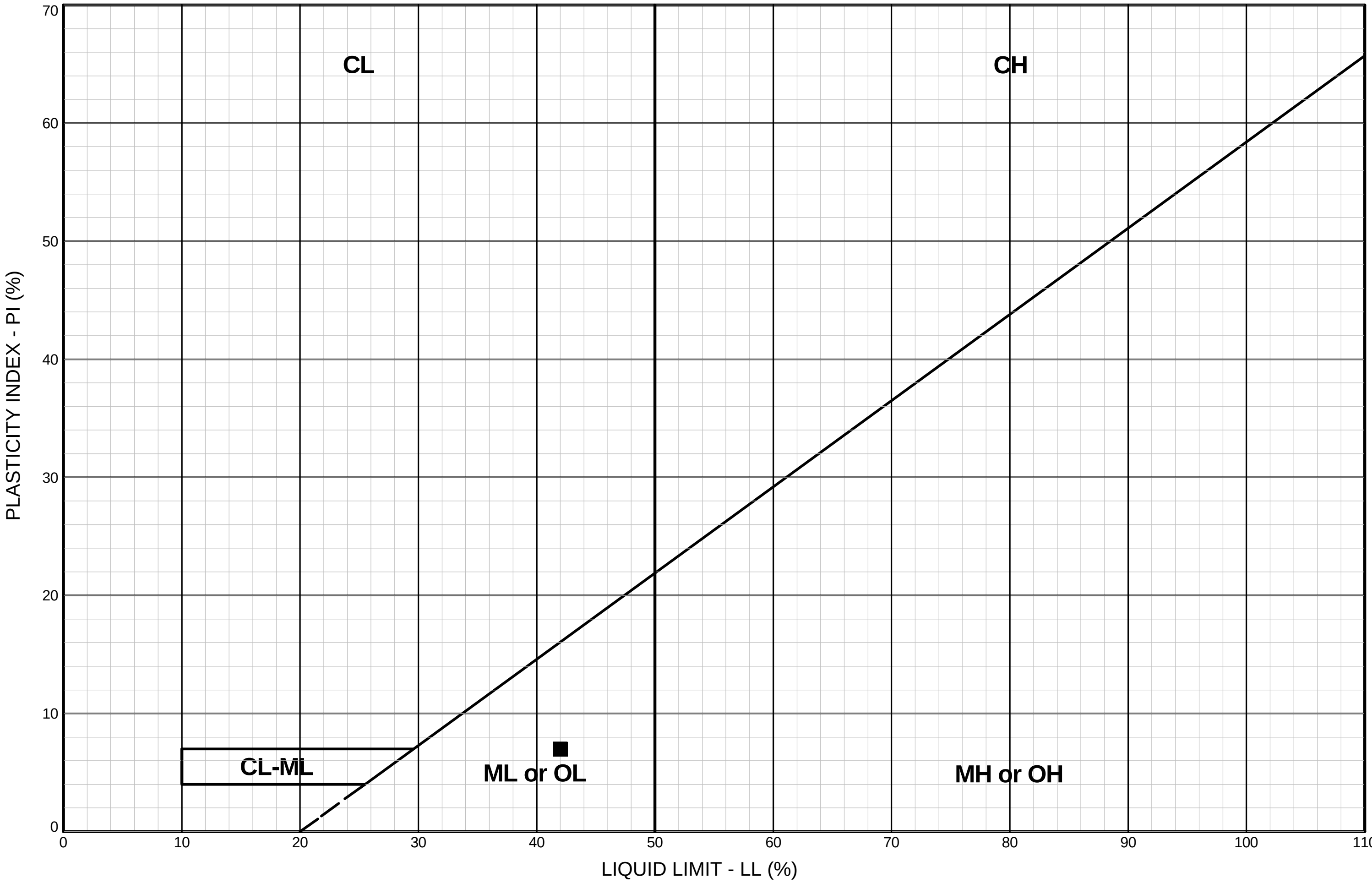
PLASTICITY CHART
BORING DD1-2 Landward

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-2

FIG. C-2



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

NOTES
AD Sample air dried before testing
ND Sample not air dried

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	SMPL PREP.
DD1-2 Levee, S-5	12.5	ML	Brown, fine sandy SILT	NP	NP	NP	23.2		JJM	ARM	ND
■ DD1-2 Levee, S-6	15.0	ML	Brown, slightly fine sandy SILT, trace of clay	42	35	7	37.4		JJM	ARM	ND
											ND
											ND
											ND
											ND
											ND

Skagit River Levee General Investigation
Skagit County, Washington

PLASTICITY CHART
BORING DD1-2 Levee

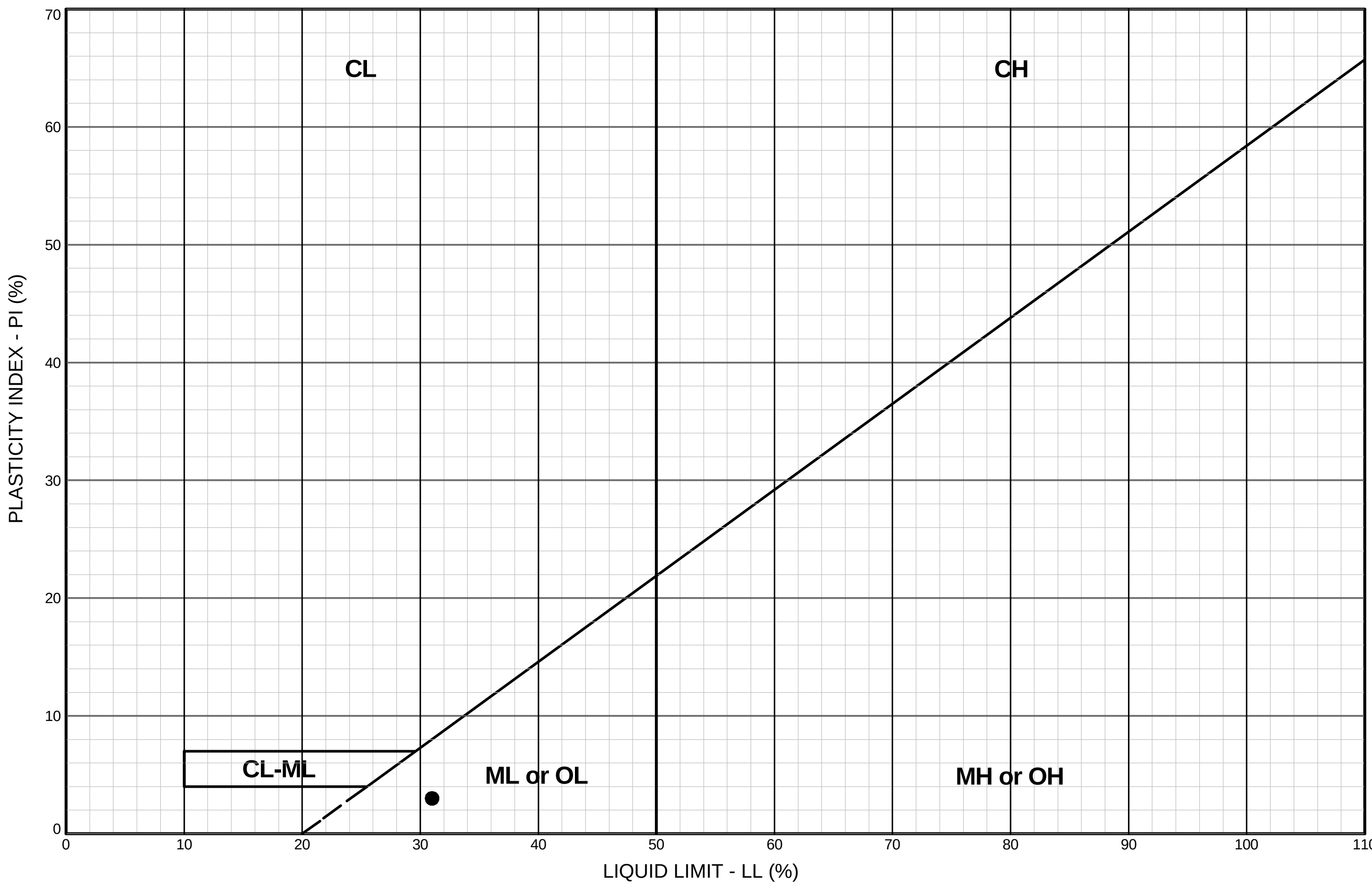
June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-3

FIG. C-3

AASHTO ATT MAIN LOCAL 21-21199.GPJ SHAN WIL.GDT 6/1/10



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

NOTES

AD Sample air dried before testing
ND Sample not air dried

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	SMPL PREP.
● DD3-1 Levee, S-6	15.0	ML	Brown, slightly clayey SILT, trace of fine sand	31	28	3	38.4		PEP	ARM	ND
											ND
											ND
											ND
											ND
											ND
											ND

Skagit River Levee General Investigation
Skagit County, Washington

PLASTICITY CHART
BORING DD3-1 Levee

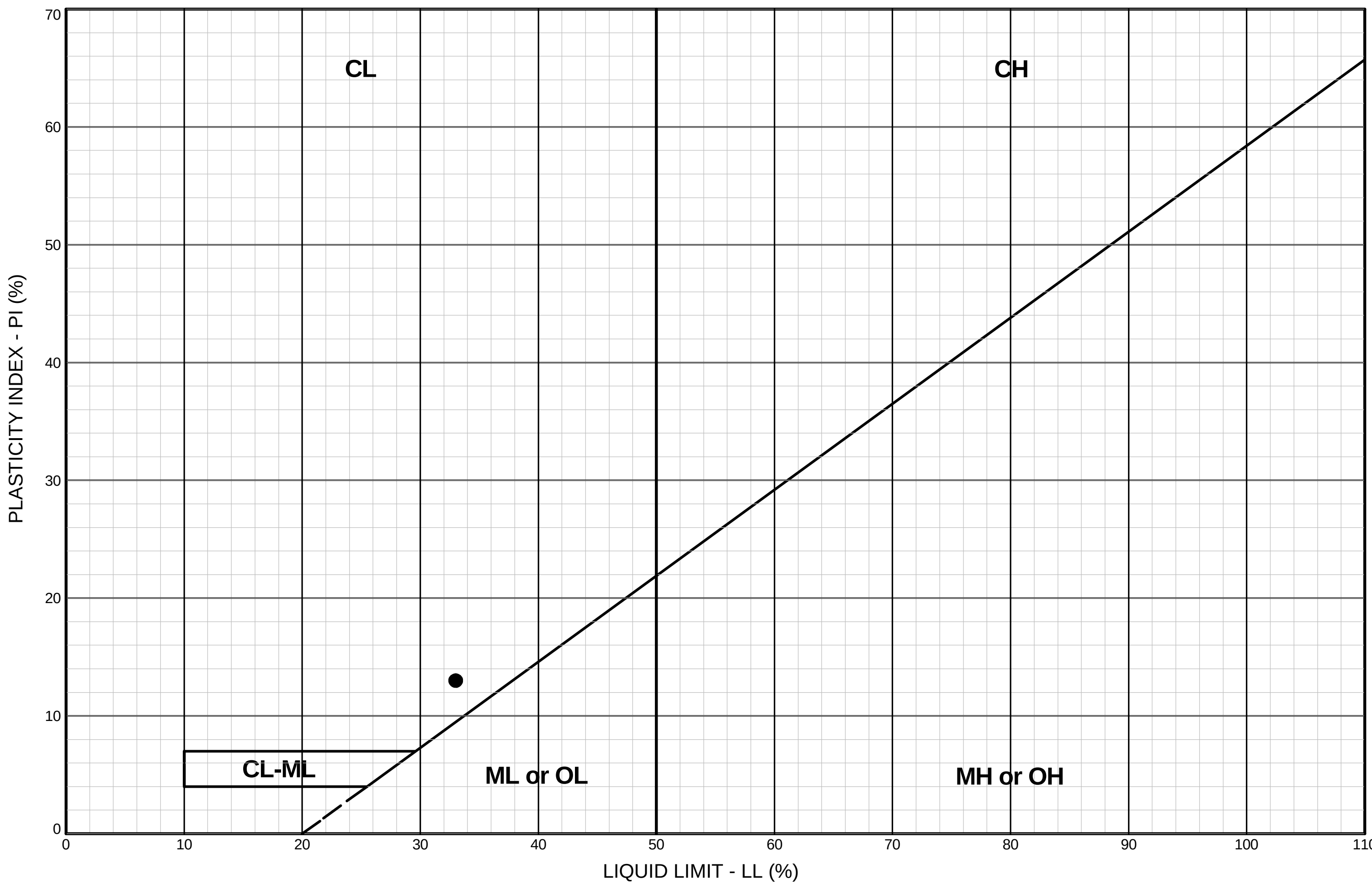
June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-4

AASHTO ATT MAIN LOCAL 21-21199.GPJ SHAN WIL.GDT 6/1/10

FIG. C-4



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

NOTES

AD Sample air dried before testing

ND Sample not air dried

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	SMPL PREP.
● DD17-1 Levee, S-2	5.0	CL	Brown, silty CLAY, trace of sand and fine gravel	33	20	13	20.5		JJM	ARM	ND
											ND
											ND
											ND
											ND
											ND
											ND

Skagit River Levee General Investigation
Skagit County, Washington

PLASTICITY CHART
BORING DD17-1 Levee

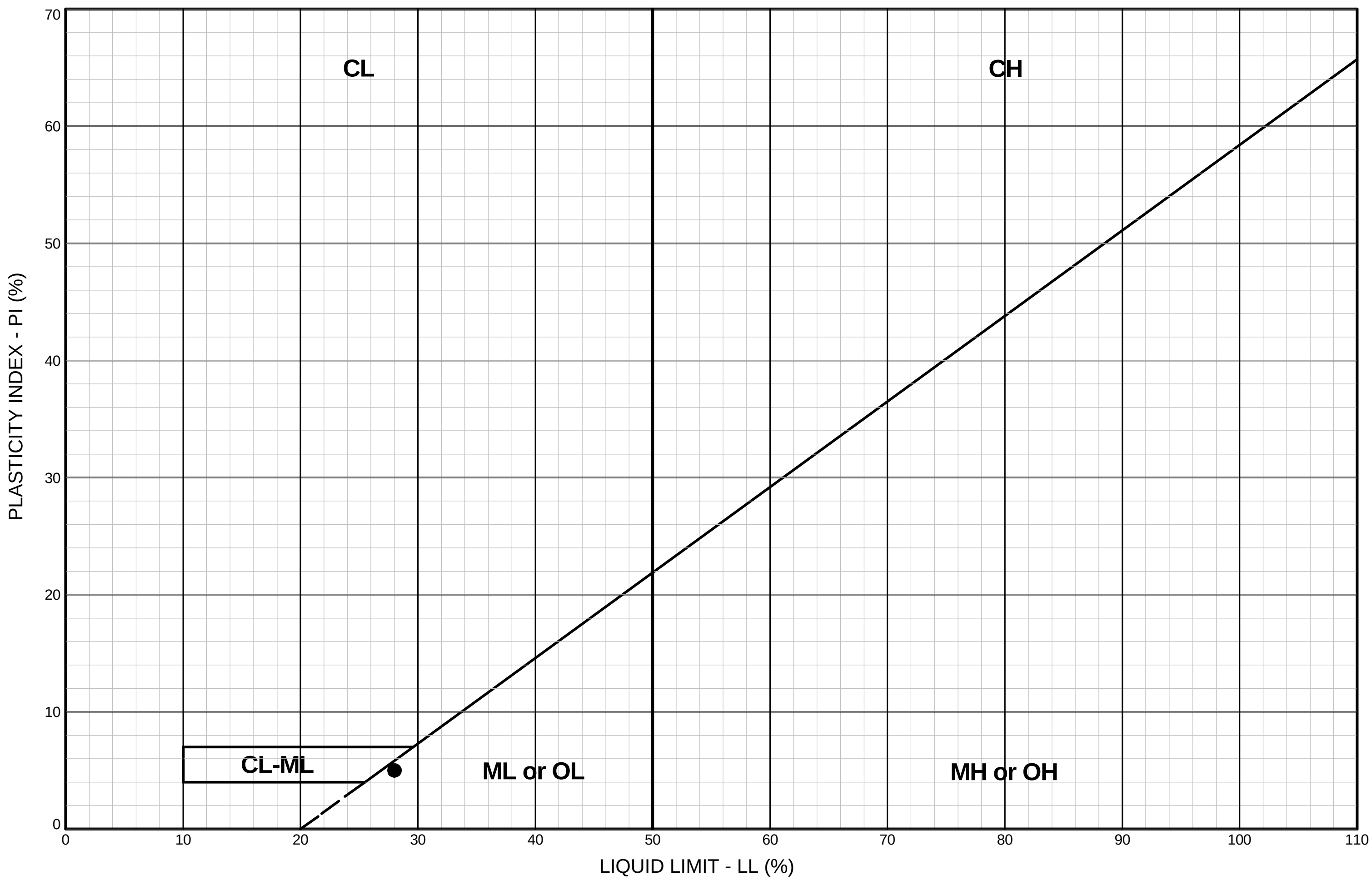
June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-5

AASHTO_ATT_MAIN_LOCAL 21-21199.GPJ SHAN_WIL.GDT 6/1/10

FIG. C-5



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

NOTES

AD Sample air dried before testing
ND Sample not air dried

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	SMPL PREP.
● DD17-2 Landward, S-4	10.0	ML	Brown, slightly clayey, fine sandy SILT	28	23	5	24.3		KTB	ARM	ND
											ND
											ND
											ND
											ND
											ND
											ND

Skagit River Levee General Investigation
Skagit County, Washington

PLASTICITY CHART
BORING DD17-2 Landward

June 2010 21-1-21199-002

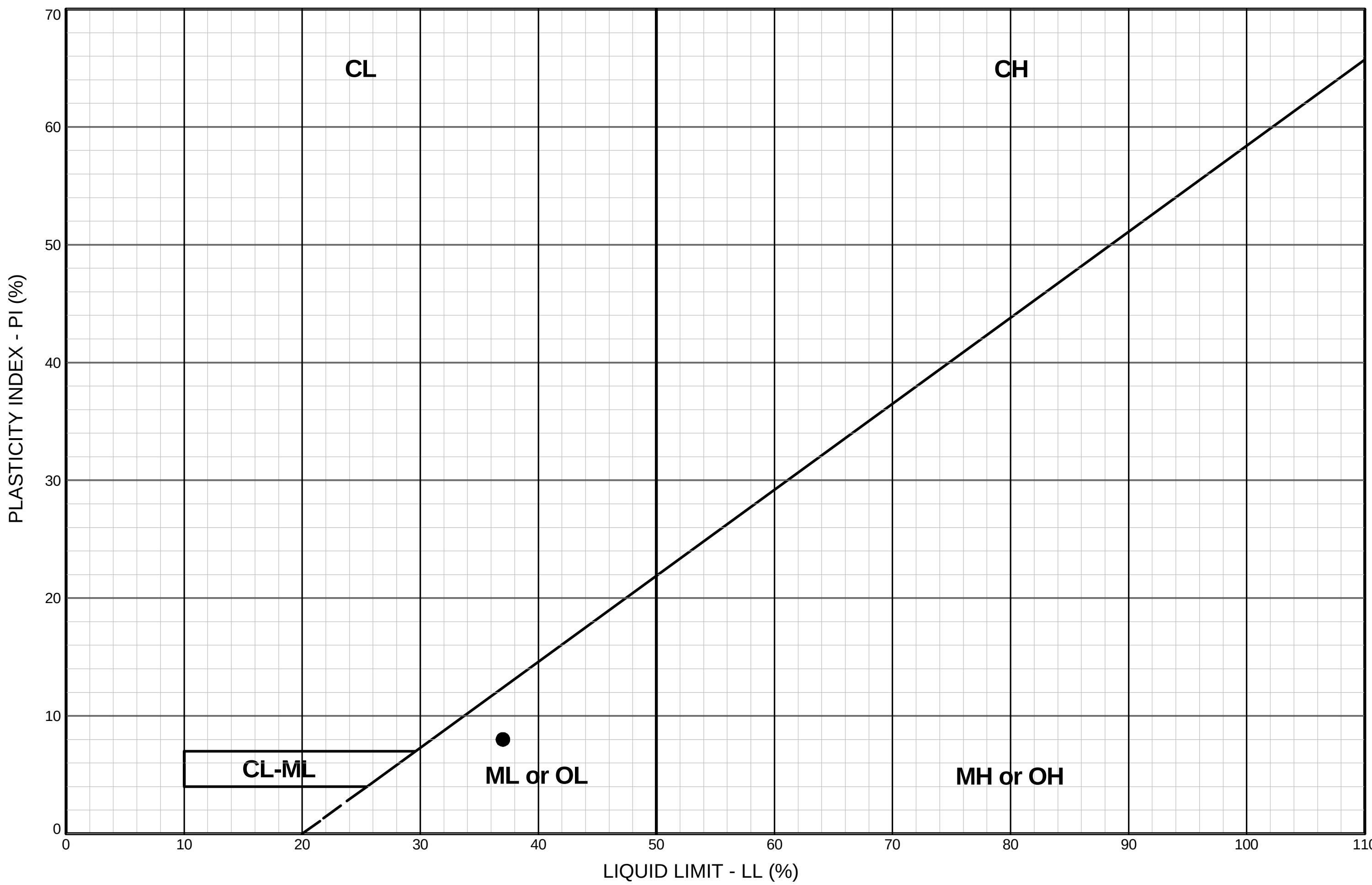
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-6

FIG. C-6

AASHTO_ATT_MAIN_LOCAL 21-21199.GPJ SHAN_WIL.GDT 6/1/10

AASHTO_ATT_MAIN_LOCAL 21-21199.GPJ SHAN_WIL.GDT 6/1/10



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

NOTES

AD Sample air dried before testing
ND Sample not air dried

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	SMPL PREP.
● DD17-2 Levee, S-8	20.0	ML	Brown, slightly fine sandy, slightly clayey SILT	37	29	8	31.9		KTB	ARM	ND
DD17-2 Levee, S-11	27.5	ML	Gray-brown, slightly fine sandy SILT	NP	NP	NP	45.0		JJM	ARM	ND
											ND
											ND
											ND
											ND
											ND

Skagit River Levee General Investigation
Skagit County, Washington

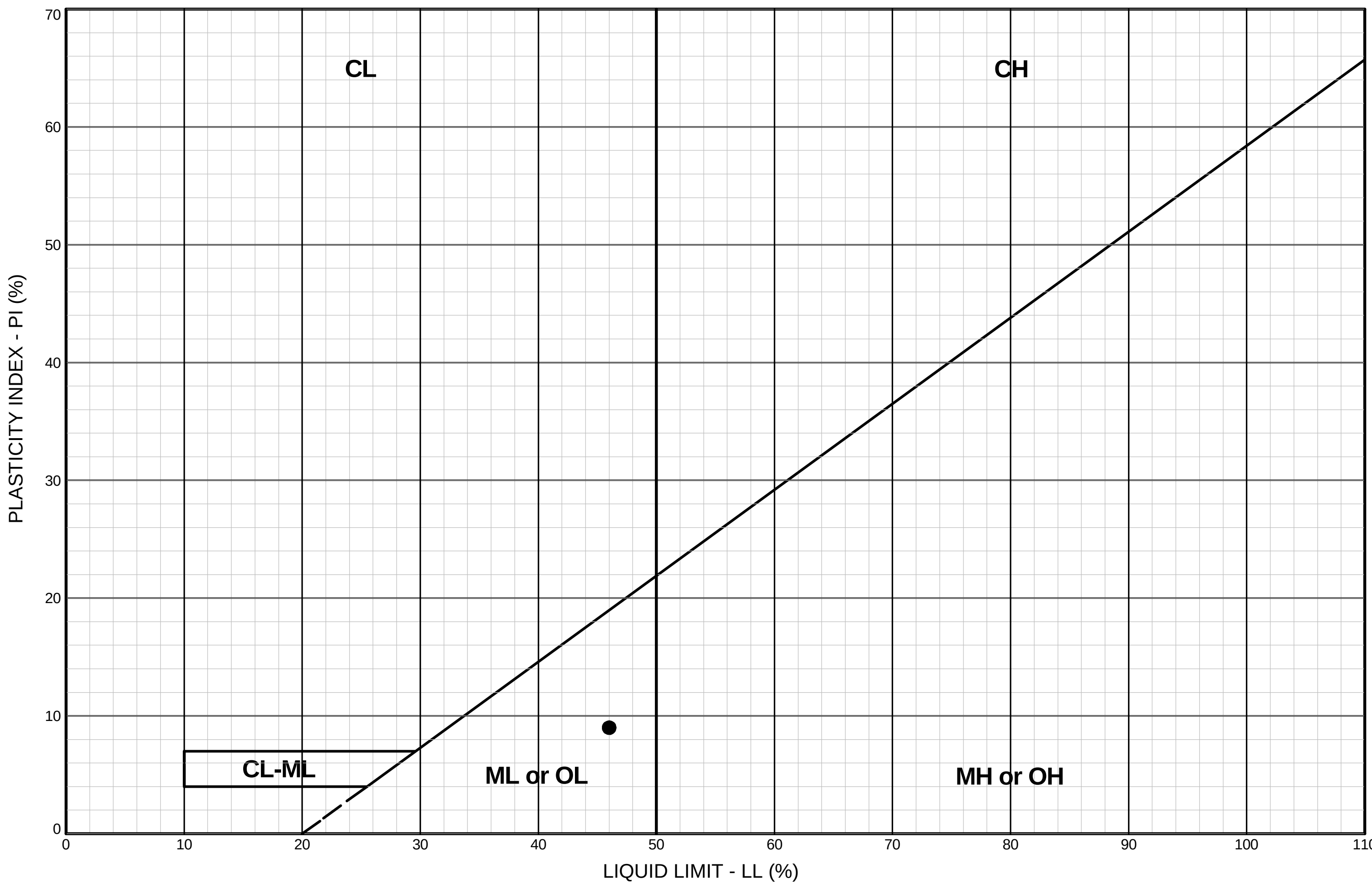
PLASTICITY CHART
BORING DD17-2 Levee

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-7

FIG. C-7



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

NOTES

AD Sample air dried before testing

ND Sample not air dried

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	SMPL PREP.
● DD17-3 Landward, S-14	50.0	ML	Gray, slightly clayey SILT	46	37	9	43.2		JJM	ARM	ND
											ND
											ND
											ND
											ND
											ND
											ND

Skagit River Levee General Investigation
Skagit County, Washington

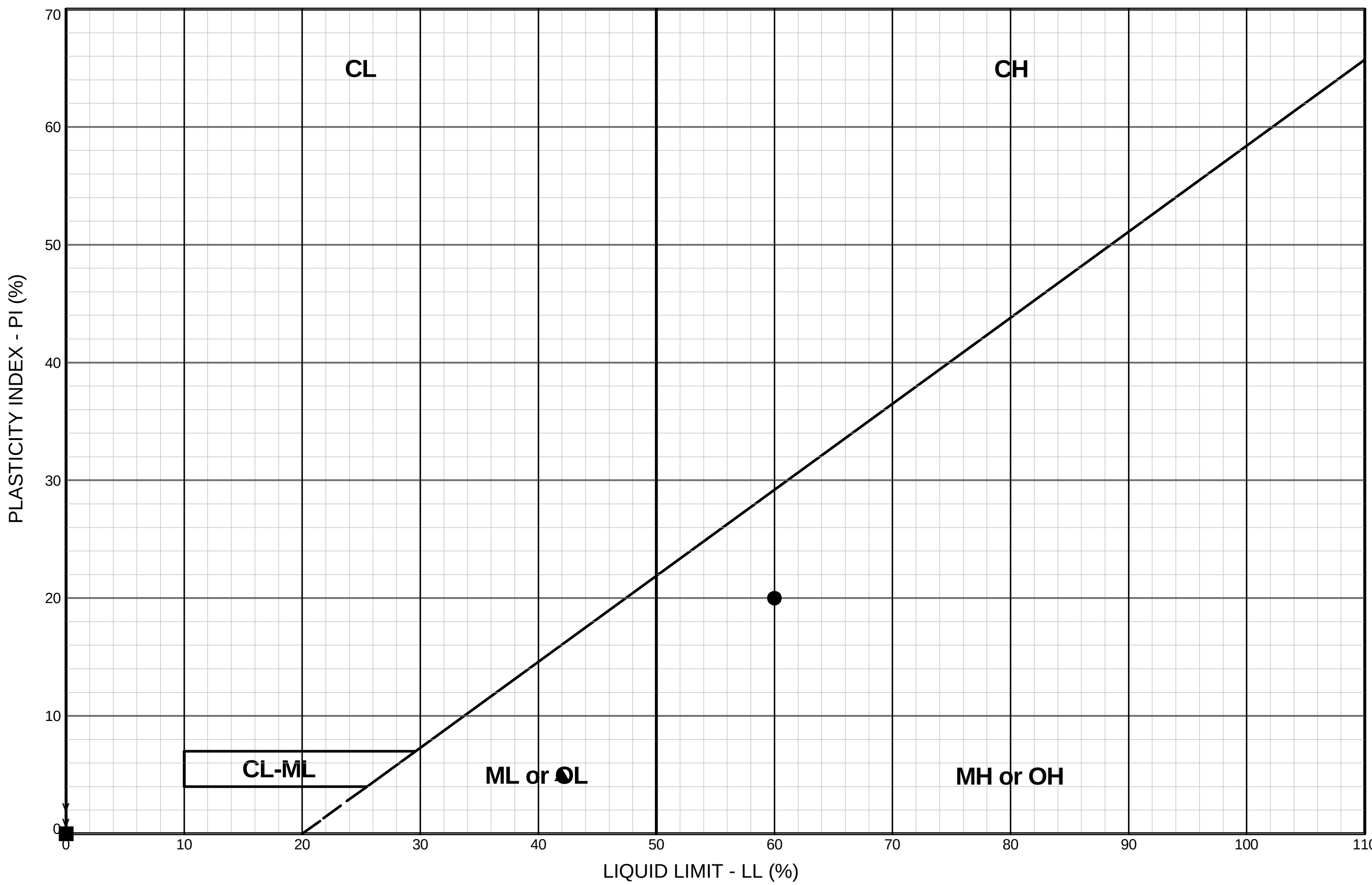
PLASTICITY CHART
BORING DD17-3 Landward

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-8

AASHTO_ATT_MAIN_LOCAL 21-21199.GPJ SHAN_WIL.GDT 6/1/10



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

NOTES

AD Sample air dried before testing

ND Sample not air dried

AASHTO_ATT_MAIN LOCAL 21-21199.GPJ SHAN_WIL.GDT 6/1/10

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	SMPL PREP.
● DD17-3 Levee, S-17	62.0	MH	Gray, clayey SILT	60	40	20	39.1		JJM	ARM	ND
DD17-3 Levee, S-17	62.9	ML	Gray SILT; scattered organics	NP	34	NP			JJM	ARM	ND
▲ DD17-3 Levee, S-17	63.3	ML	Gray, slightly clayey SILT; scattered organics	42	37	5			JJM	ARM	ND
											ND
											ND
											ND
											ND

Skagit River Levee General Investigation
Skagit County, Washington

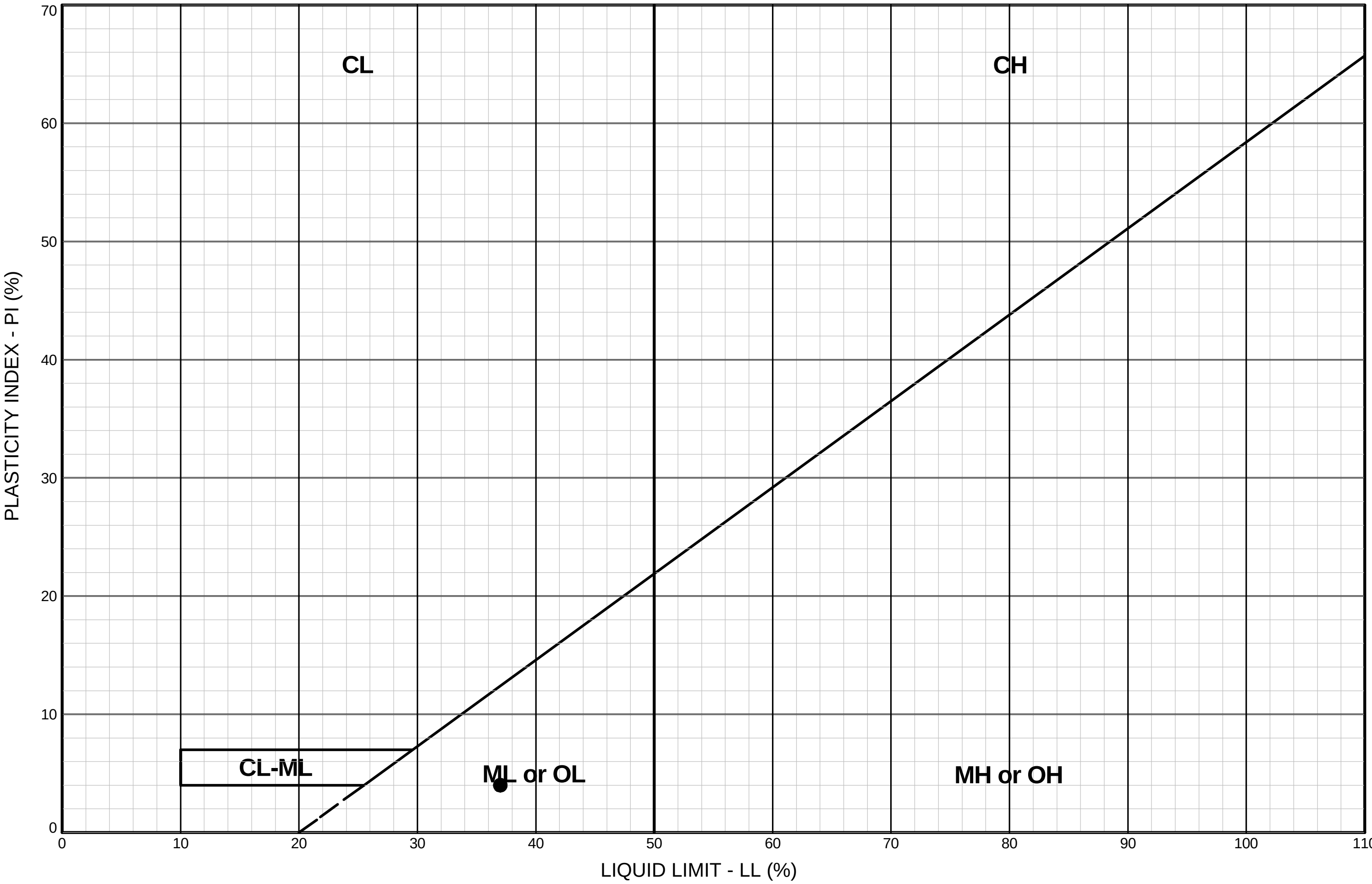
PLASTICITY CHART
BORING DD17-3 Levee

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-9

FIG. C-9



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

NOTES

AD Sample air dried before testing
ND Sample not air dried

AASHTO_ATT_MAIN_LOCAL 21-21199.GPJ SHAN_WIL.GDT 6/1/10

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	SMPL PREP.
● DD22-2 Landward, S-2	6.4	ML	Gray, slightly clayey SILT; scattered organics	37	33	4			JJM	ARM	ND
											ND
											ND
											ND
											ND
											ND
											ND

Skagit River Levee General Investigation
Skagit County, Washington

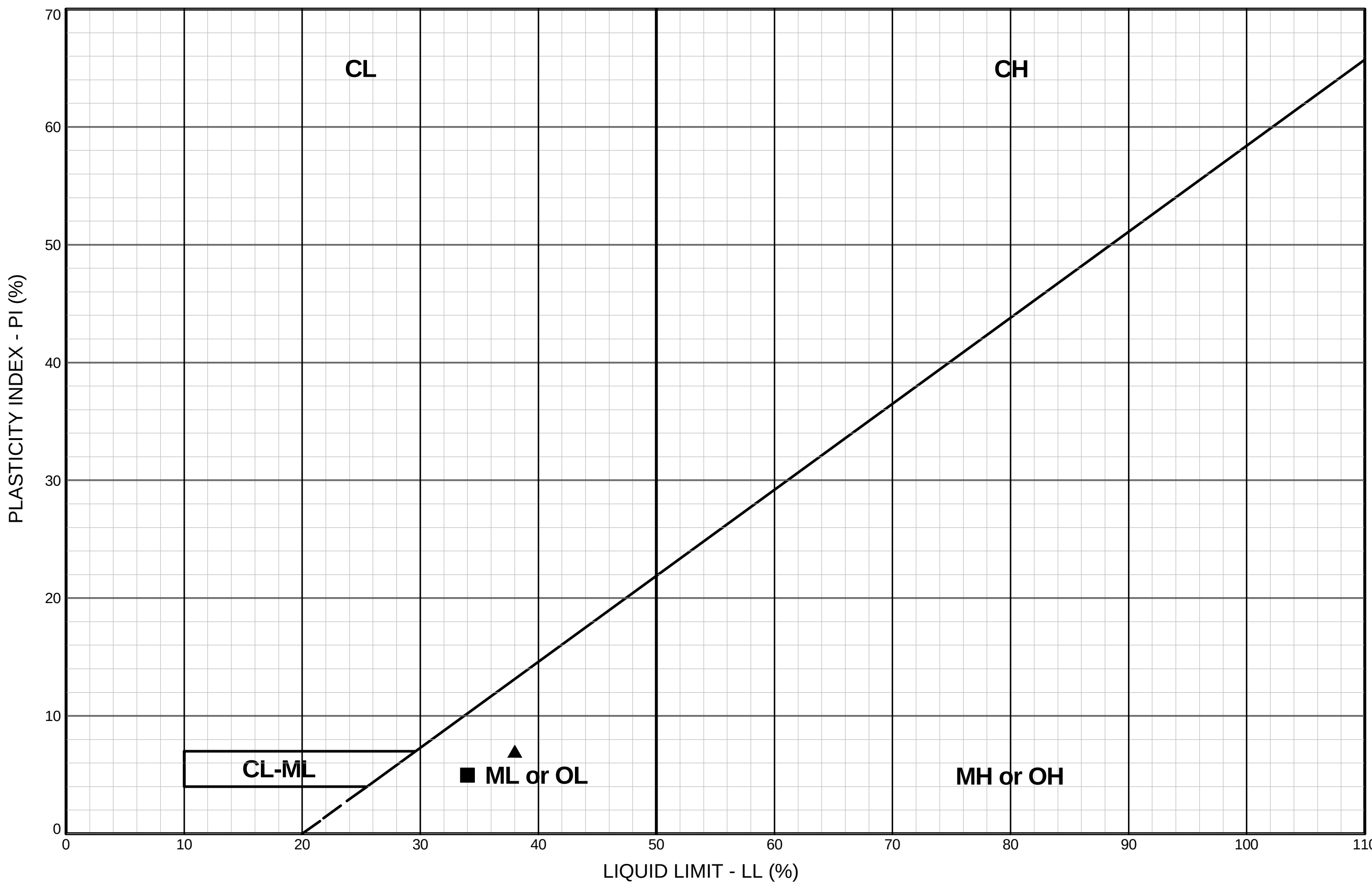
PLASTICITY CHART
BORING DD22-2 Landward

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-10

FIG. C-10



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

NOTES

AD Sample air dried before testing

ND Sample not air dried

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	SMPL PREP.
DD22-2 Levee, S-6	15.0	ML	Brown, slightly fine sandy SILT	NP	NP	NP	34.4		JJM	ARM	ND
■ DD22-2 Levee, S-7	18.6	ML	Gray-brown, clayey SILT, trace of fine sand; iron-oxide staining	34	29	5			PEP	ARM	ND
▲ DD22-2 Levee, S-8	20.0	ML	Gray-brown, clayey SILT, trace of fine sand	38	31	7	38.5		JJM	ARM	ND
											ND
											ND
											ND
											ND

Skagit River Levee General Investigation
Skagit County, Washington

PLASTICITY CHART
BORING DD22-2 Levee

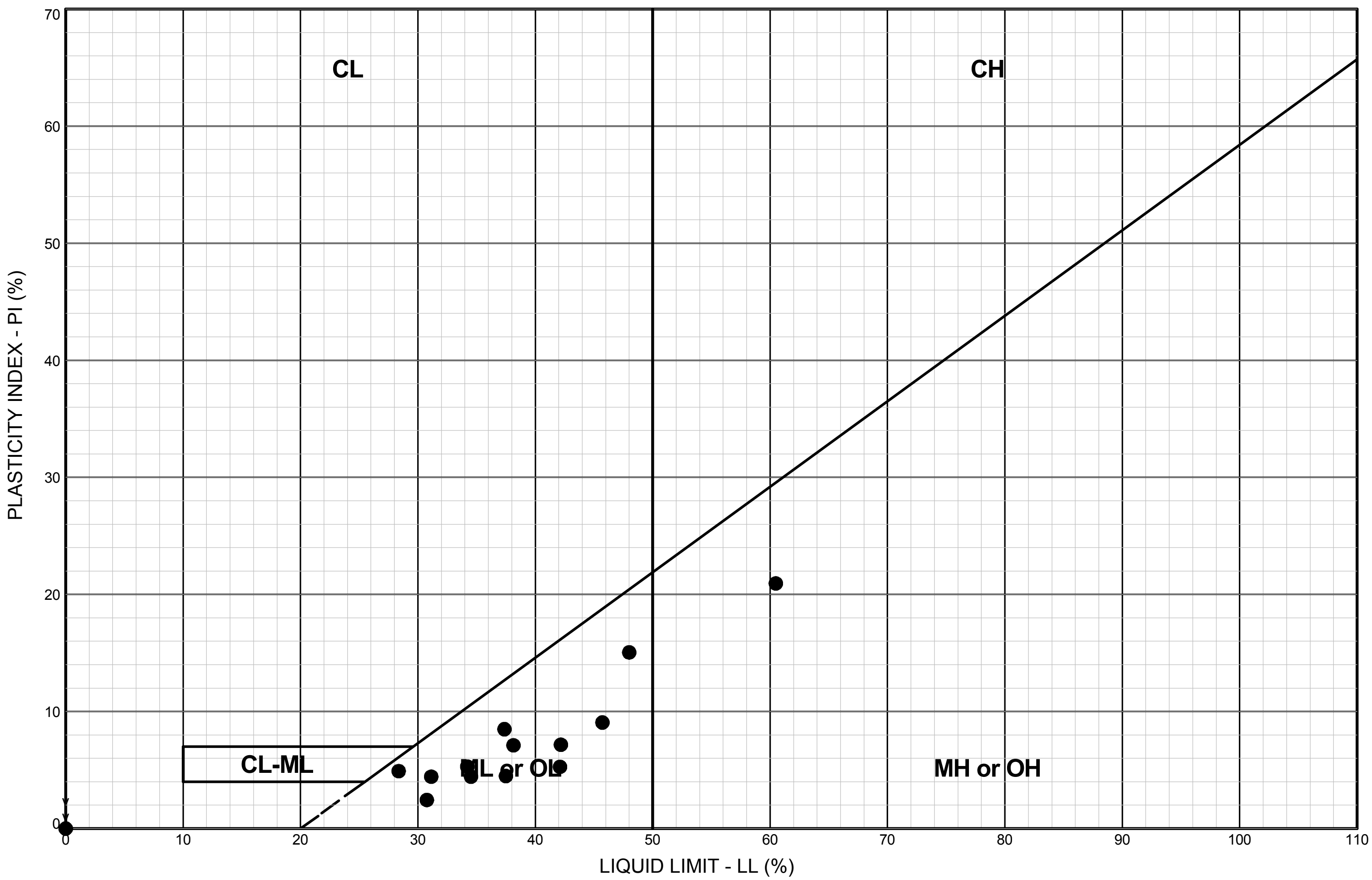
June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-11

FIG. C-11

AASHTO_ATT_MAIN_LOCAL 21-21199.GPJ SHAN_WIL.GDT 6/1/10



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

ATT_UNIT LOCAL 21-21199.GPJ SHAN_WIL.GDT 6/1/10

Skagit River Levee General Investigation
Skagit County, Washington

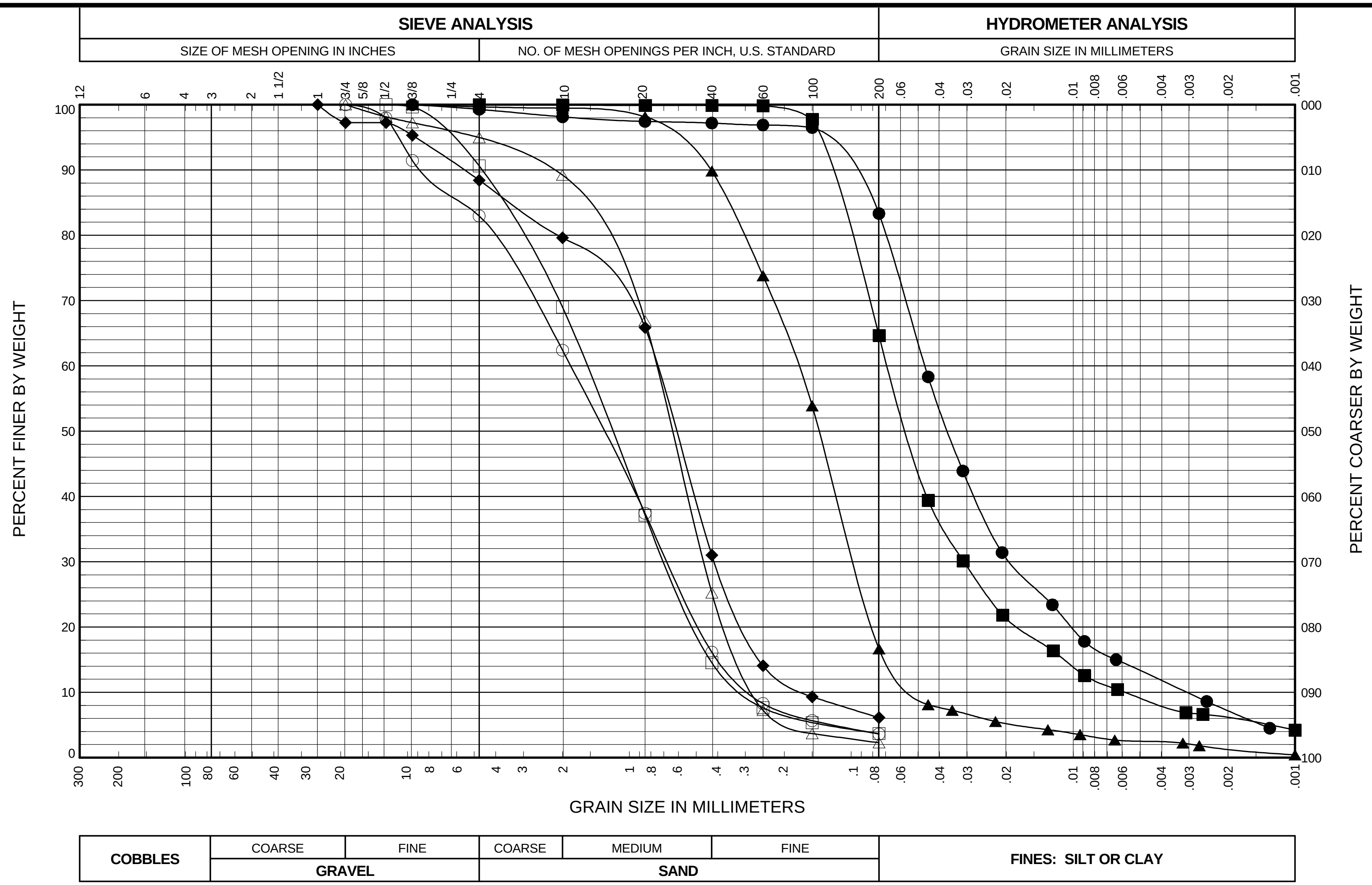
PLASTICITY CHART

Overbank Deposits (Ha[ob])

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-12



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 STND
● DD1-1 Landward, S-1	2.5	ML	Brown, fine sandy SILT				26.8	83.3	PAJ	ARM	D422
■ DD1-1 Landward, S-3	7.5	ML	Brown, fine sandy SILT; trace of organics				26.8	64.7	PEP	ARM	D422
▲ DD1-1 Landward, S-4	10.0	SM	Brown, silty, fine to medium SAND				16.8	16.6	PEP	ARM	D422
◆ DD1-1 Landward, S-6*	15.0	SP-SM	Gray, slightly silty, slightly fine gravelly SAND				20.1	6.1	EXH	ARM	D422
○ DD1-1 Landward, S-7*	17.5	SP	Gray, fine gravelly SAND, trace of silt				16.7	3.6	EXH	ARM	D422
□ DD1-1 Landward, S-8	20.0	SP	Gray, slighlty fine gravelly SAND, trace of silt				16.7	3.7	PAJ	ARM	D422
△ DD1-1 Landward, S-10*	30.0	SP	Gray, slightly fine gravelly SAND, trace of silt				21.1	2.3	EXH	ARM	D422

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

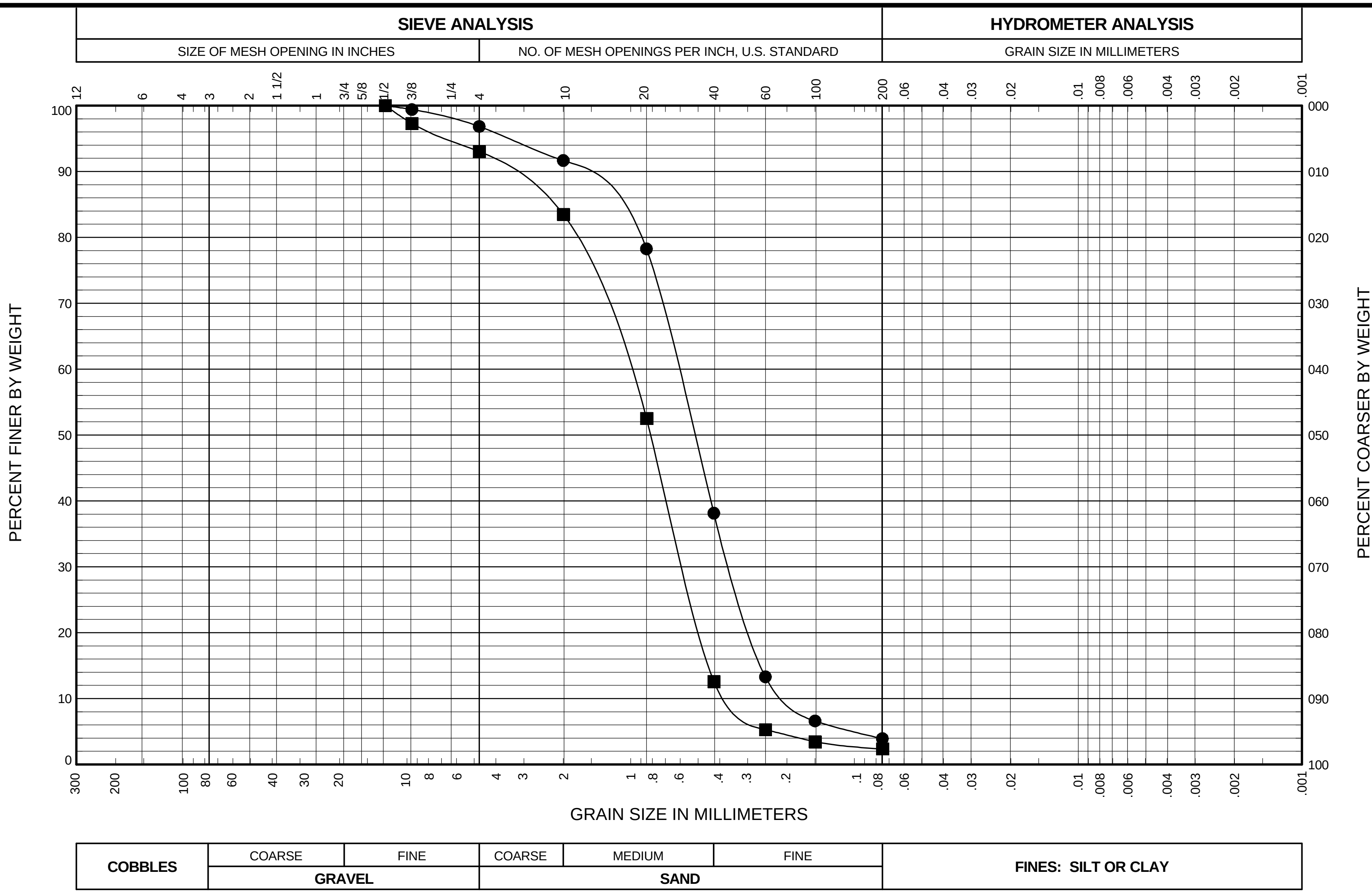
Skagit River Levee General Investigation
Skagit County, Washington

GRAIN SIZE DISTRIBUTION
BORING DD1-1 Landward

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-13
Sheet 1 of 2



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 STND
● DD1-1 Landward, S-11*	35.0	SP	Gray SAND, trace of silt and fine gravel				22.5	3.9	PAJ	ARM	D422
■ DD1-1 Landward, S-12*	40.0	SP	Gray, slightly fine gravelly SAND, trace of silt				20.3	2.4	EXH	ARM	D422

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

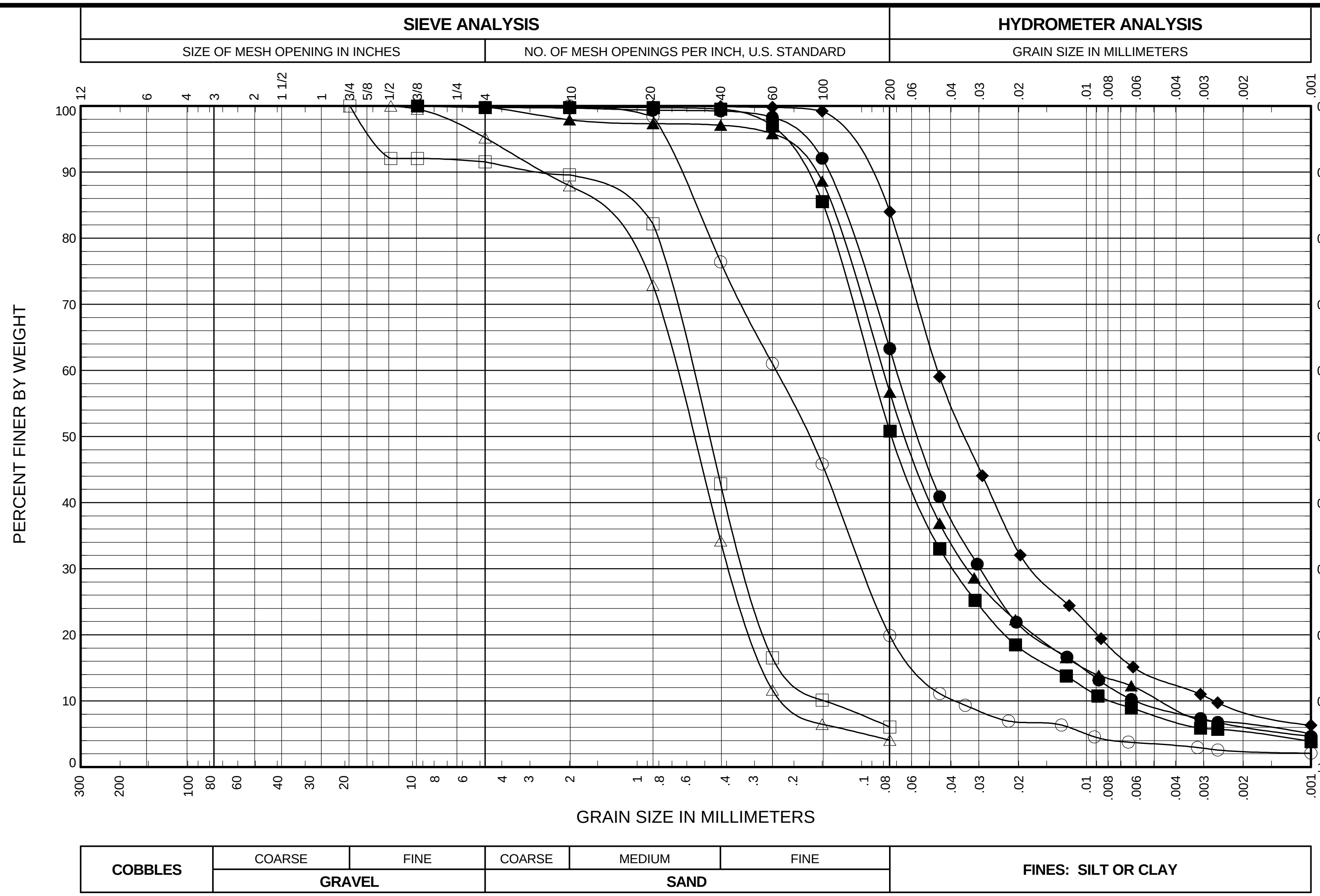
Skagit River Levee General Investigation
Skagit County, Washington

GRAIN SIZE DISTRIBUTION
BORING DD1-1 Landward

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-13
Sheet 2 of 2



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 STND
● DD1-1 Levee, S-1	2.5	ML	Brown, fine sandy SILT				12.6	63.3	AYC	ARM	D422
■ DD1-1 Levee, S-3	7.5	ML	Brown, fine sandy SILT; trace of organics				21.3	50.8	AYC	ARM	D422
▲ DD1-1 Levee, S-5	12.5	ML	Brown, fine sandy SILT				23.1	56.7	PEP	ARM	D422
◆ DD1-1 Levee, S-7	17.5	ML	Brown, fine sandy SILT, trace of clay				32.7	84.0	AYC	ARM	D422
○ DD1-1 Levee, S-9	25.0	SM	Brown, silty, fine to medium SAND				23.3	19.9	AYC	ARM	D422
□ DD1-1 Levee, S-12*	35.0	SP-SM	Gray, slightly silty, slightly fine gravelly, fine to medium SAND				20.9	6.1	EXH	ARM	D422
△ DD1-1 Levee, S-13*	40.0	SP	Gray SAND, trace of fine gravel and silt				19.7	4.1	EXH	ARM	D422

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

Skagit River Levee General Investigation
Skagit County, Washington

GRAIN SIZE DISTRIBUTION
BORING DD1-1 Levee

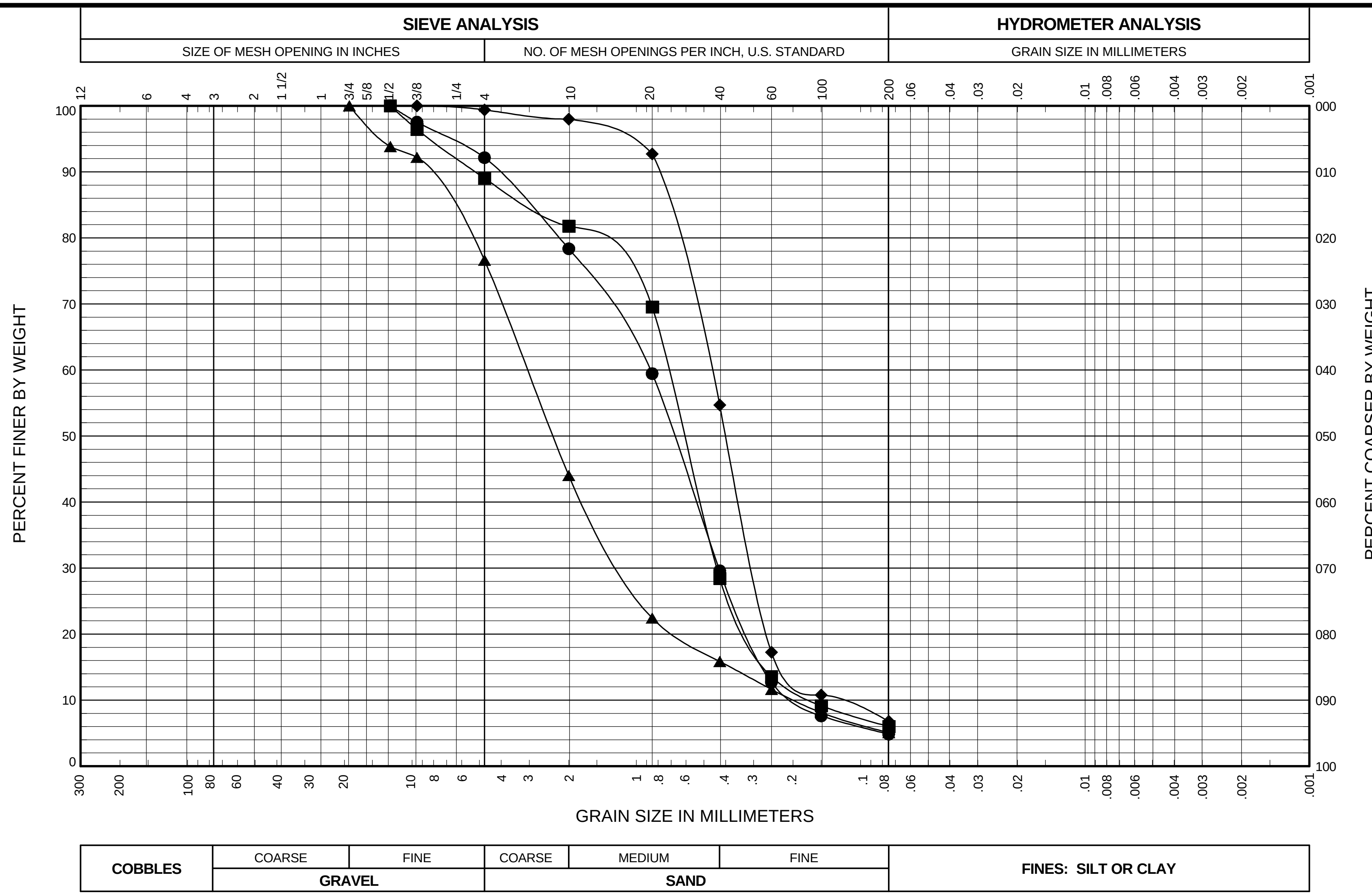
June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-14
Sheet 1 of 2

AASHTO GSA MAIN LOCAL 21-21199.GPJ SHAN WIL.GDT 6/1/10

FIG. C-14



AASHTO GSA MAIN LOCAL 21-21199.GPJ SHAN WIL.GDT 6/1/10

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 STND
● DD1-1 Levee, S-14*	45.0	SP	Gray, slightly fine gravelly SAND, trace of silt				18.7	4.9	EXH	ARM	D422
■ DD1-1 Levee, S-15*	50.0	SP-SM	Gray, slightly silty, slightly fine gravelly SAND				16.1	6.0	WBC	ARM	D422
▲ DD1-1 Levee, S-16*	55.0	SW-SM	Gray, slightly silty, fine gravelly SAND				12.5	5.1	EXH	ARM	D422
◆ DD1-1 Levee, S-17*	60.0	SP-SM	Gray, slightly silty, fine to medium SAND				23.5	6.8	EXH	ARM	D422

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

Skagit River Levee General Investigation
Skagit County, Washington

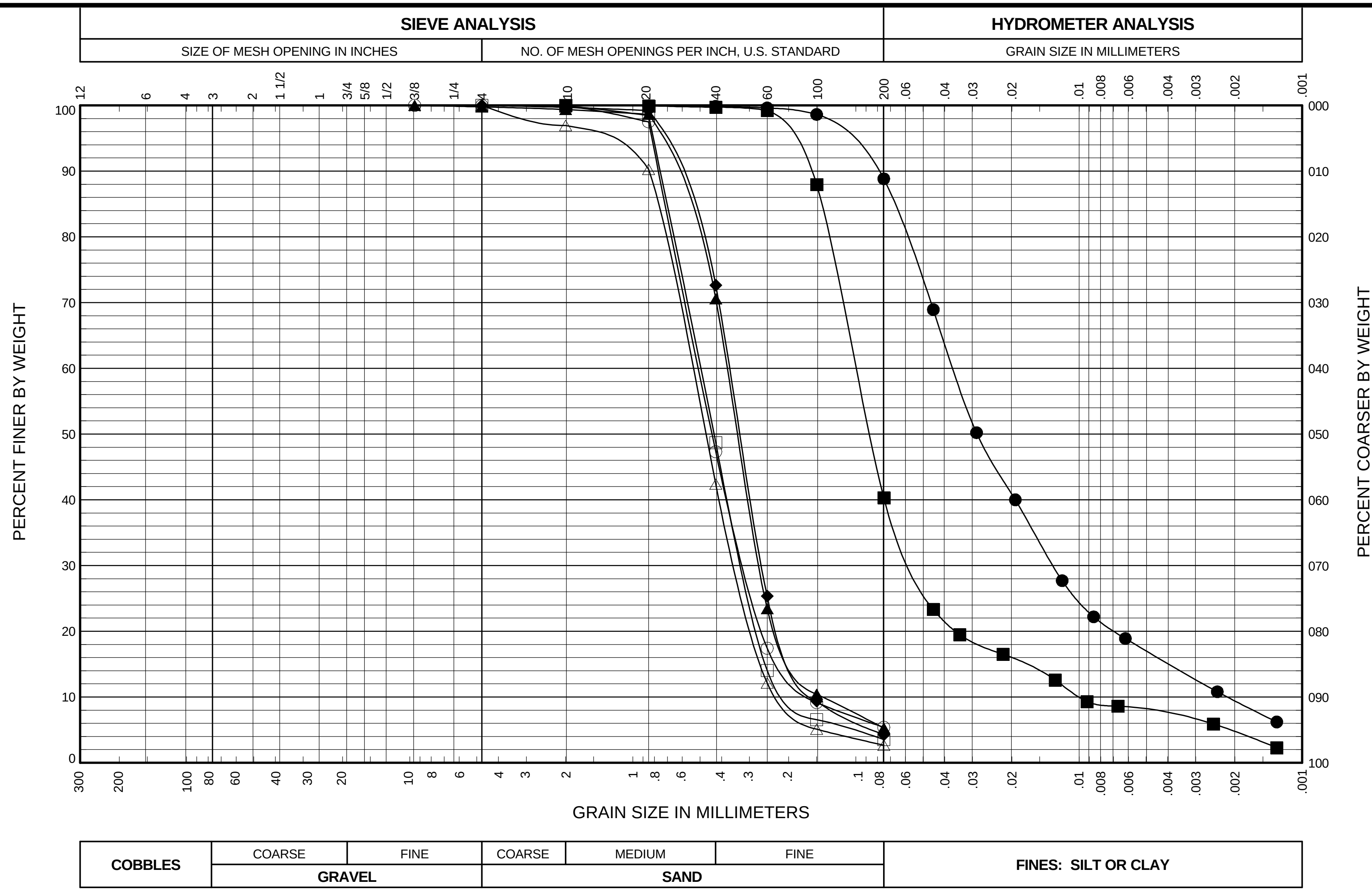
GRAIN SIZE DISTRIBUTION
BORING DD1-1 Levee

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-14
Sheet 2 of 2

FIG. C-14



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 STND
● DD1-2 Landward, S-1	2.5	ML	Brown, slightly clayey, slightly fine sandy SILT				42.0	88.8	AYC	ARM	D422
■ DD1-2 Landward, S-3	7.5	SM	Brown, silty, fine SAND				31.8	40.3	AYC	ARM	D422
▲ DD1-2 Landward, S-5*	12.5	SP-SM	Gray, slightly silty, fine to medium SAND; trace of organics (roots)				34.4	5.3	PAJ	ARM	D422
◆ DD1-2 Landward, S-6	15.0	SP	Gray, fine to medium SAND, trace of silt				29.4	4.3	EXH	ARM	D422
○ DD1-2 Landward, S-7	17.5	SP-SM	Gray, slightly silty, fine to medium SAND; trace of organics (roots)				24.2	5.4	PAJ	ARM	D422
□ DD1-2 Landward, S-8	20.0	SP	Gray, fine to medium SAND, trace of silt				25.8	3.5	EXH	ARM	D422
△ DD1-2 Landward, S-9	25.0	SP	Gray, fine to medium SAND, trace of silt; scattered wood fragments				37.5	2.7	EXH	ARM	D422

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

Skagit River Levee General Investigation
Skagit County, Washington

GRAIN SIZE DISTRIBUTION
BORING DD1-2 Landward

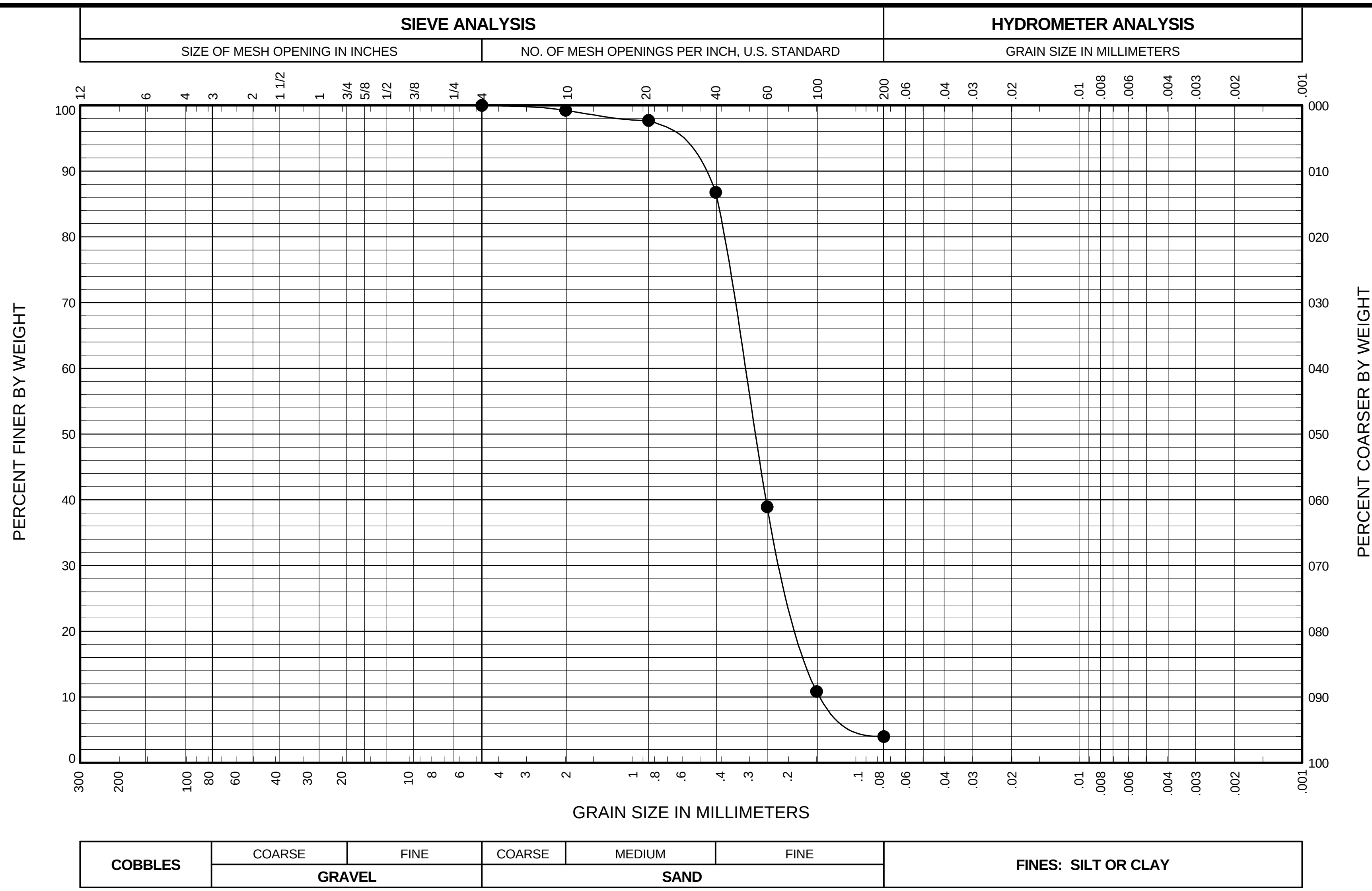
June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-15
Sheet 1 of 2

AASHTO GSA MAIN LOCAL 21-21199.GPJ SHAN WIL.GDT 6/1/10

FIG. C-15



AASHTO GSA MAIN LOCAL 21-21199.GPJ SHAN WIL.GDT 6/1/10

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 STND
● DD1-2 Landward, S-10	30.0	SP	Gray, fine to medium SAND, trace of silt				27.1	4.0	EXH	ARM	D422

Skagit River Levee General Investigation
Skagit County, Washington

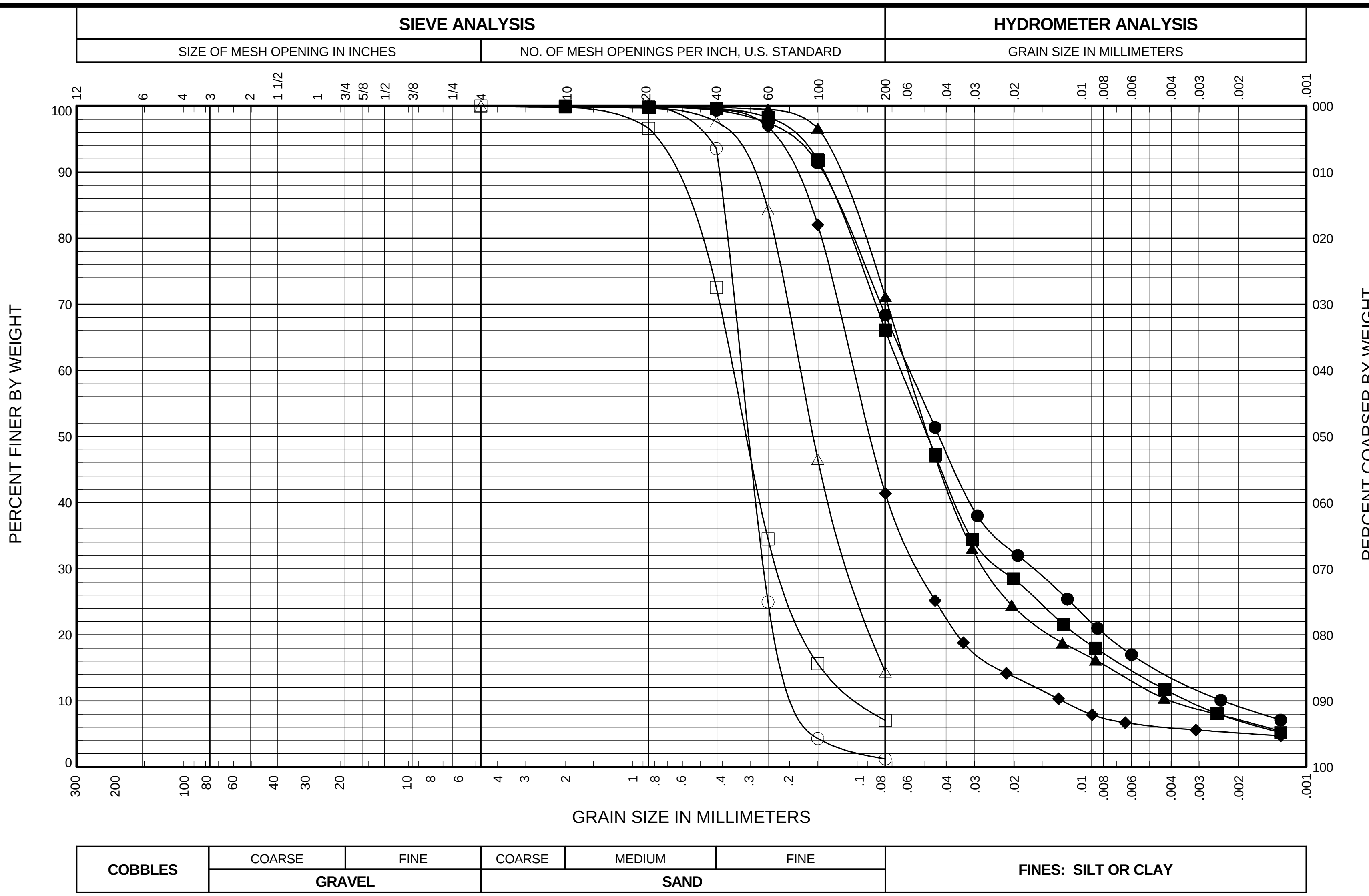
GRAIN SIZE DISTRIBUTION
BORING DD1-2 Landward

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-15
Sheet 2 of 2

FIG. C-15



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 STND
● DD1-2 Levee, S-2	5.0	ML	Brown, fine sandy SILT				25.6	68.4	AYC	ARM	D422
■ DD1-2 Levee, S-4	10.0	ML	Brown, fine sandy SILT				23.0	66.1	AYC	ARM	D422
▲ DD1-2 Levee, S-7	17.5	ML	Brown, fine sandy SILT				34.3	71.1	AYC	ARM	D422
◆ DD1-2 Levee, S-8	20.0	SM	Brown, silty, fine SAND				34.7	41.4	AYC	ARM	D422
○ DD1-2 Levee, S-9	25.0	SP	Gray, fine SAND, trace of silt				29.1	1.2	EXH	ARM	D422
□ DD1-2 Levee, S-10	30.0	SP-SM	Gray, slightly silty, fine to medium SAND				22.9	7.0	EXH	ARM	D422
△ DD1-2 Levee, S-11	35.0	SM	Gray, silty, fine SAND				27.2	14.4	EXH	ARM	D422

Skagit River Levee General Investigation
Skagit County, Washington

GRAIN SIZE DISTRIBUTION
BORING DD1-2 Levee

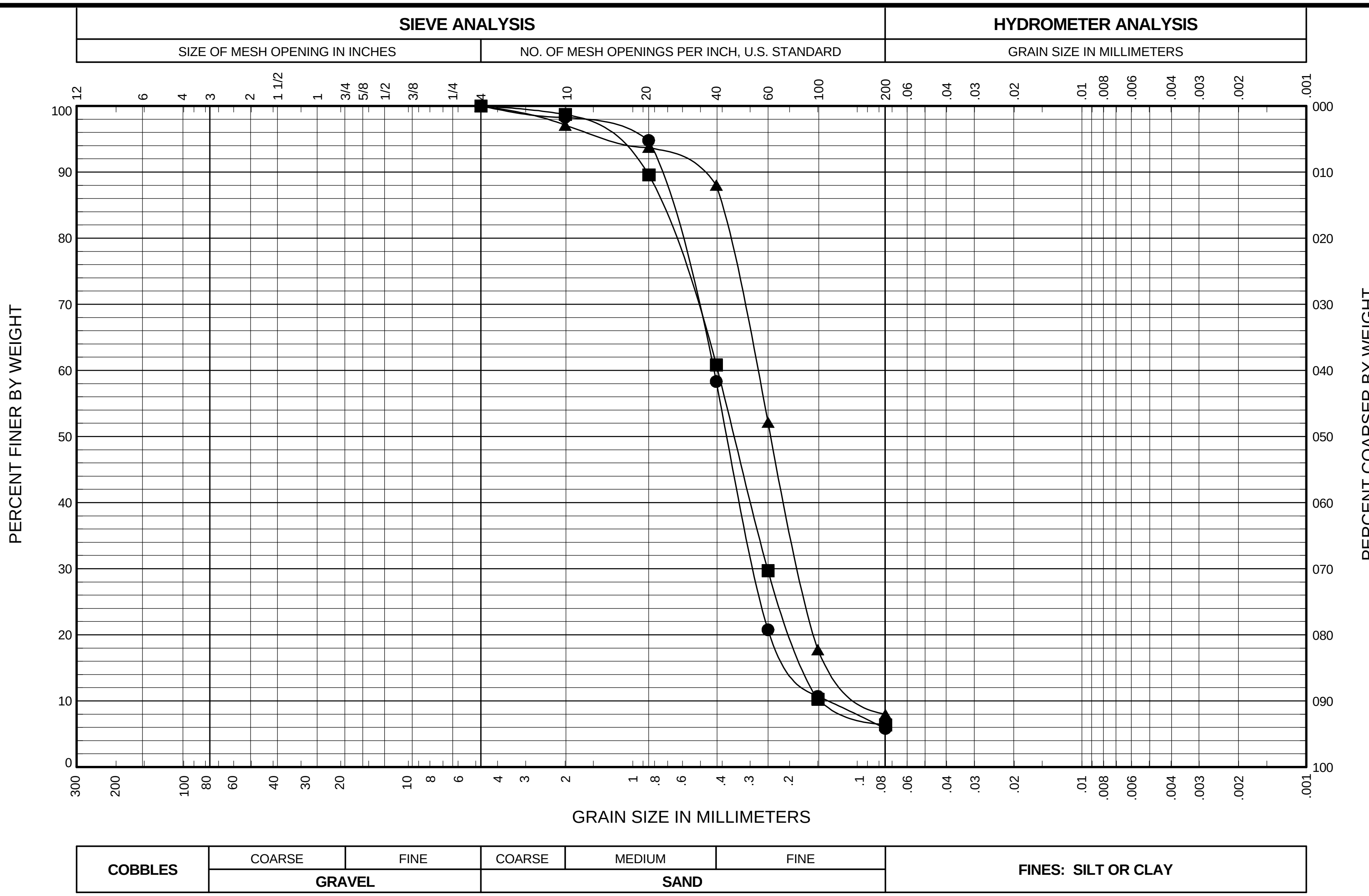
June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-16
Sheet 1 of 2

FIG. C-16

AASHTO GSA MAIN LOCAL 21-21199.GPJ SHAN WIL.GDT 6/1/10



AASHTO GSA MAIN LOCAL 21-21199.GPJ SHAN WIL.GDT 6/1/10

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 STND
● DD1-2 Levee, S-12	40.0	SP-SM	Gray, slightly silty, fine to medium SAND				23.7	5.8	EXH	ARM	D422
■ DD1-2 Levee, S-13	45.0	SP-SM	Gray, slightly silty, fine to medium SAND				24.3	6.4	EXH	ARM	D422
▲ DD1-2 Levee, S-15	55.0	SP-SM	Gray, slightly silty, fine to medium SAND				27.7	8.0	EXH	ARM	D422

Skagit River Levee General Investigation
Skagit County, Washington

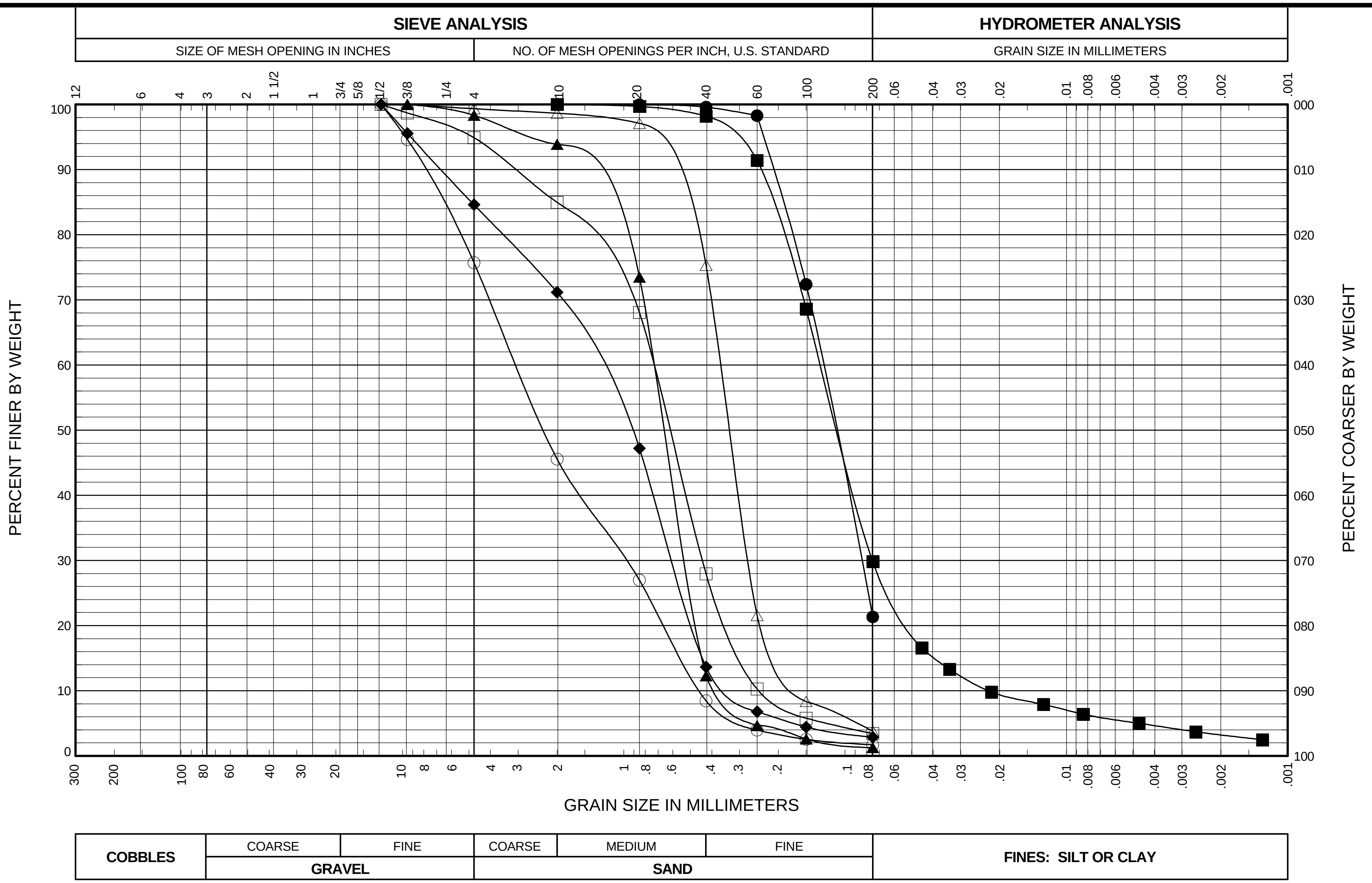
GRAIN SIZE DISTRIBUTION
BORING DD1-2 Levee

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-16
Sheet 2 of 2

FIG. C-16



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 STND
● DD3-1 Landward, S-2	5.0	SM	Brown, silty, fine SAND				11.6	21.3	EXH	ARM	D422
■ DD3-1 Landward, S-3	7.5	SM	Brown, silty, fine SAND				28.8	29.8	AYC	ARM	D422
▲ DD3-1 Landward, S-4*	10.0	SP	Gray SAND, trace of fine gravel and silt				22.3	1.3	EXH	ARM	D422
◆ DD3-1 Landward, S-5*	12.5	SP	Gray, fine gravelly SAND, trace of silt				19.0	2.9	EXH	ARM	D422
○ DD3-1 Landward, S-6	15.0	SP	Gray, fine gravelly SAND, trace of silt				16.3	1.7	EXH	ARM	D422
□ DD3-1 Landward, S-7*	17.5	SP	Gray, slightly fine gravelly SAND, trace of silt				19.7	3.4	EXH	ARM	D422
△ DD3-1 Landward, S-8*	20.0	SP	Gray, fine to medium SAND, trace of silt and fine gravel				27.7	3.8	EXH	ARM	D422

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

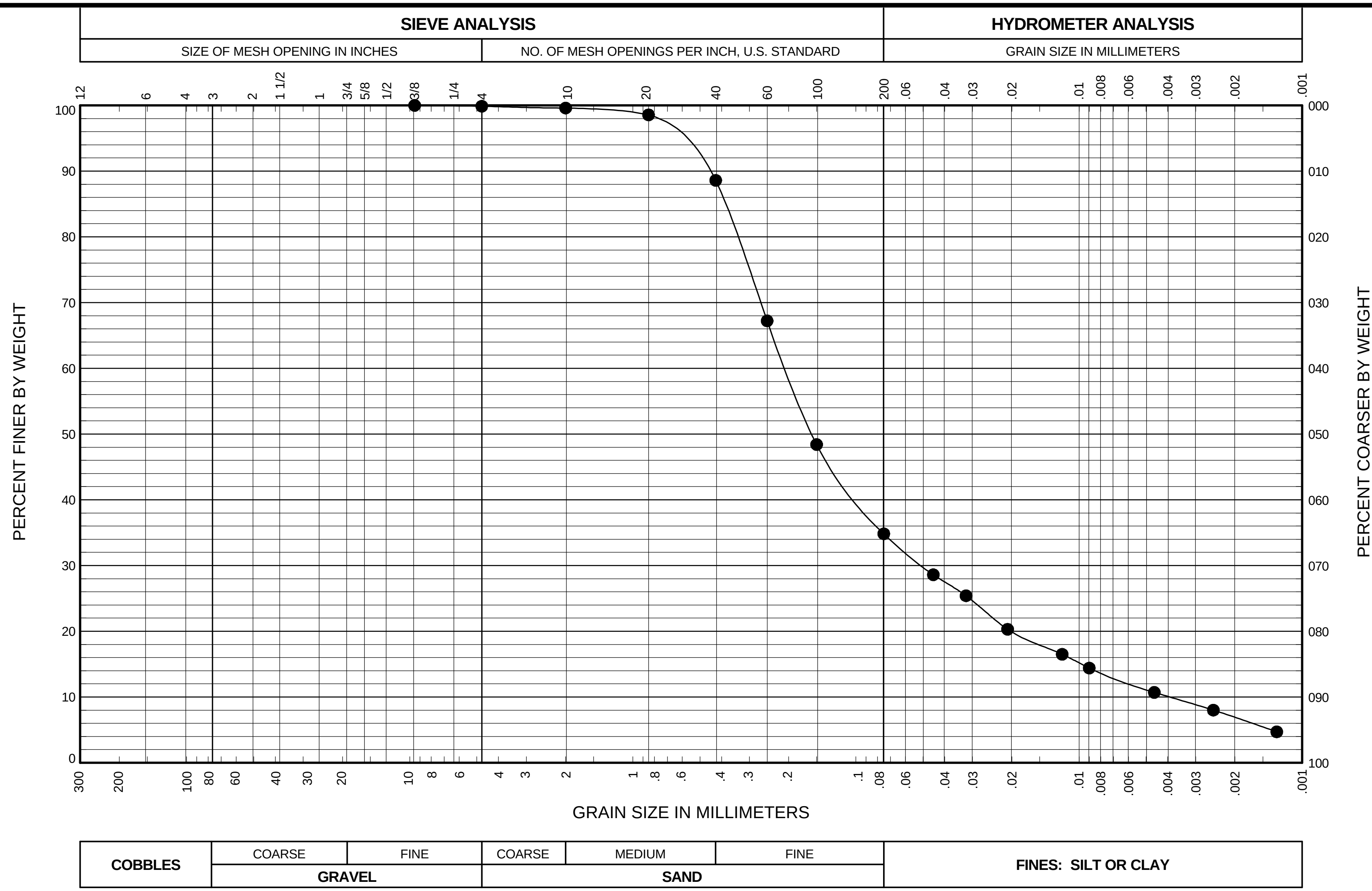
Skagit River Levee General Investigation
Skagit County, Washington

GRAIN SIZE DISTRIBUTION
BORING DD3-1 Landward

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-17
Sheet 1 of 2



AASHTO GSA MAIN LOCAL 21-21199.GPJ SHAN WIL.GDT 6/1/10

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 STND
● DD3-1 Landward, S-12	40.0	SM	Gray, silty, fine to medium SAND				25.6	34.8	PAJ	ARM	D422

Skagit River Levee General Investigation
Skagit County, Washington

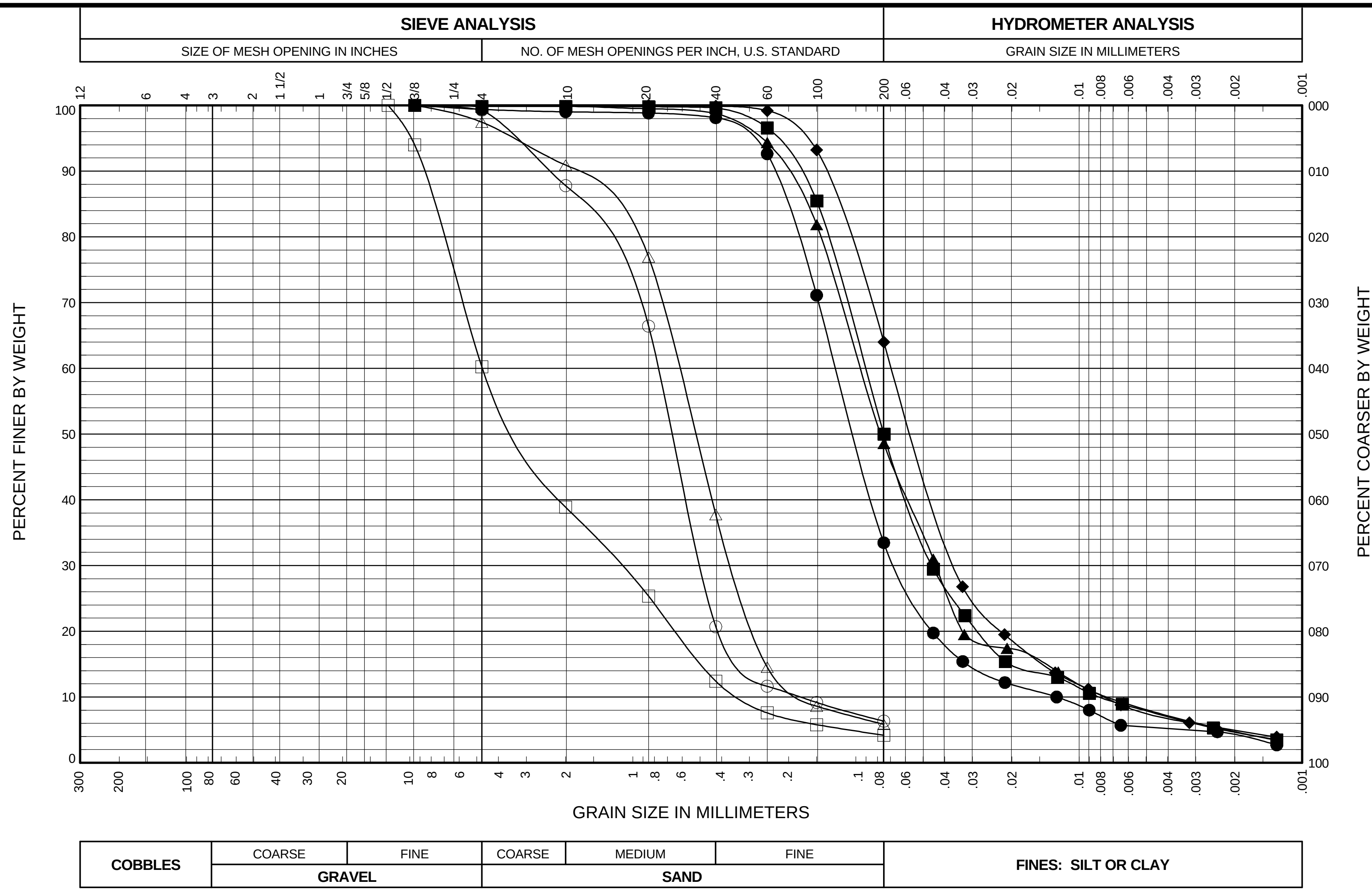
GRAIN SIZE DISTRIBUTION
BORING DD3-1 Landward

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-17
Sheet 2 of 2

FIG. C-17



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 STND
● DD3-1 Levee, S-2	5.0	SM	Brown, silty, fine SAND, trace of fine gravel				30.6	33.5	PAJ	ARM	D422
■ DD3-1 Levee, S-3	7.5	ML	Brown, fine sandy SILT, trace of fine gravel				11.9	50.0	AYC	ARM	D422
▲ DD3-1 Levee, S-4	10.0	SM	Brown, silty, fine SAND				17.5	48.5	AYC	ARM	D422
◆ DD3-1 Levee, S-7	17.9	ML	Gray-brown, fine sandy SILT				38.3	64.0	AYC	ARM	D422
○ DD3-1 Levee, S-8	20.0	SP-SM	Brown, slightly silty SAND, trace of fine gravel				19.7	6.3	EXH	ARM	D422
□ DD3-1 Levee, S-9*	25.0	SP	Gray, fine gravelly SAND, trace of silt				14.1	4.2	EXH	ARM	D422
△ DD3-1 Levee, S-10*	30.0	SP-SM	Gray, slightly silty SAND, trace of fine gravel				22.4	5.8	EXH	ARM	D422

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

Skagit River Levee General Investigation
Skagit County, Washington

GRAIN SIZE DISTRIBUTION BORING DD3-1 Levee

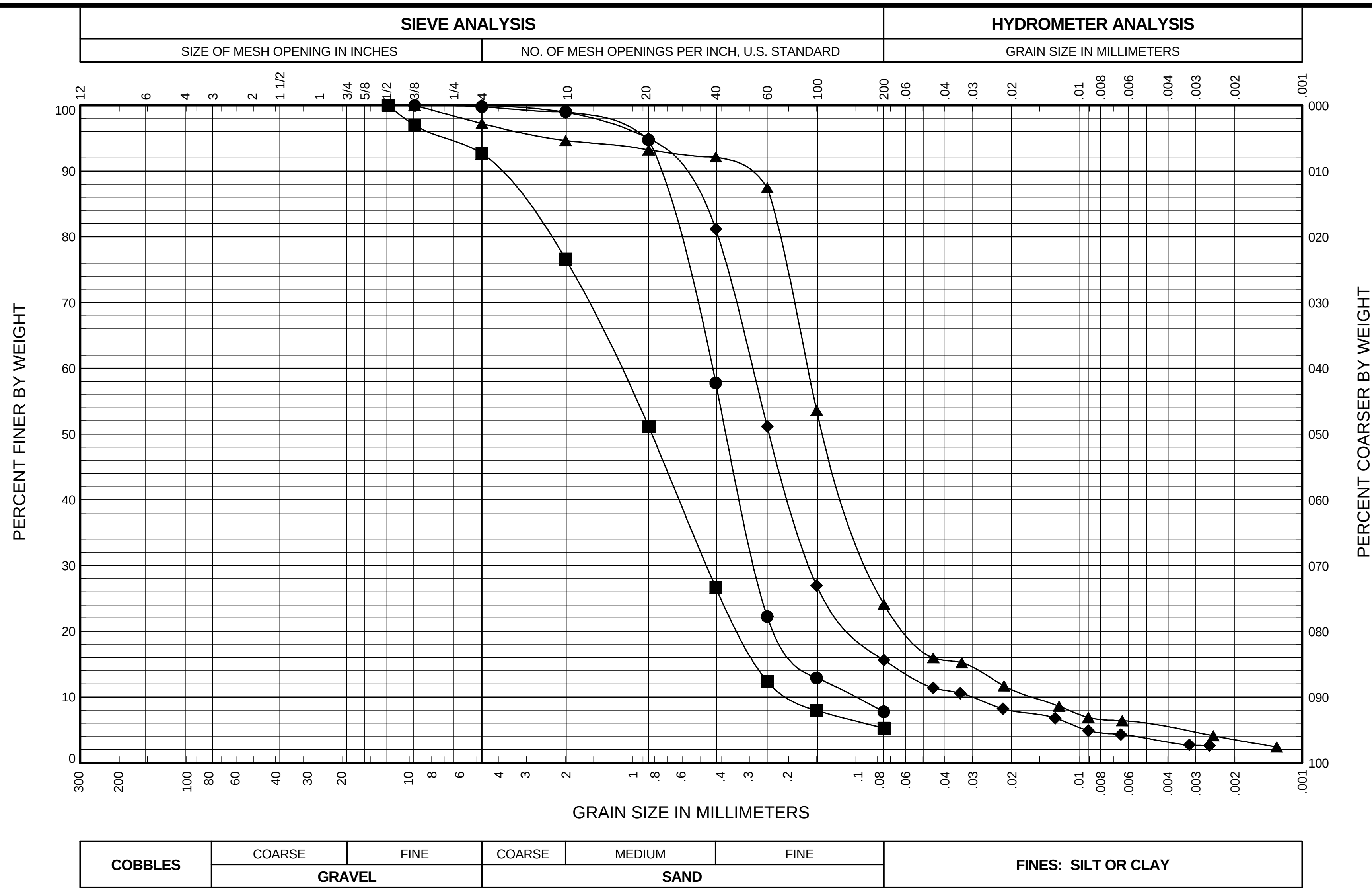
June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-18
Sheet 1 of 2

FIG. C-18

AASHTO GSA MAIN LOCAL 21-21199.GPJ SHAN WIL.GDT 6/1/10



AASHTO GSA MAIN LOCAL 21-21199.GPJ SHAN WIL.GDT 6/1/10

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 STND
● DD3-1 Levee, S-11*	35.0	SP-SM	Gray, slightly silty, fine to medium SAND, trace of fine gravel				25.7	7.7	EXH	ARM	D422
■ DD3-1 Levee, S-12*	40.0	SW-SM	Gray, slightly silty, slightly fine gravelly SAND				18.8	5.3	EXH	ARM	D422
▲ DD3-1 Levee, S-14	50.0	SM	Dark gray, silty, fine to medium SAND				33.3	24.1	AYC	ARM	D422
◆ DD3-1 Levee, S-16	60.0	SM	Gray, silty, fine to medium SAND				24.4	15.6	AYC	ARM	D422

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

Skagit River Levee General Investigation
Skagit County, Washington

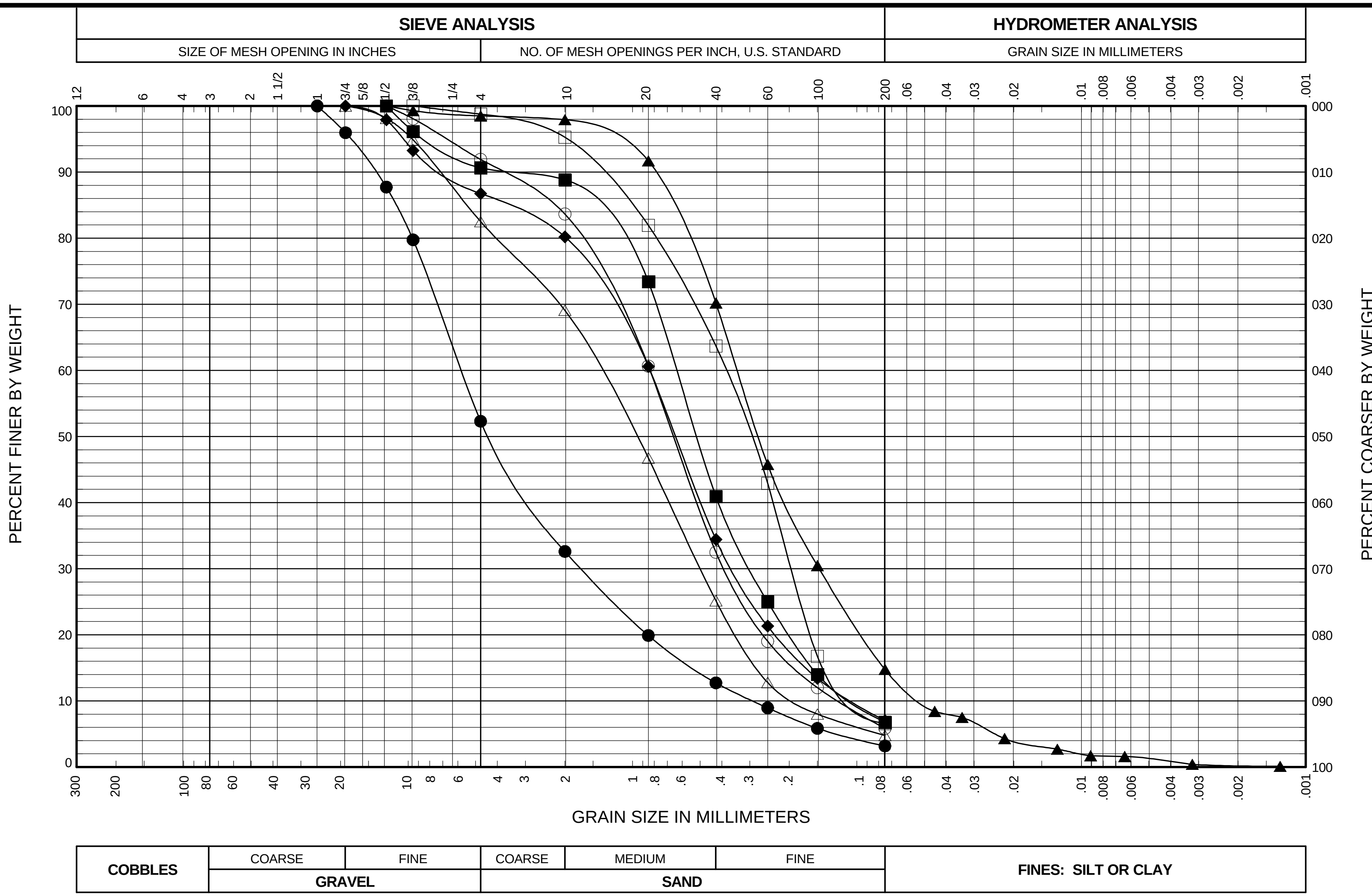
GRAIN SIZE DISTRIBUTION
BORING DD3-1 Levee

June 2010 — 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-18
Sheet 2 of 2

FIG. C-18



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 STND
● DD17-1 Landward, S-5	12.0	SW	Brown, gravelly SAND, trace of silt				10.9	3.2	EXH	ARM	D422
■ DD17-1 Landward, S-6	14.5	SW-SM	Gray, slightly silty, slightly fine gravelly, fine to medium SAND				20.5	6.8	EXH	ARM	D422
▲ DD17-1 Landward, S-7	17.0	SM	Gray, silty, fine to medium SAND, trace of fine gravel				16.5	14.8	AYC	ARM	D422
◆ DD17-1 Landward, S-8	19.5	SW-SM	Gray, slightly silty, fine gravelly SAND				19.0	7.0	EXH	ARM	D422
○ DD17-1 Landward, S-9	22.5	SW-SM	Gray, slightly silty, slightly fine gravelly SAND				18.5	5.9	EXH	ARM	D422
□ DD17-1 Landward, S-10	27.5	SP-SM	Gray, slightly silty, fine to medium SAND, trace of fine gravel				23.3	6.6	EXH	ARM	D422
△ DD17-1 Landward, S-11	32.0	SP	Gray, fine gravelly SAND, trace of silt				17.9	4.8	EXH	ARM	D422

Skagit River Levee General Investigation
Skagit County, Washington

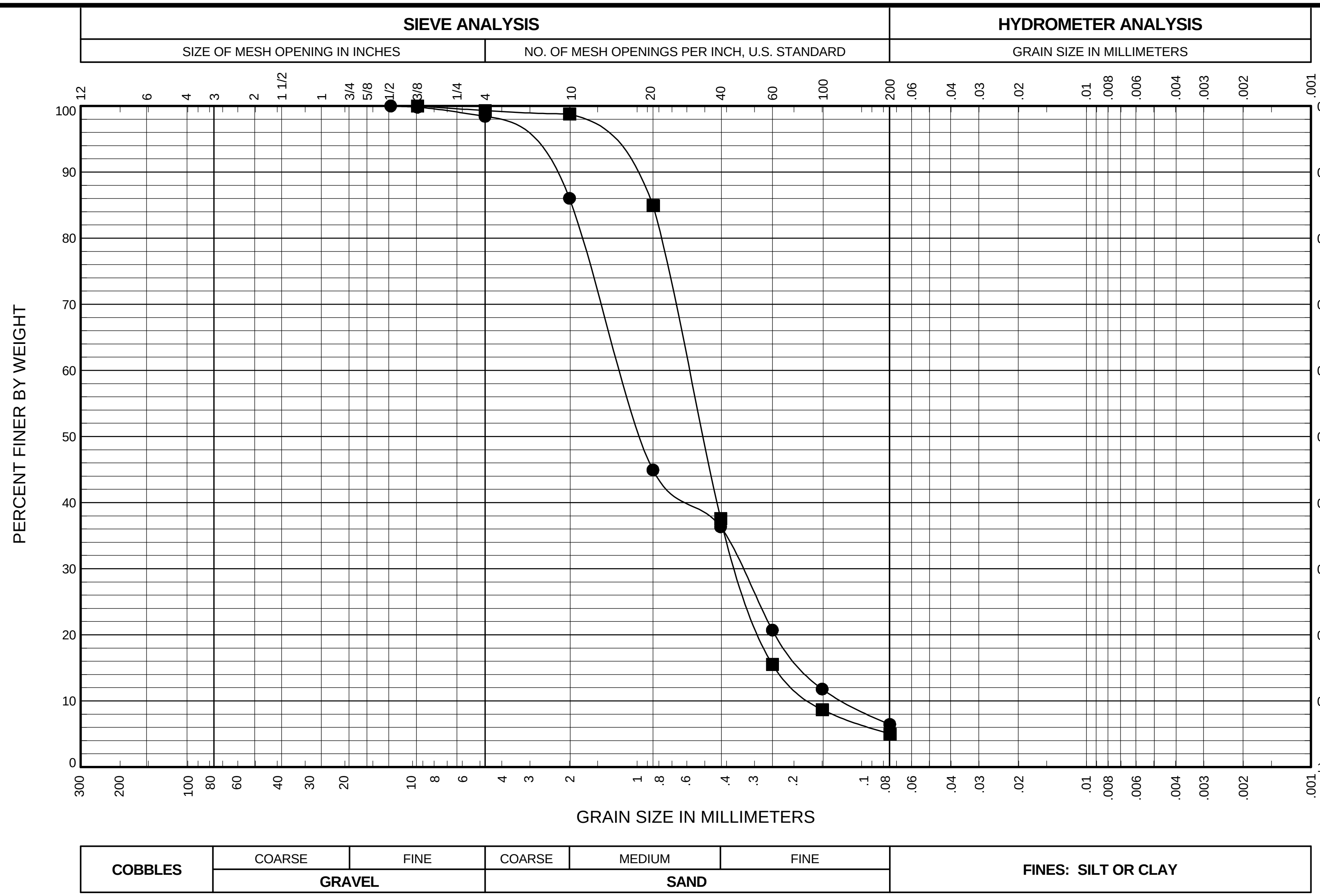
GRAIN SIZE DISTRIBUTION
BORING DD17-1 Landward

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-19
Sheet 1 of 2

AASHTO GSA MAIN LOCAL 21-21199.GPJ SHAN WIL.GDT 6/1/10



AASHTO GSA MAIN LOCAL 21-21199.GPJ SHAN WIL.GDT 6/1/10

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 STND
● DD17-1 Landward, S-12	37.0	SP-SM	Gray, slightly silty SAND, trace of fine gravel				23.5	6.5	EXH	ARM	D422
■ DD17-1 Landward, S-13	42.0	SP-SM	Gray, slightly silty, fine to medium SAND, trace of fine gravel				24.6	5.0	EXH	ARM	D422

Skagit River Levee General Investigation
Skagit County, Washington

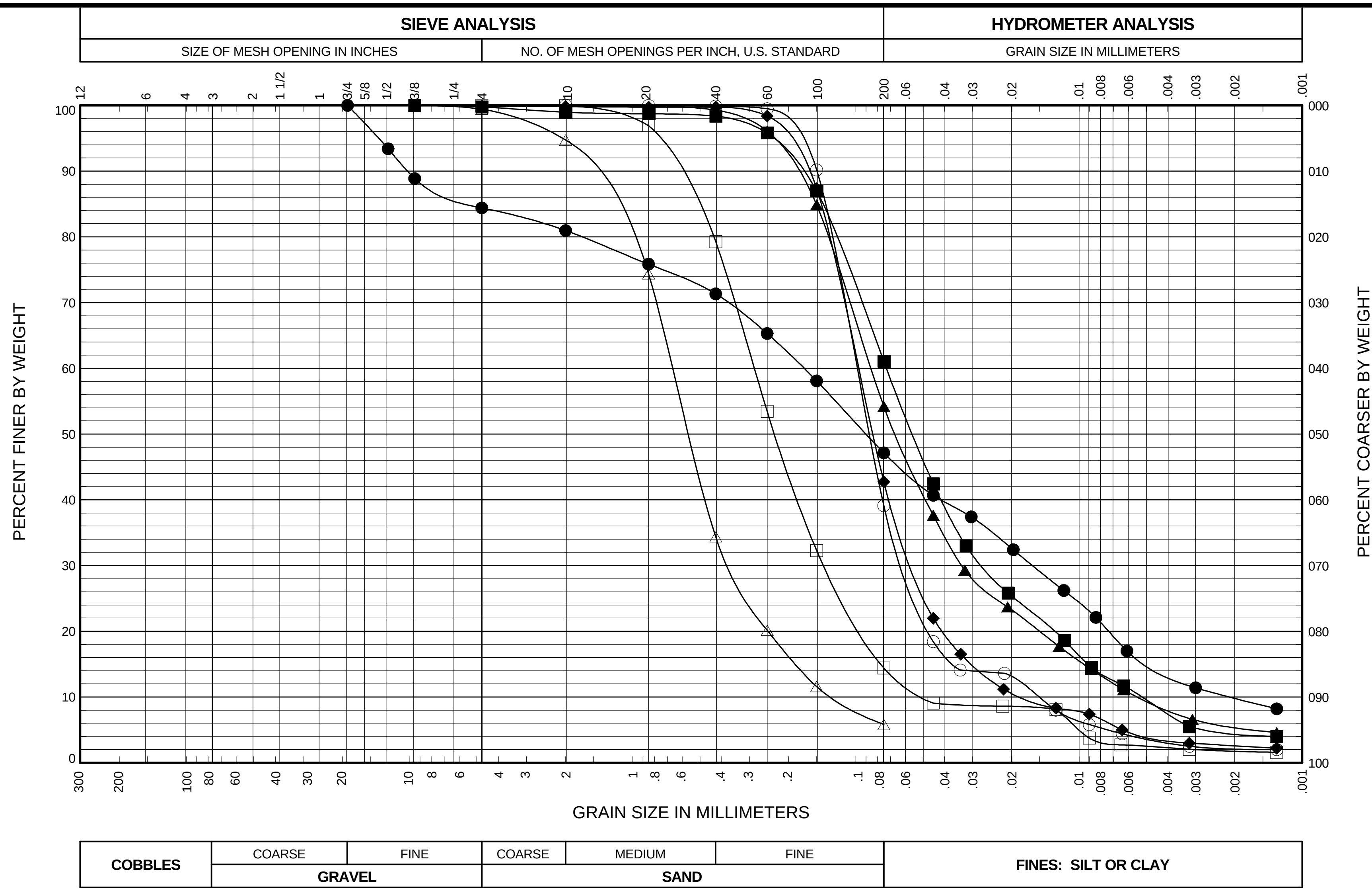
GRAIN SIZE DISTRIBUTION BORING DD17-1 Landward

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-19
Sheet 2 of 2

FIG. C-19



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 STND
● DD17-1 Levee, S-1	2.5	SM	Brown, slightly clayey, fine gravelly, silty SAND				11.1	47.1	AYC	ARM	D422
■ DD17-1 Levee, S-3	7.5	ML	Brown, fine sandy SILT				6.3	61.1	AYC	ARM	D422
▲ DD17-1 Levee, S-4	10.0	ML	Brown, fine sandy SILT				18.3	54.2	AYC	ARM	D422
◆ DD17-1 Levee, S-6	15.0	SM	Brown, silty, fine SAND, trace of fine gravel				8.3	42.7	AYC	ARM	D422
○ DD17-1 Levee, S-9	22.0	SM	Brown, silty, fine SAND				21.6	39.1	AYC	ARM	D422
□ DD17-1 Levee, S-10	27.0	SM	Brown, silty, fine to medium SAND				24.4	14.4	AYC	JFL	D422
△ DD17-1 Levee, S-11	32.0	SP-SM	Brown, slightly silty, fine to medium SAND, trace of fine gravel				22.6	5.8	EXH	ARM	D422

Skagit River Levee General Investigation
Skagit County, Washington

GRAIN SIZE DISTRIBUTION
BORING DD17-1 Levee

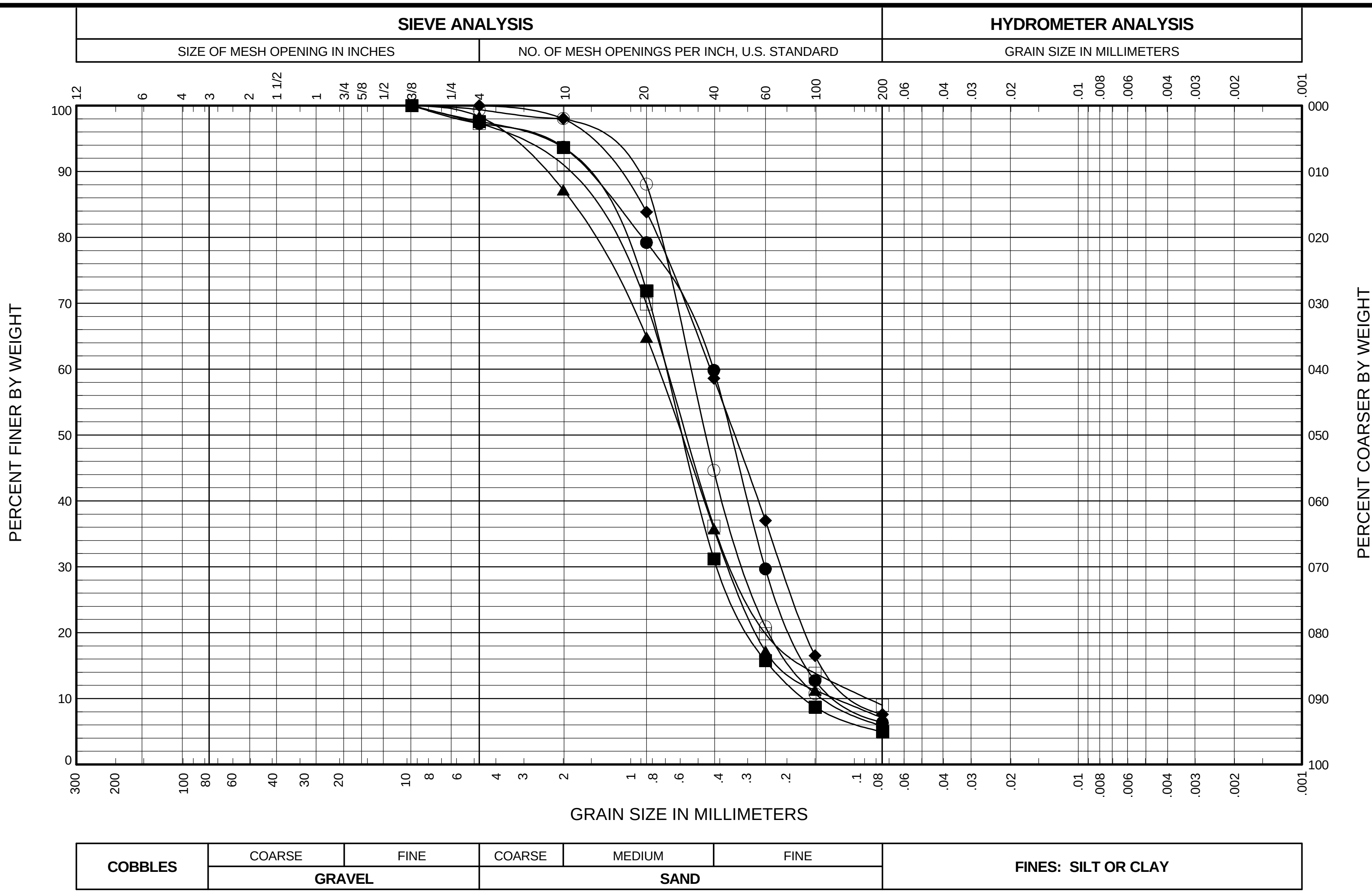
June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-20
Sheet 1 of 2

FIG. C-20

AASHTO GSA MAIN LOCAL 21-21199.GPJ SHAN WIL.GDT 6/1/10



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 STND
● DD17-1 Levee, S-12	37.0	SP-SM	Gray, slightly silty, fine to medium SAND, trace of fine gravel				22.4	6.3	EXH	ARM	D422
■ DD17-1 Levee, S-13	42.0	SP	Brown, fine to medium SAND, trace of silt and fine gravel				24.8	4.9	EXH	ARM	D422
▲ DD17-1 Levee, S-14	47.0	SW-SM	Gray, slightly silty SAND, trace of fine gravel				22.3	7.1	EXH	ARM	D422
◆ DD17-1 Levee, S-15	52.0	SP-SM	Gray, slightly silty, fine to medium SAND				25.9	7.6	EXH	ARM	D422
○ DD17-1 Levee, S-16	57.0	SP-SM	Gray, slightly silty, fine to medium SAND, trace of fine gravel				24.1	5.8	EXH	ARM	D422
□ DD17-1 Levee, S-17	62.0	SW-SM	Gray, slightly silty SAND, trace of fine gravel				19.2	9.0	EXH	ARM	D422

Skagit River Levee General Investigation
Skagit County, Washington

GRAIN SIZE DISTRIBUTION BORING DD17-1 Levee

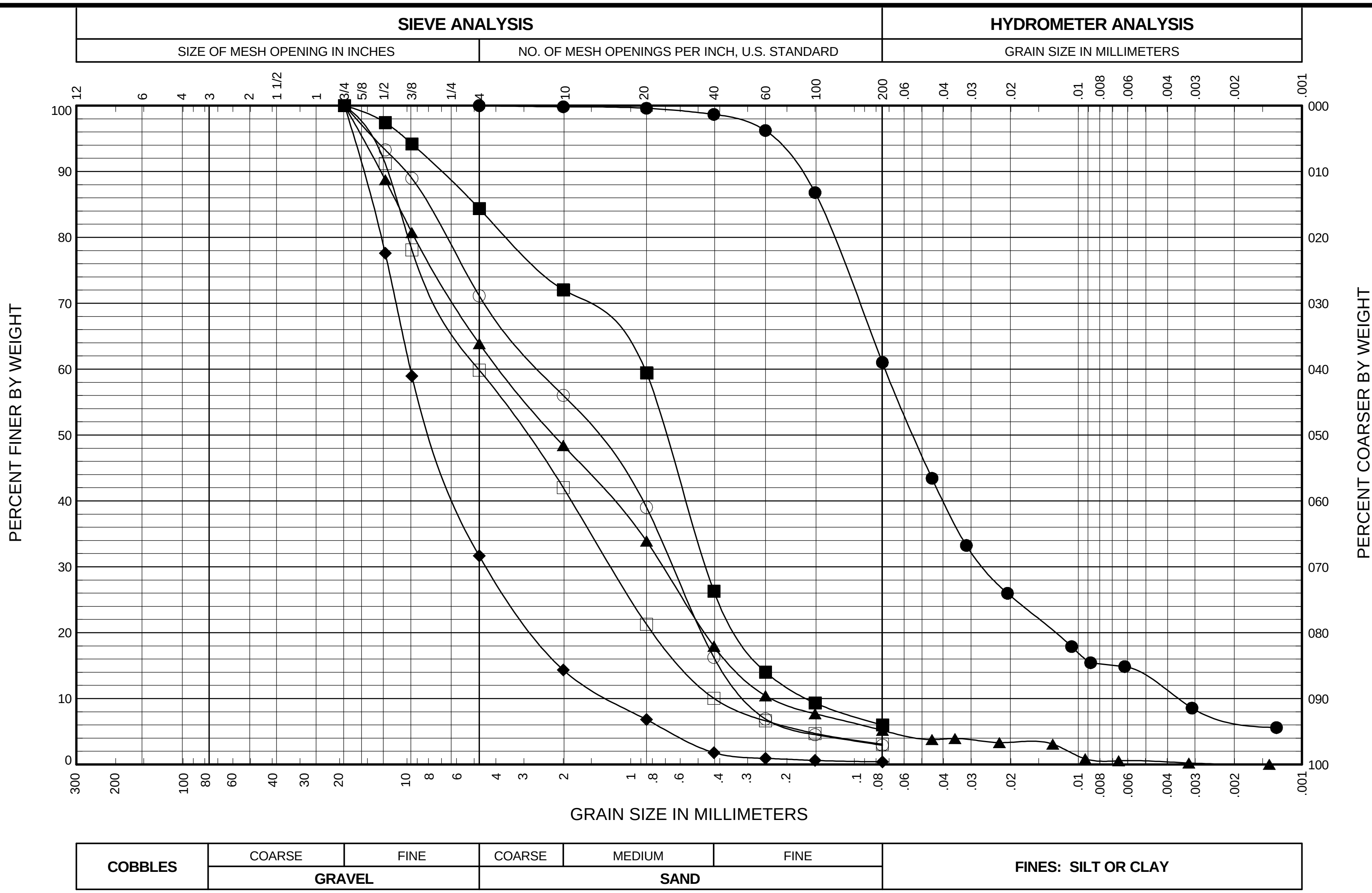
June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-20
Sheet 2 of 2

FIG. C-20

AASHTO GSA MAIN LOCAL 21-21199.GPJ SHAN WIL.GDT 6/1/10



AASHTO GSA MAIN LOCAL 21-21199.GPJ SHAN WIL.GDT 6/1/10

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 STND
● DD17-2 Landward, S-2	5.0	ML	Brown, fine sandy SILT				19.8	61.0	AYC	ARM	D422
■ DD17-2 Landward, S-5*	12.5	SP-SM	Brown, slightly silty, fine gravelly SAND				9.8	6.0	EXH	ARM	D422
▲ DD17-2 Landward, S-9	22.5	SP-SM	Gray, slightly silty, fine gravelly SAND				13.2	5.2	AYC	ARM	D422
◆ DD17-2 Landward, S-10*	27.0	GW	Gray, medium to coarse sandy, fine GRAVEL, trace of silt				12.7	0.4	EXH	ARM	D422
○ DD17-2 Landward, S-11*	32.0	SP	Gray, fine gravelly SAND, trace of silt				14.6	2.9	EXH	ARM	D422
□ DD17-2 Landward, S-12*	37.0	SP	Gray, fine gravelly SAND, trace of silt				12.5	3.1	EXH	ARM	D422

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

Skagit River Levee General Investigation
Skagit County, Washington

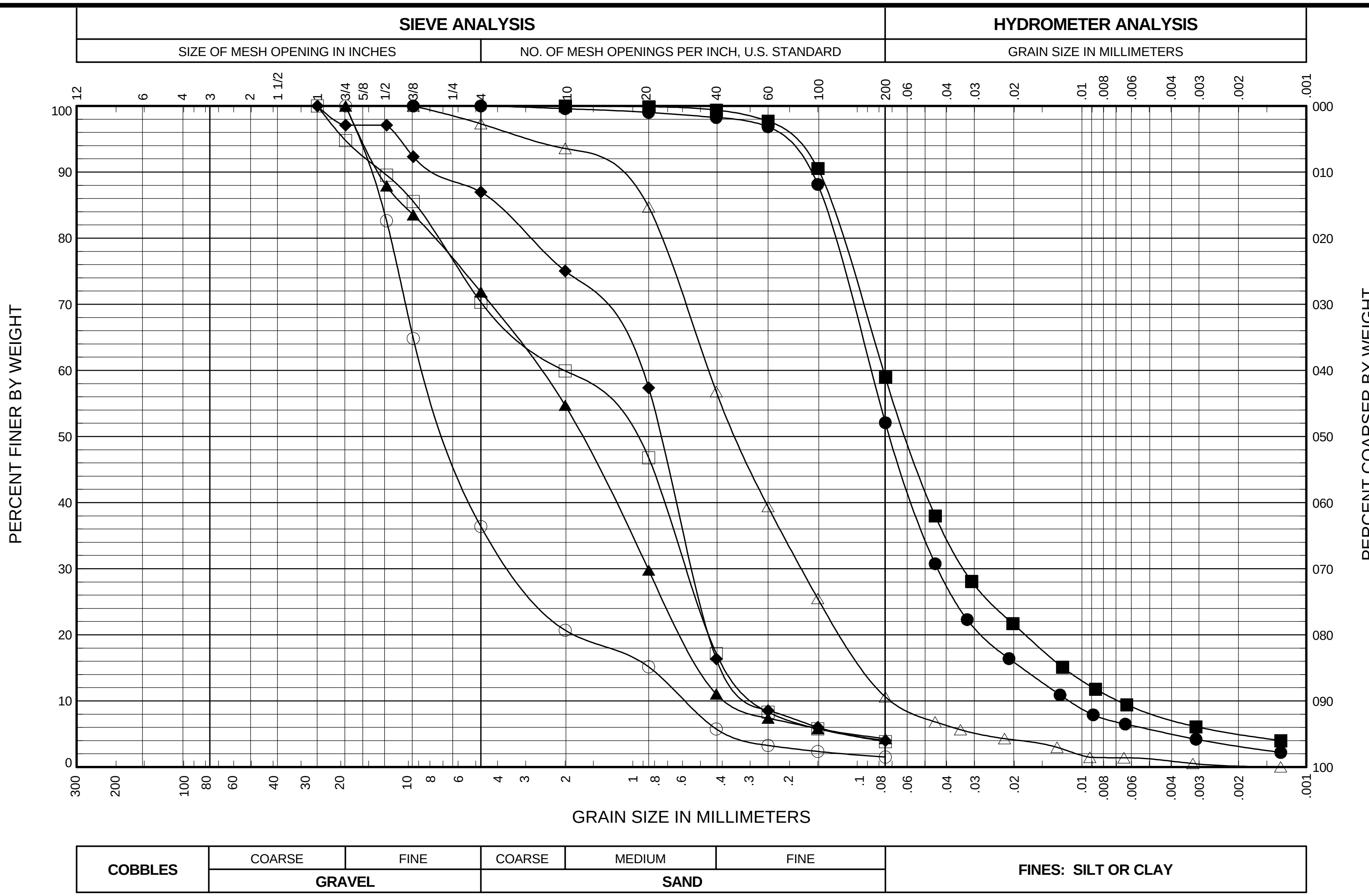
GRAIN SIZE DISTRIBUTION
BORING DD17-2 Landward

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-21

FIG. C-21



AASHTO GSA MAIN LOCAL 21-21199.GPJ SHAN WIL.GDT 6/1/10

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 STND
● DD17-2 Levee, S-3	7.5	ML	Brown, fine sandy SILT; trace of coarse organics				19.5	52.1	PAJ	ARM	D422
■ DD17-2 Levee, S-5	12.5	ML	Brown, fine sandy SILT				20.8	59.0	PAJ	ARM	D422
▲ DD17-2 Levee, S-12*	32.0	SP	Gray, fine gravelly SAND, trace of silt				12.2	4.3	EXH	ARM	D422
◆ DD17-2 Levee, S-14*	42.0	SP	Gray, gravelly SAND, trace of silt				21.5	4.0	EXH	ARM	D422
○ DD17-2 Levee, S-15*	47.0	GW	Brown, sandy, fine GRAVEL, trace of silt				7.5	1.5	EXH	ARM	D422
□ DD17-2 Levee, S-16*	52.0	SP	Brown, gravelly SAND, trace of silt				18.3	3.9	EXH	ARM	D422
△ DD17-2 Levee, S-17	57.0	SW-SM	Gray, slightly silty SAND, trace of fine gravel				24.1	10.6	PAJ	ARM	D422

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

Skagit River Levee General Investigation
Skagit County, Washington

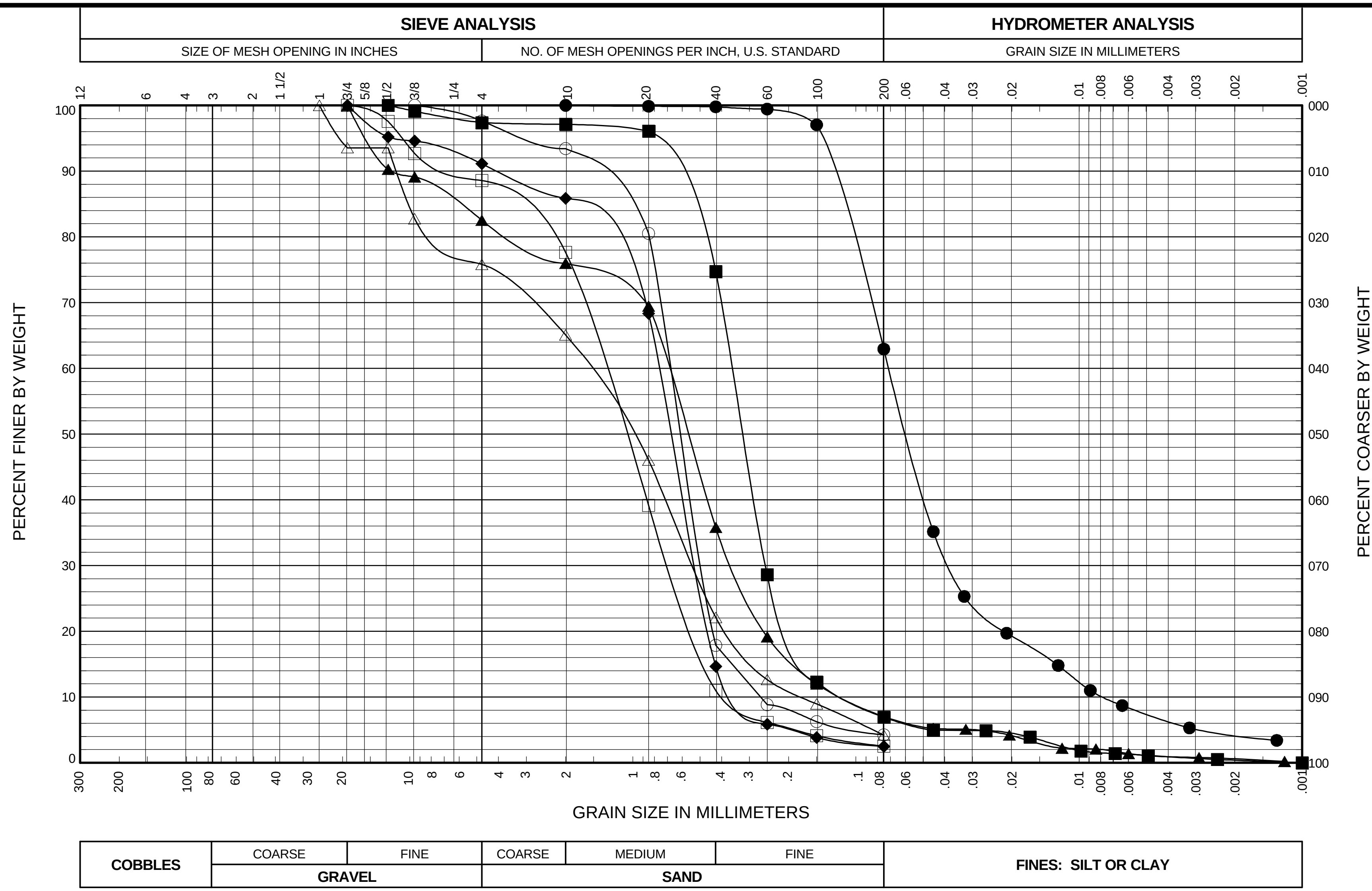
GRAIN SIZE DISTRIBUTION
BORING DD17-2 Levee

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-22

FIG. C-22



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 STND
● DD17-3 Landward, S-3	7.5	ML	Brown, fine sandy SILT				23.3	62.9	AYC	ARM	D422
■ DD17-3 Landward, S-6	15.0	SP-SM	Brown, slightly silty, fine to medium SAND, trace of fine gravel				26.9	6.9	PEP	ARM	D422
▲ DD17-3 Landward, S-8	20.0	SW-SM	Gray, slightly silty, fine gravelly SAND; trace of organics				26.0	7.0	AYC	ARM	D422
◆ DD17-3 Landward, S-9*	25.0	SP	Gray, fine gravelly SAND, trace of silt				23.7	2.5	EXH	ARM	D422
○ DD17-3 Landward, S-10	30.0	SP	Gray, fine to medium SAND, trace of silt and fine gravel				22.0	4.2	EXH	ARM	D422
□ DD17-3 Landward, S-11*	35.0	SP	Gray, slightly fine gravelly SAND, trace of silt				20.9	2.5	EXH	ARM	D422
△ DD17-3 Landward, S-12*	40.0	SW	Gray, gravelly SAND, trace of silt				11.0	4.2	EXH	ARM	D422

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

Skagit River Levee General Investigation
Skagit County, Washington

GRAIN SIZE DISTRIBUTION
BORING DD17-3 Landward

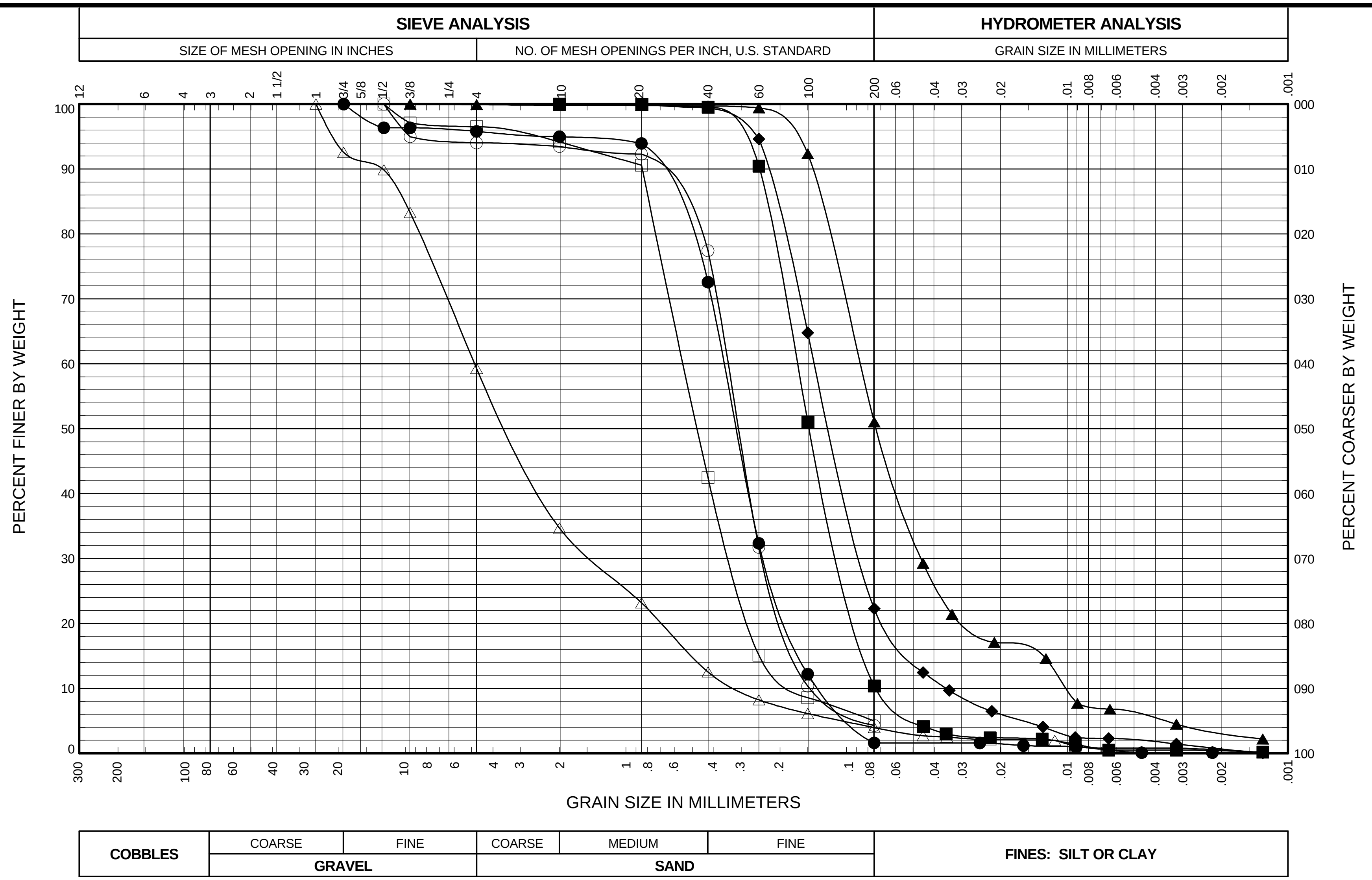
June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-23

AASHTO GSA MAIN LOCAL 21-21199.GPJ SHAN WIL.GDT 6/1/10

FIG. C-23



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 STND
● DD17-3 Levee, S-1	2.5	SP	Brown SAND, trace of gravel and silt				11.2	1.6	PEP	JFL	D422
■ DD17-3 Levee, S-3	7.5	SP-SM	Brown, slightly silty, fine SAND				15.8	10.4	AYC	ARM	D422
▲ DD17-3 Levee, S-6	15.0	ML	Gray, fine sandy SILT				19.1	51.0	AYC	ARM	D422
◆ DD17-3 Levee, S-9	22.5	SM	Gray, silty, fine SAND				24.3	22.3	PAJ	ARM	D422
○ DD17-3 Levee, S-10*	27.0	SP	Brown, slightly fine gravelly, fine to medium SAND, trace of silt				25.1	4.3	EXH	ARM	D422
□ DD17-3 Levee, S-11*	32.0	SP-SM	Brown, slightly silty, fine to medium SAND, trace of fine gravel				25.2	5.0	EXH	ARM	D422
△ DD17-3 Levee, S-12	37.0	SW	Gray, gravelly SAND, trace of silt				12.0	4.0	AYC	ARM	D422

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

Skagit River Levee General Investigation
Skagit County, Washington

GRAIN SIZE DISTRIBUTION
BORING DD17-3 Levee

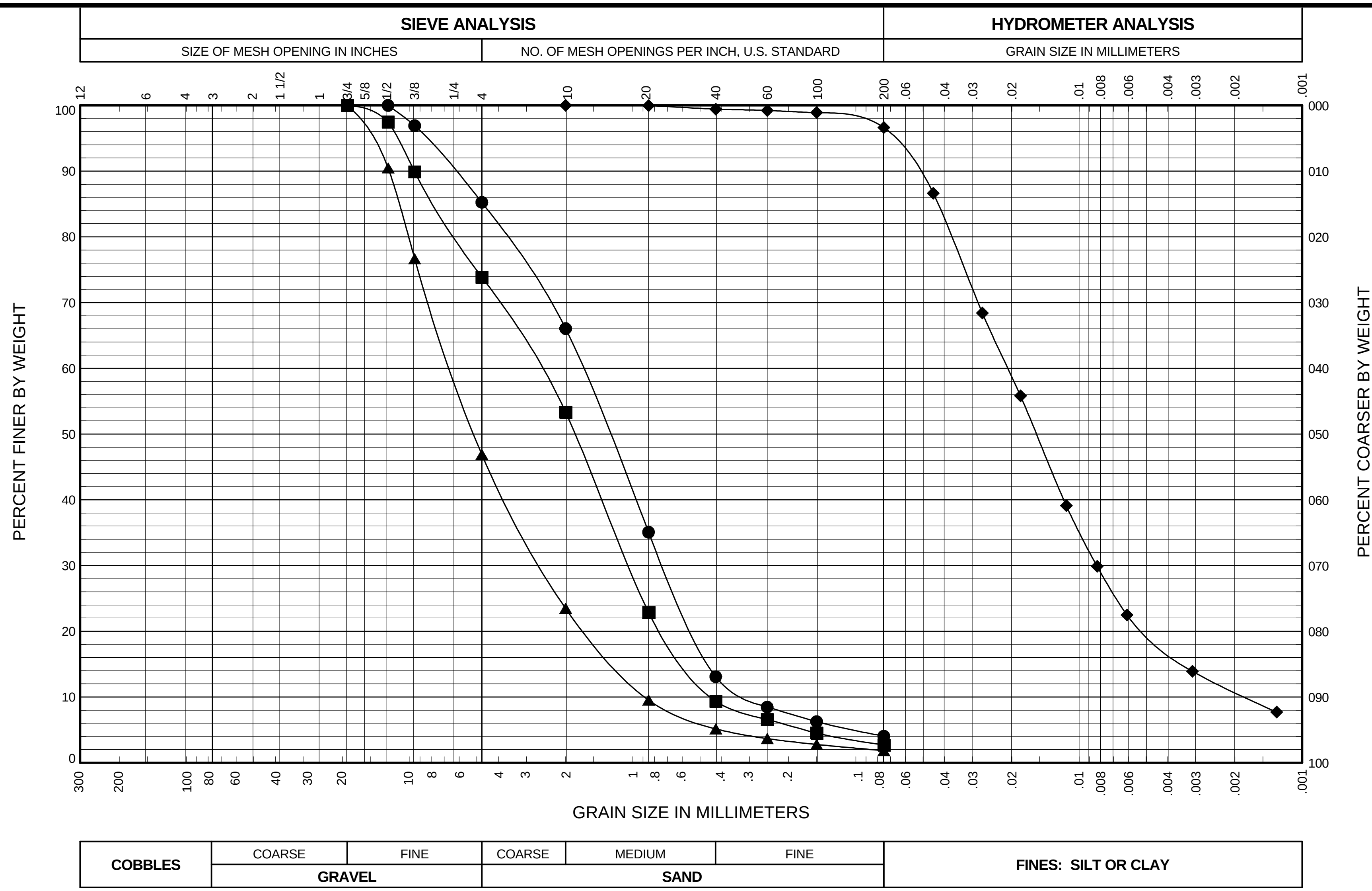
June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-24
Sheet 1 of 2

FIG. C-24

AASHTO GSA MAIN LOCAL 21-21199.GPJ SHAN WIL.GDT 6/1/10



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 STND
● DD17-3 Levee, S-13*	42.0	SP	Gray, gravelly SAND, trace of silt				16.8	4.0	EXH	ARM	D422
■ DD17-3 Levee, S-14*	47.0	SP	Brown, gravelly SAND, trace of silt				14.8	2.7	EXH	ARM	D422
▲ DD17-3 Levee, S-15*	52.0	GW	Gray, sandy GRAVEL, trace of silt				10.8	1.8	EXH	ARM	D422
◆ DD17-3 Levee, S-16	57.0	ML	Gray, clayey SILT, trace of fine sand				38.3	96.6	AYC	ARM	D422

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

Skagit River Levee General Investigation
Skagit County, Washington

GRAIN SIZE DISTRIBUTION
BORING DD17-3 Levee

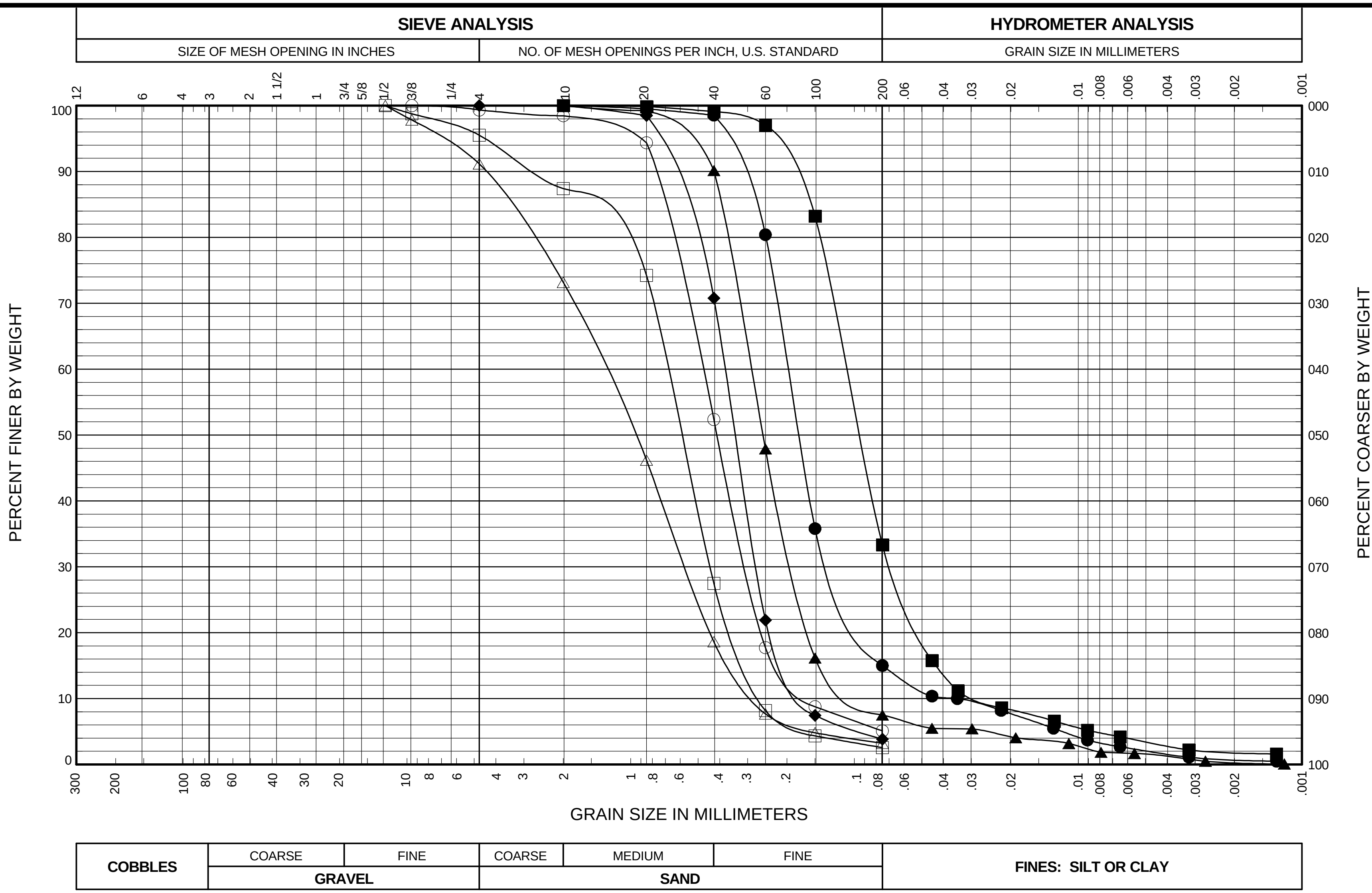
June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-24
Sheet 2 of 2

AASHTO GSA MAIN LOCAL 21-21199.GPJ SHAN WIL.GDT 6/1/10

FIG. C-24



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 STND
● DD22-1 Landward, S-1	2.5	SM	Brown, silty, fine SAND; trace of organics (roots)				17.9	15.0	AYC	ARM	D422
■ DD22-1 Landward, S-3	7.5	SM	Gray, silty, fine SAND				27.7	33.3	AYC	ARM	D422
▲ DD22-1 Landward, S-6	15.0	SP-SM	Gray, slightly silty, fine to medium SAND				30.3	7.5	AYC	ARM	D422
◆ DD22-1 Landward, S-7	17.5	SP	Gray, fine to medium SAND, trace of silt				29.1	3.9	EXH	ARM	D422
○ DD22-1 Landward, S-8	20.0	SP-SM	Gray, slightly silty, fine to medium SAND				25.6	5.1	EXH	ARM	D422
□ DD22-1 Landward, S-9*	25.0	SP	Gray SAND, trace of fine gravel and silt				24.6	2.6	EXH	ARM	D422
△ DD22-1 Landward, S-10*	30.0	SP	Gray, slightly fine gravelly SAND, trace of silt				20.1	3.2	EXH	ARM	D422

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

Skagit River Levee General Investigation
Skagit County, Washington

GRAIN SIZE DISTRIBUTION
BORING DD22-1 Landward

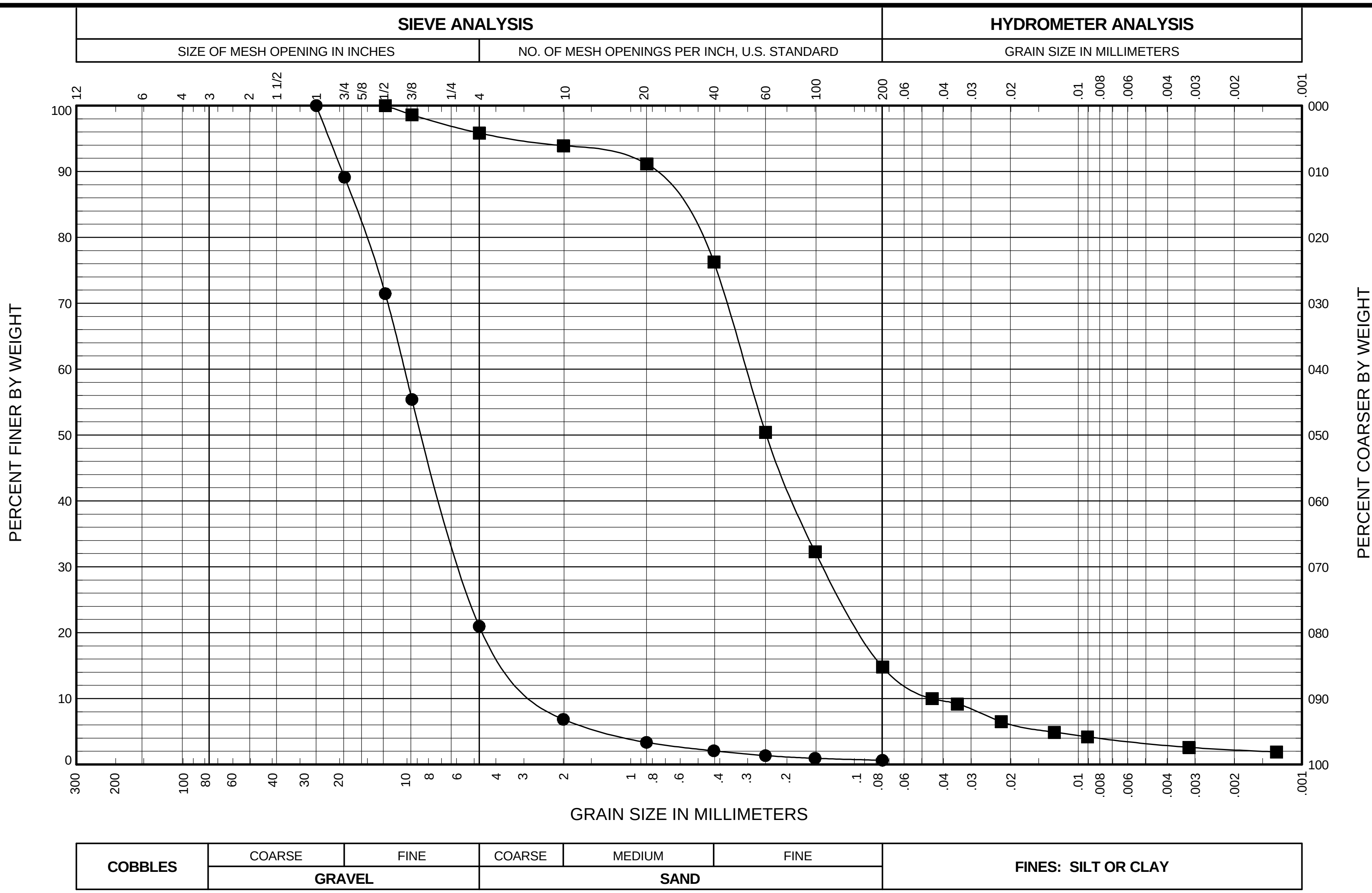
June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-25
Sheet 1 of 2

FIG. C-25

AASHTO GSA MAIN LOCAL 21-21199.GPJ SHAN WIL.GDT 6/1/10



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 STND
● DD22-1 Landward, S-11*	35.0	GW	Gray, sandy GRAVEL, trace of silt				10.4	0.6	EXH	ARM	D422
■ DD22-1 Landward, S-12	40.0	SM	Gray, silty, fine to medium SAND; numerous shell fragments				21.8	14.8	AYC	ARM	D422

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

Skagit River Levee General Investigation
Skagit County, Washington

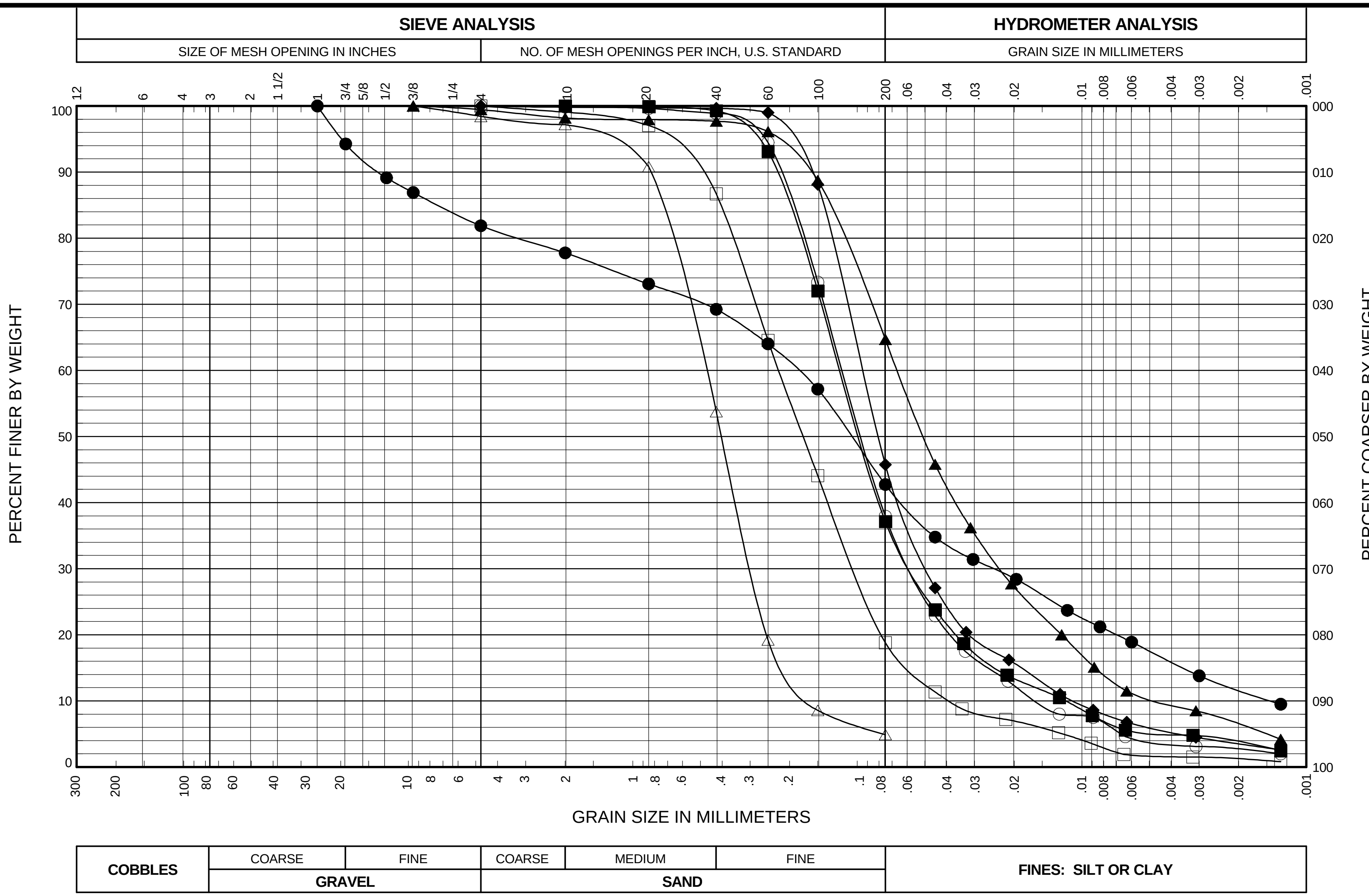
GRAIN SIZE DISTRIBUTION
BORING DD22-1 Landward

June 2010 | 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-25
Sheet 2 of 2

FIG. C-25



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 STND
● DD22-1 Levee, S-1	2.5	SM	Brown, slightly clayey, gravelly, silty SAND				11.9	42.7	AYC	ARM	D422
■ DD22-1 Levee, S-3	7.5	SM	Gray, silty, fine SAND				11.4	37.1	AYC	ARM	D422
▲ DD22-1 Levee, S-4	10.0	ML	Brown, fine sandy SILT; trace of organics (roots)				21.1	64.7	AYC	ARM	D422
◆ DD22-1 Levee, S-6	15.0	SM	Brown, silty, fine SAND				17.3	45.7	PAJ	ARM	D422
○ DD22-1 Levee, S-8	20.0	SM	Brown, silty, fine SAND; iron-oxide staining				34.7	37.9	PAJ	ARM	D422
□ DD22-1 Levee, S-9	25.0	SM	Gray, silty, fine to medium SAND				26.7	18.8	AYC	ARM	D422
△ DD22-1 Levee, S-10	30.0	SP	Gray, fine to medium SAND, trace of silt and fine gravel				24.6	4.9	EXH	ARM	D422

Skagit River Levee General Investigation
Skagit County, Washington

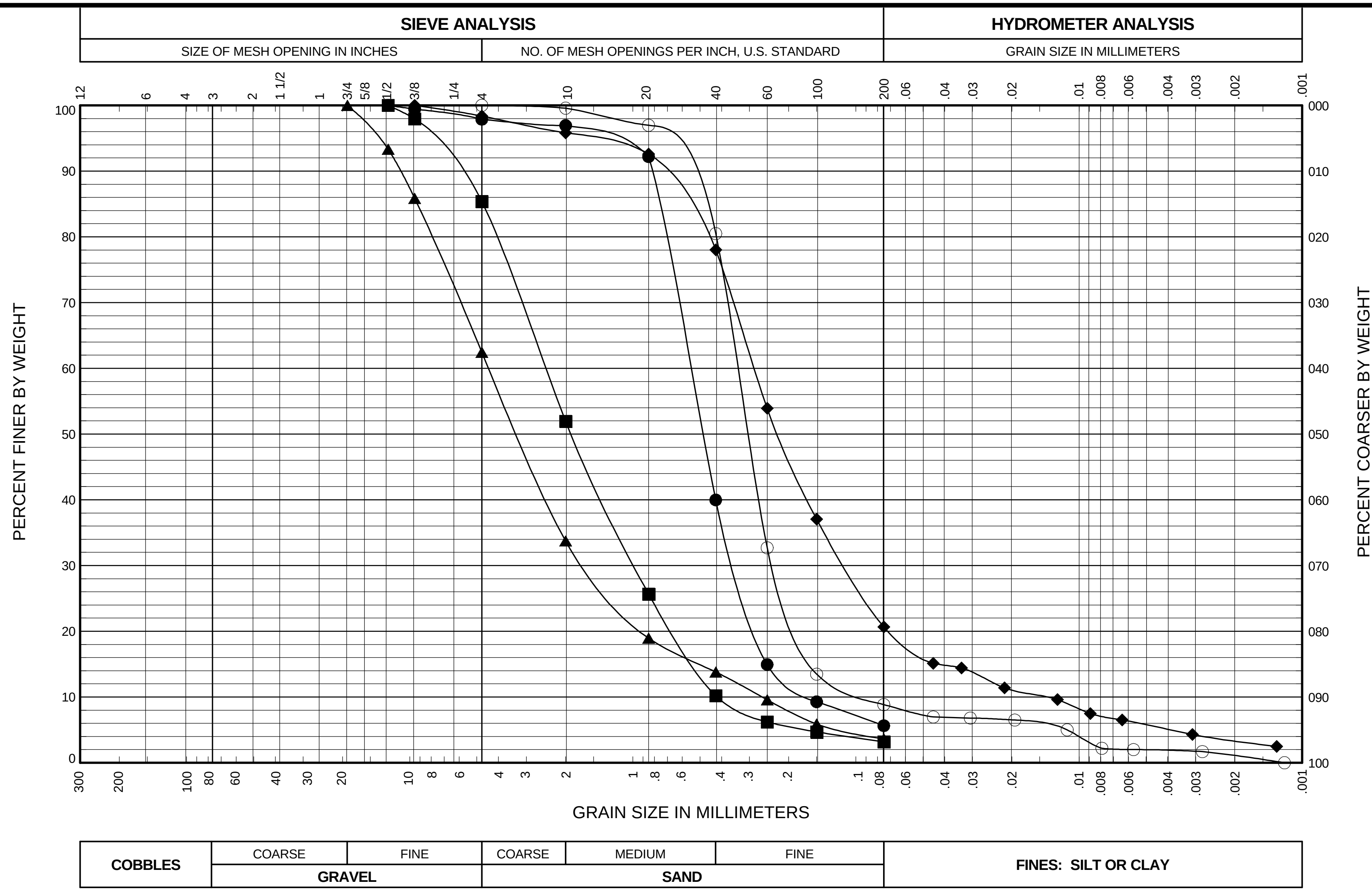
GRAIN SIZE DISTRIBUTION
BORING DD22-1 Levee

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-26
Sheet 1 of 2

AASHTO GSA MAIN LOCAL 21-21199.GPJ SHAN WIL.GDT 6/1/10



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 STND
● DD22-1 Levee, S-12*	40.0	SP-SM	Gray, slightly silty, fine to medium SAND, trace of fine gravel				24.5	5.6	EXH	ARM	D422
■ DD22-1 Levee, S-13*	45.0	SP	Gray, fine gravelly SAND, trace of silt				18.3	3.2	EXH	ARM	D422
▲ DD22-1 Levee, S-14*	50.0	SW	Gray, fine gravelly SAND, trace of silt				11.7	3.6	EXH	ARM	D422
◆ DD22-1 Levee, S-15	55.0	SM	Gray, silty, fine to medium SAND, trace of clay; scattered shell fragments				21.4	20.7	AYC	ARM	D422
○ DD22-1 Levee, S-16	60.0	SP-SM	Gray, slightly silty, fine to medium SAND; trace of shell fragments				21.4	8.8	AYC	ARM	D422

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

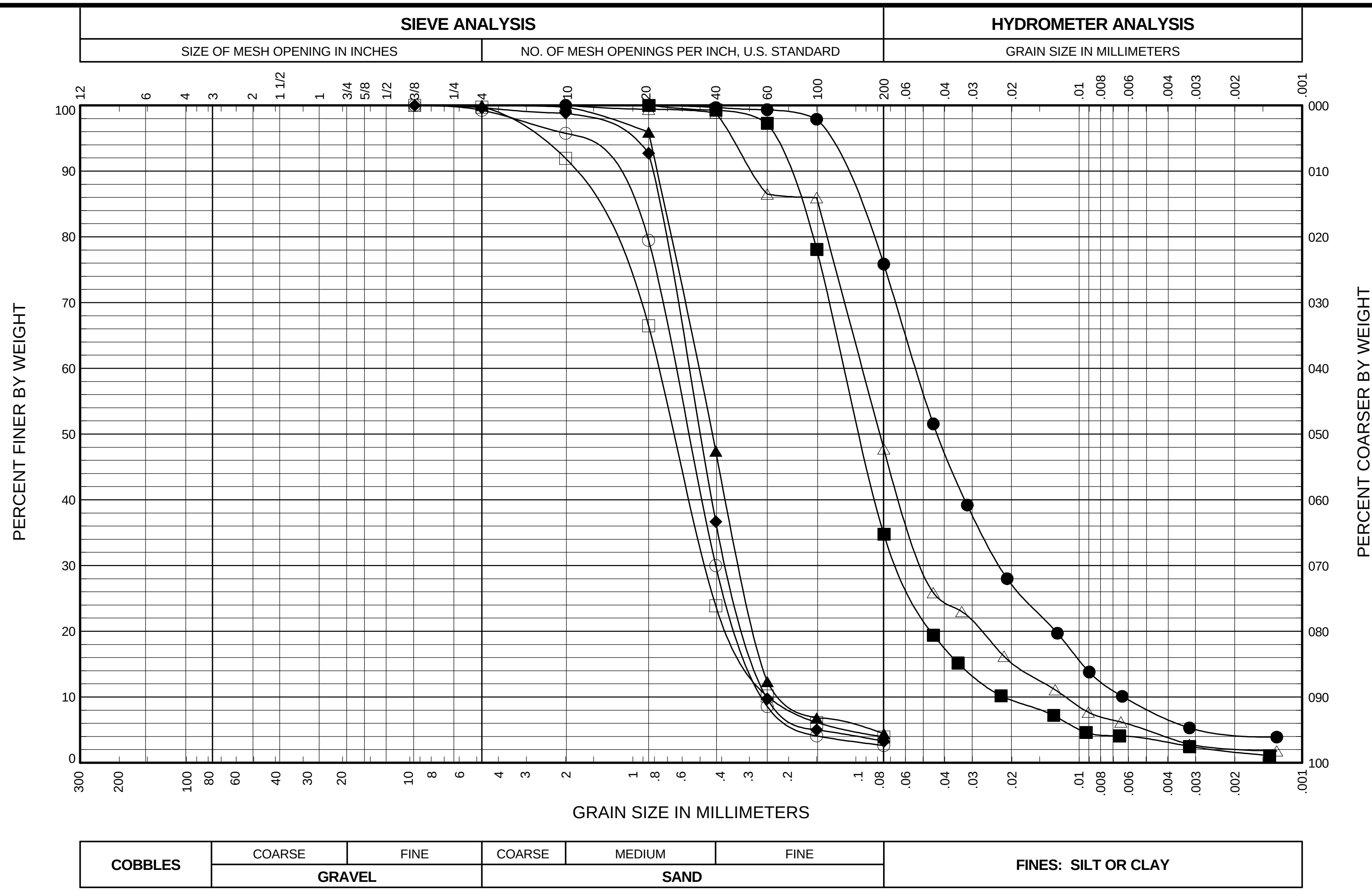
Skagit River Levee General Investigation
Skagit County, Washington

GRAIN SIZE DISTRIBUTION
BORING DD22-1 Levee

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-26
Sheet 2 of 2



AASHTO GSA MAIN LOCAL 21-21199.GPJ SHAN WIL.GDT 6/1/10

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 STND
● DD22-2 Landward, S-1	2.5	ML	Brown, fine sandy SILT, trace of clay				40.2	75.9	AYC	ARM	D422
■ DD22-2 Landward, S-4	10.0	SM	Gray, silty, fine SAND				33.7	34.8	AYC	ARM	D422
▲ DD22-2 Landward, S-6	15.0	SP	Gray, fine to medium SAND, trace of silt				24.6	4.4	EXH	ARM	D422
◆ DD22-2 Landward, S-8	20.0	SP	Gray, fine to medium SAND, trace of silt and fine gravel				25.8	3.3	EXH	ARM	D422
○ DD22-2 Landward, S-9	22.5	SP	Gray, fine to medium SAND, trace of silt and fine gravel				24.7	2.6	EXH	ARM	D422
□ DD22-2 Landward, S-10	27.0	SP	Gray SAND, trace of silt and fine gravel				21.4	3.9	EXH	ARM	D422
△ DD22-2 Landward, S-12	37.0	SM	Gray-brown, silty, fine SAND				38.0	47.8	AYC	ARM	D422

Skagit River Levee General Investigation
Skagit County, Washington

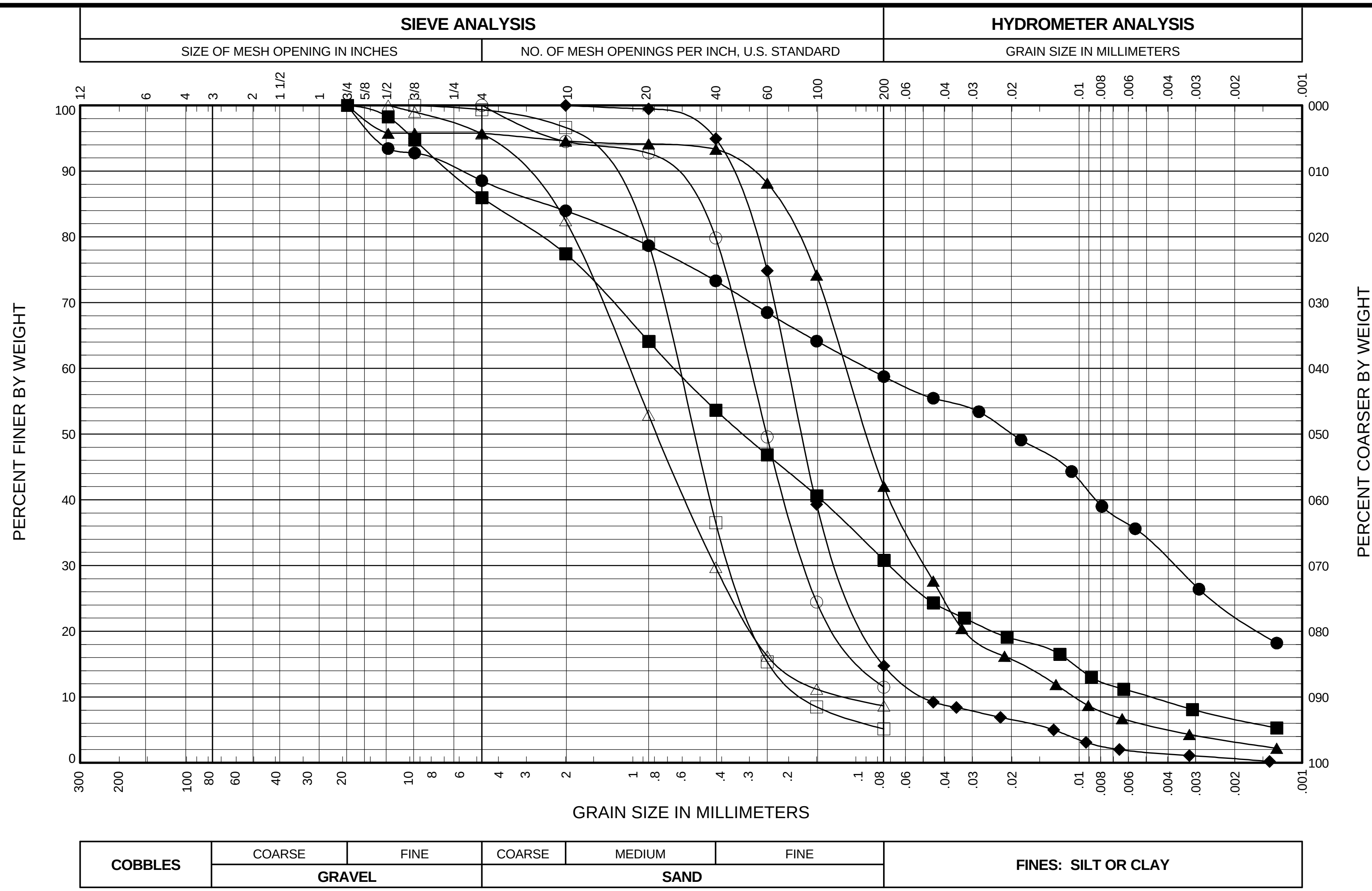
GRAIN SIZE DISTRIBUTION
BORING DD22-2 Landward

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-27

FIG. C-27



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 STND
● DD22-2 Levee, S-1	2.5	CL	Brown, slightly fine gravelly, sandy, silty CLAY				19.8	58.7	AYC	ARM	D422
■ DD22-2 Levee, S-2	5.0	SM	Brown, fine gravelly, silty SAND, trace of clay				13.8	30.8	AYC	ARM	D422
▲ DD22-2 Levee, S-4	10.0	SM	Brown, silty, fine SAND, trace of fine gravel				16.2	42.0	AYC	ARM	D422
◆ DD22-2 Levee, S-9	25.0	SM	Dark-gray, silty, fine to medium SAND				38.6	14.7	AYC	ARM	D422
○ DD22-2 Levee, S-10*	30.0	SP-SM	Gray, slightly silty SAND; scattered wood fragments				38.1	11.5	EXH	ARM	D422
□ DD22-2 Levee, S-11	35.0	SP-SM	Gray, slightly silty, fine to medium SAND				23.1	5.1	EXH	ARM	D422
△ DD22-2 Levee, S-13*	45.0	SW-SM	Gray, slightly silty SAND, trace of fine gravel				27.2	8.6	EXH	ARM	D422

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

Skagit River Levee General Investigation
Skagit County, Washington

GRAIN SIZE DISTRIBUTION
BORING DD22-2 Levee

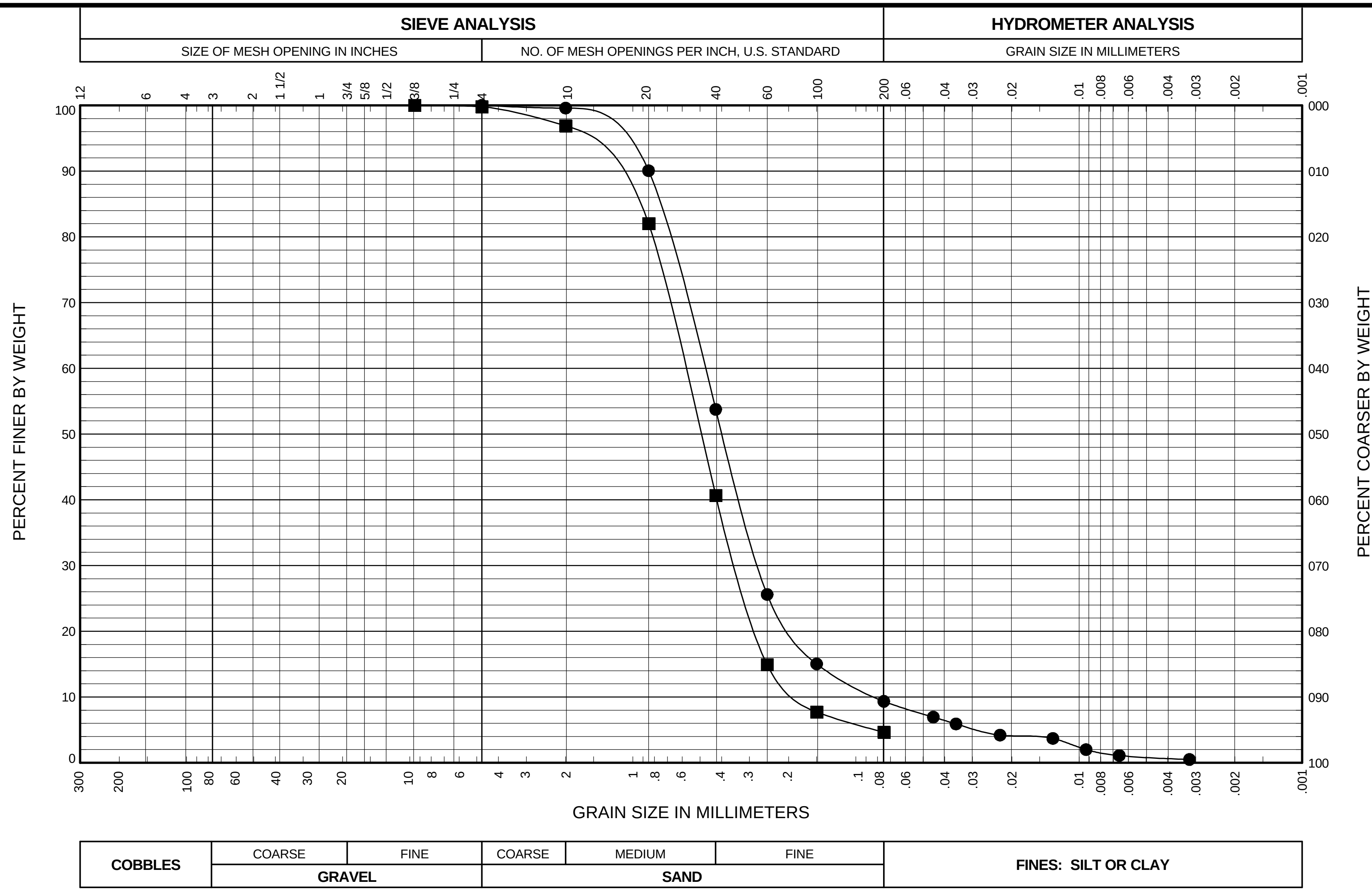
June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-28
Sheet 1 of 2

AASHTO GSA MAIN LOCAL 21-21199.GPJ SHAN WIL.GDT 6/1/10

FIG. C-28



AASHTO GSA MAIN LOCAL 21-21199.GPJ SHAN WIL.GDT 6/1/10

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 STND
● DD22-2 Levee, S-15	55.0	SP-SM	Gray, slightly silty, fine to medium SAND				25.5	9.3	AYC	ARM	D422
■ DD22-2 Levee, S-16	60.0	SP	Gray, fine to medium SAND, trace of silt				25.5	4.7	EXH	ARM	D422

Skagit River Levee General Investigation
Skagit County, Washington

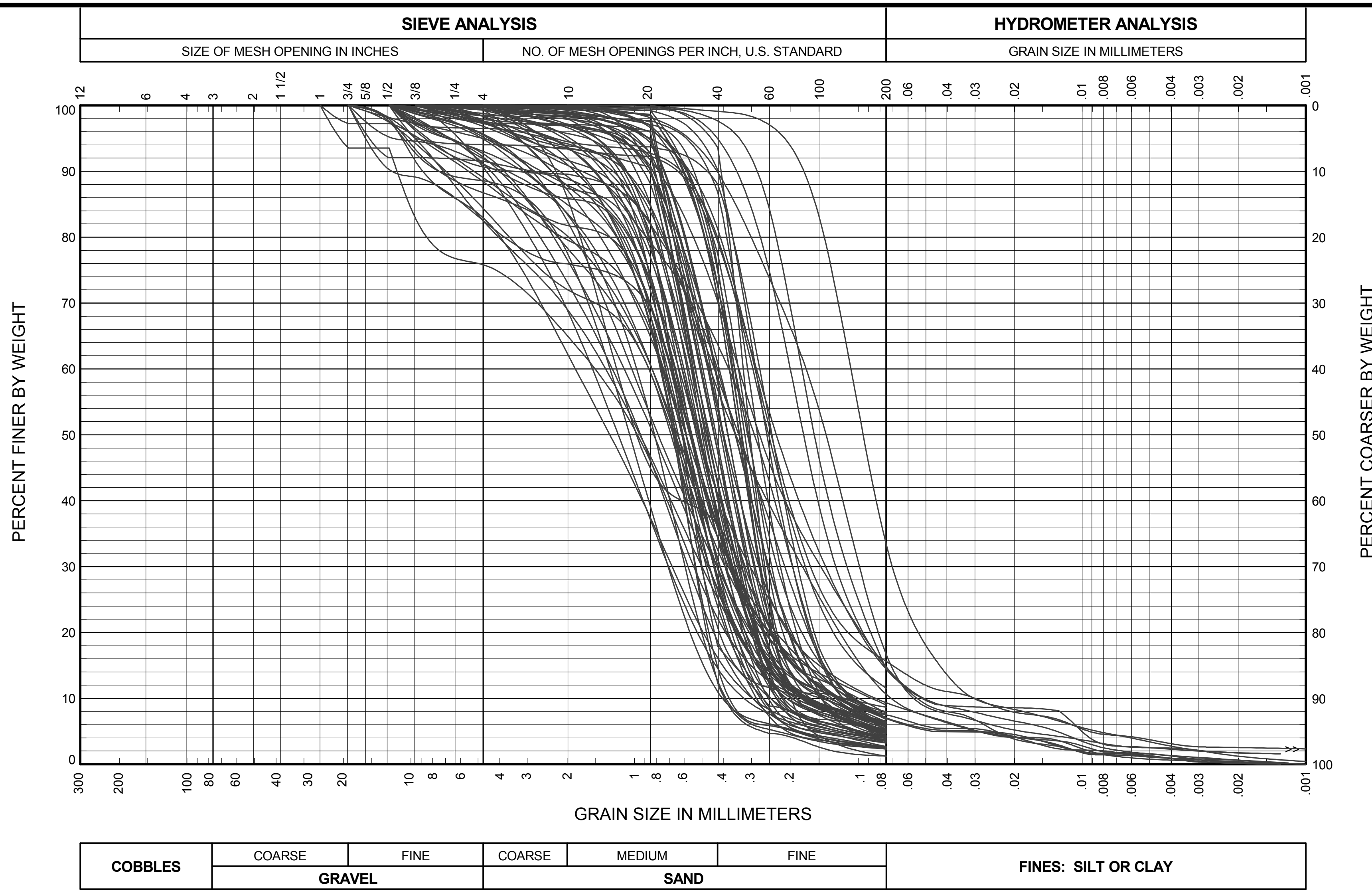
GRAIN SIZE DISTRIBUTION
BORING DD22-2 Levee

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-28
Sheet 2 of 2

FIG. C-28



GSA_UNIT LOCAL 21-21199.GPJ SHAN_WIL.GDT 6/1/10

Skagit River Levee General Investigation
Skagit County, Washington

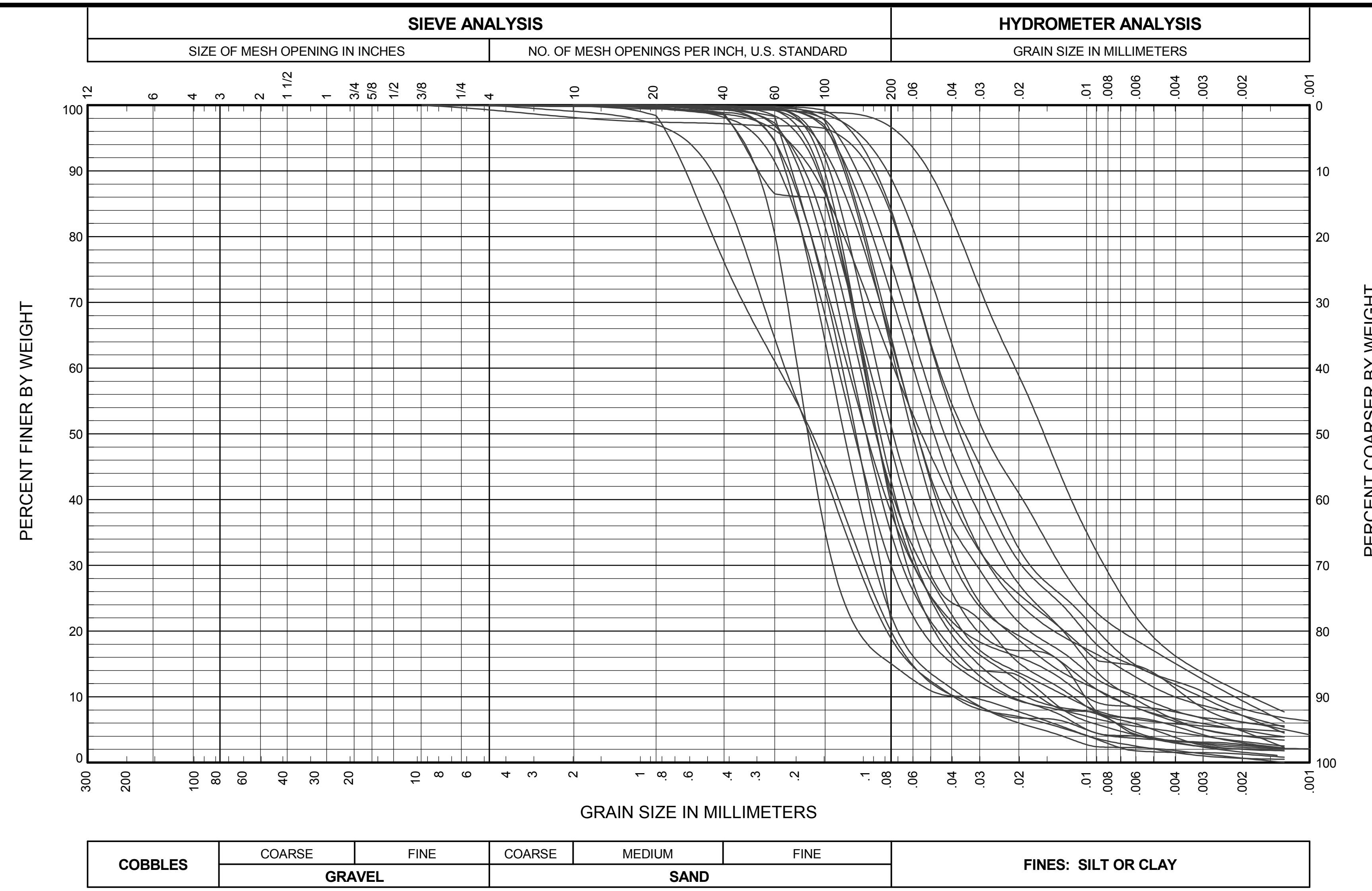
GRAIN SIZE DISTRIBUTION
Channel Deposits (Ha[cd])

June 2010 | 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-29

FIG. C-29



Skagit River Levee General Investigation
Skagit County, Washington

GRAIN SIZE DISTRIBUTION

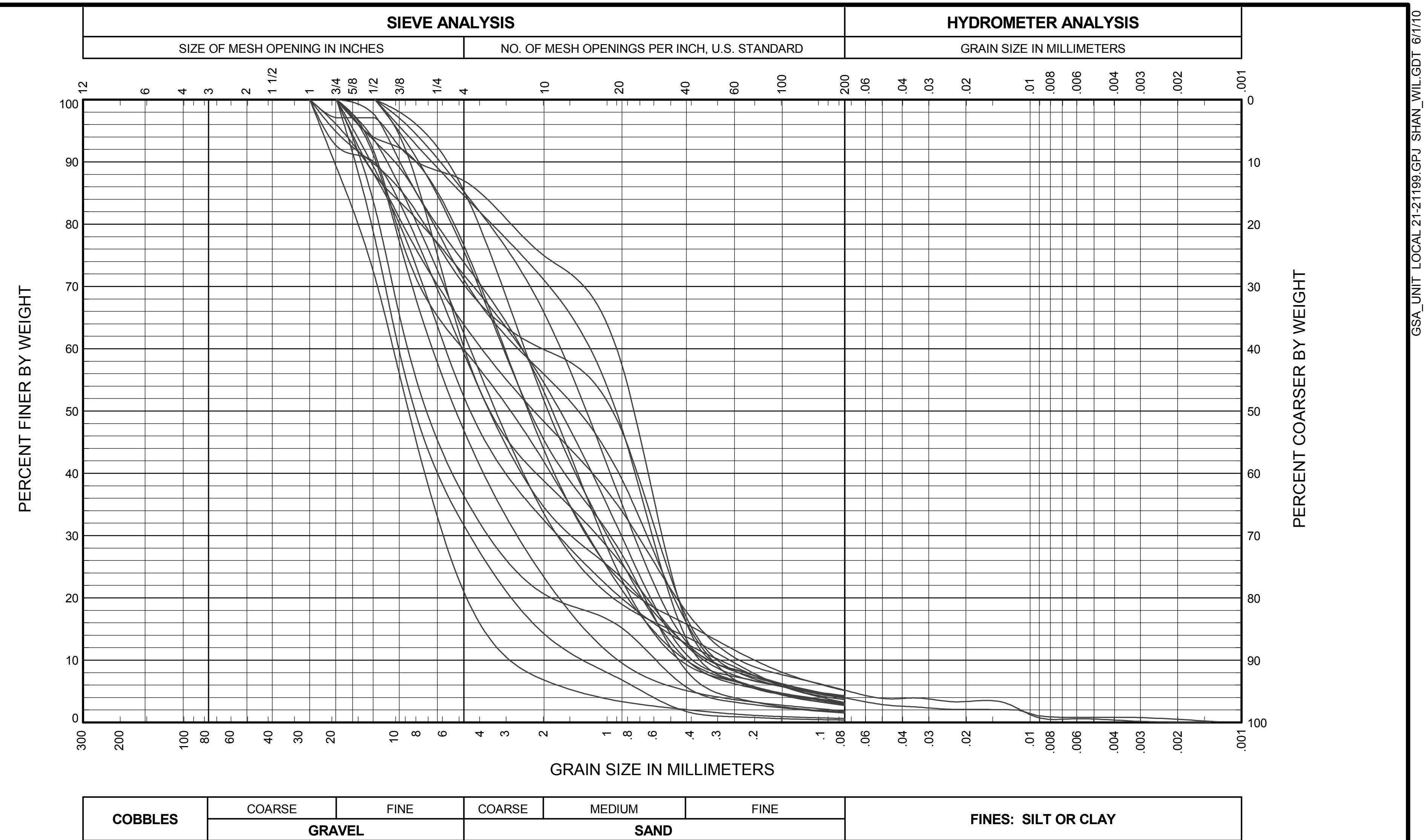
Overbank Deposits (Ha[ob])

June 2010 | 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-30

FIG. C-30



Skagit River Levee General Investigation
Skagit County, Washington

GRAIN SIZE DISTRIBUTION

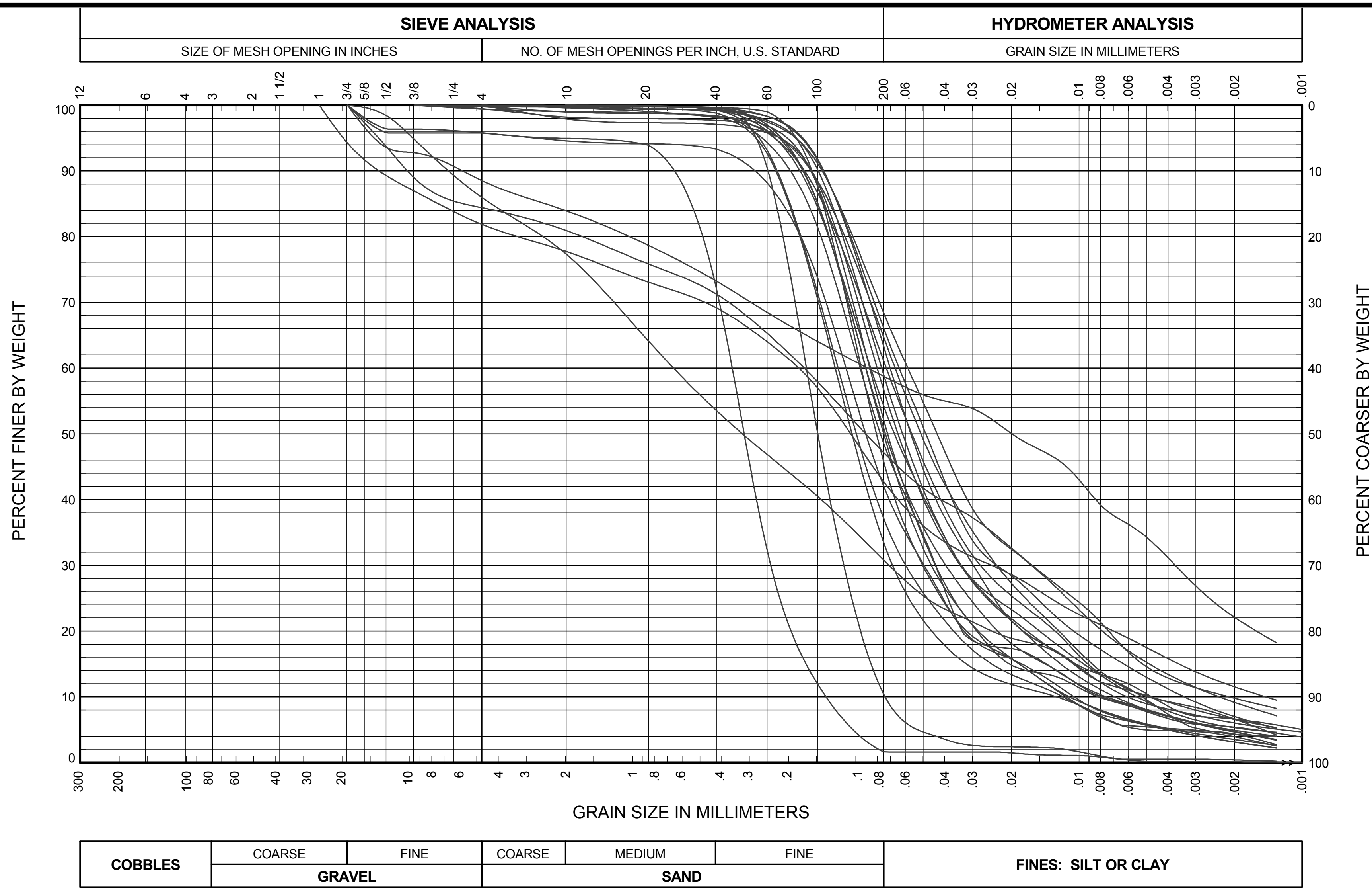
Gravelly Channel Deposits (Ha[g])

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-31

FIG. C-31



Skagit River Levee General Investigation
Skagit County, Washington

GRAIN SIZE DISTRIBUTION

Levee Fill (Hf)

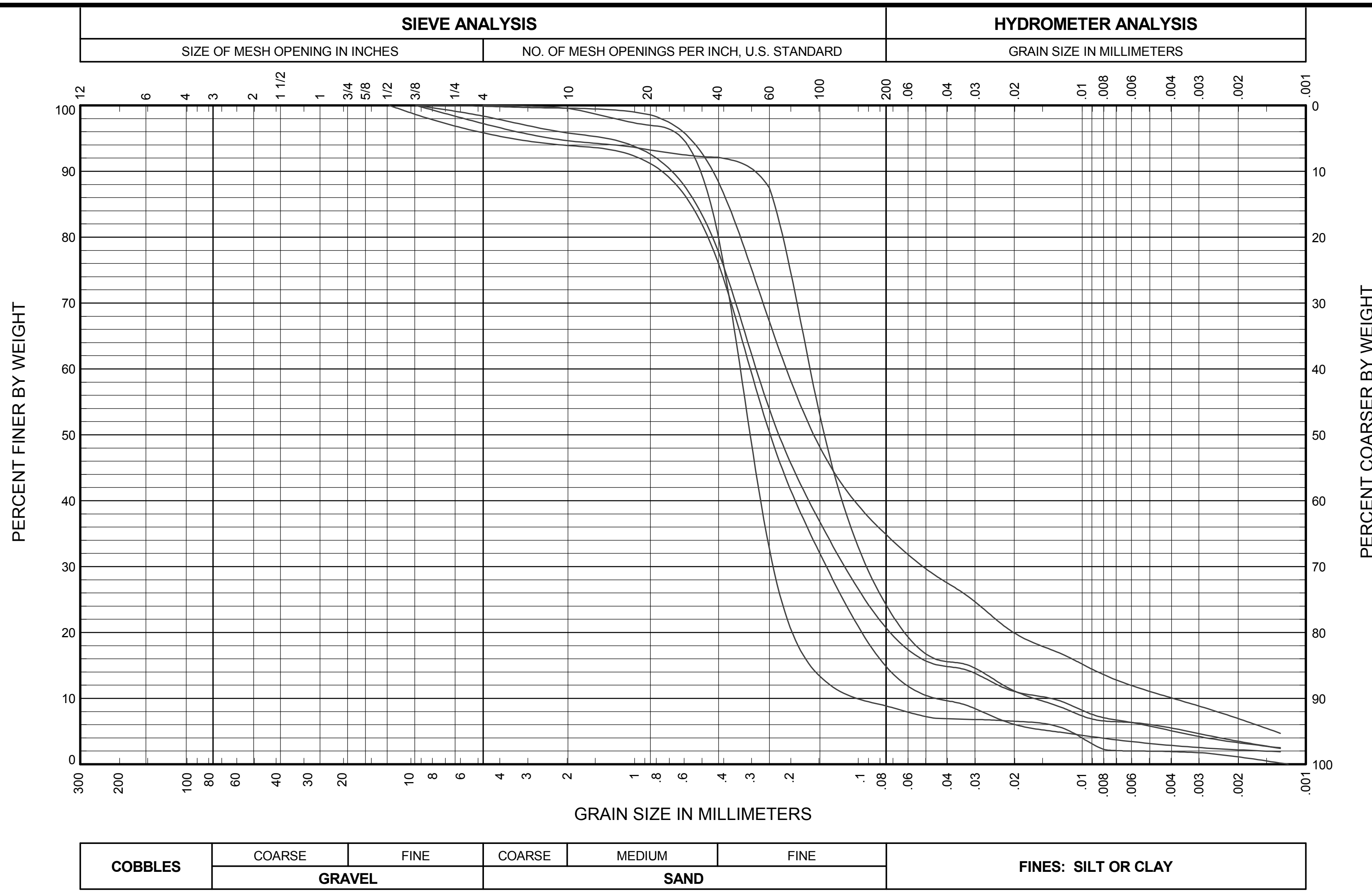
June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-32

GSA_UNIT LOCAL 21-21199.GPJ SHAN_WIL.GDT 6/1/10

FIG. C-32



GSA_UNIT LOCAL 21-21199.GPJ SHAN_WIL.GDT 6/1/10

Skagit River Levee General Investigation
Skagit County, Washington

GRAIN SIZE DISTRIBUTION

Estuary Deposits (He)

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-33

ONE DIMENSIONAL CONSOLIDATION TEST NO. 1
S U M M A R Y O F T E S T D A T A

Boring DD17-3 Levee
Sample S-17
Depth, ft 62.9

Tested By / Date AKV 12/3/2009
Calc. By / Date AKV 1/6/2010
Check By / Date AJC 1/15/2010

CLASSIFICATION:
Gray, slightly clayey, SILT; scattered organics;

SAMPLE DATA:
Spec. Grav. (est.) : 2.70
Specimen : UNDISTURBED

SPECIMEN DATA:

	Before Test	After Test
Height, inches :	.786	.632
Diameter, inches :	2.503	2.503
Wet Density, pcf :	106.9	123.4
Dry Density, pcf :	73.9	91.6
Water Content, % :	44.7	34.7
Void Ratio :	1.280	.834
Saturation, % :	94	112

Spec Load kg	d 100 0.01mm	Defl Corr 0.01mm	Consol Pressure tsf	Settlement %	Void Ratio	t 50 min.	d 50 0.01mm	Coeff of Consol cm2/sec	Coeff of Perm cm/sec
.1	.9	.6	.03	.0	1.280	.3	.8	1.09E-02	
.2	4.7	1.8	.06	.1	1.277	.2	4.1	1.63E-02	6.36E-07
.4	11.9	3.8	.13	.4	1.271	.2	11.0	1.62E-02	6.57E-07
.8	22.4	6.7	.26	.8	1.263	.2	21.4	1.61E-02	4.78E-07
1.6	36.7	10.6	.52	1.3	1.251	.2	35.4	1.60E-02	3.23E-07
3.2	57.0	15.0	1.03	2.1	1.233	.2	55.1	1.57E-02	2.42E-07
6.4	89.0	19.8	2.06	3.5	1.202	.2	85.3	1.53E-02	2.02E-07
12.8	148.6	26.3	4.13	6.1	1.141	.2	139.3	1.46E-02	1.87E-07
3.2	144.2	20.8	1.03	6.2	1.140	.1	145.3	2.88E-02	
.8	122.2	14.7	.26	5.4	1.158	.2	126.1	1.46E-02	
.2	101.7	10.9	.06	4.5	1.177	.2	107.3	1.48E-02	
.8	105.0	13.0	.26	4.6	1.176	.2	104.0	1.49E-02	4.36E-08
3.2	128.7	19.1	1.03	5.5	1.155	.2	127.1	1.46E-02	1.67E-07
12.8	172.5	26.2	4.13	7.3	1.114	.2	167.5	1.41E-02	8.37E-08
25.6	243.7	32.0	8.26	10.6	1.039	.2	231.8	1.32E-02	1.05E-07
51.2	341.8	39.7	16.52	15.1	.936	.2	327.7	1.20E-02	6.57E-08
102.4	449.3	34.0	33.04	20.8	.806	.2	432.8	1.05E-02	3.59E-08
25.6	449.3	25.6	8.26	21.2	.797	.2	450.0	1.01E-02	
6.4	428.5	19.2	2.06	20.5	.813	.2	430.6	1.03E-02	
1.6	406.4	15.6	.52	19.6	.834	.2	410.4	1.05E-02	

Skagit River Levee General Investigation
Skagit County, WA

CONSOLIDATION TEST
DD17-3 Levee, S-17, 62.9'

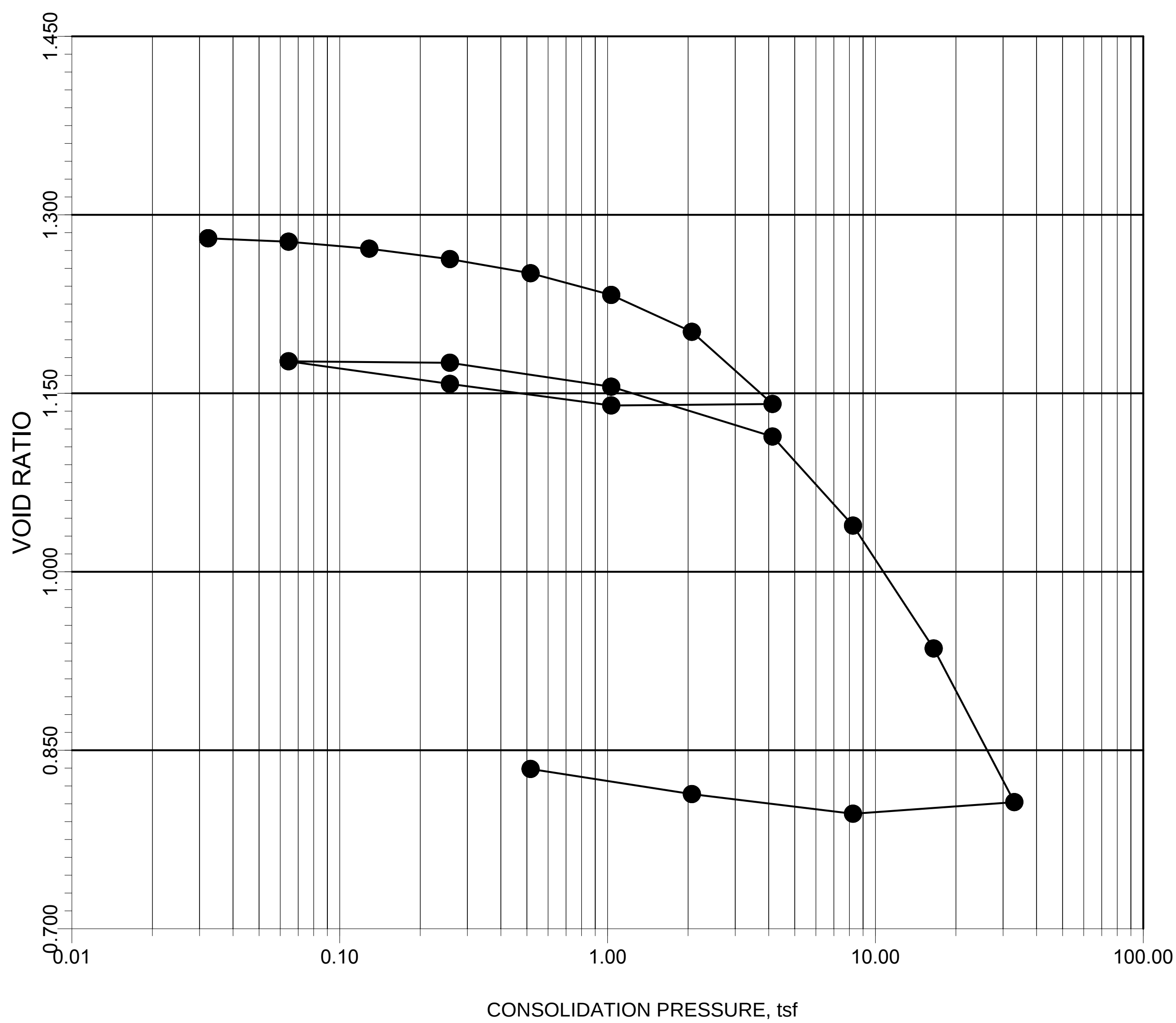
June 2010 21-1-21199-002

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. C-34 (1/3)

ONE DIMENSIONAL CONSOLIDATION TEST NO. 1
VOID RATIO VS LOG10(CONSOLIDATION PRESSURE)

Boring	DD17-3 Levee	Tested	By / Date	AKV	12/3/2009
Sample	S-17	Calc.	By / Date	AKV	1/6/2010
Depth, ft	62.9	Check	By / Date	AJC	1/15/2010



Skagit River Levee General Investigation
Skagit County, WA

CONSOLIDATION TEST
DD17-3 Levee, S-17, 62.9'

June 2010 21-1-21199-002

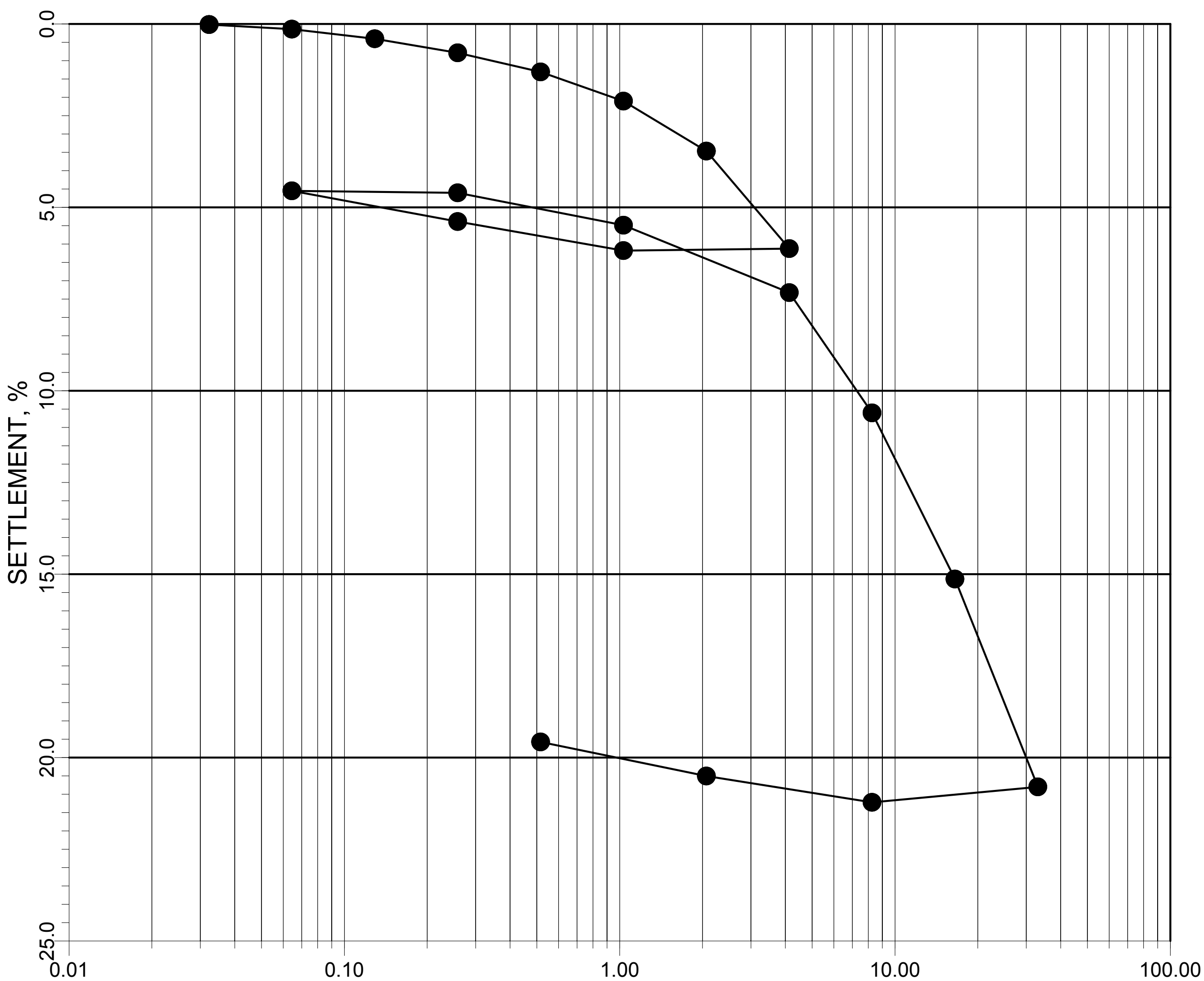
SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. C-34 (2/3)

I:\Groups\Lab\LabPrgm\Projects\21-21199-002\DD17_R3_S17_62_9.ODC :: 3/3/2010 7:07:24 PM

ONE DIMENSIONAL CONSOLIDATION TEST NO. 1
SETTLEMENT VS LOG10(CONSOLIDATION PRESSURE)

Boring	DD17-3 Levee	Tested	By / Date	AKV	12/3/2009
Sample	S-17	Calc.	By / Date	AKV	1/6/2010
Depth, ft	62.9	Check	By / Date	AJC	1/15/2010



I:\Groups\Lab\LabPrgm\Projects\21-21199-002\DD17_R3_S17_62_9.ODC :: 3/3/2010 7:07:50 PM

Skagit River Levee General Investigation
Skagit County, WA

CONSOLIDATION TEST
DD17-3 Levee, S-17, 62.9'

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. C-34 (3/3)

ONE DIMENSIONAL CONSOLIDATION TEST NO. 2
S U M M A R Y O F T E S T D A T A

Boring DD22-2 Landward
Sample S-2
Depth, ft 6.4

Tested By / Date AKV 12/10/2009
Calc. By / Date AKV 1/6/2010
Check By / Date AJC 1/15/2010

CLASSIFICATION:
Gray, slightly clayey SILT; ML

SAMPLE DATA:
Spec. Grav. (est.) : 2.70
Specimen : UNDISTURBED

SPECIMEN DATA:

	Before Test	After Test
Height, inches :	.788	.664
Diameter, inches :	2.502	2.502
Wet Density, pcf :	108.0	118.3
Dry Density, pcf :	73.3	86.8
Water Content, % :	47.5	36.4
Void Ratio :	1.298	.938
Saturation, % :	99	104

Spec Load kg	d 100 0.01mm	Defl Corr 0.01mm	Consol Pressure tsf	Settlement %	Void Ratio	t 50 min.	d 50 0.01mm	Coeff of Consol cm2/sec	Coeff of Perm cm/sec
.1	2.0	.6	.03	.1	1.298	.2	1.4	2.05E-02	
.2	8.7	1.8	.06	.3	1.292	.2	6.5	1.42E-02	1.22E-06
.4	20.5	3.8	.13	.8	1.281	.2	17.0	1.62E-02	1.23E-06
.8	37.8	6.7	.26	1.6	1.264	.2	32.6	1.60E-02	8.91E-07
1.6	63.7	10.6	.52	2.7	1.239	.2	57.0	1.57E-02	6.69E-07
3.2	100.3	15.0	1.03	4.3	1.202	.3	91.4	9.81E-03	3.06E-07
6.4	154.2	19.8	2.07	6.7	1.146	.2	141.2	1.81E-02	4.30E-07
12.8	225.9	26.3	4.13	10.0	1.071	.2	208.9	1.70E-02	2.68E-07
3.2	224.6	20.8	1.03	10.2	1.066	.2	225.7	1.56E-02	
.8	205.1	14.7	.26	9.5	1.081	.2	210.5	1.57E-02	
.2	186.2	10.9	.06	8.8	1.099	.3	193.2	9.70E-03	
.8	187.7	13.0	.26	8.7	1.099	.2	185.8	1.61E-02	2.37E-08
3.2	208.9	19.1	1.03	9.5	1.082	.1	204.8	1.93E-02	1.89E-07
12.8	250.1	26.2	4.13	11.2	1.043	.2	243.6	1.63E-02	8.95E-08
25.6	312.8	32.0	8.27	14.0	.977	.2	297.4	1.46E-02	1.00E-07
51.2	394.4	39.7	16.53	17.7	.892	.2	398.0	1.23E-02	5.50E-08
12.8	395.5	34.0	4.13	18.1	.885	.2	396.4	1.38E-02	
3.2	375.4	25.6	1.03	17.5	.898	.2	379.0	1.39E-02	
.8	351.9	19.2	.26	16.6	.918	.3	359.8	7.81E-03	
.2	330.3	15.6	.06	15.7	.938	.6	337.6	3.92E-03	

I:\Groups\Lab\LabPrgm\Projects\21-21199-002\DD22_3_S2_6_4.ODC :: 3/3/2010 7:08:28 PM

Skagit River Levee General Investigation
Skagit County, WA

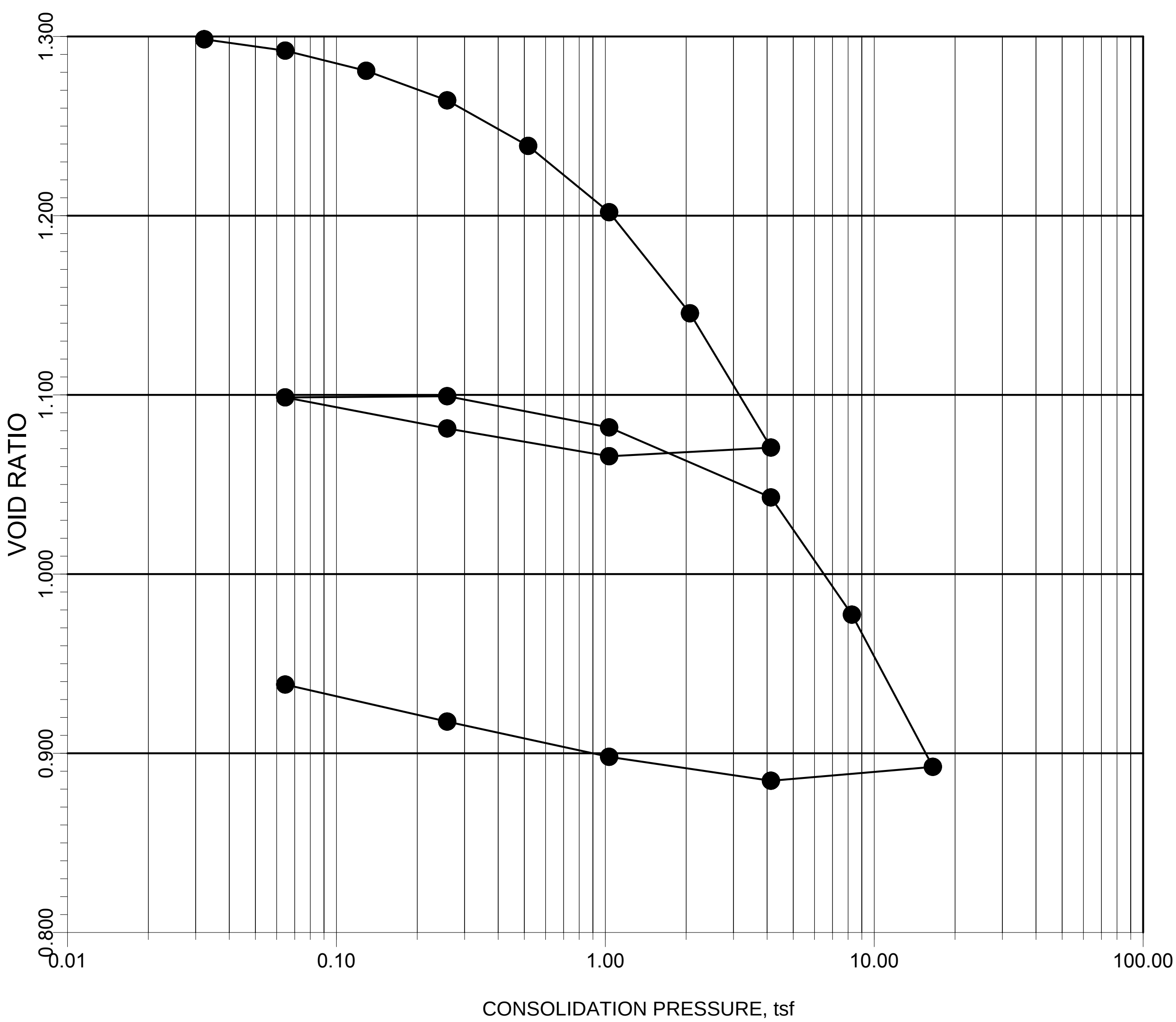
CONSOLIDATION TEST
DD22-2 Landward, S-2, 6.4'

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

ONE DIMENSIONAL CONSOLIDATION TEST NO. 2
VOID RATIO VS LOG10(CONSOLIDATION PRESSURE)

Boring	DD22-2 Landward	Tested By / Date	AKV 12/10/2009
Sample	S-2	Calc. By / Date	AKV 1/6/2010
Depth, ft	6.4	Check By / Date	AJC 1/15/2010



Skagit River Levee General Investigation
Skagit County, WA

CONSOLIDATION TEST
DD22-2 Landward, S-2, 6.4'

June 2010 21-1-21199-002

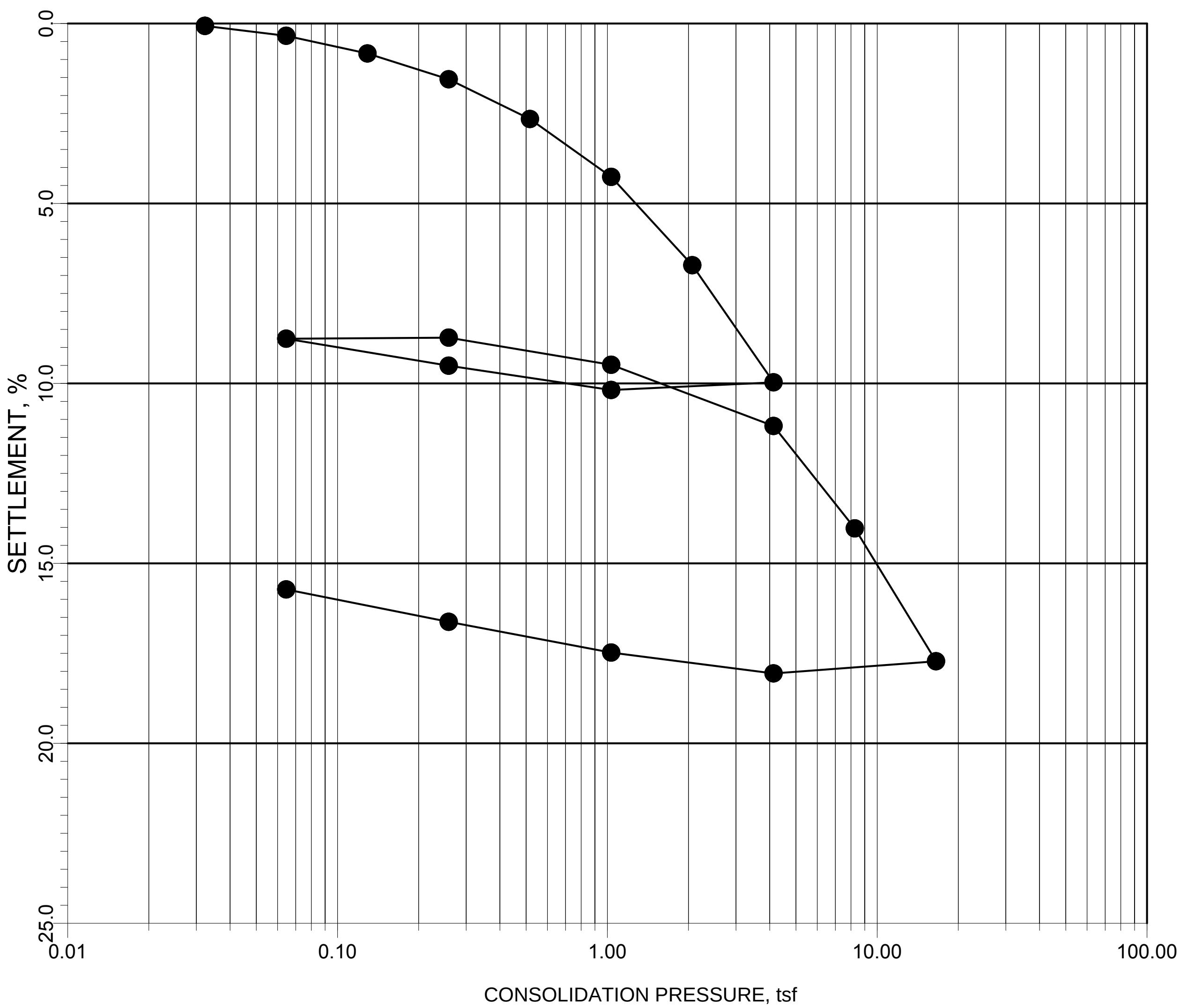
SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. C-35 (2/3)

I:\Groups\Lab\LabPrgm\Projects\21-21199-002\DD22_3_S2_6_4.ODC :: 3/3/2010 7:08:47 PM

ONE DIMENSIONAL CONSOLIDATION TEST NO. 2
SETTLEMENT VS LOG10(CONSOLIDATION PRESSURE)

Boring	DD22-2 Landward	Tested	By / Date	AKV 12/10/2009
Sample	S-2	Calc.	By / Date	AKV 1/6/2010
Depth, ft	6.4	Check	By / Date	AJC 1/15/2010



Skagit River Levee General Investigation
Skagit County, WA

CONSOLIDATION TEST
DD22-2 Landward, S-2, 6.4'

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. C-35 (3/3)

I:\Groups\Lab\LabPrgm\Projects\21-21199-002\DD22_3_S2_6_4.ODC :: 3/3/2010 7:09:13 PM

CONSOLIDATED, UNDRAINED TRIAXIAL COMPRESSION TEST 1a

SUMMARY OF TEST DATA

Boring	DD17-3 Levee	Tested By/Date	AKV 12/10/2009
Sample	S-17	Calc. By/Date	AKV 1/10/2010
Depth (ft)	63.3	Checked By/Date	JFL 1/29/2010

SAMPLE CLASSIFICATION:

Gray-brown, slightly clayey SILT; scattered organics; ML

B-value at end of saturation phase	1.00
Consolidation Stress, psf	2506
Cell pressure during shear, psf	6480
Initial Pore Pressure(U_0), psf	3963
Shear Rate, in/min	0.0035

SPECIMEN DATA:

	Initial	post-consol	post-shear
Height, inches	5.725	5.703	5.415
Diameter, inches	2.5845	2.5845	
Aspect Ratio	2.22	2.21	
Weight, grams	828.85	787.74	787.74
Water	46.5%	39.2%	39.2%
Wet Density, pcf	105.1	100.3	100.3
Dry Density, pcf	71.7	72.0	72.0

Axial Strain inch/inch	Deviator Stress psf	Excess Pore Pres. (psf)	Eff. Major Principal Stress (psf)	Eff. Minor Principal Stress (psf)	Eff. Princ Stress Ratio	Stress Path Parameters (psf) P	P'	Q
0.0016	861	429	2937	2076	1.41	2936	2507	430
0.0033	1346	739	3113	1767	1.76	3179	2440	673
0.0050	1618	918	3205	1587	2.02	3314	2396	809
0.0066	1866	1028	3343	1478	2.26	3438	2410	933
0.0083	2067	1108	3465	1398	2.48	3539	2431	1033
0.0100	2205	1168	3543	1338	2.65	3608	2440	1103
0.0116	2292	1228	3570	1278	2.79	3651	2424	1146
0.0133	2417	1267	3655	1238	2.95	3714	2447	1209
0.0150	2497	1297	3706	1208	3.07	3754	2457	1249
0.0167	2588	1307	3787	1198	3.16	3800	2492	1294
0.0183	2657	1317	3845	1188	3.24	3834	2516	1328
0.0200	2725	1347	3883	1158	3.35	3868	2521	1362
0.0217	2736	1347	3894	1158	3.36	3873	2526	1368
0.0233	2792	1387	3911	1118	3.50	3902	2514	1396
0.0250	2803	1387	3922	1118	3.51	3907	2520	1402
0.0266	2859	1377	3987	1128	3.53	3935	2558	1430
0.0283	2909	1397	4018	1108	3.63	3960	2563	1455
0.0300	2926	1417	4014	1088	3.69	3969	2551	1463
0.0316	2942	1397	4050	1108	3.65	3977	2579	1471
0.0333	2992	1407	4090	1098	3.72	4001	2594	1496
0.0350	3002	1417	4091	1088	3.76	4007	2590	1501
0.0366	3024	1427	4102	1078	3.80	4018	2590	1512
0.0383	2990	1437	4058	1068	3.80	4001	2563	1495
0.0400	3039	1437	4108	1068	3.84	4025	2588	1520
0.0417	3066	1447	4124	1058	3.90	4039	2591	1533
0.0433	3087	1437	4156	1068	3.89	4049	2612	1544
0.0450	3098	1447	4156	1058	3.93	4055	2607	1549
0.0467	3086	1437	4155	1068	3.89	4049	2611	1543
0.0483	3096	1447	4155	1058	3.93	4054	2607	1548
0.0500	3079	1457	4127	1048	3.94	4045	2588	1539

Skagit River Levees General Investigation
Skagit County, Washington

CU TRIAXIAL TEST

Boring DD17-3 Levee, Depth= 63.3'

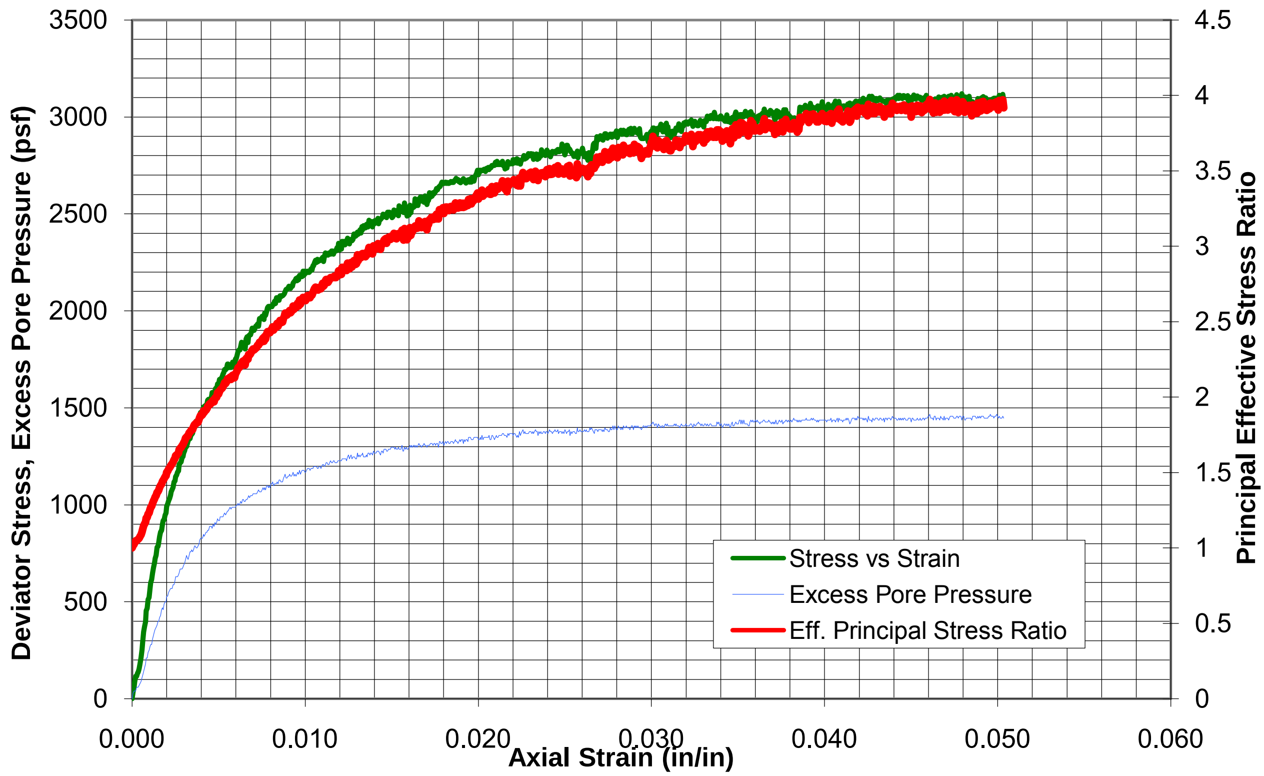
June 2010 21-1-21199-002

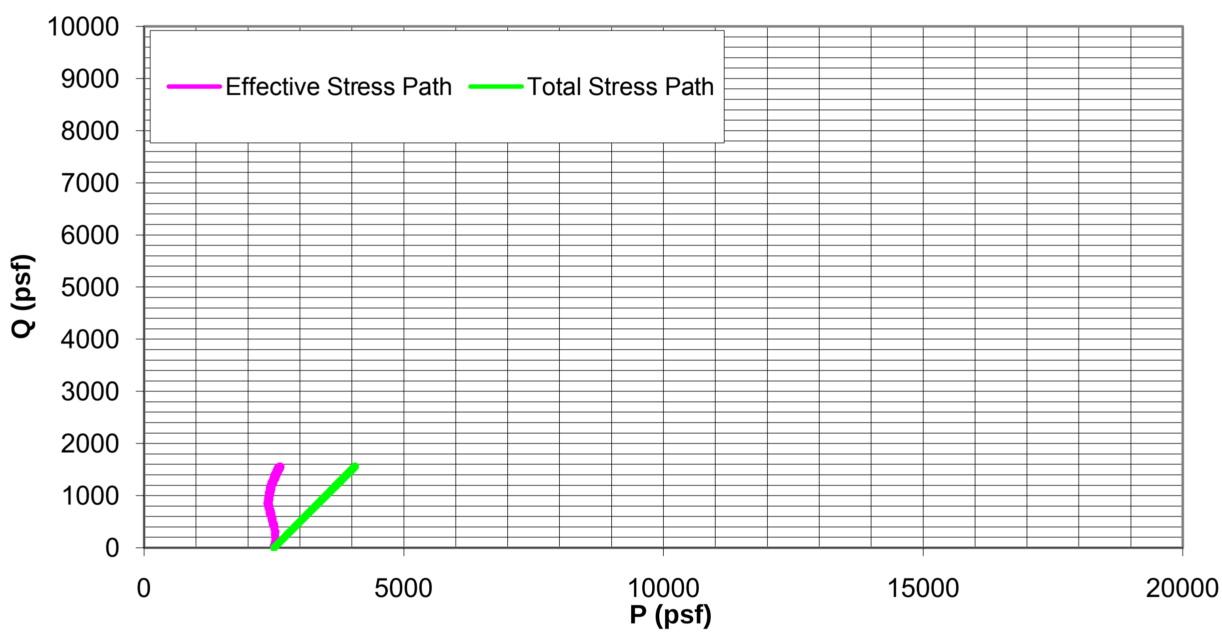
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-36 (1/8)

CONSOLIDATED, UNDRAINED TRIAXIAL COMPRESSION TEST NO. 1a

Boring	DD17-3 Levee	Tested By/Date	AKV 12/10/2009
Sample	S-17	Calc. By/Date	AKV 1/10/2010
Depth (ft)	63.3	Checked By/Date	JFL 1/29/2010





Effective Stress at end-of-consolidation, psf	2506
Cell pressure during shear, psf	6480

Skagit River Levees General Investigation
Skagit County, Washington

CU TRIAXIAL TEST

Boring DD17-3 Levee, Depth= 63.3'

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-36 (2/8)

CONSOLIDATED, UNDRAINED TRIAXIAL COMPRESSION TEST 1b

SUMMARY OF TEST DATA

Boring	DD17-3 Levee	Tested By/Date	AKV 12/11/2009
Sample	S-17	Calc. By/Date	AKV 1/10/2010
Depth (ft)	63.3	Checked By/Date	JFL 1/29/2010

SAMPLE CLASSIFICATION:
Gray-brown, slightly clayey SILT; scattered organics; ML

B-value at end of saturation phase	1.00
Consolidation Stress, psf	4997
Cell pressure during shear, psf	8971
Initial Pore Pressure(U_0), psf	4030
Shear Rate, in/min	0.0035

SPECIMEN DATA:

	Initial	post-consol	post-shear
Height, inches	5.415	5.462	5.175
Diameter, inches	2.652	2.652	
Aspect Ratio	2.04	2.06	
Weight, grams	780.05	787.74	787.74
Water	37.9%	39.2%	39.2%
Wet Density, pcf	99.3	99.4	99.4
Dry Density, pcf	72.0	71.4	71.4

Axial Strain inch/inch	Deviator Stress psf	Excess Pore Pres. (psf)	Eff. Major Principal Stress (psf)	Eff. Minor Principal Stress (psf)	Eff. Princ Stress Ratio	Stress Path Parameters (psf) P	P'	Q
0.0017	1199	679	5518	4318	1.28	5596	4918	600
0.0035	2051	1317	5731	3679	1.56	6022	4705	1026
0.0053	2710	1727	5980	3270	1.83	6352	4625	1355
0.0070	3089	1986	6100	3011	2.03	6541	4555	1545
0.0088	3370	2186	6181	2811	2.20	6682	4496	1685
0.0106	3601	2335	6262	2661	2.35	6797	4462	1800
0.0124	3718	2455	6259	2542	2.46	6856	4401	1859
0.0141	3974	2535	6436	2462	2.61	6984	4449	1987
0.0159	4074	2635	6436	2362	2.72	7034	4399	2037
0.0176	4205	2695	6507	2302	2.83	7100	4405	2103
0.0194	4277	2745	6529	2252	2.90	7135	4391	2139
0.0212	4349	2795	6551	2202	2.97	7171	4377	2174
0.0229	4447	2844	6599	2152	3.07	7220	4376	2223
0.0247	4550	2874	6672	2122	3.14	7272	4397	2275
0.0265	4636	2914	6719	2083	3.23	7315	4401	2318
0.0282	4680	2944	6733	2053	3.28	7337	4393	2340
0.0300	4729	2974	6752	2023	3.34	7361	4387	2365
0.0318	4741	3004	6733	1993	3.38	7367	4363	2370
0.0336	4794	3024	6767	1973	3.43	7394	4370	2397
0.0353	4806	3054	6749	1943	3.47	7400	4346	2403
0.0371	4823	3044	6775	1953	3.47	7408	4364	2411
0.0388	4818	3074	6741	1923	3.51	7406	4332	2409
0.0406	4871	3094	6774	1903	3.56	7432	4338	2436
0.0424	4856	3094	6759	1903	3.55	7425	4331	2428
0.0441	4862	3124	6735	1873	3.60	7428	4304	2431
0.0459	4878	3144	6731	1853	3.63	7436	4292	2439
0.0477	4707	3144	6560	1853	3.54	7350	4206	2353
0.0495	4900	3134	6762	1863	3.63	7447	4313	2450
0.0512	4941	3144	6794	1853	3.67	7468	4324	2471
0.0526	4866	3144	6719	1853	3.63	7430	4286	2433

Skagit River Levee General Investigation
Skagit County, Washington

CU TRIAXIAL TEST

Boring DD17-3 Levee, Depth= 63.3'

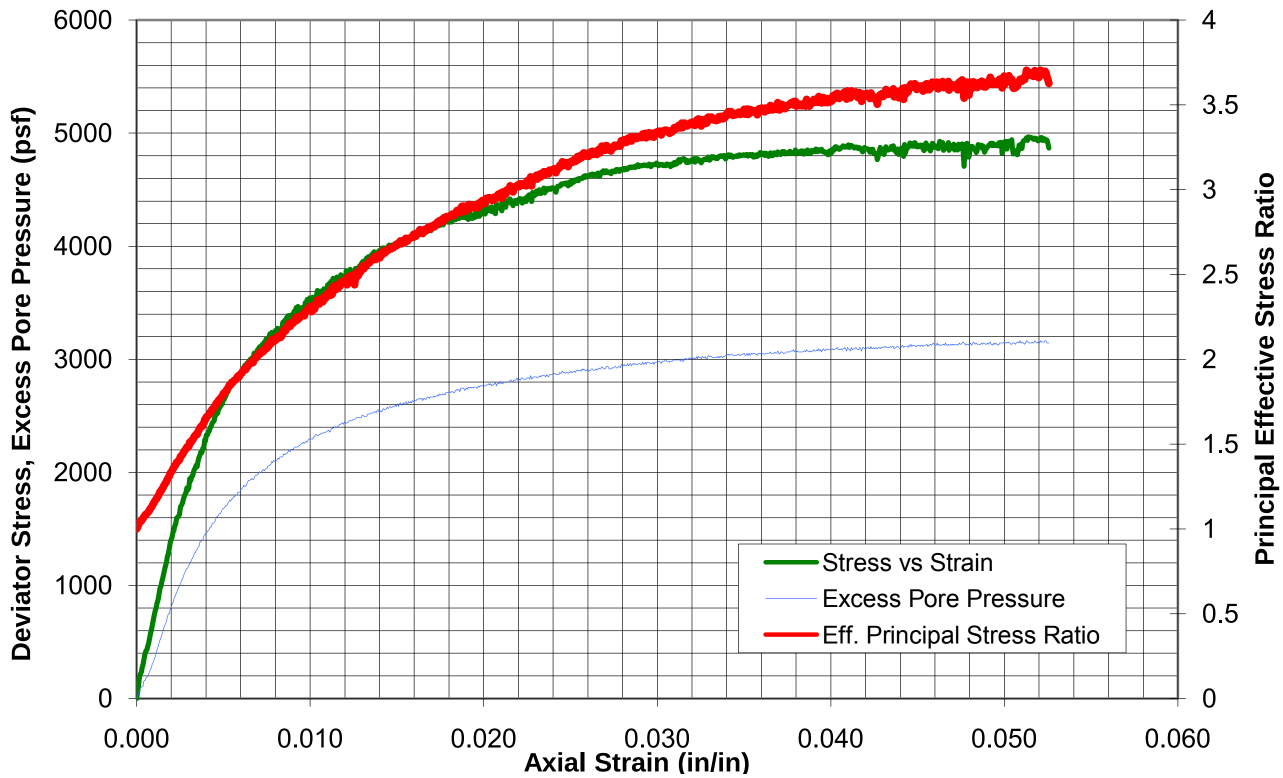
June 2010 21-1-21199-002

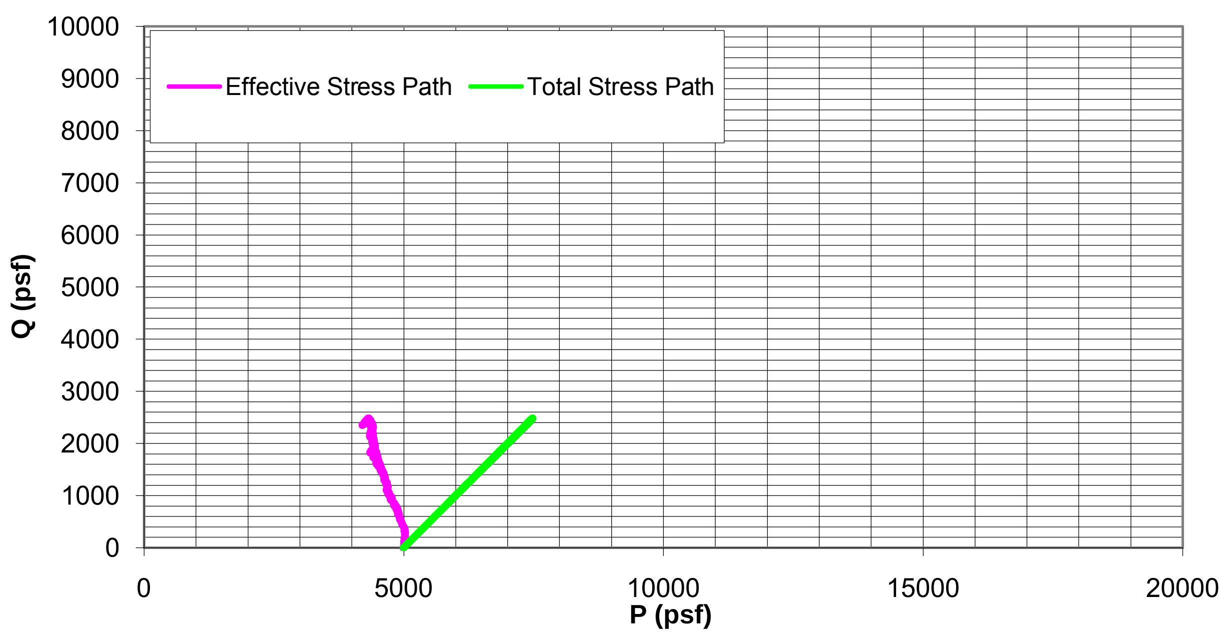
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-36 (3/8)

CONSOLIDATED, UNDRAINED TRIAXIAL COMPRESSION TEST NO. 1b

Boring	DD17-3 Levee	Tested By/Date	AKV 12/11/2009
Sample	S-17	Calc. By/Date	AKV 1/10/2010
Depth (ft)	63.3	Checked By/Date	JFL 1/29/2010





Effective Stress at end-of-consolidation, psf 4997
Cell pressure during shear, psf 8971

Skagit River Levee General Investigation
Skagit County, Washington

CU TRIAXIAL TEST

Boring DD17-3 Levee, Depth= 63.3'

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-36 (4/8)

CONSOLIDATED, UNDRAINED TRIAXIAL COMPRESSION TEST 1c

SUMMARY OF TEST DATA

Boring	DD17-3 Levee	Tested By/Date	AKV 12/11/2009
Sample	S-17	Calc. By/Date	AKV 1/11/2010
Depth (ft)	63.3	Checked By/Date	JFL 1/29/2010

SAMPLE CLASSIFICATION:
Gray-brown, slightly clayey SILT; scattered organics

B-value at end of saturation phase	1.00
Consolidation Stress, psf	9994
Cell pressure during shear, psf	13968
Initial Pore Pressure(U_0), psf	4487
Shear Rate, in/min	0.0035

SPECIMEN DATA:

	Initial	post-consol	post-shear
Height, inches	5.415	5.455	4.361
Diameter, inches	2.7252	2.7252	
Aspect Ratio	1.99	2.00	
Weight, grams	738.85	787.74	787.74
Water	30.6%	39.2%	39.2%
Wet Density, pcf	89.1	94.3	94.3
Dry Density, pcf	68.2	67.7	67.7

Axial Strain inch/inch	Deviator Stress psf	Excess Pore Pres. (psf)	Eff. Major Principal Stress (psf)	Eff. Minor Principal Stress (psf)	Eff. Princ Stress Ratio	Stress Path Parameters (psf) P	P'	Q
0.0067	4937	3413	11518	6580	1.75	12462	9049	2469
0.0134	6560	4751	11803	5243	2.25	13274	8523	3280
0.0201	7263	5320	11937	4674	2.55	13625	8305	3631
0.0268	7693	5619	12068	4375	2.76	13840	8221	3847
0.0335	7922	5809	12107	4185	2.89	13955	8146	3961
0.0402	8062	5918	12137	4075	2.98	14025	8106	4031
0.0469	8165	5998	12160	3995	3.04	14076	8078	4083
0.0536	8247	6058	12182	3936	3.10	14117	8059	4123
0.0603	8283	6098	12178	3896	3.13	14135	8037	4141
0.0670	8244	6118	12119	3876	3.13	14116	7998	4122
0.0737	8292	6148	12137	3846	3.16	14139	7992	4146
0.0804	8299	6168	12125	3826	3.17	14143	7976	4150
0.0871	8279	6178	12095	3816	3.17	14133	7955	4139
0.0938	8205	6168	12031	3826	3.14	14096	7928	4103
0.1005	8113	6168	11939	3826	3.12	14050	7882	4056
0.1072	8003	6158	11839	3836	3.09	13995	7837	4001
0.1139	7737	6148	11583	3846	3.01	13862	7714	3869
0.1206	7212	6198	11008	3796	2.90	13600	7402	3606
0.1273	6905	6268	10631	3726	2.85	13446	7178	3452
0.1340	6611	6348	10257	3646	2.81	13299	6951	3305
0.1407	6352	6397	9948	3596	2.77	13170	6772	3176
0.1474	6158	6447	9704	3546	2.74	13072	6625	3079
0.1540	5970	6497	9467	3496	2.71	12979	6482	2985
0.1608	5815	6527	9281	3467	2.68	12901	6374	2907
0.1675	5713	6567	9140	3427	2.67	12850	6283	2857
0.1742	5583	6577	8999	3417	2.63	12785	6208	2791
0.1809	5509	6617	8885	3377	2.63	12748	6131	2754
0.1876	5418	6637	8775	3357	2.61	12703	6066	2709
0.1943	5333	6647	8679	3347	2.59	12660	6013	2666
0.2006	5205	6657	8542	3337	2.56	12596	5939	2603

Skagit River Levee General Investigation

Skagit County, Washington

CU TRIAXIAL TEST

Boring DD17-3 Levee, Depth= 63.3'

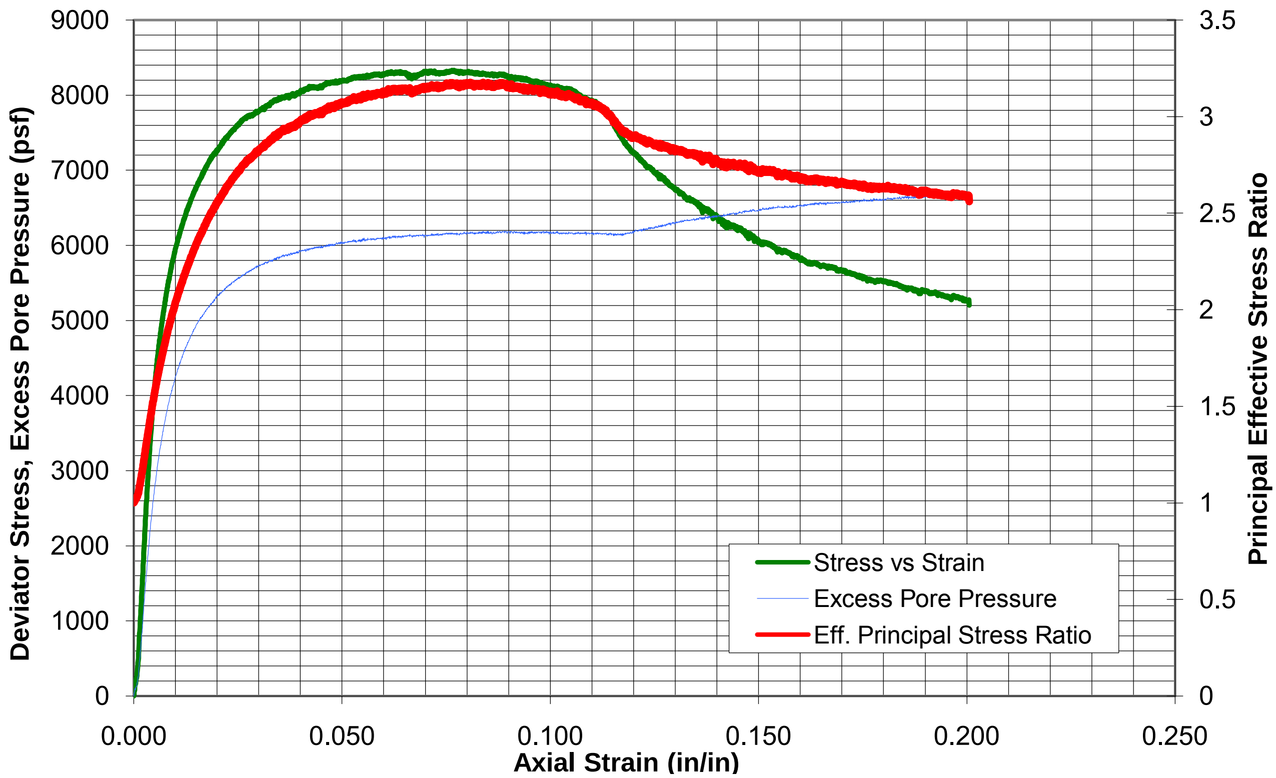
June 2010 21-1-21199-002

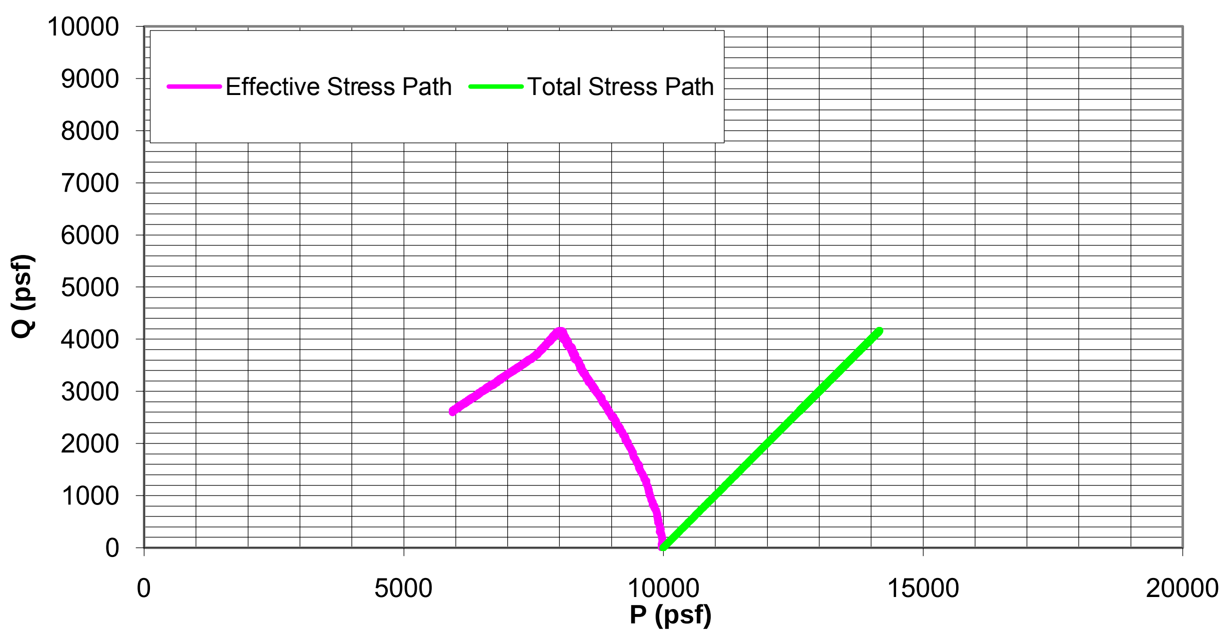
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-36 (5/8)

CONSOLIDATED, UNDRAINED TRIAXIAL COMPRESSION TEST NO. 1c

Boring	DD17-3 Levee	Tested By/Date	AKV 12/11/2009
Sample	S-17	Calc. By/Date	AKV 1/11/2010
Depth (ft)	63.3	Checked By/Date	JFL 1/29/2010





Effective Stress at end-of-consolidation, psf	9994
Cell pressure during shear, psf	13968

Skagit River Levee General Investigation
Skagit County, Washington

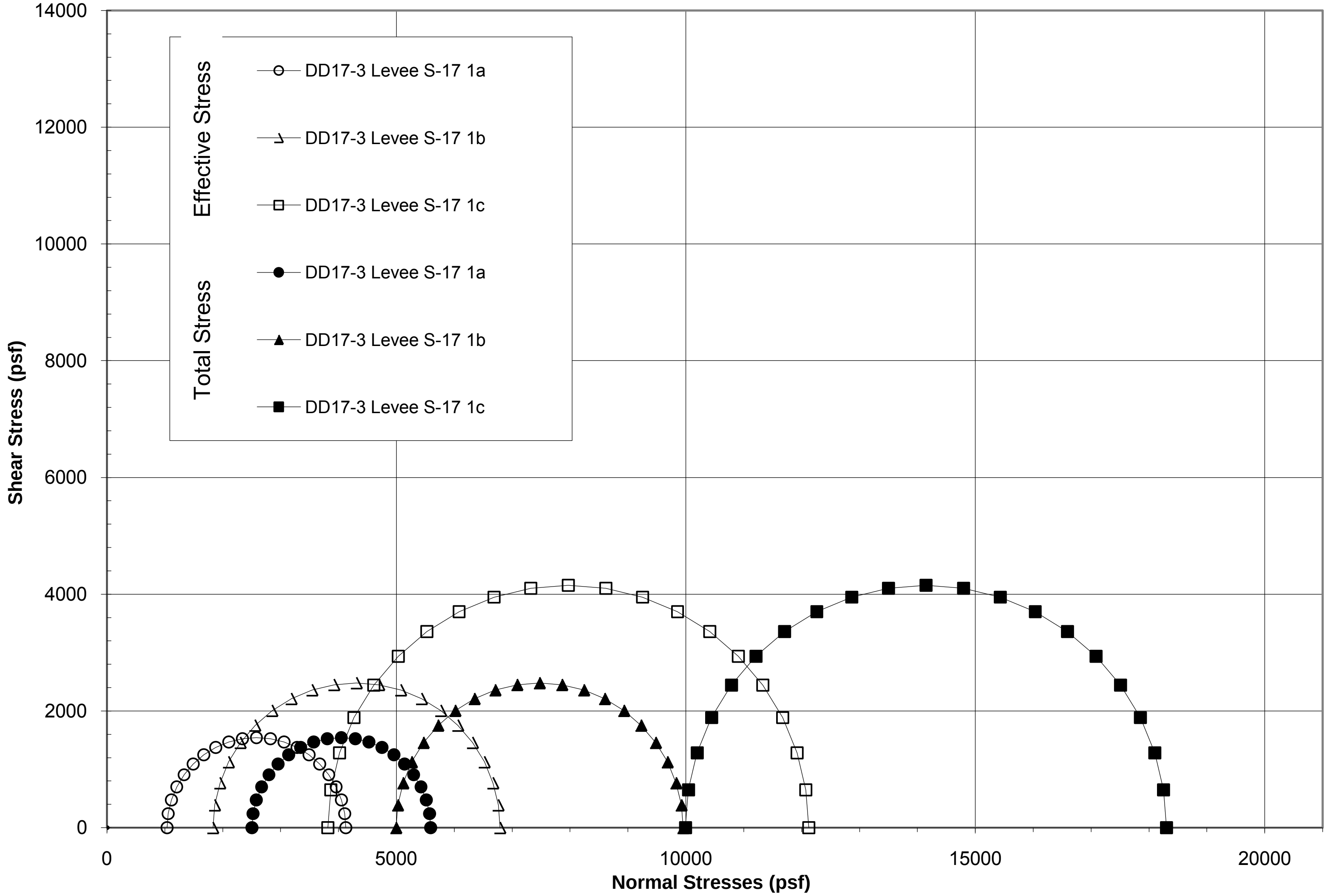
CU TRIAXIAL TEST

Boring DD17-3 Levee, Depth= 63.3'

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-36 (6/8)



Notes:

1. Mohr's circles plotted here are based upon effective stresses computed from TXCU testing.
2. Mohr's circles in this plot are based upon the maxium principal stress **ratio** observed during loading.
3. psf = pounds per square foot

FIG. C-36

Skagit River Levees General Investigation
Skagit County, Washington

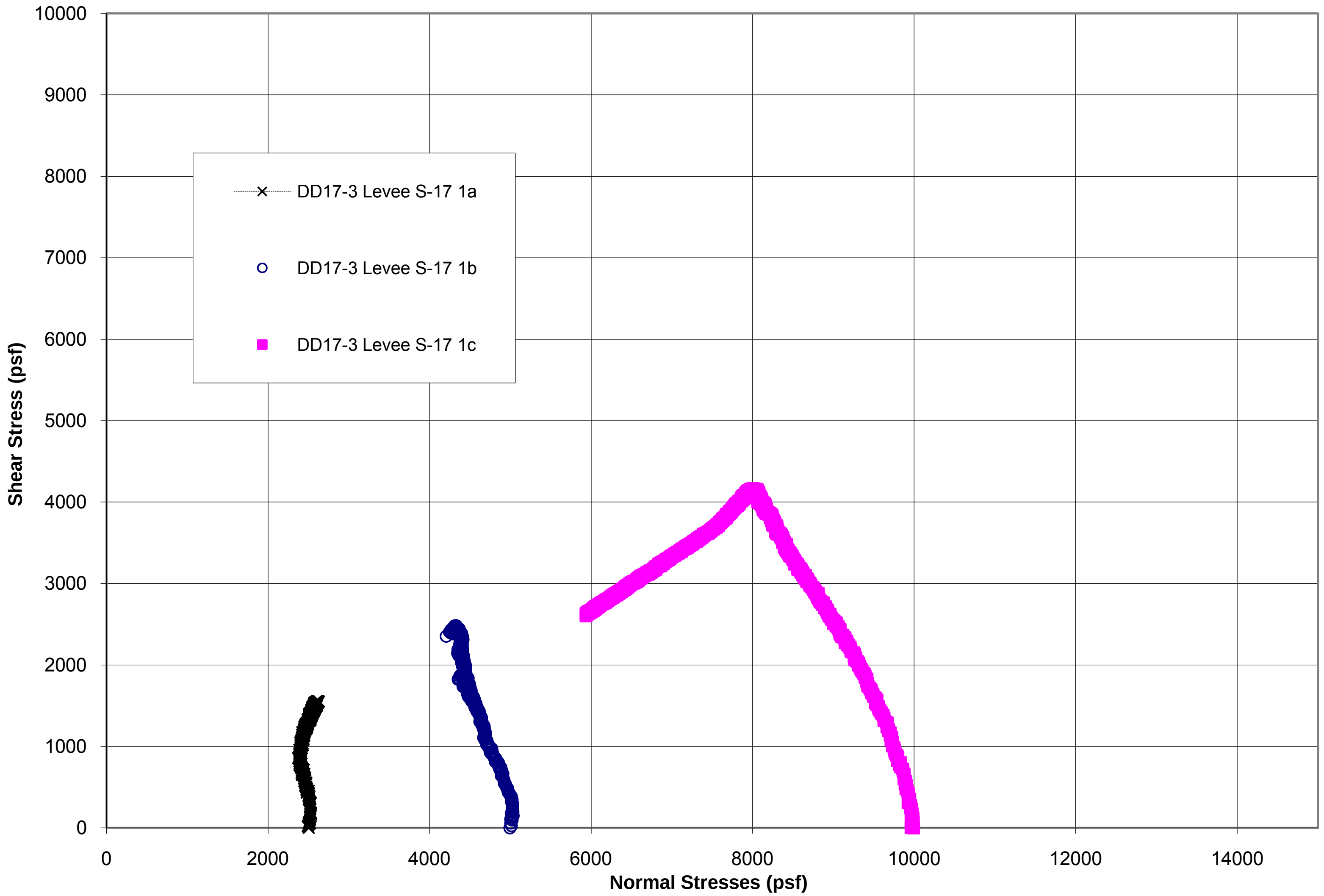
MOHR'S CIRCLES PLOT

Boring DD17-3 Levee, Depth= 63.3'

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-36 (7/8)



Notes:

Effective stress paths plotted here are computed from results of triaxial TXCU testing

Skagit River Levees General Investigation
Skagit County, Washington

STRESS PATHS PLOT

Boring DD17-3 Levee, Depth= 63.3'

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-36 (8/8)

CONSOLIDATED, UNDRAINED TRIAXIAL COMPRESSION TEST 2a

SUMMARY OF TEST DATA

Boring DD1-2 Landward
Sample S-2
Depth (ft) 6.2

Tested By/Date AKV 12/29/2009
Calc. By/Date AKV 1/29/2010
Checked By/Date JFL 2/10/2010

SAMPLE CLASSIFICATION:
Gray, slightly clayey SILT; trace organics; ML

B-value at end of saturation phase	1.00
Consolidation Stress, psf	576
Cell pressure during shear, psf	4608
Initial Pore Pressure(U_0), psf	4037
Shear Rate, in/min	0.0035

SPECIMEN DATA:

	Initial	post-consol	post-shear
Height, inches	4.891	4.851	4.660
Diameter, inches	2.4652	2.4652	
Aspect Ratio	1.98	1.97	
Weight, grams	652.89	632.41	632.41
Water	45.7%	41.1%	41.1%
Wet Density, pcf	106.5	104.0	104.0
Dry Density, pcf	73.1	73.7	73.7

Axial Strain inch/inch	Deviator Stress psf	Excess Pore Pres. (psf)	Eff. Major Principal Stress (psf)	Eff. Minor Principal Stress (psf)	Eff. Princ Stress Ratio	Stress Path Parameters (psf) P	P'	Q
0.0013	88	100	564	476	1.18	620	520	44
0.0025	251	130	697	446	1.56	701	572	125
0.0039	281	170	688	406	1.69	717	547	141
0.0051	375	180	771	396	1.95	763	584	187
0.0065	436	200	813	376	2.16	794	595	218
0.0077	466	210	833	366	2.27	809	600	233
0.0091	427	210	794	366	2.17	790	580	214
0.0103	420	220	776	356	2.18	786	566	210
0.0117	506	230	853	346	2.46	829	599	253
0.0129	530	230	876	346	2.53	841	611	265
0.0143	559	230	906	346	2.61	856	626	280
0.0155	626	230	973	346	2.81	889	660	313
0.0169	674	239	1011	337	3.00	913	674	337
0.0181	679	239	1016	337	3.02	916	676	340
0.0195	708	239	1045	337	3.11	930	691	354
0.0207	670	250	996	326	3.05	911	661	335
0.0221	742	230	1089	346	3.14	947	718	371
0.0233	759	230	1106	346	3.19	956	726	380
0.0247	751	230	1098	346	3.17	952	722	376
0.0259	706	239	1043	337	3.10	929	690	353
0.0273	748	230	1094	346	3.16	950	720	374
0.0285	777	220	1133	356	3.18	964	745	388
0.0299	781	239	1118	337	3.32	967	727	391
0.0311	755	230	1101	346	3.18	953	724	377
0.0325	796	239	1132	337	3.36	974	734	398
0.0337	825	230	1171	346	3.38	988	759	412
0.0351	756	220	1112	356	3.12	954	734	378
0.0363	858	220	1214	356	3.41	1005	785	429
0.0377	832	220	1188	356	3.33	992	772	416
0.0389	854	220	1210	356	3.40	1003	783	427

Skagit River Levee General Investigation
Skagit County, Washington

CU TRIAXIAL TEST

Boring DD1-2 Landward, Depth= 6.2'

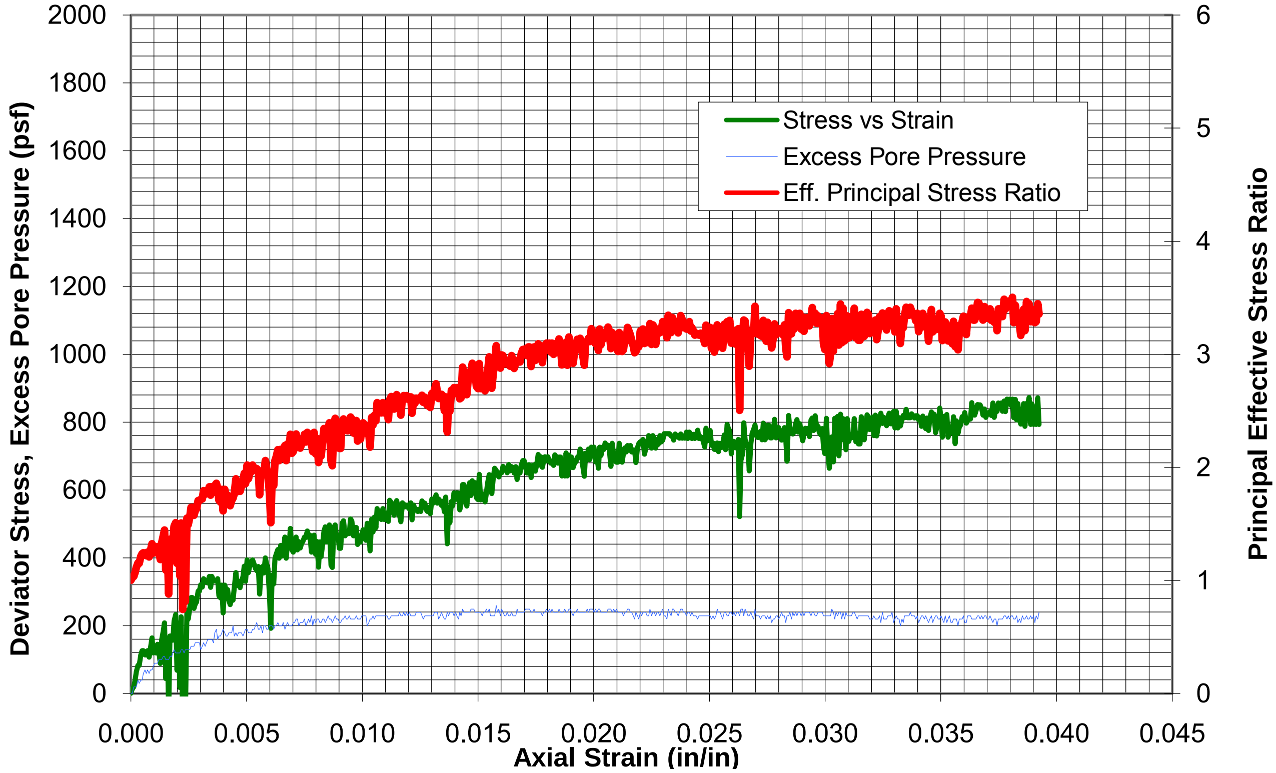
June 2010 21-1-21199-002

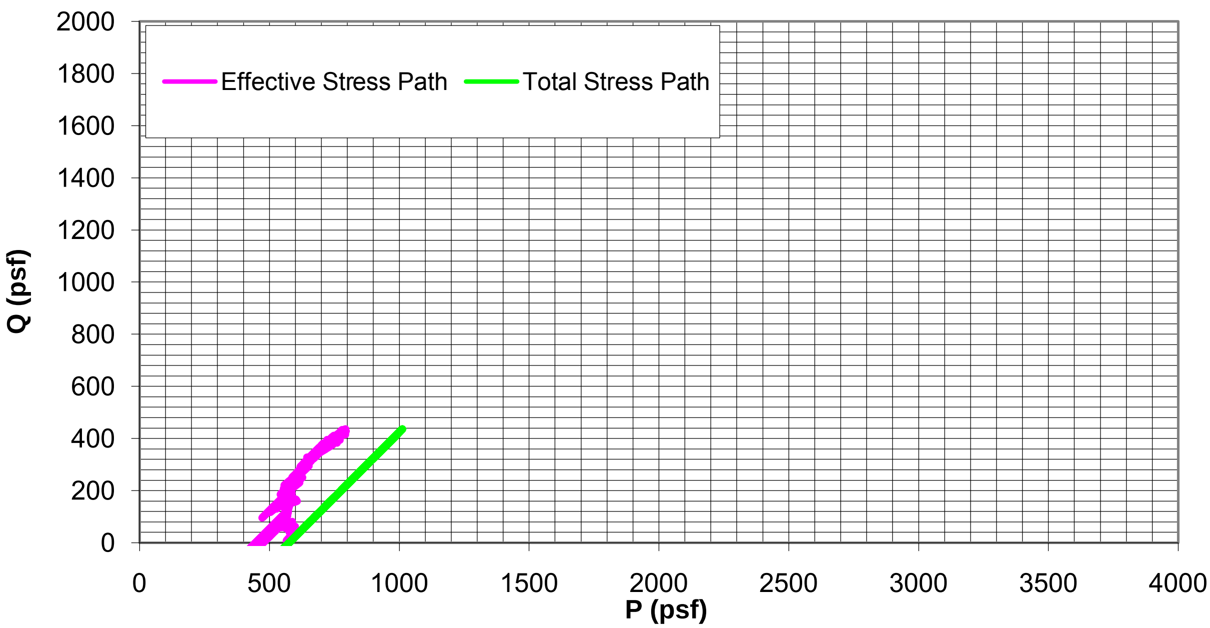
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-37 (1/8)

CONSOLIDATED, UNDRAINED TRIAXIAL COMPRESSION TEST NO. 2a

Boring DD1-2 Landward	Tested By/Date AKV 12/29/2009
Sample S-2	Calc. By/Date AKV 1/29/2010
Depth (ft) 6.2	Checked By/Date JFL 2/10/2010





Effective Stress at end-of-consolidation, psf	576
Cell pressure during shear, psf	4608

Skagit River Levee General Investigation
Skagit County, Washington

CU TRIAXIAL TEST

Boring DD1-2 Landward, Depth= 6.2'

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-37 (2/8)

CONSOLIDATED, UNDRAINED TRIAXIAL COMPRESSION TEST 2b

SUMMARY OF TEST DATA

Boring	DD1-2 Landward	Tested By/Date	AKV 12/30/2009
Sample	S-2	Calc. By/Date	AKV 1/29/2010
Depth (ft)	6.2	Checked By/Date	JFL 2/10/2010

SAMPLE CLASSIFICATION:
Gray, slightly clayey SILT; trace of organics; ML

B-value at end of saturation phase	1.00
Consolidation Stress, psf	1152
Cell pressure during shear, psf	5184
Initial Pore Pressure(U_0), psf	3878
Shear Rate, in/min	0.0035

SPECIMEN DATA:

	Initial	post-consol	post-shear
Height, inches	4.660	4.712	4.479
Diameter, inches	2.5162	2.5162	
Aspect Ratio	1.85	1.87	
Weight, grams	647.29	632.41	632.41
Water	44.5%	41.1%	41.1%
Wet Density, pcf	106.4	102.8	102.8
Dry Density, pcf	73.6	72.8	72.8

Axial Strain inch/inch	Deviator Stress psf	Excess Pore Pres. (psf)	Eff. Major Principal Stress (psf)	Eff. Minor Principal Stress (psf)	Eff. Princ Stress Ratio	Stress Path Parameters (psf) P	P'	Q
0.0016	435	210	1378	942	1.46	1370	1160	218
0.0033	646	299	1498	853	1.76	1475	1175	323
0.0050	716	359	1509	793	1.90	1510	1151	358
0.0067	859	399	1611	753	2.14	1581	1182	429
0.0083	923	429	1645	723	2.28	1613	1184	461
0.0100	1028	439	1741	713	2.44	1666	1227	514
0.0116	1092	459	1785	693	2.58	1698	1239	546
0.0133	1131	489	1794	663	2.71	1717	1228	565
0.0149	1176	499	1829	653	2.80	1740	1241	588
0.0166	1221	499	1874	653	2.87	1762	1263	610
0.0183	1230	509	1873	643	2.91	1767	1258	615
0.0200	1268	509	1911	643	2.97	1786	1277	634
0.0217	1295	529	1918	623	3.08	1799	1270	647
0.0233	1304	519	1937	633	3.06	1804	1285	652
0.0250	1336	529	1959	623	3.14	1820	1291	668
0.0266	1362	529	1986	623	3.19	1833	1304	681
0.0283	1389	529	2012	623	3.23	1846	1317	694
0.0299	1374	539	1987	613	3.24	1839	1300	687
0.0316	1347	529	1970	623	3.16	1825	1297	673
0.0333	1402	539	2015	613	3.29	1853	1314	701
0.0350	1405	539	2018	613	3.29	1854	1316	702
0.0367	1419	519	2052	633	3.24	1862	1343	710
0.0383	1404	539	2017	613	3.29	1854	1315	702
0.0400	1436	549	2039	603	3.38	1870	1321	718
0.0416	1432	539	2045	613	3.34	1868	1329	716
0.0433	1435	549	2038	603	3.38	1869	1320	717
0.0449	1454	539	2068	613	3.37	1879	1340	727
0.0466	1451	539	2064	613	3.37	1877	1339	725
0.0483	1470	539	2084	613	3.40	1887	1348	735
0.0496	1416	539	2029	613	3.31	1860	1321	708

Skagit River Levee General Investigation
Skagit County, Washington

CU TRIAXIAL TEST

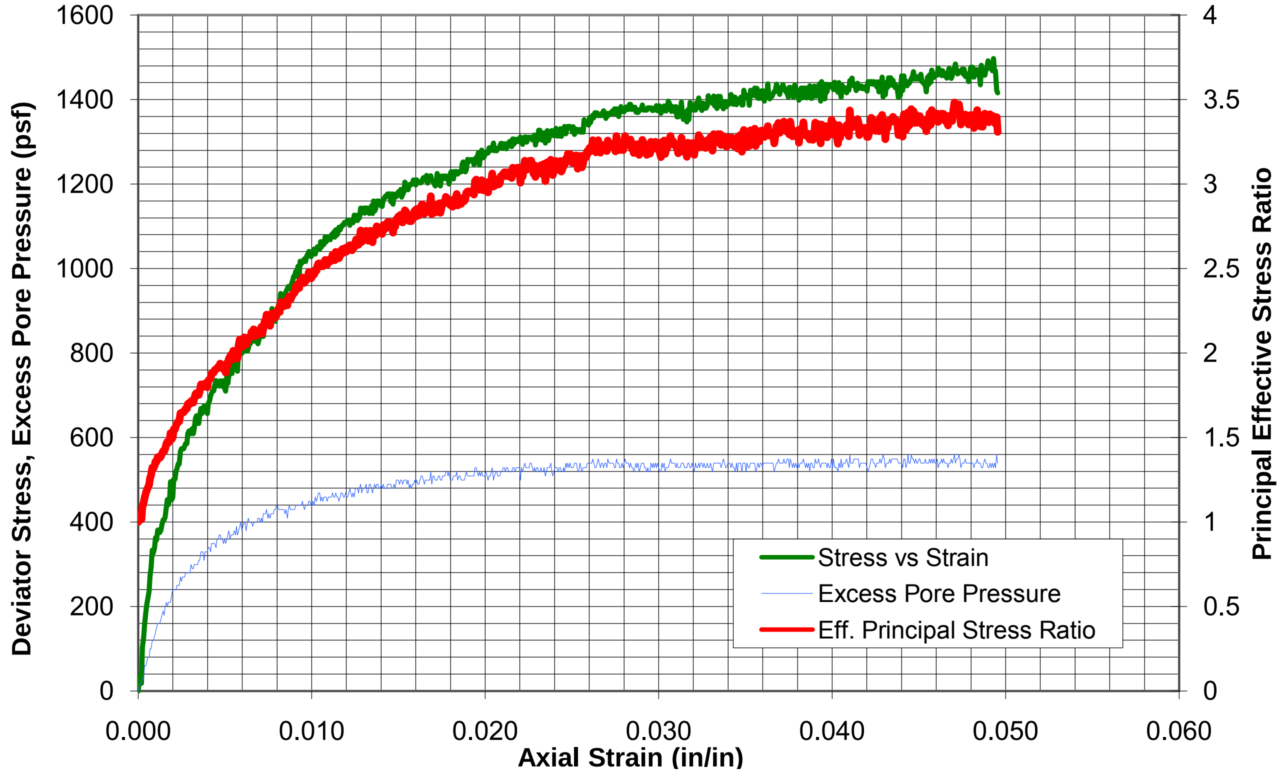
Boring DD1-2 Landward, Depth= 6.2'

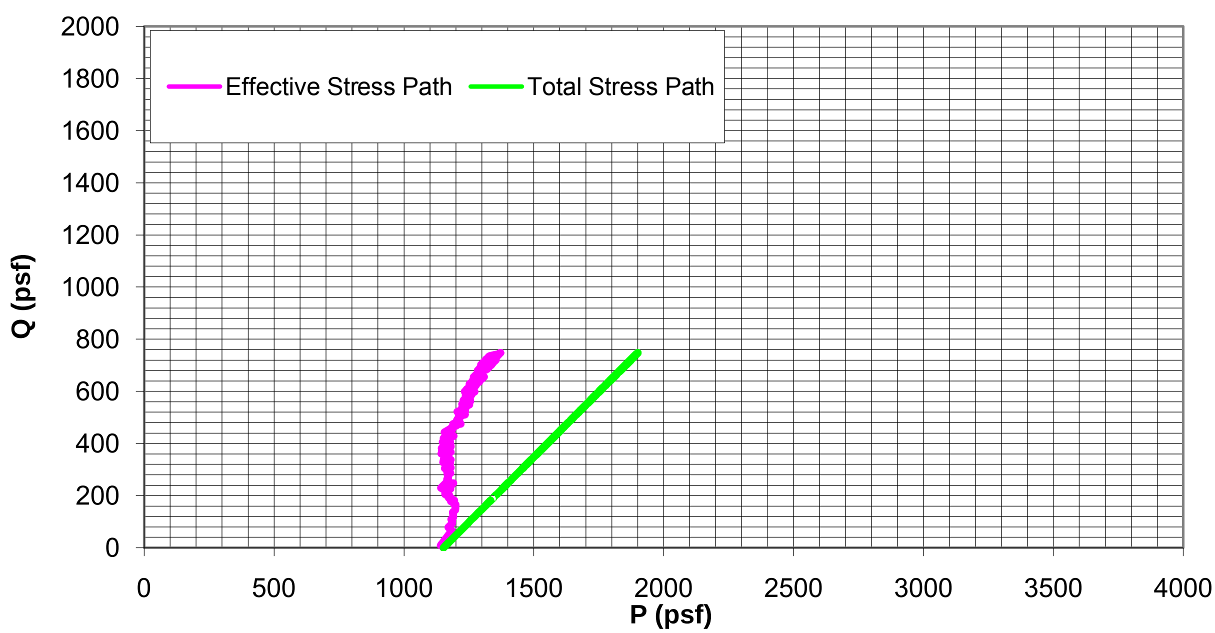
June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

CONSOLIDATED, UNDRAINED TRIAXIAL COMPRESSION TEST NO. 2b

Boring DD1-2 Landward	Tested By/Date AKV 12/30/2009
Sample S-2	Calc. By/Date AKV 1/29/2010
Depth (ft) 6.2	Checked By/Date JFL 2/10/2010





Effective Stress at end-of-consolidation, psf	1152
Cell pressure during shear, psf	5184

Skagit River Levee General Investigation
Skagit County, Washington

CU TRIAXIAL TEST
Boring DD1-2 Landward, Depth= 6.2'

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-37 (4/8)

CONSOLIDATED, UNDRAINED TRIAXIAL COMPRESSION TEST 2c

SUMMARY OF TEST DATA

Boring DD1-2 Landward
Sample S-2
Depth (ft) 6.2

Tested By/Date AKV 12/31/2009
Calc. By/Date AKV 1/29/2010
Checked By/Date JFL 2/10/2010

SAMPLE CLASSIFICATION:
Gray, slightly clayey SILT; trace of organics; ML

B-value at end of saturation phase	1.00
Consolidation Stress, psf	2304
Cell pressure during shear, psf	6336
Initial Pore Pressure(U_0), psf	3838
Shear Rate, in/min	0.0035

SPECIMEN DATA:

	Initial	post-consol	post-shear
Height, inches	4.479	4.520	3.454
Diameter, inches	2.5812	2.5812	
Aspect Ratio	1.74	1.75	
Weight, grams	637.89	632.41	632.41
Water	42.4%	41.1%	41.1%
Wet Density, pcf	103.7	101.8	101.8
Dry Density, pcf	72.8	72.2	72.2

Axial Strain inch/inch	Deviator Stress psf	Excess Pore Pres. (psf)	Eff. Major Principal Stress (psf)	Eff. Minor Principal Stress (psf)	Eff. Princ Stress Ratio	Stress Path Parameters (psf) P	P'	Q
0.0079	1725	988	3041	1316	2.31	3166	2178	862
0.0157	2149	1208	3246	1096	2.96	3379	2171	1075
0.0236	2331	1307	3327	997	3.34	3469	2162	1165
0.0314	2409	1337	3375	967	3.49	3508	2171	1204
0.0393	2496	1347	3452	957	3.61	3552	2205	1248
0.0472	2575	1337	3542	967	3.66	3592	2254	1288
0.0550	2594	1347	3550	957	3.71	3601	2254	1297
0.0629	2649	1337	3616	967	3.74	3629	2291	1325
0.0708	2703	1327	3679	977	3.77	3655	2328	1351
0.0787	2723	1327	3700	977	3.79	3666	2338	1362
0.0865	2744	1297	3750	1007	3.73	3676	2378	1372
0.0944	2779	1287	3795	1017	3.73	3693	2406	1389
0.1022	2771	1297	3778	1007	3.75	3690	2392	1386
0.1101	2794	1277	3820	1027	3.72	3701	2423	1397
0.1180	2811	1277	3837	1027	3.74	3709	2432	1405
0.1258	2746	1257	3793	1047	3.62	3677	2420	1373
0.1337	2782	1247	3839	1057	3.63	3695	2448	1391
0.1416	2817	1247	3873	1057	3.67	3712	2465	1408
0.1494	2822	1208	3918	1096	3.57	3715	2507	1411
0.1573	2801	1208	3897	1096	3.55	3704	2497	1400
0.1652	2809	1178	3935	1126	3.49	3709	2531	1405
0.1730	2778	1188	3895	1116	3.49	3693	2506	1389
0.1809	2771	1178	3897	1126	3.46	3690	2512	1386
0.1888	2768	1178	3895	1126	3.46	3688	2511	1384
0.1966	2761	1188	3877	1116	3.47	3684	2497	1380
0.2045	2753	1178	3879	1126	3.44	3680	2503	1376
0.2123	2730	1188	3847	1116	3.45	3669	2482	1365
0.2202	2703	1178	3829	1126	3.40	3655	2478	1351
0.2281	2676	1178	3802	1126	3.38	3642	2464	1338
0.2358	2605	1168	3742	1136	3.29	3607	2439	1303

Skagit River Levee General Investigation
Skagit County, Washington

CU TRIAXIAL TEST

Boring DD1-2 Landward, Depth= 6.2'

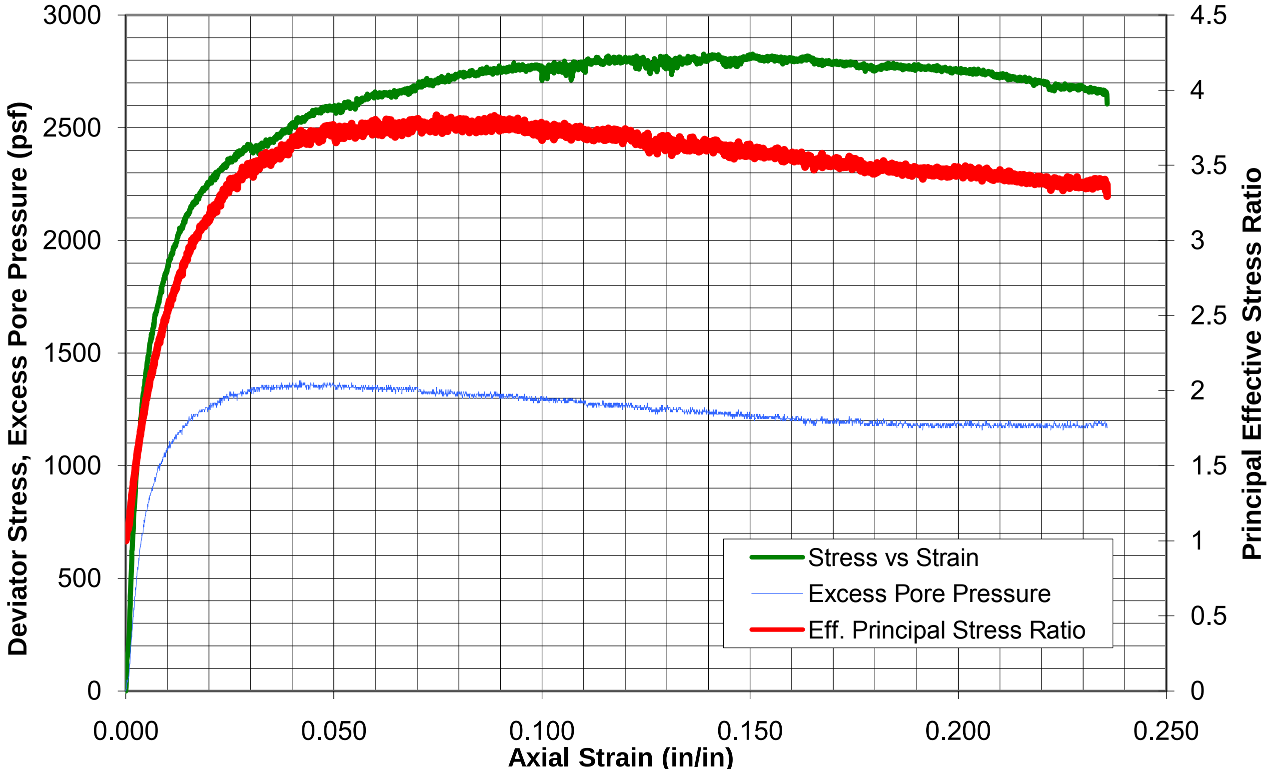
June 2010 21-1-21199-002

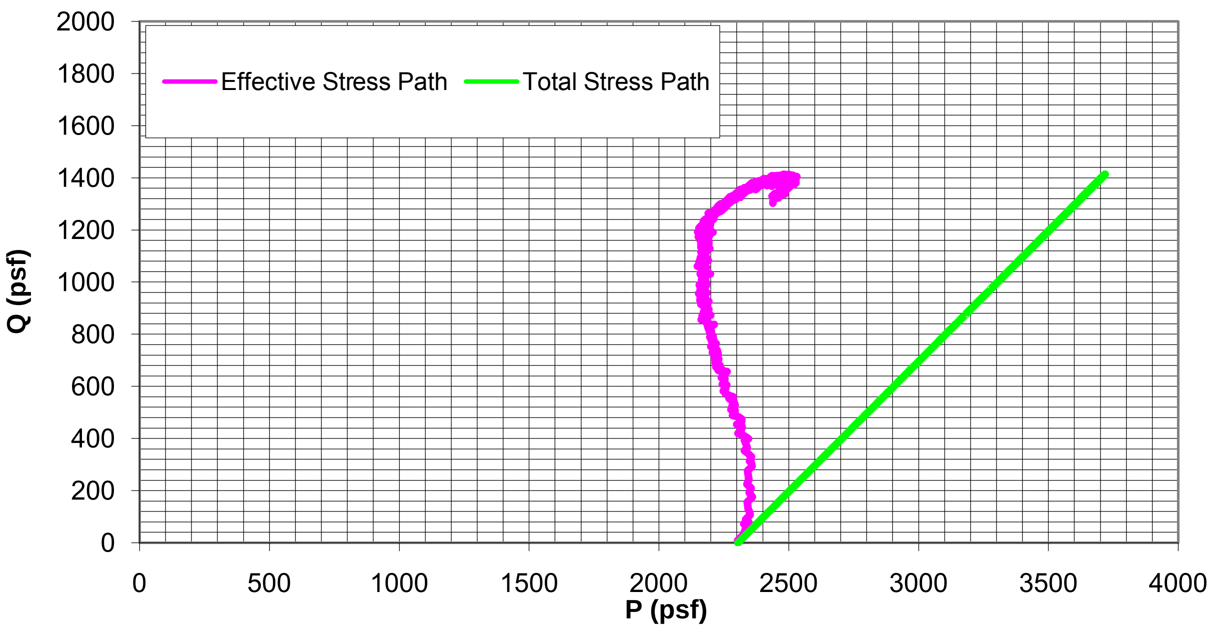
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-37 (5/8)

CONSOLIDATED, UNDRAINED TRIAXIAL COMPRESSION TEST NO. 2c

Boring DD1-2 Landward	Tested By/Date AKV 12/31/2009
Sample S-2	Calc. By/Date AKV 1/29/2010
Depth (ft) 6.2	Checked By/Date JFL 2/10/2010





Effective Stress at end-of-consolidation, psf	2304
Cell pressure during shear, psf	6336

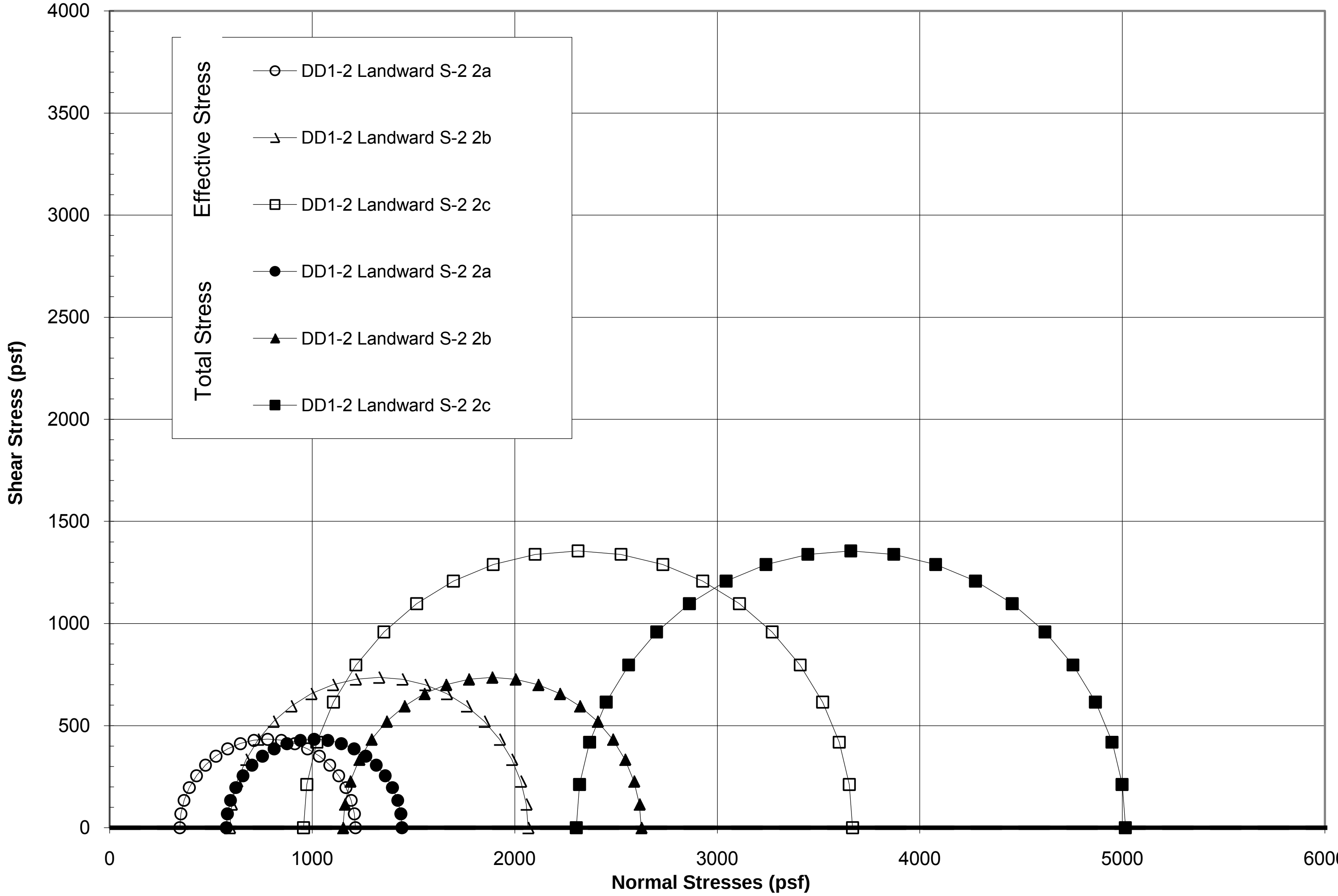
Skagit River Levee General Investigation
Skagit County, Washington

CU TRIAXIAL TEST
Boring DD1-2 Landward, Depth= 6.2'

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-37 (6/8)



Notes:

1. Mohr's circles plotted here are based upon effective stresses computed from TXCU testing.
2. Mohr's circles in this plot are based upon the maxium principal stress **ratio** observed during loading.
3. psf = pounds per square foot

Skagit River Levee General Investigation
Skagit County, Washington

MOHR'S CIRCLES PLOT

Boring DD1-2 Landward, Depth= 6.2'

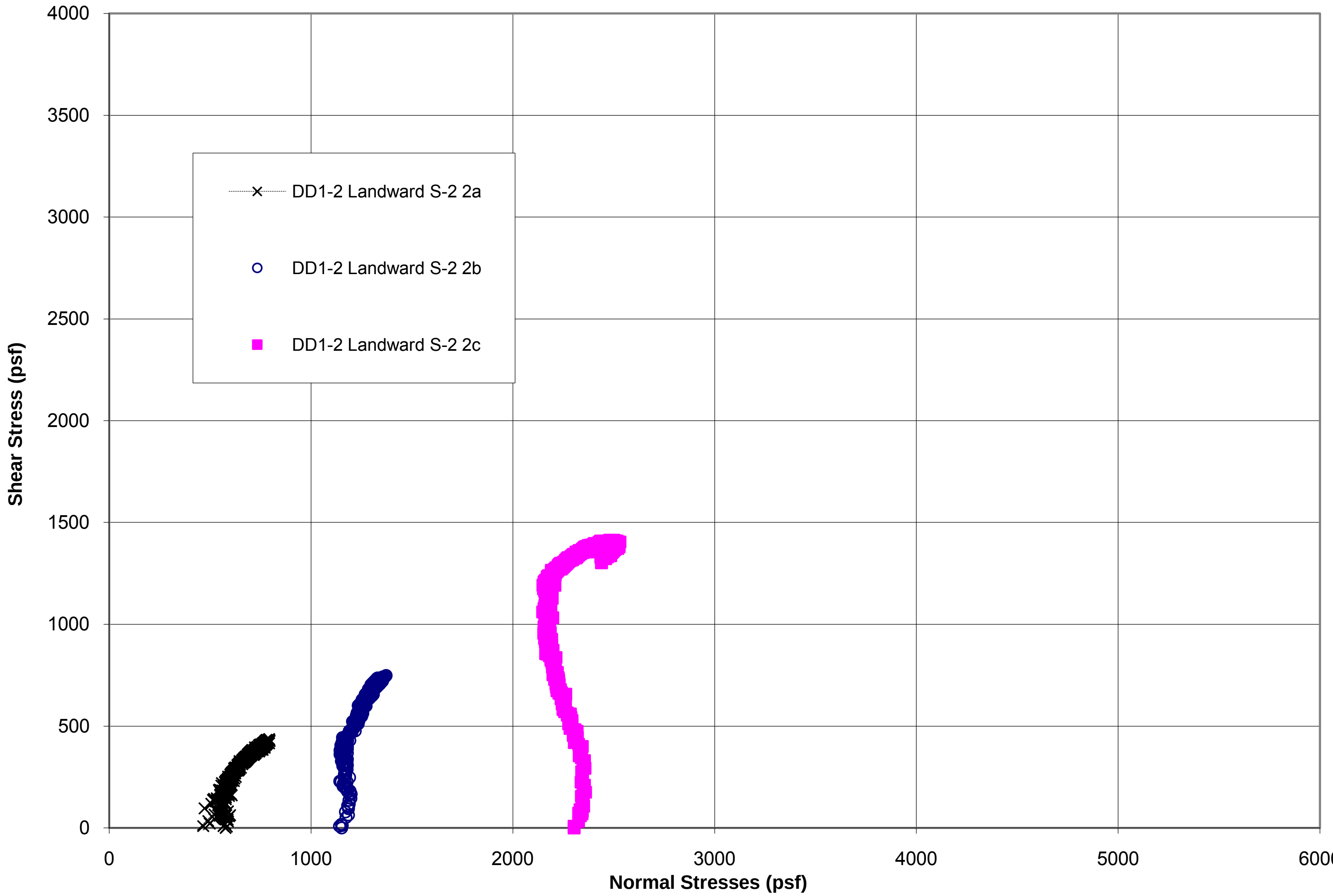
June 2010

21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-37 (7/8)

FIG. C-37



Notes:

Effective stress paths plotted here are computed from results of triaxial TXCU testing

Skagit River Levee General Investigation
Skagit County, Washington

STRESS PATHS PLOT

Boring DD1-2 Landward, Depth= 6.2'

June 2010 | 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-37 (8/8)

FIG. C-37

CONSOLIDATED, UNDRAINED TRIAXIAL COMPRESSION TEST 3a

SUMMARY OF TEST DATA

Boring	DD22-2 Levee	Tested By/Date	AKV 1/4/2010
Sample	S-7	Calc. By/Date	AKV 1/29/2010
Depth (ft)	18.6	Checked By/Date	JFL 2/11/2010

SAMPLE CLASSIFICATION:
Gray-brown, slightly clayey SILT; scattered organics; ML

B-value at end of saturation phase	0.99
Consolidation Stress, psf	576
Cell pressure during shear, psf	4680
Initial Pore Pressure(U_0), psf	4118
Shear Rate, in/min	0.0035

SPECIMEN DATA:

	Initial	post-consol	post-shear
Height, inches	6.076	5.839	5.518
Diameter, inches	2.5337	2.5337	
Aspect Ratio	2.40	2.30	
Weight, grams	884.08	856.08	856.08
Water	41.1%	36.7%	36.7%
Wet Density, pcf	109.9	110.8	110.8
Dry Density, pcf	77.9	81.1	81.1

Axial Strain inch/inch	Deviator Stress psf	Excess Pore Pres. (psf)	Eff. Major Principal Stress (psf)	Eff. Minor Principal Stress (psf)	Eff. Princ Stress Ratio	Stress Path Parameters (psf) P	P'	Q
0.0019	376	140	812	436	1.86	764	624	188
0.0037	469	180	866	396	2.18	811	631	235
0.0056	557	220	913	356	2.56	854	635	278
0.0074	632	220	988	356	2.77	892	672	316
0.0093	695	210	1061	366	2.90	923	714	347
0.0112	740	210	1106	366	3.02	946	736	370
0.0131	814	210	1181	366	3.22	983	774	407
0.0149	894	200	1271	376	3.38	1023	824	447
0.0168	933	190	1319	386	3.41	1042	853	466
0.0186	1018	180	1415	396	3.57	1085	905	509
0.0205	1097	170	1504	406	3.70	1125	955	549
0.0224	1147	150	1573	426	3.69	1150	1000	574
0.0243	1208	160	1624	416	3.90	1180	1020	604
0.0261	1263	150	1689	426	3.96	1208	1058	632
0.0280	1318	130	1764	446	3.95	1235	1105	659
0.0298	1378	120	1834	456	4.02	1265	1145	689
0.0317	1438	110	1904	466	4.09	1295	1185	719
0.0336	1487	100	1963	476	4.12	1319	1219	743
0.0354	1564	90	2050	486	4.22	1358	1268	782
0.0373	1606	80	2102	496	4.24	1379	1299	803
0.0392	1636	80	2132	496	4.30	1394	1314	818
0.0410	1695	70	2201	506	4.35	1423	1354	847
0.0429	1736	40	2273	536	4.24	1444	1404	868
0.0448	1772	30	2318	546	4.25	1462	1432	886
0.0466	1802	20	2358	556	4.24	1477	1457	901
0.0485	1848	20	2404	556	4.32	1500	1480	924
0.0504	1901	20	2456	556	4.42	1526	1506	950
0.0523	1930	0	2506	576	4.35	1541	1541	965
0.0541	1931	-30	2537	606	4.19	1541	1571	965
0.0549	1974	-10	2560	586	4.37	1563	1573	987

Skagit River Levee General Investigation
Skagit County, Washington

CU TRIAXIAL TEST

Boring DD22-2 Levee, Depth= 18.6'

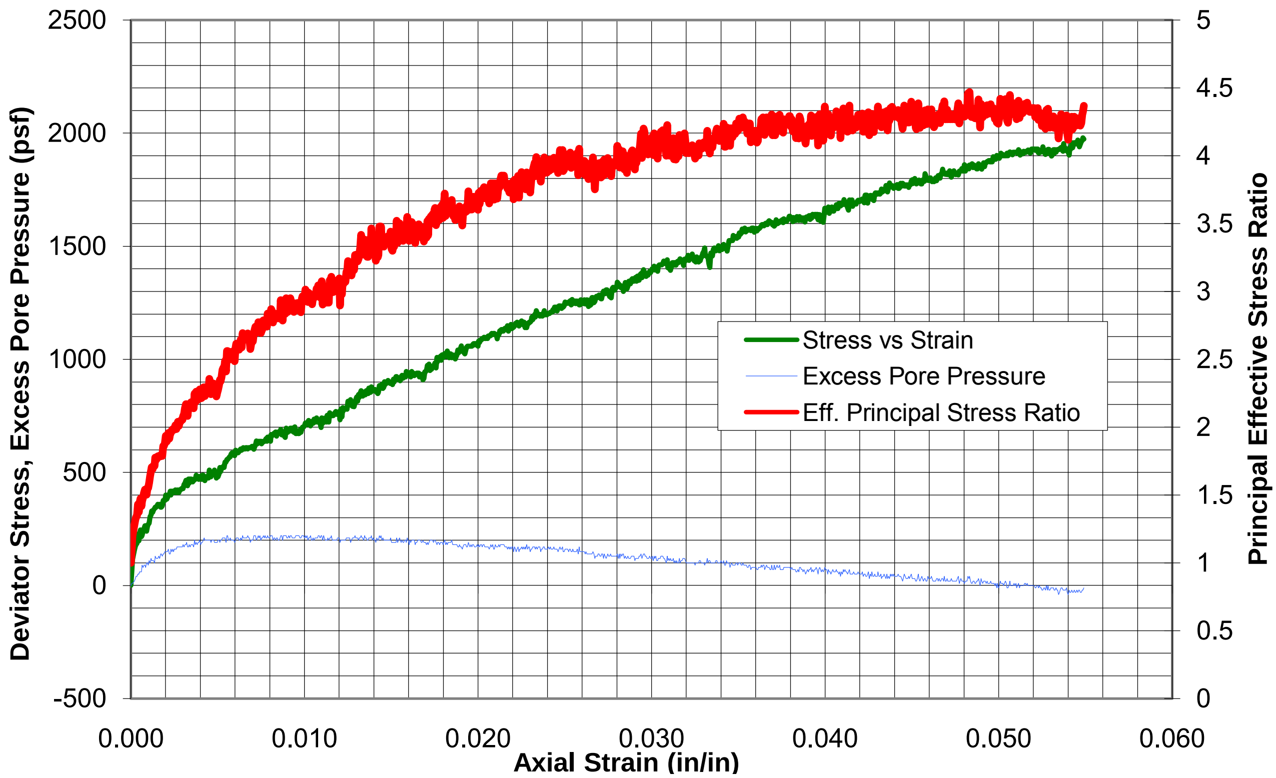
June 2010 21-1-21199-002

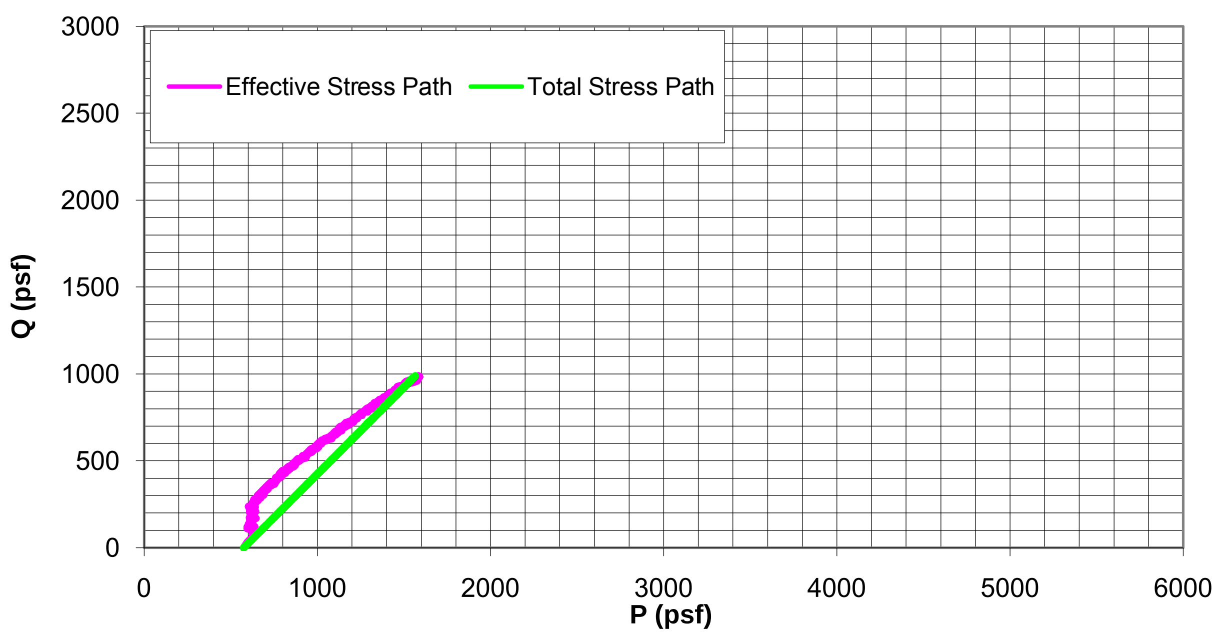
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-38 (1/8)

CONSOLIDATED, UNDRAINED TRIAXIAL COMPRESSION TEST NO. 3a

Boring DD22-2 Levee	Tested By/Date AKV 1/4/2010
Sample S-7	Calc. By/Date AKV 1/29/2010
Depth (ft) 18.6	Checked By/Date JFL 2/11/2010





Effective Stress at end-of-consolidation, psf	576
Cell pressure during shear, psf	4680

Skagit River Levee General Investigation
Skagit County, Washington

CU TRIAXIAL TEST

Boring DD22-2 Levee, Depth= 18.6'

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-38 (2/8)

CONSOLIDATED, UNDRAINED TRIAXIAL COMPRESSION TEST 3b

SUMMARY OF TEST DATA

Boring	DD22-2 Levee	Tested By/Date	AKV 1/4/2010
Sample	S-7	Calc. By/Date	AKV 1/29/2010
Depth (ft)	18.6	Checked By/Date	JFL 2/11/2010

SAMPLE CLASSIFICATION:
Gray-brown, slightly clayey SILT; scattered organics; ML

B-value at end of saturation phase	0.99
Consolidation Stress, psf	1152
Cell pressure during shear, psf	5256
Initial Pore Pressure(U_0), psf	4128
Shear Rate, in/min	0.0035

SPECIMEN DATA:

	Initial	post-consol	post-shear
Height, inches	5.518	5.628	5.338
Diameter, inches	2.6082	2.6082	
Aspect Ratio	2.12	2.16	
Weight, grams	881.48	856.08	856.08
Water	40.7%	36.7%	36.7%
Wet Density, pcf	113.9	108.4	108.4
Dry Density, pcf	80.9	79.4	79.4

Axial Strain inch/inch	Deviator Stress psf	Excess Pore Pres. (psf)	Eff. Major Principal Stress (psf)	Eff. Minor Principal Stress (psf)	Eff. Princ Stress Ratio	Stress Path Parameters (psf) P	P'	Q
0.0017	529	249	1432	903	1.59	1417	1167	265
0.0034	758	339	1571	813	1.93	1531	1192	379
0.0052	959	359	1751	793	2.21	1631	1272	479
0.0069	1119	389	1881	763	2.47	1711	1322	559
0.0087	1256	379	2029	773	2.62	1780	1401	628
0.0104	1381	379	2154	773	2.79	1843	1463	691
0.0121	1495	369	2278	783	2.91	1900	1530	748
0.0139	1653	369	2436	783	3.11	1979	1609	827
0.0156	1783	339	2596	813	3.19	2043	1704	891
0.0173	1918	329	2741	823	3.33	2111	1782	959
0.0190	2013	329	2836	823	3.45	2159	1829	1007
0.0208	2108	309	2951	843	3.50	2206	1897	1054
0.0225	2159	309	3002	843	3.56	2231	1922	1079
0.0242	2220	299	3073	853	3.60	2262	1963	1110
0.0260	2309	289	3172	863	3.68	2307	2017	1155
0.0277	2403	289	3265	863	3.79	2353	2064	1201
0.0294	2436	299	3289	853	3.86	2370	2071	1218
0.0312	2480	279	3353	873	3.84	2392	2113	1240
0.0329	2475	249	3377	903	3.74	2389	2140	1237
0.0347	2551	259	3443	893	3.86	2427	2168	1275
0.0364	2611	259	3503	893	3.93	2457	2198	1305
0.0381	2643	249	3546	903	3.93	2474	2224	1322
0.0398	2681	230	3604	922	3.91	2493	2263	1341
0.0416	2708	230	3630	922	3.94	2506	2276	1354
0.0433	2713	219	3645	933	3.91	2508	2289	1356
0.0450	2740	210	3682	942	3.91	2522	2312	1370
0.0468	2760	190	3723	962	3.87	2532	2343	1380
0.0485	2808	200	3761	952	3.95	2556	2357	1404
0.0502	2802	180	3775	972	3.88	2553	2374	1401
0.0515	2765	180	3738	972	3.84	2535	2355	1383

Skagit River Levee General Investigation
Skagit County, Washington

CU TRIAXIAL TEST

Boring DD22-2 Levee, Depth= 18.6'

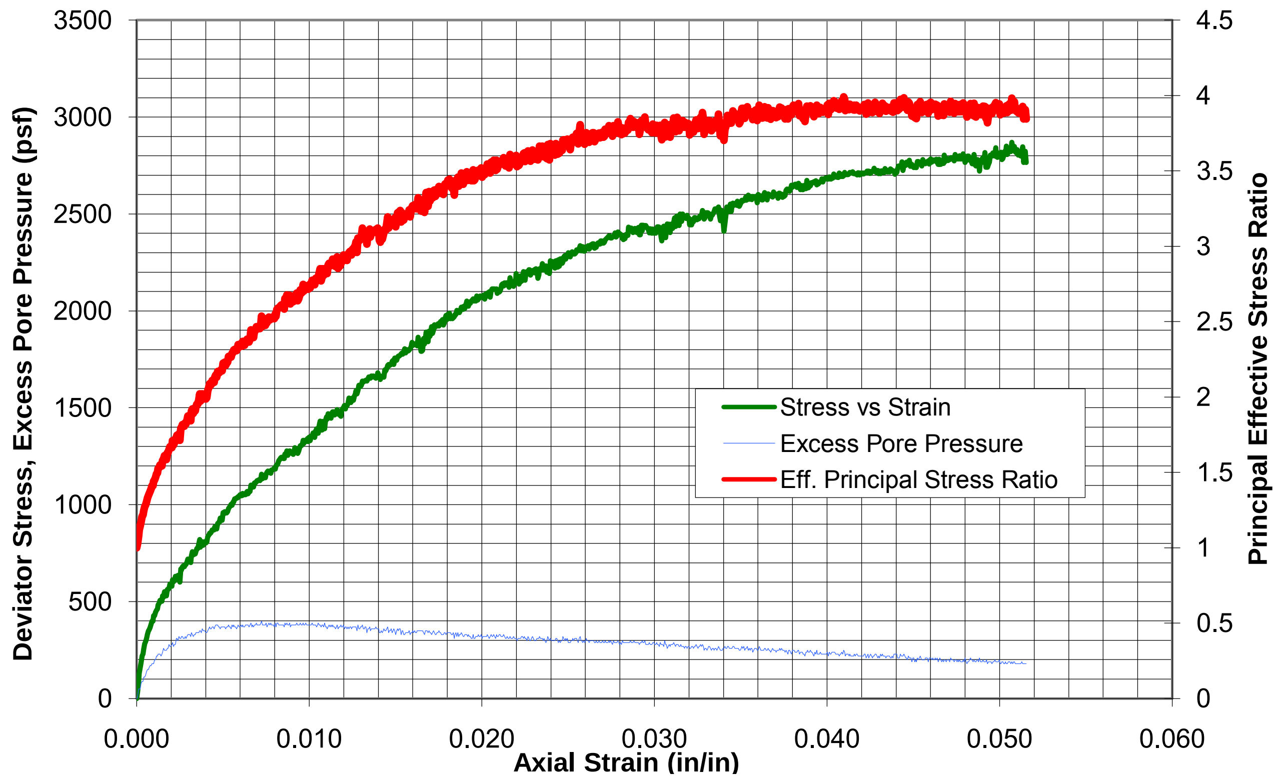
June 2010 21-1-21199-002

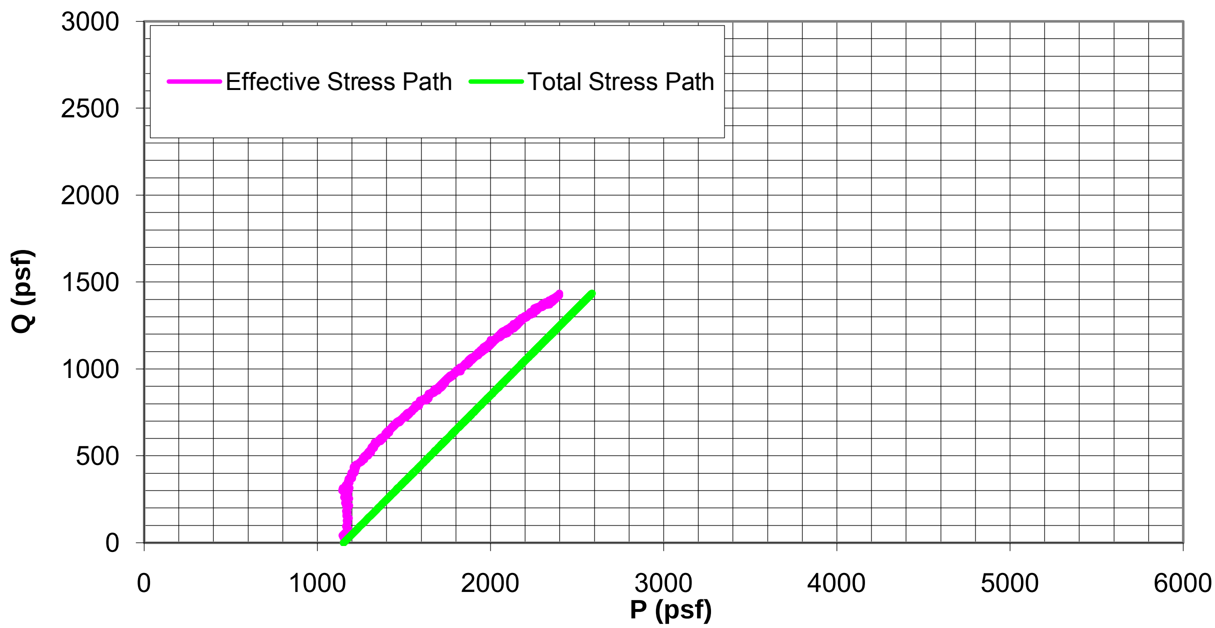
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-38 (3/8)

CONSOLIDATED, UNDRAINED TRIAXIAL COMPRESSION TEST NO. 3b

Boring DD22-2 Levee	Tested By/Date AKV 1/4/2010
Sample S-7	Calc. By/Date AKV 1/29/2010
Depth (ft) 18.6	Checked By/Date JFL 2/11/2010





Effective Stress at end-of-consolidation, psf	1152
Cell pressure during shear, psf	5256

Skagit River Levee General Investigation
Skagit County, Washington

CU TRIAXIAL TEST

Boring DD22-2 Levee, Depth= 18.6'

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-38 (4/8)

CONSOLIDATED, UNDRAINED TRIAXIAL COMPRESSION TEST 3c

SUMMARY OF TEST DATA

Boring	DD22-2 Levee	Tested By/Date	AKV 1/4/2010
Sample	S-7	Calc. By/Date	AKV 1/29/2010
Depth (ft)	18.6	Checked By/Date	JFL 2/11/2010

SAMPLE CLASSIFICATION:

Gray-brown, slightly clayey SILT; scattered organics; ML

B-value at end of saturation phase	0.99
Consolidation Stress, psf	2304
Cell pressure during shear, psf	6336
Initial Pore Pressure(U_0), psf	4058
Shear Rate, in/min	0.0035

SPECIMEN DATA:

	Initial	post-consol	post-shear
Height, inches	5.338	5.439	4.325
Diameter, inches	2.6781	2.6781	
Aspect Ratio	1.99	2.03	
Weight, grams	869.08	856.08	856.08
Water	38.7%	36.7%	36.7%
Wet Density, pcf	110.1	106.4	106.4
Dry Density, pcf	79.4	77.9	77.9

Axial Strain inch/inch	Deviator Stress psf	Excess Pore Pres. (psf)	Eff. Major Principal Stress (psf)	Eff. Minor Principal Stress (psf)	Eff. Princ Stress Ratio	Stress Path Parameters (psf) P	P'	Q
0.0068	1907	878	3333	1426	2.34	3258	2379	954
0.0136	2694	918	4080	1386	2.94	3651	2733	1347
0.0205	3270	938	4636	1366	3.39	3939	3001	1635
0.0273	3609	928	4985	1376	3.62	4108	3180	1804
0.0341	3808	908	5204	1396	3.73	4208	3300	1904
0.0410	3952	868	5388	1436	3.75	4280	3412	1976
0.0478	4109	838	5575	1466	3.80	4359	3520	2055
0.0546	4233	798	5739	1506	3.81	4421	3622	2117
0.0615	4345	769	5880	1535	3.83	4476	3708	2172
0.0683	4435	739	6000	1565	3.83	4521	3783	2217
0.0751	4508	719	6093	1585	3.84	4558	3839	2254
0.0820	4569	669	6204	1635	3.79	4588	3920	2284
0.0888	4619	639	6285	1665	3.77	4614	3975	2310
0.0956	4630	599	6335	1705	3.72	4619	4020	2315
0.1025	4741	579	6466	1725	3.75	4674	4095	2370
0.1093	4748	529	6523	1775	3.68	4678	4149	2374
0.1162	4713	519	6498	1785	3.64	4661	4142	2357
0.1230	4664	509	6459	1795	3.60	4636	4127	2332
0.1298	4619	489	6434	1815	3.55	4614	4125	2310
0.1367	4528	499	6333	1805	3.51	4568	4069	2264
0.1434	4494	479	6319	1825	3.46	4551	4072	2247
0.1503	4400	509	6194	1795	3.45	4504	3995	2200
0.1571	4311	479	6136	1825	3.36	4459	3980	2155
0.1640	4272	519	6057	1785	3.39	4440	3921	2136
0.1708	4162	529	5937	1775	3.35	4385	3856	2081
0.1776	4094	539	5859	1765	3.32	4351	3812	2047
0.1845	3991	559	5736	1745	3.29	4299	3740	1995
0.1913	3884	569	5619	1735	3.24	4246	3677	1942
0.1981	3809	599	5514	1705	3.23	4208	3610	1904
0.2049	3692	619	5377	1685	3.19	4150	3531	1846

Skagit River Levee General Investigation
Skagit County, Washington

CU TRIAXIAL TEST

Boring DD22-2 Levee, Depth= 18.6'

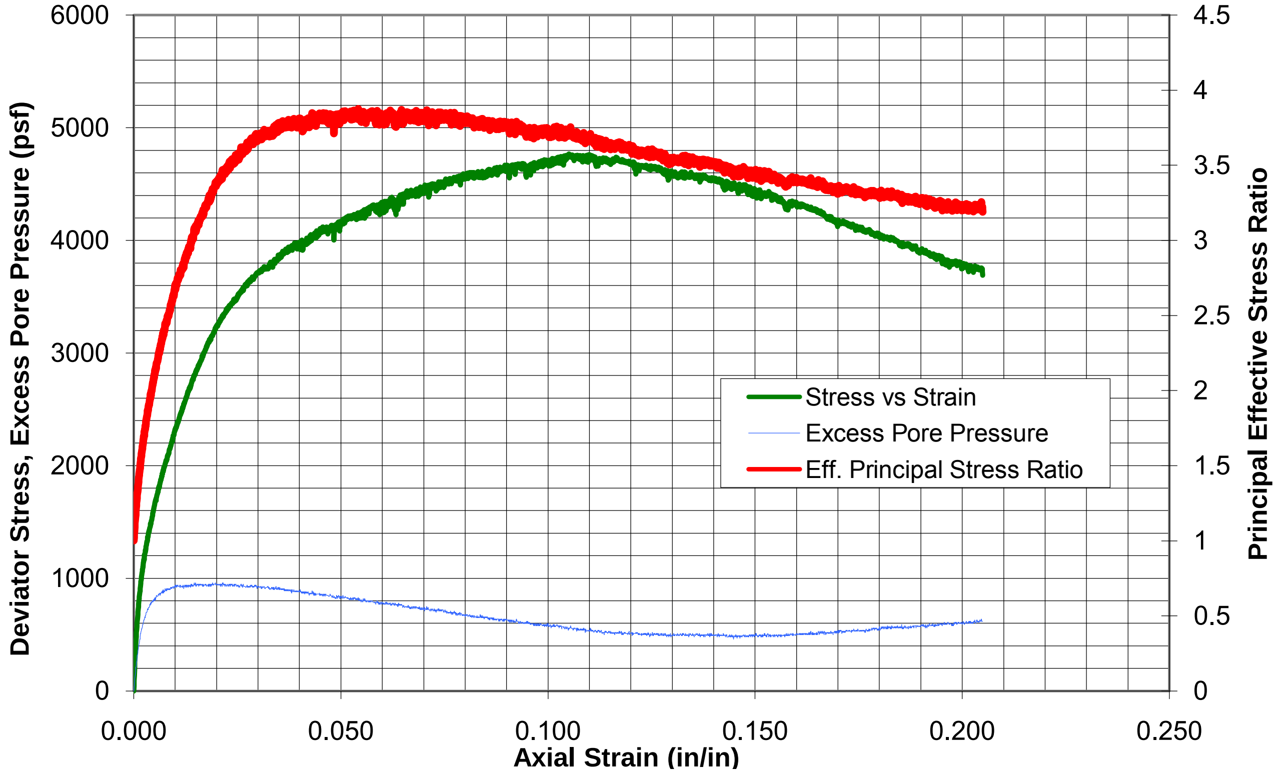
June 2010 21-1-21199-002

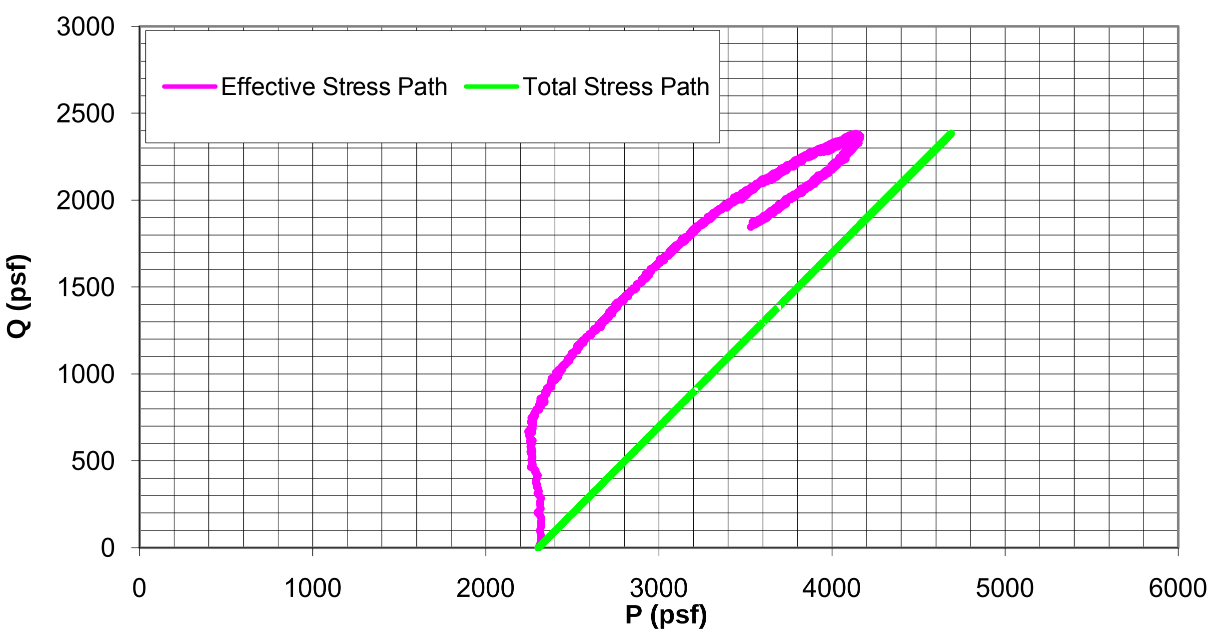
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-38 (5/8)

CONSOLIDATED, UNDRAINED TRIAXIAL COMPRESSION TEST NO. 3c

Boring	DD22-2 Levee	Tested By/Date	AKV 1/4/2010
Sample	S-7	Calc. By/Date	AKV 1/29/2010
Depth (ft)	18.6	Checked By/Date	JFL 2/11/2010





Effective Stress at end-of-consolidation, psf	2304
Cell pressure during shear, psf	6336

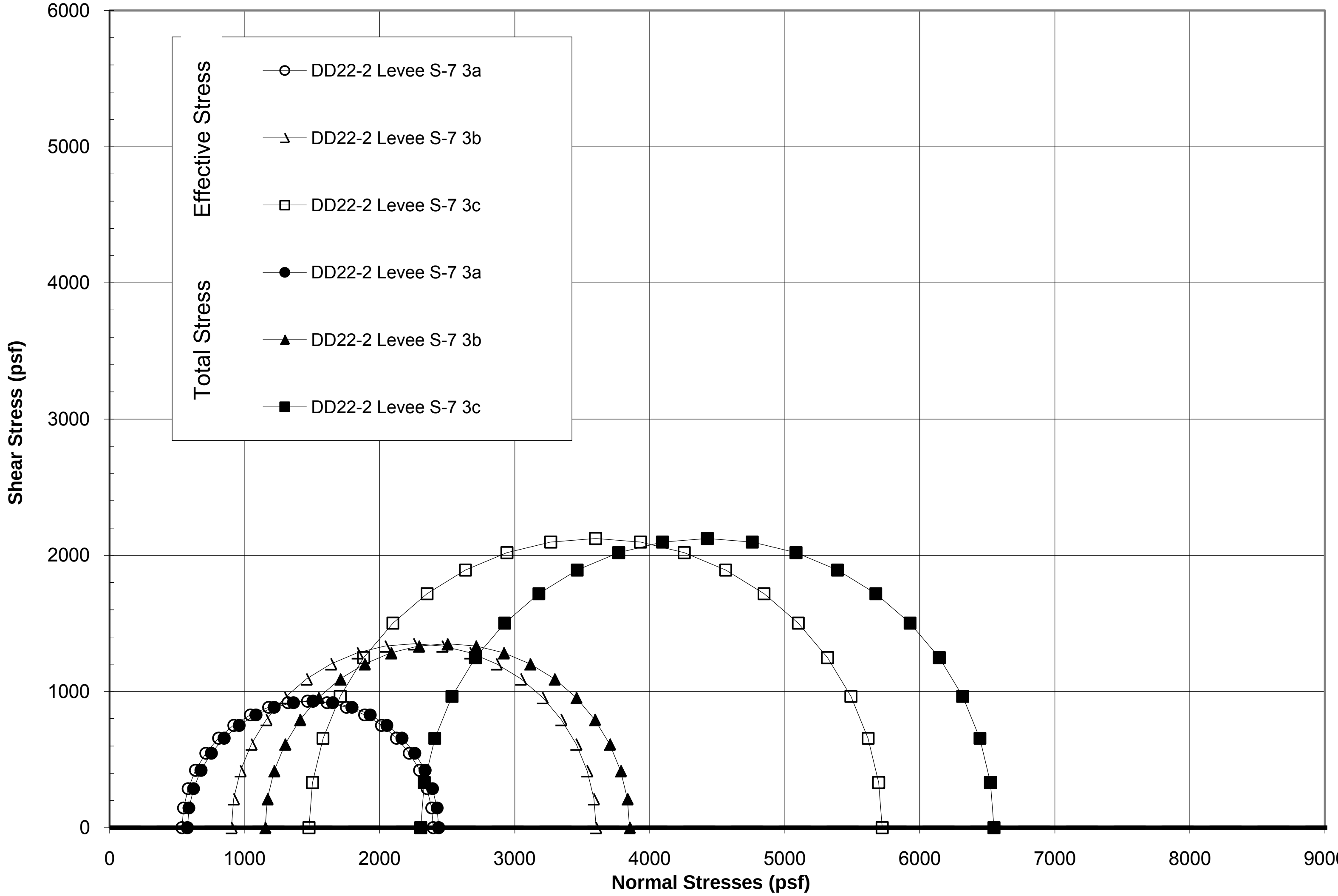
Skagit River Levee General Investigation
Skagit County, Washington

CU TRIAXIAL TEST
Boring DD22-2 Levee, Depth= 18.6'

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-38 (6/8)



Notes:

1. Mohr's circles plotted here are based upon effective stresses computed from TXCU testing.
2. Mohr's circles in this plot are based upon the maxium principal stress **ratio** observed during loading.
3. psf = pounds per square foot

Skagit River Levee General Investigation
Skagit County, Washington

MOHR'S CIRCLES PLOT

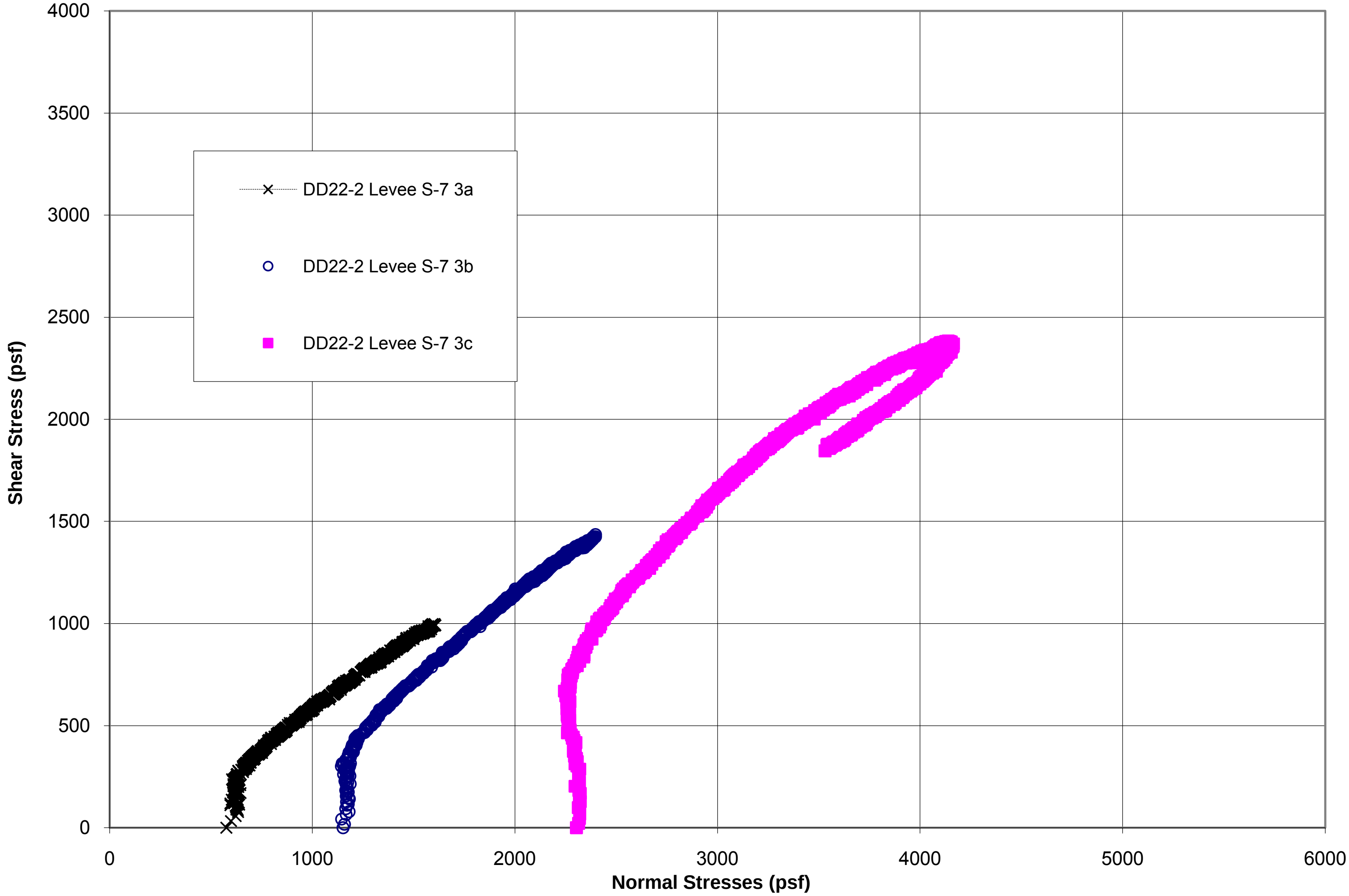
Boring DD22-2 Levee, Depth=18.6'

June 2010 | 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-38 (7/8)

FIG. C-38



Notes:

Effective stress paths plotted here are computed from results of triaxial TXCU testing

Skagit River Levee General Investigation
Skagit County, Washington

STRESS PATHS PLOT

Boring DD22-2 Levee, Depth=18.6'

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-38 (8/8)

FIG. C-38

HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-03)

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 NORTH 34TH STREET • SUITE 100
P.O. BOX 300303 • SEATTLE, WASHINGTON 98103
206-632-8020 FAX 206-695-6777

Project	Skagit River Levees	Job No.	21-1-21199-002		
Boring No.	DD1-1 Landward	Tested By	AKV	On	1/27/2010
Sample No.	S-2/S-3	Comp By	AKV	On	2/2/2010
Depth (ft)	5.0/7.5	Checked By	JFL	On	2/5/2010

WATER CONTENT DATA:

	Before Test	After Test
Pan No.	tin cup	Z-24
Wet+Tare	55.81	309.94
Dry+Tare	45.58	262.71
Tare	3.09	102.99
WC, %	24.1	29.6

DESCRIPTION:

Gray-brown, silty, fine SAND; SM

SPECIMEN DATA:

	Before Test	After Consol.	After Test
Height, m	0.0505	0.0501	0.0500
Diameter, m	0.0553	0.0553	0.0553
Wet Weight, g	199.17	199.07	206.95
Volume, ml	121.4	120.4	120.2
Area, m^2	0.00240	0.00240	0.00240
Wet Unit Wt, pcf	102.4	103.2	107.5
Dry Unit Wt, pcf	82.5	79.6	82.9
Est. Saturation,%	62.4	71.5	77.4

OTHER INFORMATION:

Burette Corr. Factor, BCF (vol. to height), 1ml = 0.0047 m

a = 2.13E-04 m^2

Specific Gravity ☑ Assumed ☐ Measured = 2.7

B-Coefficient = 0.97

Volume of Solid = 59.5 ml

Pore Volume (P.V.)= 61.9 ml

NOTE:

Sample comprised of
95% S-2, 5% S-3

FALLING-HEAD INCREASING TAILWATER LEVEL HYDRAULIC CONDUCTIVITY CALCULATION (METHOD C):

$$k = \frac{aL}{2At}\ln\left(\frac{h_1}{h_2}\right)$$

$$k_{20} = R_T k$$

a = cross-sectional area of standpipe, m^2
L = length of the sample, m
A = cross-sectional area of the sample, m^2
t = elapsed time between determination of h_1 and h_2, sec.

h_1 = head loss across the specimen at time t_1, m,
h_2 = head loss across the specimen at time t_2, m,
k_{20} = corrected hydraulic conductivity at temperature of 20 °C
R_T = correction factor for viscosity of water at various temperatures, T
= $2.2902(0.9842^T)/T^{0.1702}$

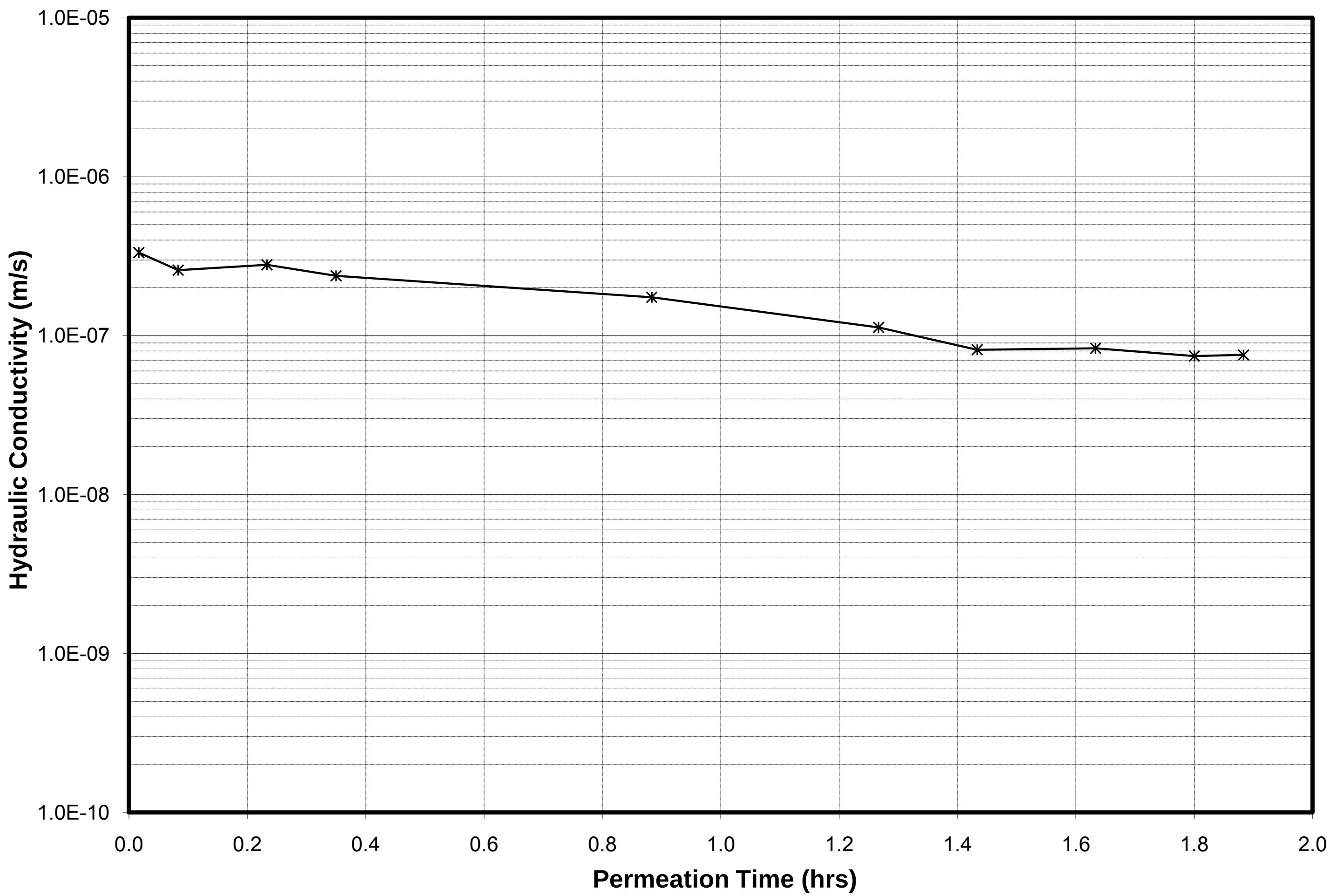
MEASURED DATA:

Read Time			Elapsed Time	Temp T	Pressure Readings			Burette Readings						Head Loss h	Effective Stresses		Calculated Flow Volumes				Gradient (i)	*K*	*R_T*	k_{20}
day	hr	min	(hr)	(°C)	P_{cell} (psi)	P_{in} (psi)	P_{out} (psi)	V_{cell} (ml)	V_{in} (ml)	V_{out} (ml)	H_{cell} (m)	H_{in} (m)	H_{out} (m)	(m)	σ'_{max} (psi)	σ'_{min} (psi)	Inflow (ml)	Outflow (ml)	Storage (ml)	Cum. P.V.		(m/sec)		(m/sec)
1	0	0	0.00	22.2	75.0	71.5	70.1	0.0	100.2	1.0	0.000	0.471	0.005	1.401	4.8	2.8				0	27.7			
1	0	1	0.02	22.2	75.0	71.5	70.1	0.0	98.9	2.5	0.000	0.465	0.012	1.388	4.8	2.8	1.3	1.5	-0.2	0.0226	27.5	3.5E-07	0.949	3.3E-07
1	0	5	0.08	22.2	75.0	71.5	70.1	0.0	94.6	6.7	0.000	0.445	0.031	1.348	4.8	2.9	4.3	4.2	0.1	0.0913	26.7	2.7E-07	0.949	2.6E-07
1	0	14	0.23	22.2	75.0	71.5	70.1	0.0	84.6	16.4	0.000	0.398	0.077	1.255	4.7	2.9	10.0	9.7	0.3	0.2504	24.9	2.9E-07	0.949	2.8E-07
1	0	21	0.35	22.2	75.0	71.5	70.1	0.0	78.4	22.5	0.000	0.368	0.106	1.198	4.7	3.0	6.2	6.1	0.1	0.3497	23.7	2.5E-07	0.949	2.4E-07
1	0	53	0.88	22.2	75.0	71.5	70.1	0.0	59.8	41.1	0.000	0.281	0.193	1.023	4.6	3.1	18.6	18.6	0.0	0.6502	20.3	1.8E-07	0.949	1.7E-07
1	1	16	1.27	22.2	75.0	71.5	70.1	0.0	52.1	48.8	0.000	0.245	0.229	0.950	4.5	3.2	7.7	7.7	0.0	0.7746	18.8	1.2E-07	0.949	1.1E-07
1	1	26	1.43	22.2	75.0	71.5	70.1	0.0	49.8	51.1	0.000	0.234	0.240	0.929	4.5	3.2	2.3	2.3	0.0	0.8118	18.4	8.6E-08	0.949	8.1E-08
1	1	38	1.63	22.2	75.0	71.5	70.1	0.0	47.1	53.9	0.000	0.221	0.253	0.903	4.5	3.2	2.7	2.8	-0.1	0.8562	17.9	8.8E-08	0.949	8.3E-08
1	1	48	1.80	22.2	75.0	71.5	70.1	0.0	45.1	55.9	0.000	0.212	0.263	0.884	4.5	3.2	2.0	2.0	0.0	0.8885	17.5	7.8E-08	0.949	7.4E-08
1	1	53	1.88	22.2	75.0	71.5	70.1	0.0	44.1	56.9	0.000	0.207	0.267	0.875	4.4	3.2	1.0	1.0	0.0	0.9046	17.3	8.0E-08	0.949	7.6E-08
																							Average for last 4:	7.9E-08

HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-03)

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 NORTH 34TH STREET • SUITE 100
P.O. BOX 300303 • SEATTLE, WASHINGTON 98103
206-632-8020 FAX 206-695-6777

Project	Skagit River Levees	Job No.	21-1-21199-002		
Boring No.	DD1-1 Landward	Tested by	AKV	On	1/27/2010
Sample No.	S-2/S-3	Comp by	AKV	On	2/2/2010
Depth (ft)	5.0/7.5	Checked by	JFL	On	2/5/2010



HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-03)

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 NORTH 34TH STREET • SUITE 100
P.O. BOX 300303 • SEATTLE, WASHINGTON 98103
206-632-8020 FAX 206-695-6777

Project	Skagit River Levees	Job No.	21-1-21199-002		
Boring No.	DD1-1 Levee	Tested By	AKV	On	1/19/2010
Sample No.	S-10	Comp By	AKV	On	2/2/2010
Depth (ft)	27.4	Checked By	JFL	On	2/5/2010

WATER CONTENT DATA:

	Before Test	After Test
Pan No.	tin cup	Z-24
Wet+Tare	130.76	309.94
Dry+Tare	93.76	262.71
Tare	2.99	102.99
WC, %	40.8	29.6

DESCRIPTION:

Gray-brown, fine sandy SILT; ML

SPECIMEN DATA:

	Before Test	After Consol.	After Test
Height, m	0.0557	0.0555	0.0553
Diameter, m	0.0505	0.0505	0.0505
Wet Weight, g	203.76	203.66	206.95
Volume, ml	111.7	111.3	110.9
Area, m^2	0.00201	0.00201	0.00201
Wet Unit Wt, pcf	113.8	114.2	116.5
Dry Unit Wt, pcf	80.9	88.2	89.9
Est. Saturation,%	101.6	87.6	91.3

OTHER INFORMATION:

Burette Corr. Factor, BCF (vol. to height), 1ml = 0.0047 m

a = 2.13E-04 m^2

Specific Gravity ☑ Assumed ☐ Measured = 2.7

B-Coefficient = 0.97

Volume of Solid = 53.6 ml

Pore Volume (P.V.)= 58.1 ml

NOTE:

FALLING-HEAD INCREASING TAILWATER LEVEL HYDRAULIC CONDUCTIVITY CALCULATION (METHOD C):

$$k = \frac{aL}{2At}\ln\left(\frac{h_1}{h_2}\right)$$

$$k_{20} = R_T k$$

a = cross-sectional area of standpipe, m^2
L = length of the sample, m
A = cross-sectional area of the sample, m^2
t = elapsed time between determination of h_1 and h_2, sec.

h_1 = head loss across the specimen at time t_1, m,
h_2 = head loss across the specimen at time t_2, m,
k_{20} = corrected hydraulic conductivity at temperature of 20 °C
R_T = correction factor for viscosity of water at various temperatures, T
= $2.2902(0.9842^T)/T^{0.1702}$

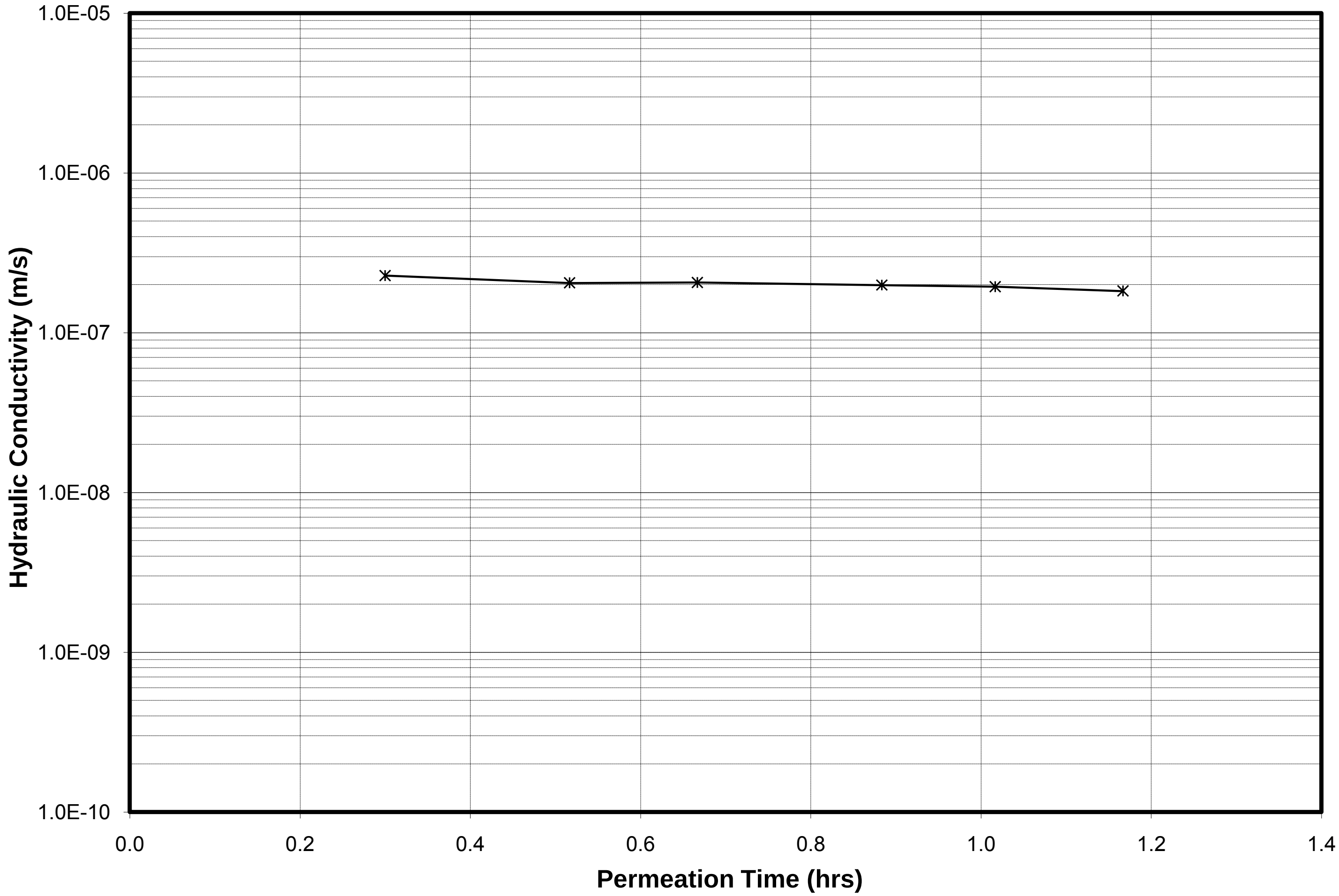
MEASURED DATA:

Read Time			Elapsed Time	Temp T	Pressure Readings			Burette Readings						Head Loss h	Effective Stresses		Calculated Flow Volumes				Gradient (i)	K	R_T	k_{20}
					P_{cell}	P_{in}	P_{out}	V_{cell}	V_{in}	V_{out}	H_{cell}	H_{in}	H_{out}		σ'_{max}	σ'_{min}	Inflow	Outflow	Storage	Cum.				
day	hr	min	(hr)	(°C)	(psi)	(psi)	(psi)	(ml)	(ml)	(ml)	(m)	(m)	(m)	(m)	(psi)	(psi)	(ml)	(ml)	(ml)	P.V.		(m/sec)		(m/sec)
1	0	0	0.00	22.7	48.9	37.0	35.0	0.0	90.0	7.5	0.000	0.423	0.035	1.740	13.8	11.3				0	31.2			
1	0	18	0.30	22.7	48.9	37.0	35.0	0.0	74.0	23.0	0.000	0.348	0.108	1.592	13.7	11.4	16.0	15.5	0.5	0.2711	28.6	2.4E-07	0.938	2.3E-07
1	0	31	0.52	22.7	48.9	37.0	35.0	0.0	64.5	32.5	0.000	0.303	0.153	1.502	13.6	11.5	9.5	9.5	0.0	0.4346	27.0	2.2E-07	0.938	2.1E-07
1	0	40	0.67	22.7	48.9	37.0	35.0	0.0	58.2	38.8	0.000	0.274	0.182	1.443	13.6	11.5	6.3	6.3	0.0	0.5430	25.9	2.2E-07	0.938	2.1E-07
1	0	53	0.88	22.7	48.9	37.0	35.0	0.0	49.9	47.2	0.000	0.235	0.222	1.365	13.5	11.6	8.3	8.4	-0.1	0.6867	24.5	2.1E-07	0.938	2.0E-07
1	1	1	1.02	22.7	48.9	37.0	35.0	0.0	45.1	52.0	0.000	0.212	0.244	1.319	13.5	11.6	4.8	4.8	0.0	0.7693	23.7	2.1E-07	0.938	1.9E-07
1	1	10	1.17	22.7	48.9	37.0	35.0	0.0	40.2	56.9	0.000	0.189	0.267	1.273	13.4	11.6	4.9	4.9	0.0	0.8536	22.9	1.9E-07	0.938	1.8E-07
																							Average for last 4:	2.0E-07

HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-03)

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 NORTH 34TH STREET • SUITE 100
P.O. BOX 300303 • SEATTLE, WASHINGTON 98103
206-632-8020 FAX 206-695-6777

Project	Skagit River Levees	Job No.	21-1-21199-002		
Boring No.	DD1-1 Levee	Tested by	AKV	On	1/19/2010
Sample No.	S-10	Comp by	AKV	On	2/2/2010
Depth (ft)	27.4	Checked by	JFL	On	2/5/2010



HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-03)

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 NORTH 34TH STREET · SUITE 100
P.O. BOX 300303 · SEATTLE, WASHINGTON 98103
206-632-8020 FAX 206-695-6777

Project	Skagit River Levees	Job No.	21-1-21199-002		
Boring No.	DD3-1 Landward	Tested By	AKV	On	1/28/2010
Sample No.	D-12	Comp By	AKV	On	2/2/2010
Depth (ft)	40	Checked By	JFL	On	2/5/2010

WATER CONTENT DATA:

	Before Test	After Test
Pan No.	tin cup	Z-24
Wet+Tare	104.26	194.15
Dry+Tare	90.29	182.19
Tare	3.07	109.86
WC, %	16.0	16.5

DESCRIPTION:

Gray, silty, fine to medium SAND, trace of clay; trace of shell fragments; SM

SPECIMEN DATA:

	Before Test	After Consol.	After Test
Height, m	0.0403	0.0402	0.0402
Diameter, m	0.0355	0.0355	0.0355
Wet Weight, g	84.62	84.42	84.29
Volume, ml	39.8	39.7	39.8
Area, m^2	0.00099	0.00099	0.00099
Wet Unit Wt, pcf	132.6	132.5	132.2
Dry Unit Wt, pcf	114.3	113.7	113.5
Est. Saturation,%	91.2	92.7	92.1

OTHER INFORMATION:

Burette Corr. Factor, BCF (vol. to height), 1ml = 0.0047 m

a = 2.13E-04 m^2

Specific Gravity ☑ Assumed ☐ Measured = 2.7

B-Coefficient = 0.95

Volume of Solid = 27.0 ml

Pore Volume (P.V.)= 12.8 ml

NOTE:

FALLING-HEAD INCREASING TAILWATER LEVEL HYDRAULIC CONDUCTIVITY CALCULATION (METHOD C):

$$k = \frac{aL}{2At}\ln\left(\frac{h_1}{h_2}\right)$$

$$k_{20} = R_T k$$

a = cross-sectional area of standpipe, m^2

L = length of the sample, m

A = cross-sectional area of the sample, m^2

t = elapsed time between determination of h_1 and h_2, sec.

h_1 = head loss across the specimen at time t_1, m,

h_2 = head loss across the specimen at time t_2, m,

k_{20} = corrected hydraulic conductivity at temperature of 20 °C

R_T = correction factor for viscosity of water at various temperatures, T = $2.2902(0.9842^T)/T^{0.1702}$

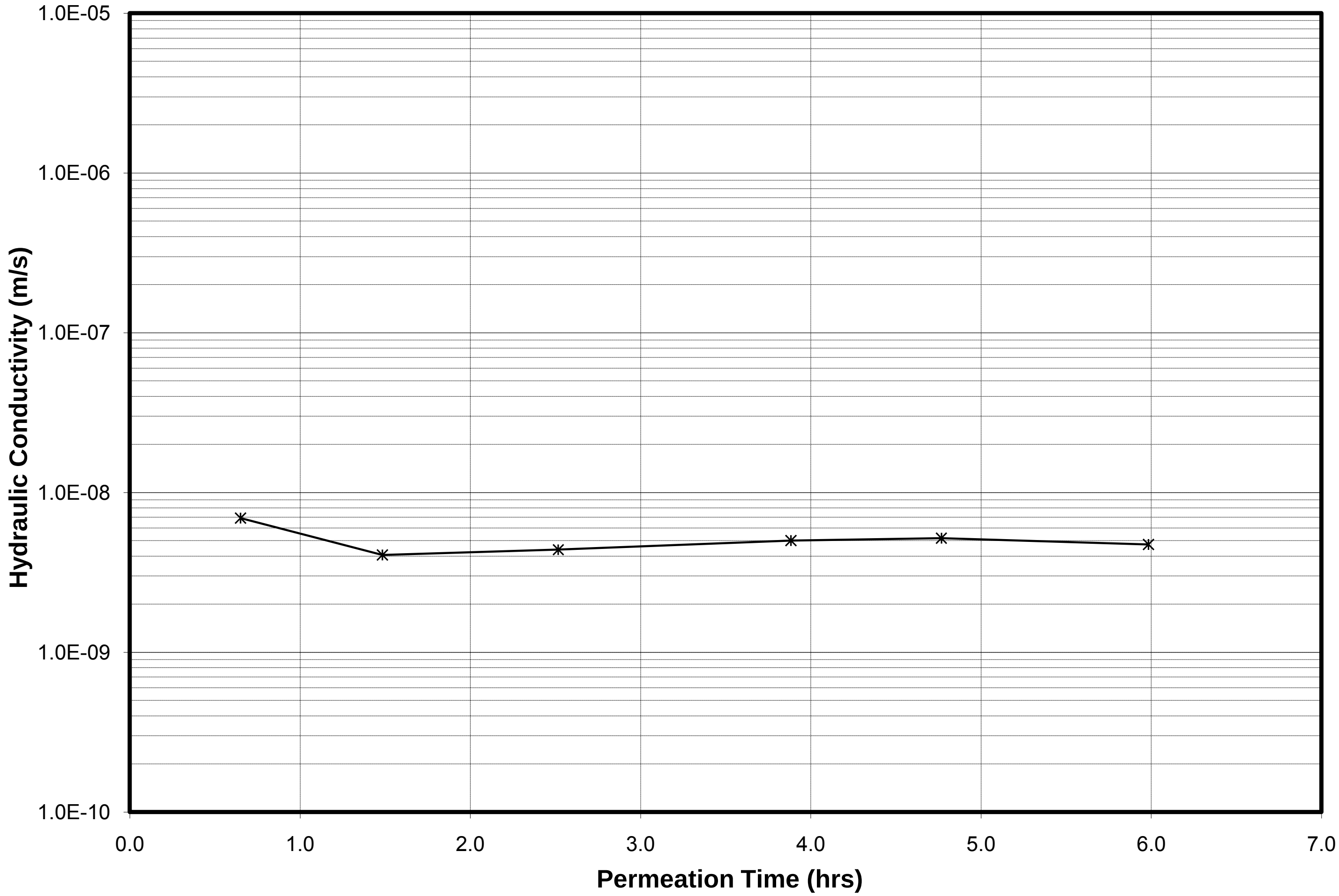
MEASURED DATA:

Read Time			Elapsed Time	Temp	Pressure Readings			Burette Readings						Head Loss	Effective Stresses		Calculated Flow Volumes				Gradient	K	R_T	k_{20}
			Time	T	P_{cell}	P_{in}	P_{out}	V_{cell}	V_{in}	V_{out}	H_{cell}	H_{in}	H_{out}	h	σ'_{max}	σ'_{min}	Inflow	Outflow	Storage	Cum.	(i)			
day	hr	min	(hr)	(°C)	(psi)	(psi)	(psi)	(ml)	(ml)	(ml)	(m)	(m)	(m)	(m)	(psi)	(psi)	(ml)	(ml)	(ml)	P.V.		(m/sec)		(m/sec)
1	14	35	0.00	22.0	67.0	51.5	50.5	0.0	79.8	16.3	0.000	0.375	0.077	0.962	16.3	15.0				0	23.9			
1	15	14	0.65	22.0	67.0	51.5	50.5	0.0	79.4	16.7	0.000	0.373	0.078	0.958	16.3	15.0	0.4	0.4	0.0	0.0312	23.8	7.3E-09	0.953	6.9E-09
1	16	4	1.48	22.0	67.0	51.5	50.5	0.0	79.1	17.0	0.000	0.372	0.080	0.955	16.3	15.0	0.3	0.3	0.0	0.0546	23.7	4.3E-09	0.953	4.1E-09
1	17	6	2.52	22.0	67.0	51.5	50.5	0.0	78.7	17.4	0.000	0.370	0.082	0.952	16.3	15.0	0.4	0.4	0.0	0.0859	23.6	4.6E-09	0.953	4.4E-09
1	18	28	3.88	22.0	67.0	51.5	50.5	0.0	78.1	18.0	0.000	0.367	0.085	0.946	16.3	15.0	0.6	0.6	0.0	0.1327	23.5	5.2E-09	0.953	5.0E-09
1	19	21	4.77	22.0	67.0	51.5	50.5	0.0	77.7	18.4	0.000	0.365	0.086	0.942	16.3	15.0	0.4	0.4	0.0	0.1639	23.4	5.4E-09	0.953	5.2E-09
1	20	34	5.98	22.0	67.0	51.5	50.5	0.0	77.2	18.9	0.000	0.363	0.089	0.938	16.3	15.0	0.5	0.5	0.0	0.2030	23.3	5.0E-09	0.953	4.7E-09
																							Average for last 4:	4.8E-09

HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-03)

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 NORTH 34TH STREET • SUITE 100
P.O. BOX 300303 • SEATTLE, WASHINGTON 98103
206-632-8020 FAX 206-695-6777

Project	Skagit River Levees	Job No.	21-1-21199-002		
Boring No.	DD3-1 Landward	Tested by	AKV	On	1/28/2010
Sample No.	D-12	Comp by	AKV	On	2/2/2010
Depth (ft)	40	Checked by	JFL	On	2/5/2010



HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-03)

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 NORTH 34TH STREET • SUITE 100
P.O. BOX 300303 • SEATTLE, WASHINGTON 98103
206-632-8020 FAX 206-695-6777

Project	Skagit River Levees	Job No.	21-1-21199-002		
Boring No.	DD3-1 Levee	Tested By	AKV	On	1/29/2010
Sample No.	S-7	Comp By	AKV	On	2/3/2010
Depth (ft)	18.1	Checked By	JFL	On	2/5/2010

WATER CONTENT DATA:

	Before Test	After Test
Pan No.	tin cup	Z-24
Wet+Tare	125.74	297.34
Dry+Tare	94.90	243.35
Tare	2.96	98.57
WC, %	33.5	37.3

DESCRIPTION:

Gray-brown, silty, fine SAND;
oxide staining; trace of organics; SM

SPECIMEN DATA:

	Before Test	After Consol.	After Test
Height, m	0.0556	0.0550	0.0550
Diameter, m	0.0506	0.0506	0.0506
Wet Weight, g	195.39	194.39	198.77
Volume, ml	111.8	110.6	110.6
Area, m^2	0.00201	0.00201	0.00201
Wet Unit Wt, pcf	109.0	109.7	112.1
Dry Unit Wt, pcf	81.6	79.9	81.7
Est. Saturation,%	85.1	90.8	94.7

OTHER INFORMATION:

Burette Corr. Factor, BCF (vol. to height), 1ml = 0.0047 m

a = 2.13E-04 m^2

Specific Gravity ☑ Assumed ☐ Measured = 2.7

B-Coefficient = 0.95

Volume of Solid = 54.2 ml

Pore Volume (P.V.)= 57.7 ml

NOTE:

FALLING-HEAD INCREASING TAILWATER LEVEL HYDRAULIC CONDUCTIVITY CALCULATION (METHOD C):

$$k = \frac{aL}{2At}\ln\left(\frac{h_1}{h_2}\right)$$

$$k_{20} = R_T k$$

a = cross-sectional area of standpipe, m^2
L = length of the sample, m
A = cross-sectional area of the sample, m^2
t = elapsed time between determination of h_1 and h_2, sec.

h_1 = head loss across the specimen at time t_1, m,
h_2 = head loss across the specimen at time t_2, m,
k_{20} = corrected hydraulic conductivity at temperature of 20 °C
R_T = correction factor for viscosity of water at various temperatures, T
= $2.2902(0.9842^T)/T^{0.1702}$

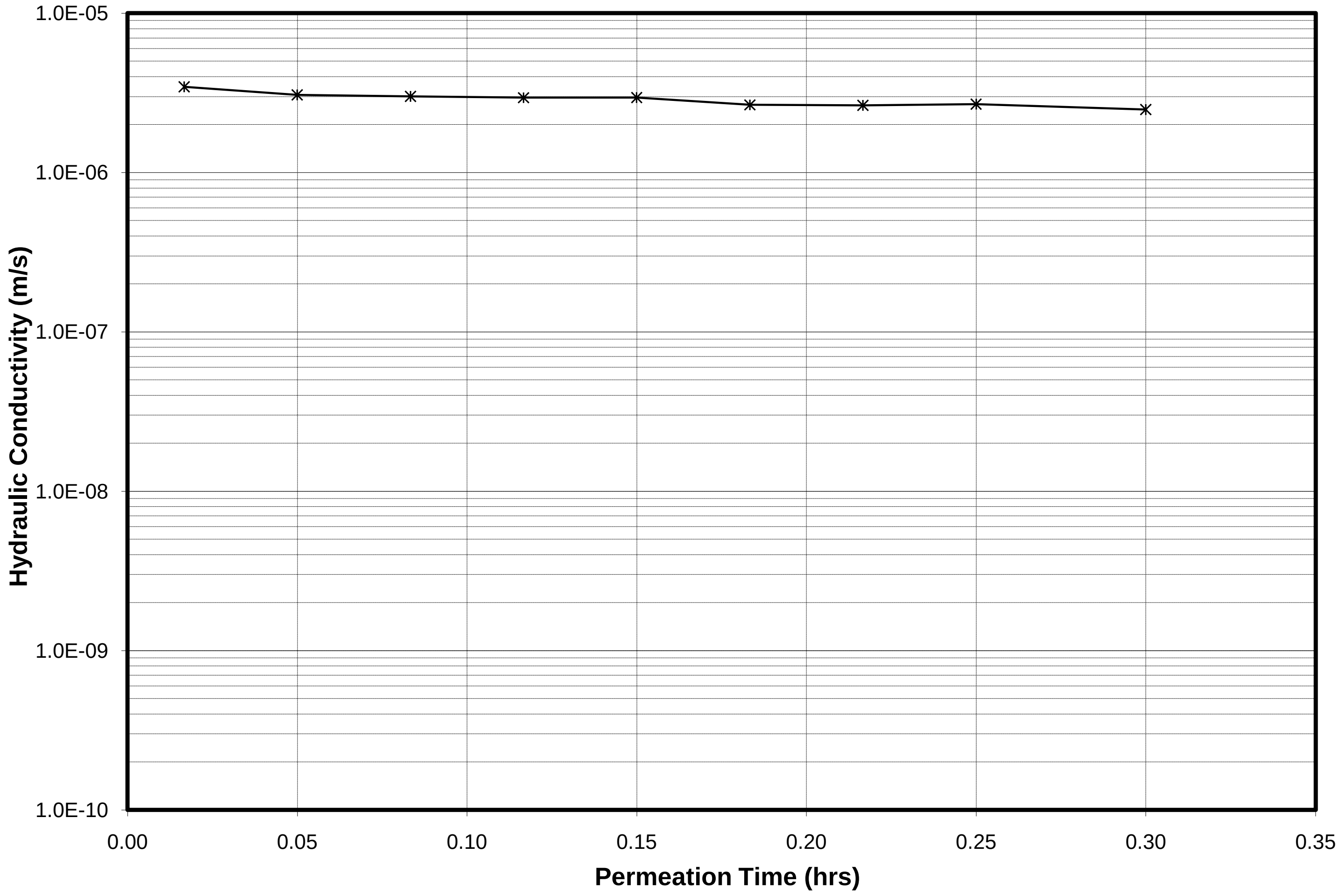
MEASURED DATA:

Read Time			Elapsed	Temp	Pressure Readings			Burette Readings						Head Loss	Effective Stresses		Calculated Flow Volumes				Gradient	*K*	R_T	k_{20}
			Time	T	P_{cell}	P_{in}	P_{out}	V_{cell}	V_{in}	V_{out}	H_{cell}	H_{in}	H_{out}	h	σ'_{max}	σ'_{min}	Inflow	Outflow	Storage	Cum.	(i)			
day	hr	min	(hr)	(°C)	(psi)	(psi)	(psi)	(ml)	(ml)	(ml)	(m)	(m)	(m)	(m)	(psi)	(psi)	(ml)	(ml)	(ml)	P.V.		(m/sec)		(m/sec)
1	0	0	0.00	22.4	49.7	41.5	40.5	0.0	100.0	1.0	0.000	0.470	0.005	1.113	9.1	7.5				0	20.0			
1	0	1	0.02	22.4	49.7	41.5	40.5	0.0	91.5	9.5	0.000	0.430	0.045	1.034	9.1	7.6	8.5	8.5	0.0	0.1474	18.6	3.7E-06	0.944	3.5E-06
1	0	3	0.05	22.4	49.7	41.5	40.5	0.0	77.8	23.1	0.000	0.366	0.109	0.905	9.0	7.7	13.7	13.6	0.1	0.3842	16.3	3.3E-06	0.944	3.1E-06
1	0	5	0.08	22.4	49.7	41.5	40.5	0.0	66.1	34.8	0.000	0.311	0.164	0.795	8.9	7.8	11.7	11.7	0.0	0.5871	14.3	3.2E-06	0.944	3.0E-06
1	0	7	0.12	22.4	49.7	41.5	40.5	0.0	56.0	44.9	0.000	0.263	0.211	0.700	8.8	7.8	10.1	10.1	0.0	0.7623	12.6	3.1E-06	0.944	2.9E-06
1	0	9	0.15	22.4	49.7	41.5	40.5	0.0	47.1	53.8	0.000	0.221	0.253	0.617	8.8	7.9	8.9	8.9	0.0	0.9167	11.1	3.1E-06	0.944	3.0E-06
1	0	11	0.18	22.4	49.7	41.5	40.5	0.0	40.0	60.9	0.000	0.188	0.286	0.550	8.7	7.9	7.1	7.1	0.0	1.0398	9.9	2.8E-06	0.944	2.7E-06
1	0	13	0.22	22.4	49.7	41.5	40.5	0.0	33.7	67.2	0.000	0.158	0.316	0.491	8.7	8.0	6.3	6.3	0.0	1.1491	8.8	2.8E-06	0.944	2.6E-06
1	0	15	0.25	22.4	49.7	41.5	40.5	0.0	28.0	72.9	0.000	0.132	0.343	0.437	8.6	8.0	5.7	5.7	0.0	1.2480	7.9	2.8E-06	0.944	2.7E-06
1	0	18	0.30	22.4	49.7	41.5	40.5	0.0	21.1	79.8	0.000	0.099	0.375	0.372	8.6	8.1	6.9	6.9	0.0	1.3677	6.7	2.6E-06	0.944	2.5E-06
																							Average for last 4:	2.6E-06

HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-03)

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 NORTH 34TH STREET • SUITE 100
P.O. BOX 300303 • SEATTLE, WASHINGTON 98103
206-632-8020 FAX 206-695-6777

Project	Skagit River Levees	Job No.	21-1-21199-002		
Boring No.	DD3-1 Levee	Tested by	AKV	On	1/29/2010
Sample No.	S-7	Comp by	AKV	On	2/3/2010
Depth (ft)	18.1	Checked by	JFL	On	2/5/2010



HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-03)

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 NORTH 34TH STREET • SUITE 100
P.O. BOX 300303 • SEATTLE, WASHINGTON 98103
206-632-8020 FAX 206-695-6777

Project	Skagit River Levees	Job No.	21-1-21199-002		
Boring No.	DD3-1 Levee	Tested By	AKV	On	1/22/2010
Sample No.	D-15	Comp By	AKV	On	1/29/2010
Depth (ft)	56.1	Checked By	JFL	On	2/5/2010

WATER CONTENT DATA:

	Before Test	After Test
Pan No.	tin cup	Z-24
Wet+Tare	138.57	378.11
Dry+Tare	115.80	325.39
Tare	2.96	103.22
WC, %	20.2	23.7

DESCRIPTION:

Gray, fine to medium SAND, trace of silt; SP

SPECIMEN DATA:

	Before Test	After Consol.	After Test
Height, m	0.0686	0.0684	0.0682
Diameter, m	0.0501	0.0501	0.0501
Wet Weight, g	276.06	274.06	274.89
Volume, ml	135.1	134.7	134.3
Area, m^2	0.00197	0.00197	0.00197
Wet Unit Wt, pcf	127.5	127.0	127.7
Dry Unit Wt, pcf	106.1	102.6	103.2
Est. Saturation,%	92.7	99.8	101.4

OTHER INFORMATION:

Burette Corr. Factor, BCF (vol. to height), 1ml = 0.0047 m

a = 2.13E-04 m^2

Specific Gravity ☑ Assumed ☐ Measured = 2.7

B-Coefficient = 0.95

Volume of Solid = 85.1 ml

Pore Volume (P.V.)= 50.0 ml

NOTE:

FALLING-HEAD INCREASING TAILWATER LEVEL HYDRAULIC CONDUCTIVITY CALCULATION (METHOD C):

$$k = \frac{aL}{2At}\ln\left(\frac{h_1}{h_2}\right)$$

$$k_{20} = R_T k$$

a = cross-sectional area of standpipe, m^2
L = length of the sample, m
A = cross-sectional area of the sample, m^2
t = elapsed time between determination of h_1 and h_2, sec.

h_1 = head loss across the specimen at time t_1, m,
h_2 = head loss across the specimen at time t_2, m,
k_{20} = corrected hydraulic conductivity at temperature of 20 °C
R_T = correction factor for viscosity of water at various temperatures, T
= $2.2902(0.9842^T)/T^{0.1702}$

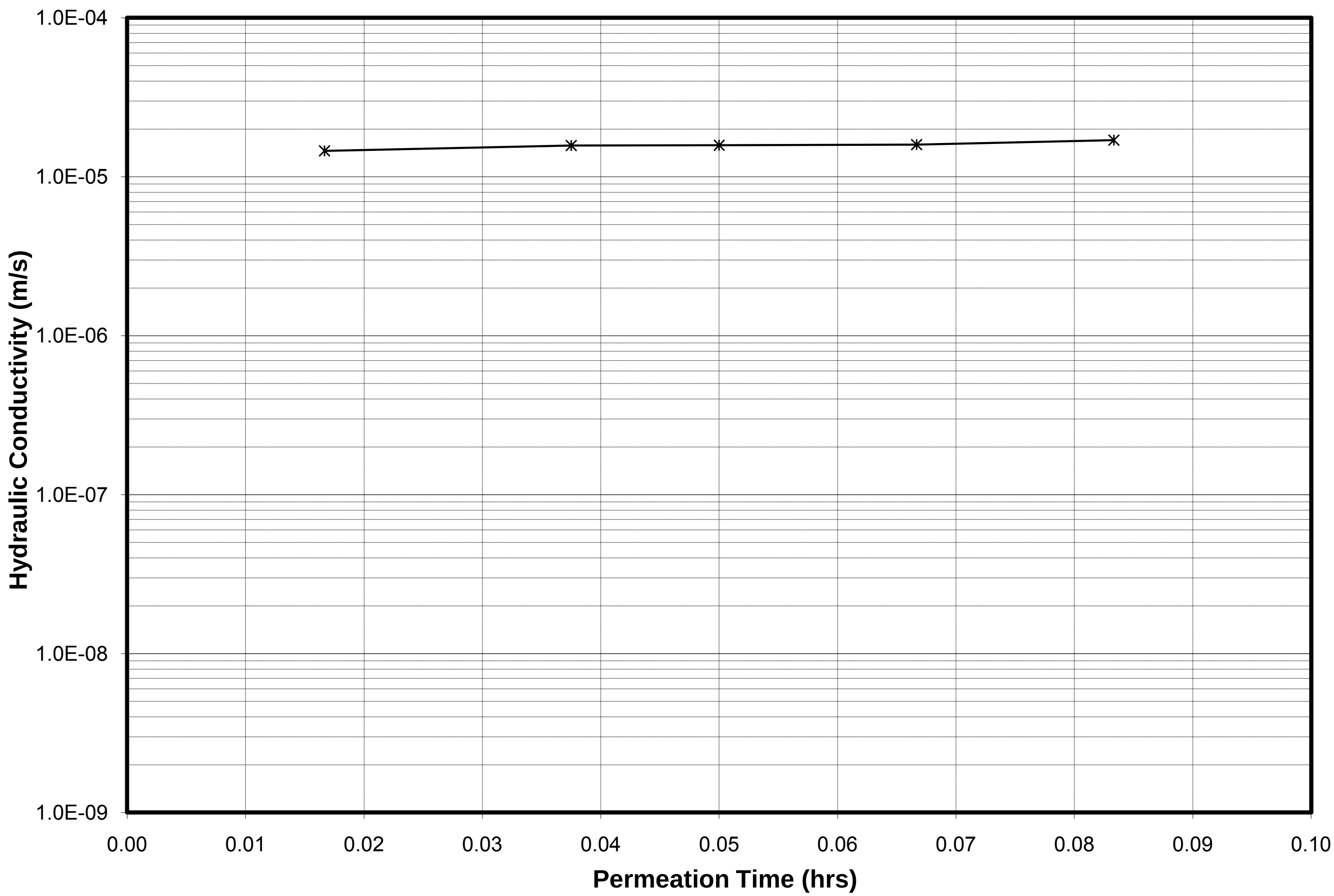
MEASURED DATA:

Read Time			Elapsed Time	Temp T	Pressure Readings P_{cell}	P_{in}	P_{out}	Burette Readings V_{cell}	V_{in}	V_{out}	H_{cell}	H_{in}	H_{out}	Head Loss h	Effective Stresses σ'_{max}	σ'_{min}	Calculated Flow Volumes Inflow	Outflow	Storage	Cum. P.V.	Gradient (i)	K	R_T	k_{20}
day	hr	min	(hr)	(°C)	(psi)	(psi)	(psi)	(ml)	(ml)	(ml)	(m)	(m)	(m)	(m)	(psi)	(psi)	(ml)	(ml)	(ml)	P.V.		(m/sec)		(m/sec)
1	0	0	0.00	22.3	65.0	41.5	40.5	0.0	98.3	2.0	0.000	0.462	0.009	1.088	24.4	22.8				0	15.9			
1	0	1	0.02	22.3	65.0	41.5	40.5	0.0	72.8	27.5	0.000	0.342	0.129	0.848	24.2	23.0	25.5	25.5	0.0	0.5100	12.4	1.5E-05	0.947	1.5E-05
1	0	2.3	0.04	22.3	65.0	41.5	40.5	0.0	47.0	53.2	0.000	0.221	0.250	0.606	24.0	23.2	25.8	25.7	0.1	1.0251	8.8	1.7E-05	0.947	1.6E-05
1	0	3	0.05	22.3	65.0	41.5	40.5	0.0	35.1	64.9	0.000	0.165	0.305	0.495	24.0	23.3	11.9	11.7	0.2	1.2611	7.2	1.7E-05	0.947	1.6E-05
1	0	4	0.07	22.3	65.0	41.5	40.5	0.0	22.5	77.4	0.000	0.106	0.364	0.377	23.9	23.3	12.6	12.5	0.1	1.5121	5.5	1.7E-05	0.947	1.6E-05
1	0	5	0.08	22.3	65.0	41.5	40.5	0.0	12.4	87.5	0.000	0.058	0.411	0.282	23.8	23.4	10.1	10.1	0.0	1.7141	4.1	1.8E-05	0.947	1.7E-05
																							Average for last 4:	1.6E-05

HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-03)

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 NORTH 34TH STREET • SUITE 100
P.O. BOX 300303 • SEATTLE, WASHINGTON 98103
206-632-8020 FAX 206-695-6777

Project	Skagit River Levees	Job No.	21-1-21199-002		
Boring No.	DD3-1 Levee	Tested by	AKV	On	1/22/2010
Sample No.	D-15	Comp by	AKV	On	1/29/2010
Depth (ft)	56.1	Checked by	JFL	On	2/5/2010



HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-03)

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 NORTH 34TH STREET • SUITE 100
P.O. BOX 300303 • SEATTLE, WASHINGTON 98103
206-632-8020 FAX 206-695-6777

Project	Skagit River Levees		Job No.	21-1-21199-002		
Boring No.	DD17-1 Landward		Tested By	AKV	On	1/26/2010
Sample No.	S-2/S-3		Comp By	AKV	On	2/3/2010
Depth (ft)	5.0/7.5		Checked By	JFL	On	2/8/2010

WATER CONTENT DATA:

	Before Test	After Test
Pan No.	tin cup	Z-24
Wet+Tare	76.03	321.58
Dry+Tare	62.34	275.62
Tare	3.02	103.04
WC, %	23.1	26.6

DESCRIPTION:

Gray-brown, silty, fine SAND; SM

SPECIMEN DATA:

	Before Test	After Consol.	After Test
Height, m	0.0562	0.0558	0.0562
Diameter, m	0.0507	0.0507	0.0507
Wet Weight, g	211.96	211.86	218.54
Volume, ml	113.5	112.7	113.5
Area, m^2	0.00202	0.00202	0.00202
Wet Unit Wt, pcf	116.5	117.3	120.1
Dry Unit Wt, pcf	94.7	92.6	94.9
Est. Saturation,%	79.9	87.8	92.7

OTHER INFORMATION:

Burette Corr. Factor, BCF (vol. to height), 1ml = 0.0047 m

a = 2.13E-04 m^2

Specific Gravity ☑ Assumed ☐ Measured = 2.7

B-Coefficient = 0.96

Volume of Solid = 63.8 ml

Pore Volume (P.V.)= 49.7 ml

NOTE:

Sample comprised of
50% S-2, 50% S-3

FALLING-HEAD INCREASING TAILWATER LEVEL HYDRAULIC CONDUCTIVITY CALCULATION (METHOD C):

$$k = \frac{aL}{2At}\ln\left(\frac{h_1}{h_2}\right)$$

$$k_{20} = R_T k$$

a = cross-sectional area of standpipe, m^2
L = length of the sample, m
A = cross-sectional area of the sample, m^2
t = elapsed time between determination of h_1 and h_2, sec.

h_1 = head loss across the specimen at time t_1, m,
h_2 = head loss across the specimen at time t_2, m,
k_{20} = corrected hydraulic conductivity at temperature of 20 °C
R_T = correction factor for viscosity of water at various temperatures, T
= $2.2902(0.9842^T)/T^{0.1702}$

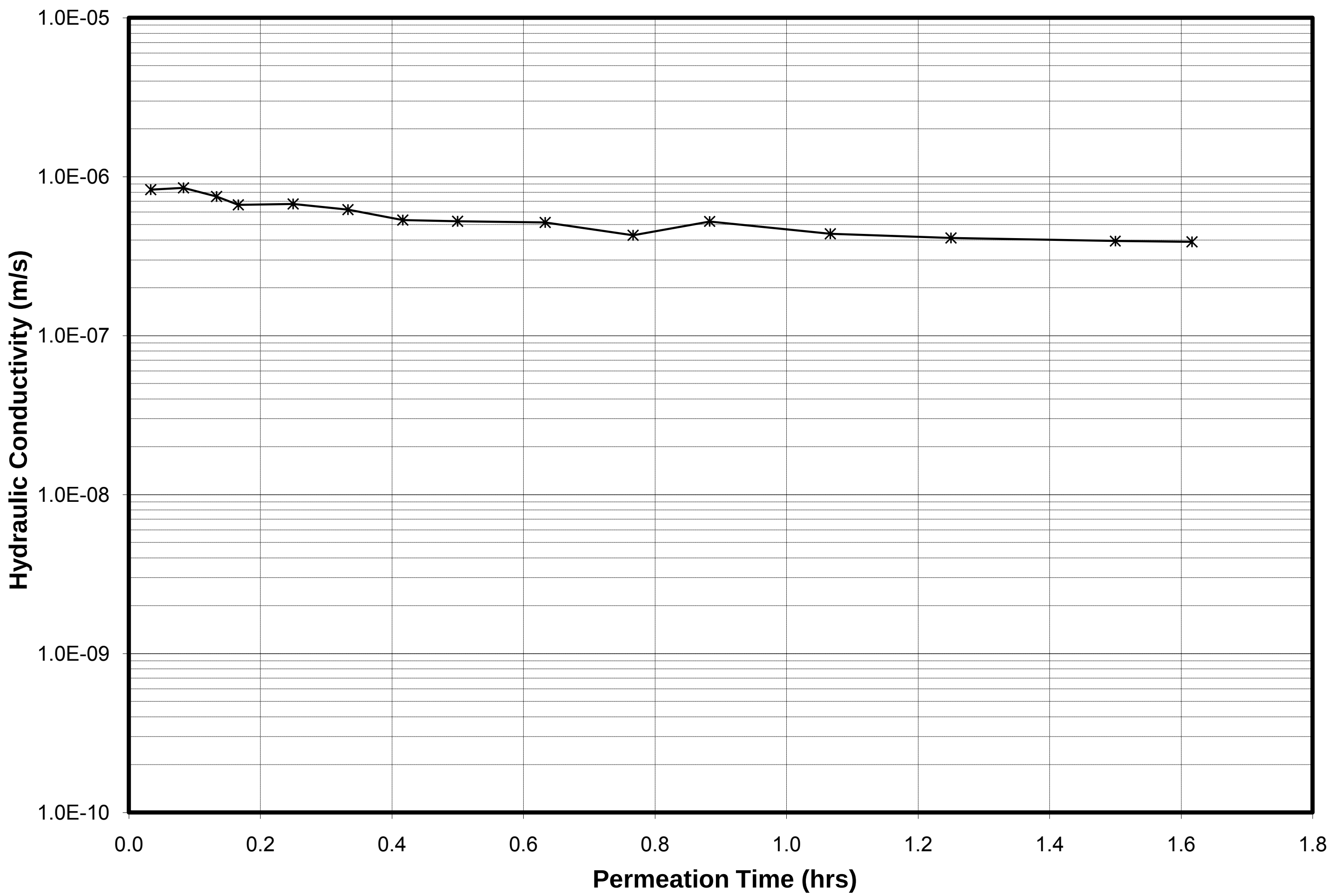
MEASURED DATA:

Read Time			Elapsed Time	Temp T	Pressure Readings			Burette Readings						Head Loss h	Effective Stresses		Calculated Flow Volumes				Gradient (i)	K	R_T	k_{20}
					P_{cell}	P_{in}	P_{out}	V_{cell}	V_{in}	V_{out}	H_{cell}	H_{in}	H_{out}		σ'_{max}	σ'_{min}	Inflow	Outflow	Storage	Cum.				
day	hr	min	(hr)	(°C)	(psi)	(psi)	(psi)	(ml)	(ml)	(ml)	(m)	(m)	(m)	(m)	(psi)	(psi)	(ml)	(ml)	(ml)	P.V.		(m/sec)		(m/sec)
1	0	0	0.00	22.4	80.7	76.5	75.5	0.0	98.7	0.1	0.000	0.464	0.000	1.111	5.1	3.5				0	19.8			
1	0	2	0.03	22.4	80.7	76.5	75.5	0.0	94.2	3.9	0.000	0.443	0.018	1.072	5.1	3.6	4.5	3.8	0.7	0.0835	19.1	8.8E-07	0.944	8.3E-07
1	0	5	0.08	22.4	80.7	76.5	75.5	0.0	88.1	10.0	0.000	0.414	0.047	1.015	5.1	3.6	6.1	6.1	0.0	0.2061	18.1	9.0E-07	0.944	8.5E-07
1	0	8	0.13	22.4	80.7	76.5	75.5	0.0	83.1	15.2	0.000	0.391	0.071	0.967	5.0	3.6	5.0	5.2	-0.2	0.3087	17.2	8.0E-07	0.944	7.5E-07
1	0	10	0.17	22.4	80.7	76.5	75.5	0.0	80.0	17.9	0.000	0.376	0.084	0.939	5.0	3.7	3.1	2.7	0.4	0.3670	16.7	7.1E-07	0.944	6.7E-07
1	0	15	0.25	22.4	80.7	76.5	75.5	0.0	73.1	25.0	0.000	0.344	0.118	0.874	5.0	3.7	6.9	7.1	-0.2	0.5078	15.6	7.2E-07	0.944	6.8E-07
1	0	20	0.33	22.4	80.7	76.5	75.5	0.0	67.1	31.0	0.000	0.315	0.146	0.817	4.9	3.8	6.0	6.0	0.0	0.6285	14.5	6.6E-07	0.944	6.2E-07
1	0	25	0.42	22.4	80.7	76.5	75.5	0.0	62.2	35.8	0.000	0.292	0.168	0.772	4.9	3.8	4.9	4.8	0.1	0.7260	13.7	5.7E-07	0.944	5.3E-07
1	0	30	0.50	22.4	80.7	76.5	75.5	0.0	57.7	40.3	0.000	0.271	0.189	0.729	4.9	3.8	4.5	4.5	0.0	0.8165	13.0	5.6E-07	0.944	5.3E-07
1	0	38	0.63	22.4	80.7	76.5	75.5	0.0	51.1	46.9	0.000	0.240	0.220	0.667	4.8	3.9	6.6	6.6	0.0	0.9492	11.9	5.5E-07	0.944	5.2E-07
1	0	46	0.77	22.4	80.7	76.5	75.5	0.0	46.1	52.0	0.000	0.217	0.244	0.620	4.8	3.9	5.0	5.1	-0.1	1.0508	11.0	4.6E-07	0.944	4.3E-07
1	0	53	0.88	22.4	80.7	76.5	75.5	0.0	41.1	57.0	0.000	0.193	0.268	0.573	4.7	3.9	5.0	5.0	0.0	1.1513	10.2	5.6E-07	0.944	5.2E-07
1	1	4	1.07	22.4	80.7	76.5	75.5	0.0	35.1	63.0	0.000	0.165	0.296	0.516	4.7	4.0	6.0	6.0	0.0	1.2720	9.2	4.7E-07	0.944	4.4E-07
1	1	15	1.25	22.4	80.7	76.5	75.5	0.0	30.0	68.1	0.000	0.141	0.320	0.469	4.7	4.0	5.1	5.1	0.0	1.3746	8.3	4.4E-07	0.944	4.1E-07
1	1	30	1.50	22.4	80.7	76.5	75.5	0.0	24.0	74.0	0.000	0.113	0.348	0.413	4.6	4.0	6.0	5.9	0.1	1.4942	7.3	4.2E-07	0.944	3.9E-07
1	1	37	1.62	22.4	80.7	76.5	75.5	0.0	21.5	76.5	0.000	0.101	0.360	0.389	4.6	4.1	2.5	2.5	0.0	1.5445	6.9	4.1E-07	0.944	3.9E-07
																							Average for last 4:	4.1E-07

HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-03)

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 NORTH 34TH STREET • SUITE 100
P.O. BOX 300303 • SEATTLE, WASHINGTON 98103
206-632-8020 FAX 206-695-6777

Project	Skagit River Levees	Job No.	21-1-21199-002		
Boring No.	DD17-1 Landward	Tested by	AKV	On	1/26/2010
Sample No.	S-2/S-3	Comp by	AKV	On	2/3/2010
Depth (ft)	5.0/7.5	Checked by	JFL	On	2/8/2010



HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-03)

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 NORTH 34TH STREET • SUITE 100
P.O. BOX 300303 • SEATTLE, WASHINGTON 98103
206-632-8020 FAX 206-695-6777

Project	Skagit River Levees	Job No.	21-1-21199-002		
Boring No.	DD17-1 Levee	Tested By	AKV	On	1/29/2010
Sample No.	S-5/S-6	Comp By	AKV	On	2/5/2010
Depth (ft)	12.5/15.0	Checked By	JFL	On	2/8/2010

WATER CONTENT DATA:

	Before Test	After Test
Pan No.	tin cup	Z-24
Wet+Tare	89.48	323.70
Dry+Tare	76.29	269.44
Tare	3.08	102.68
WC, %	18.0	32.5

DESCRIPTION:

Gray-brown, silty, fine SAND; SM

SPECIMEN DATA:

	Before Test	After Consol.	After Test
Height, m	0.0595	0.0593	0.0592
Diameter, m	0.0507	0.0507	0.0507
Wet Weight, g	197.55	196.85	221.02
Volume, ml	120.0	119.6	119.5
Area, m^2	0.00202	0.00202	0.00202
Wet Unit Wt, pcf	102.8	102.7	115.4
Dry Unit Wt, pcf	87.1	77.5	87.1
Est. Saturation,%	52.0	74.9	94.0

OTHER INFORMATION:

Burette Corr. Factor, BCF (vol. to height), 1ml = 0.0047 m

a = 2.13E-04 m^2

Specific Gravity ☑ Assumed ☐ Measured = 2.7

B-Coefficient = 0.97

Volume of Solid = 62.0 ml

Pore Volume (P.V.)= 58.0 ml

NOTE:

Sample comprised of
50% S-5, 50% S-6

FALLING-HEAD INCREASING TAILWATER LEVEL HYDRAULIC CONDUCTIVITY CALCULATION (METHOD C):

$$k = \frac{aL}{2At}\ln\left(\frac{h_1}{h_2}\right)$$

$$k_{20} = R_T k$$

a = cross-sectional area of standpipe, m^2
L = length of the sample, m
A = cross-sectional area of the sample, m^2
t = elapsed time between determination of h_1 and h_2, sec.

h_1 = head loss across the specimen at time t_1, m,
h_2 = head loss across the specimen at time t_2, m,
k_{20} = corrected hydraulic conductivity at temperature of 20 °C
R_T = correction factor for viscosity of water at various temperatures, T
= $2.2902(0.9842^T)/T^{0.1702}$

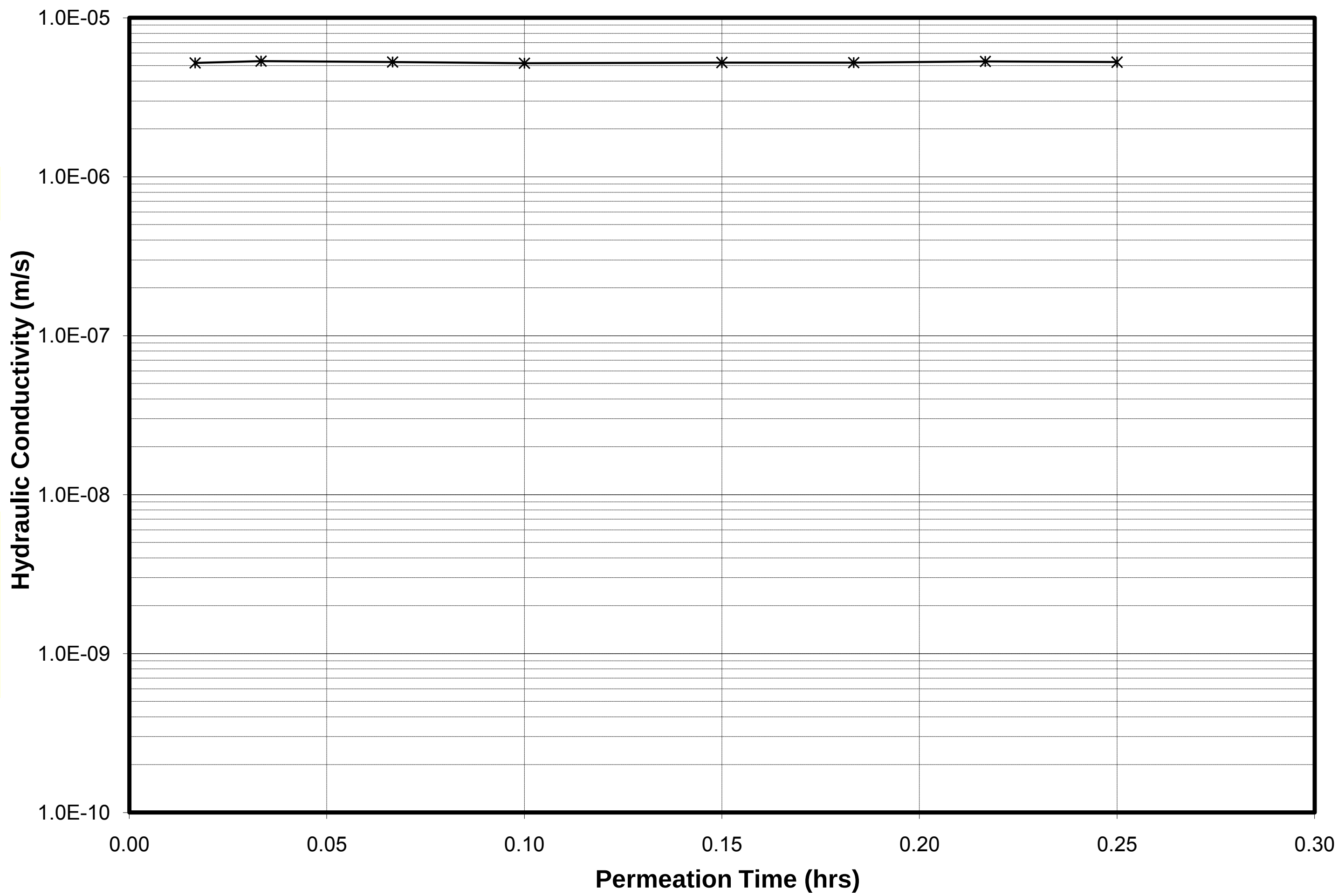
MEASURED DATA:

Read Time			Elapsed Time	Temp T	Pressure Readings			Burette Readings						Head Loss h	Effective Stresses		Calculated Flow Volumes				Gradient (i)	K	R_T	k_{20}
day	hr	min	(hr)	(°C)	P_{cell} (psi)	P_{in} (psi)	P_{out} (psi)	V_{cell} (ml)	V_{in} (ml)	V_{out} (ml)	H_{cell} (m)	H_{in} (m)	H_{out} (m)	(m)	σ'_{max} (psi)	σ'_{min} (psi)	Inflow (ml)	Outflow (ml)	Storage (ml)	Cum. P.V.		(m/sec)		(m/sec)
1	0	0	0.00	22.0	101.2	91.5	90.5	0.0	95.5	1.0	0.000	0.449	0.005	1.088	10.6	9.1				0	18.3			
1	0	1	0.02	22.0	101.2	91.5	90.5	0.0	83.8	12.3	0.000	0.394	0.058	0.980	10.5	9.1	11.7	11.3	0.4	0.1984	16.5	5.5E-06	0.953	5.2E-06
1	0	2	0.03	22.0	101.2	91.5	90.5	0.0	73.1	22.8	0.000	0.344	0.107	0.881	10.5	9.2	10.7	10.5	0.2	0.3812	14.8	5.6E-06	0.953	5.3E-06
1	0	4	0.07	22.0	101.2	91.5	90.5	0.0	55.2	40.7	0.000	0.259	0.191	0.712	10.3	9.3	17.9	17.9	0.0	0.6900	12.0	5.5E-06	0.953	5.3E-06
1	0	6	0.10	22.0	101.2	91.5	90.5	0.0	41.0	55.0	0.000	0.193	0.259	0.579	10.2	9.4	14.2	14.3	-0.1	0.9358	9.7	5.4E-06	0.953	5.2E-06
1	0	9	0.15	22.0	101.2	91.5	90.5	0.0	24.4	71.7	0.000	0.115	0.337	0.422	10.1	9.5	16.6	16.7	-0.1	1.2230	7.1	5.5E-06	0.953	5.2E-06
1	0	11	0.18	22.0	101.2	91.5	90.5	0.0	15.9	80.2	0.000	0.075	0.377	0.342	10.1	9.6	8.5	8.5	0.0	1.3697	5.8	5.5E-06	0.953	5.2E-06
1	0	13	0.22	22.0	101.2	91.5	90.5	0.0	8.9	87.2	0.000	0.042	0.410	0.276	10.0	9.6	7.0	7.0	0.0	1.4904	4.6	5.6E-06	0.953	5.3E-06
1	0	15	0.25	22.0	101.2	91.5	90.5	0.0	3.3	92.8	0.000	0.016	0.436	0.224	10.0	9.7	5.6	5.6	0.0	1.5870	3.8	5.5E-06	0.953	5.3E-06
																							Average for last 4:	5.3E-06

HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-03)

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 NORTH 34TH STREET • SUITE 100
P.O. BOX 300303 • SEATTLE, WASHINGTON 98103
206-632-8020 FAX 206-695-6777

Project	Skagit River Levees	Job No.	21-1-21199-002		
Boring No.	DD17-1 Levee	Tested by	AKV	On	1/29/2010
Sample No.	S-5/S-6	Comp by	AKV	On	2/5/2010
Depth (ft)	12.5/15.0	Checked by	JFL	On	2/8/2010



HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-03)

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 NORTH 34TH STREET • SUITE 100
P.O. BOX 300303 • SEATTLE, WASHINGTON 98103
206-632-8020 FAX 206-695-6777

Project	Skagit River Levees	Job No.	21-1-21199-002		
Boring No.	DD17-2 Landward	Tested By	AKV	On	1/18/2010
Sample No.	S-3	Comp By	AKV	On	1/29/2010
Depth (ft)	7.5	Checked By	JFL	On	2/8/2010

WATER CONTENT DATA:

	Before Test	After Test
Pan No.	tin cup	Z-24
Wet+Tare	133.34	326.54
Dry+Tare	110.37	286.24
Tare	2.95	98.15
WC, %	21.4	21.4

DESCRIPTION:

Gray-brown, fine sandy SILT;
scattered organics; ML

SPECIMEN DATA:

	Before Test	After Consol.	After Test
Height, m	0.0544	0.0544	0.0543
Diameter, m	0.0510	0.0510	0.0510
Wet Weight, g	228.73	227.93	228.39
Volume, ml	111.1	111.0	111.0
Area, m^2	0.00204	0.00204	0.00204
Wet Unit Wt, pcf	128.5	128.1	128.4
Dry Unit Wt, pcf	105.9	105.5	105.8
Est. Saturation,%	97.6	96.9	97.6

OTHER INFORMATION:

Burette Corr. Factor, BCF (vol. to height), 1ml = 0.0047 m

a = 2.13E-04 m^2

Specific Gravity ☑ Assumed ☐ Measured = 2.7

B-Coefficient = 0.98

Volume of Solid = 69.8 ml

Pore Volume (P.V.)= 41.3 ml

NOTE:

FALLING-HEAD INCREASING TAILWATER LEVEL HYDRAULIC CONDUCTIVITY CALCULATION (METHOD C):

$$k = \frac{aL}{2At}\ln\left(\frac{h_1}{h_2}\right)$$

$$k_{20} = R_T k$$

a = cross-sectional area of standpipe, m^2
L = length of the sample, m
A = cross-sectional area of the sample, m^2
t = elapsed time between determination of h_1 and h_2, sec.

h_1 = head loss across the specimen at time t_1, m,
h_2 = head loss across the specimen at time t_2, m,
k_{20} = corrected hydraulic conductivity at temperature of 20 °C
R_T = correction factor for viscosity of water at various temperatures, T
= $2.2902(0.9842^T)/T^{0.1702}$

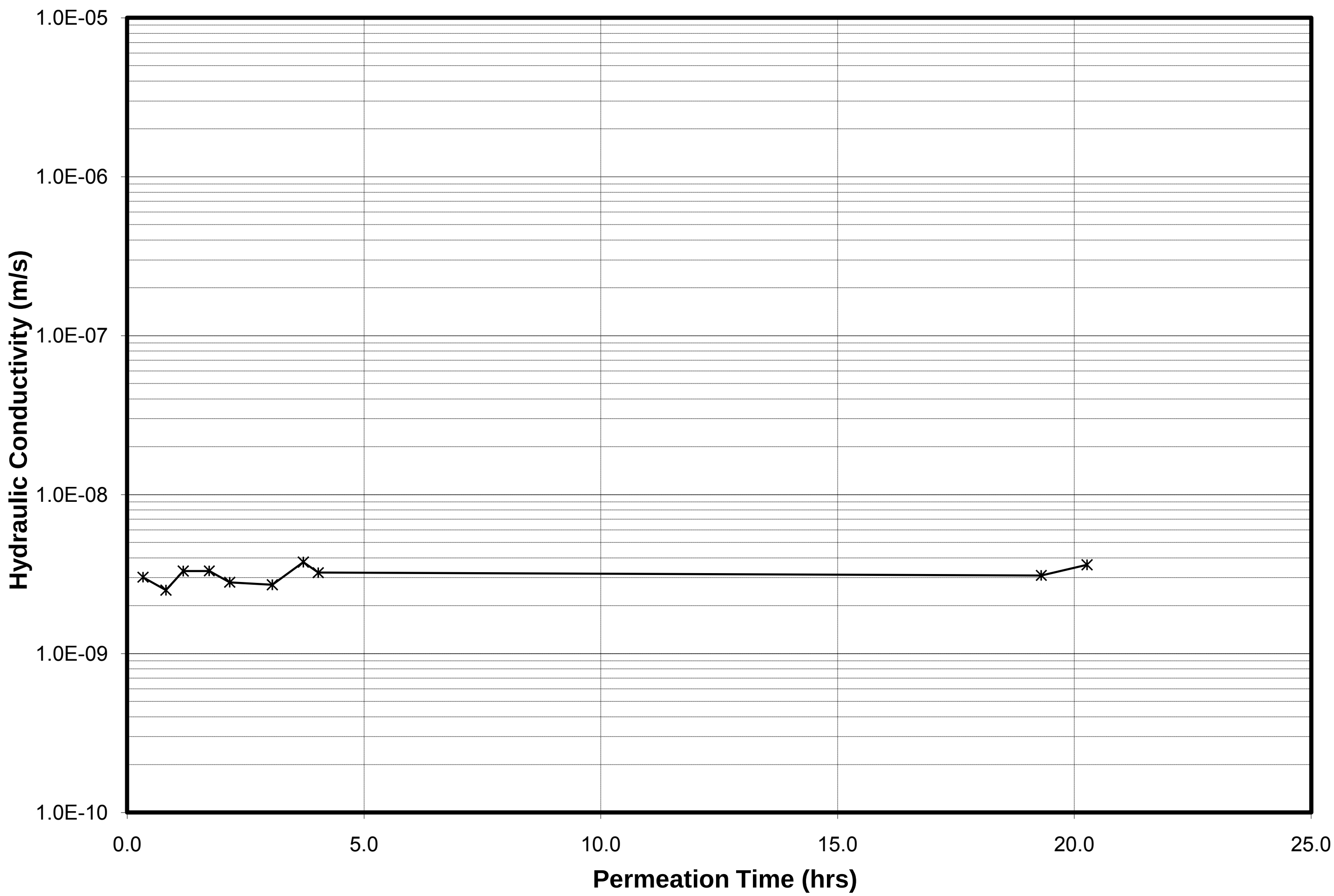
MEASURED DATA:

Read Time			Elapsed Time	Temp T	Pressure Readings			Burette Readings						Head Loss h	Effective Stresses		Calculated Flow Volumes				Gradient (i)	K	R_T	k_{20}
day	hr	min	(hr)	(°C)	P_{cell} (psi)	P_{in} (psi)	P_{out} (psi)	V_{cell} (ml)	V_{in} (ml)	V_{out} (ml)	H_{cell} (m)	H_{in} (m)	H_{out} (m)	(m)	σ'_{max} (psi)	σ'_{min} (psi)	Inflow (ml)	Outflow (ml)	Storage (ml)	Cum. P.V.		(m/sec)		(m/sec)
1	0	0	0.00	23.4	35.7	32.0	30.0	0.0	77.2	5.0	0.000	0.363	0.024	1.692	5.6	3.2				0	31.1			
1	0	20	0.33	23.5	35.7	32.0	30.0	0.0	76.9	5.2	0.000	0.361	0.024	1.690	5.6	3.2	0.3	0.2	0.1	0.0061	31.1	3.3E-09	0.921	3.0E-09
1	0	49	0.82	23.5	35.7	32.0	30.0	0.0	76.5	5.4	0.000	0.360	0.025	1.687	5.6	3.2	0.4	0.2	0.2	0.0133	31.0	2.7E-09	0.920	2.5E-09
1	1	11	1.18	23.5	35.7	32.0	30.0	0.0	76.2	5.7	0.000	0.358	0.027	1.684	5.6	3.2	0.3	0.3	0.0	0.0206	31.0	3.6E-09	0.920	3.3E-09
1	1	44	1.73	23.5	35.7	32.0	30.0	0.0	75.7	6.1	0.000	0.356	0.029	1.680	5.6	3.2	0.5	0.4	0.1	0.0315	30.9	3.6E-09	0.920	3.3E-09
1	2	10	2.17	23.5	35.7	32.0	30.0	0.0	75.4	6.4	0.000	0.354	0.030	1.677	5.6	3.2	0.3	0.3	0.0	0.0388	30.8	3.1E-09	0.920	2.8E-09
1	3	4	3.07	23.5	35.7	32.0	30.0	0.0	74.8	7.0	0.000	0.352	0.033	1.672	5.6	3.2	0.6	0.6	0.0	0.0533	30.7	2.9E-09	0.920	2.7E-09
1	3	43	3.72	23.5	35.7	32.0	30.0	0.0	74.2	7.6	0.000	0.349	0.036	1.666	5.6	3.2	0.6	0.6	0.0	0.0678	30.6	4.1E-09	0.920	3.8E-09
1	4	2	4.03	23.5	35.7	32.0	30.0	0.0	74.0	7.9	0.000	0.348	0.037	1.664	5.6	3.2	0.2	0.3	-0.1	0.0739	30.6	3.5E-09	0.920	3.2E-09
1	19	18	19.30	23.5	35.7	32.0	30.0	0.0	62.8	19.1	0.000	0.295	0.090	1.559	5.5	3.3	11.2	11.2	0.0	0.3452	28.7	3.4E-09	0.920	3.1E-09
1	20	16	20.27	23.5	35.7	32.0	30.0	0.0	62.0	19.9	0.000	0.291	0.094	1.551	5.5	3.3	0.8	0.8	0.0	0.3645	28.5	3.9E-09	0.920	3.6E-09
																							Average for last 4:	3.4E-09

HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-03)

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 NORTH 34TH STREET · SUITE 100
P.O. BOX 300303 · SEATTLE, WASHINGTON 98103
206-632-8020 FAX 206-695-6777

Project	Skagit River Levees	Job No.	21-1-21199-002		
Boring No.	DD17-2 Landward	Tested by	AKV	On	1/18/2010
Sample No.	S-3	Comp by	AKV	On	1/29/2010
Depth (ft)	7.5	Checked by	JFL	On	2/8/2010



HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-03)

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 NORTH 34TH STREET • SUITE 100
P.O. BOX 300303 • SEATTLE, WASHINGTON 98103
206-632-8020 FAX 206-695-6777

Project	Skagit River Levees		Job No.	21-1-21199-002		
Boring No.	DD17-2 Levee		Tested By	AKV	On	1/20/2010
Sample No.	S-10		Comp By	AKV	On	2/2/2010
Depth (ft)	24.5		Checked By	JFL	On	2/7/2010

WATER CONTENT DATA:

	Before Test	After Test
Pan No.	tin cup	Z-24
Wet+Tare	154.11	324.00
Dry+Tare	111.45	258.82
Tare	2.95	103.48
WC, %	39.3	42.0

DESCRIPTION:

Gray, fine sandy SILT; oxide staining; ML

SPECIMEN DATA:

	Before Test	After Consol.	After Test
Height, m	0.0605	0.0585	0.0585
Diameter, m	0.0512	0.0512	0.0512
Wet Weight, g	222.64	217.64	220.52
Volume, ml	124.4	120.2	120.2
Area, m^2	0.00206	0.00206	0.00206
Wet Unit Wt, pcf	111.7	113.0	114.5
Dry Unit Wt, pcf	80.2	79.6	80.6
Est. Saturation,%	96.4	101.4	104.0

OTHER INFORMATION:

Burette Corr. Factor, BCF (vol. to height), 1ml = 0.0047 m

a = 2.13E-04 m^2

Specific Gravity ☑ Assumed ☐ Measured = 2.7

B-Coefficient = 0.97

Volume of Solid = 59.2 ml

Pore Volume (P.V.)= 65.2 ml

NOTE:

FALLING-HEAD INCREASING TAILWATER LEVEL HYDRAULIC CONDUCTIVITY CALCULATION (METHOD C):

$$k = \frac{aL}{2At}\ln\left(\frac{h_1}{h_2}\right)$$

$$k_{20} = R_T k$$

a = cross-sectional area of standpipe, m^2
L = length of the sample, m
A = cross-sectional area of the sample, m^2
t = elapsed time between determination of h_1 and h_2, sec.

h_1 = head loss across the specimen at time t_1, m,
h_2 = head loss across the specimen at time t_2, m,
k_{20} = corrected hydraulic conductivity at temperature of 20 °C
R_T = correction factor for viscosity of water at various temperatures, T
= $2.2902(0.9842^T)/T^{0.1702}$

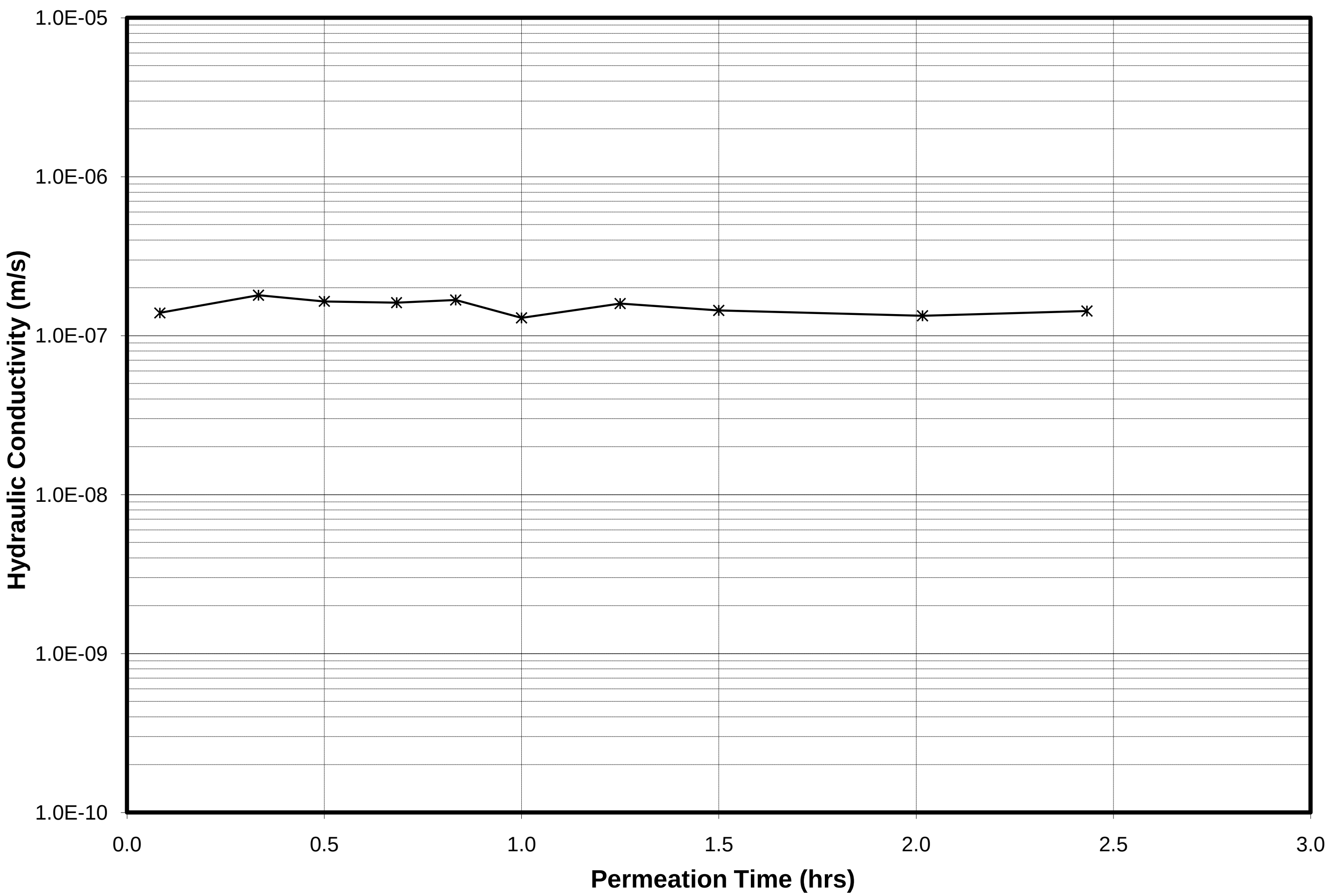
MEASURED DATA:

Read Time			Elapsed Time	Temp T	Pressure Readings			Burette Readings						Head Loss h	Effective Stresses		Calculated Flow Volumes				Gradient (i)	*K*	*R_T*	k_{20}
day	hr	min	(hr)	(°C)	P_{cell} (psi)	P_{in} (psi)	P_{out} (psi)	V_{cell} (ml)	V_{in} (ml)	V_{out} (ml)	H_{cell} (m)	H_{in} (m)	H_{out} (m)	(m)	σ'$_{max}$ (psi)	σ'$_{min}$ (psi)	Inflow (ml)	Outflow (ml)	Storage (ml)	Cum. P.V.		(m/sec)		(m/sec)
1	0	0	0.00	22.4	44.0	31.5	30.5	0.0	98.2	7.0	0.000	0.462	0.033	1.072	13.4	11.8				0	17.7			
1	0	5	0.08	22.4	44.0	31.5	30.5	0.0	96.1	8.1	0.000	0.452	0.038	1.057	13.4	11.9	2.1	1.1	1.0	0.0245	17.5	1.5E-07	0.944	1.4E-07
1	0	20	0.33	22.4	44.0	31.5	30.5	0.0	90.5	14.5	0.000	0.425	0.068	1.000	13.3	11.9	5.6	6.4	-0.8	0.1166	16.5	1.9E-07	0.944	1.8E-07
1	0	30	0.50	22.4	44.0	31.5	30.5	0.0	86.9	17.9	0.000	0.408	0.084	0.968	13.3	11.9	3.6	3.4	0.2	0.1703	16.0	1.7E-07	0.944	1.6E-07
1	0	41	0.68	22.4	44.0	31.5	30.5	0.0	83.2	21.5	0.000	0.391	0.101	0.933	13.3	11.9	3.7	3.6	0.1	0.2263	15.4	1.7E-07	0.944	1.6E-07
1	0	50	0.83	22.4	44.0	31.5	30.5	0.0	80.2	24.5	0.000	0.377	0.115	0.905	13.3	12.0	3.0	3.0	0.0	0.2723	15.0	1.8E-07	0.944	1.7E-07
1	1	0	1.00	22.4	44.0	31.5	30.5	0.0	77.7	27.0	0.000	0.365	0.127	0.882	13.2	12.0	2.5	2.5	0.0	0.3107	14.6	1.4E-07	0.944	1.3E-07
1	1	15	1.25	22.4	44.0	31.5	30.5	0.0	73.3	31.5	0.000	0.345	0.148	0.840	13.2	12.0	4.4	4.5	-0.1	0.3790	13.9	1.7E-07	0.944	1.6E-07
1	1	30	1.50	22.4	44.0	31.5	30.5	0.0	69.5	35.4	0.000	0.327	0.166	0.804	13.2	12.0	3.8	3.9	-0.1	0.4381	13.3	1.5E-07	0.944	1.4E-07
1	2	1	2.02	22.4	44.0	31.5	30.5	0.0	62.6	42.3	0.000	0.294	0.199	0.739	13.1	12.1	6.9	6.9	0.0	0.5439	12.2	1.4E-07	0.944	1.3E-07
1	2	26	2.43	22.4	44.0	31.5	30.5	0.0	57.0	47.7	0.000	0.268	0.224	0.687	13.1	12.1	5.6	5.4	0.2	0.6283	11.4	1.5E-07	0.944	1.4E-07
																							Average for last 4:	1.5E-07

HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-03)

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 NORTH 34TH STREET • SUITE 100
P.O. BOX 300303 • SEATTLE, WASHINGTON 98103
206-632-8020 FAX 206-695-6777

Project	Skagit River Levees	Job No.	21-1-21199-002		
Boring No.	DD17-2 Levee	Tested by	AKV	On	1/20/2010
Sample No.	S-10	Comp by	AKV	On	2/2/2010
Depth (ft)	24.5	Checked by	JFL	On	2/7/2010



HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-03)

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 NORTH 34TH STREET • SUITE 100
P.O. BOX 300303 • SEATTLE, WASHINGTON 98103
206-632-8020 FAX 206-695-6777

Project	Skagit River Levees	Job No.	21-1-21199-002		
Boring No.	DD17-3 Landward	Tested By	AKV	On	1/20/2010
Sample No.	S-2	Comp By	AKV	On	2/2/2010
Depth (ft)	5.9	Checked By	JFL	On	2/8/2010

WATER CONTENT DATA:

	Before Test	After Test
Pan No.	tin cup	Z-24
Wet+Tare	103.87	410.66
Dry+Tare	86.70	342.93
Tare	3.11	164.02
WC, %	20.5	37.9

DESCRIPTION:

Gray-brown, slightly silty, fine SAND; SP-SM

SPECIMEN DATA:

	Before Test	After Consol.	After Test
Height, m	0.0675	0.0674	0.0674
Diameter, m	0.0513	0.0513	0.0513
Wet Weight, g	214.79	214.39	246.64
Volume, ml	139.7	139.7	139.6
Area, m^2	0.00207	0.00207	0.00207
Wet Unit Wt, pcf	95.9	95.8	110.2
Dry Unit Wt, pcf	79.6	69.5	79.9
Est. Saturation,%	49.7	71.7	92.3

OTHER INFORMATION:

Burette Corr. Factor, BCF (vol. to height), 1ml = 0.0047 m

a = 2.13E-04 m^2

Specific Gravity ☑ Assumed ☐ Measured = 2.7

B-Coefficient = 0.95

Volume of Solid = 66.0 ml

Pore Volume (P.V.)= 73.7 ml

NOTE:

FALLING-HEAD INCREASING TAILWATER LEVEL HYDRAULIC CONDUCTIVITY CALCULATION (METHOD C):

$$k = \frac{aL}{2At}\ln\left(\frac{h_1}{h_2}\right)$$

$$k_{20} = R_T k$$

a = cross-sectional area of standpipe, m^2

L = length of the sample, m

A = cross-sectional area of the sample, m^2

t = elapsed time between determination of h_1 and h_2, sec.

h_1 = head loss across the specimen at time t_1, m,

h_2 = head loss across the specimen at time t_2, m,

k_{20} = corrected hydraulic conductivity at temperature of 20 °C

R_T = correction factor for viscosity of water at various temperatures, T

= $2.2902(0.9842^T)/T^{0.1702}$

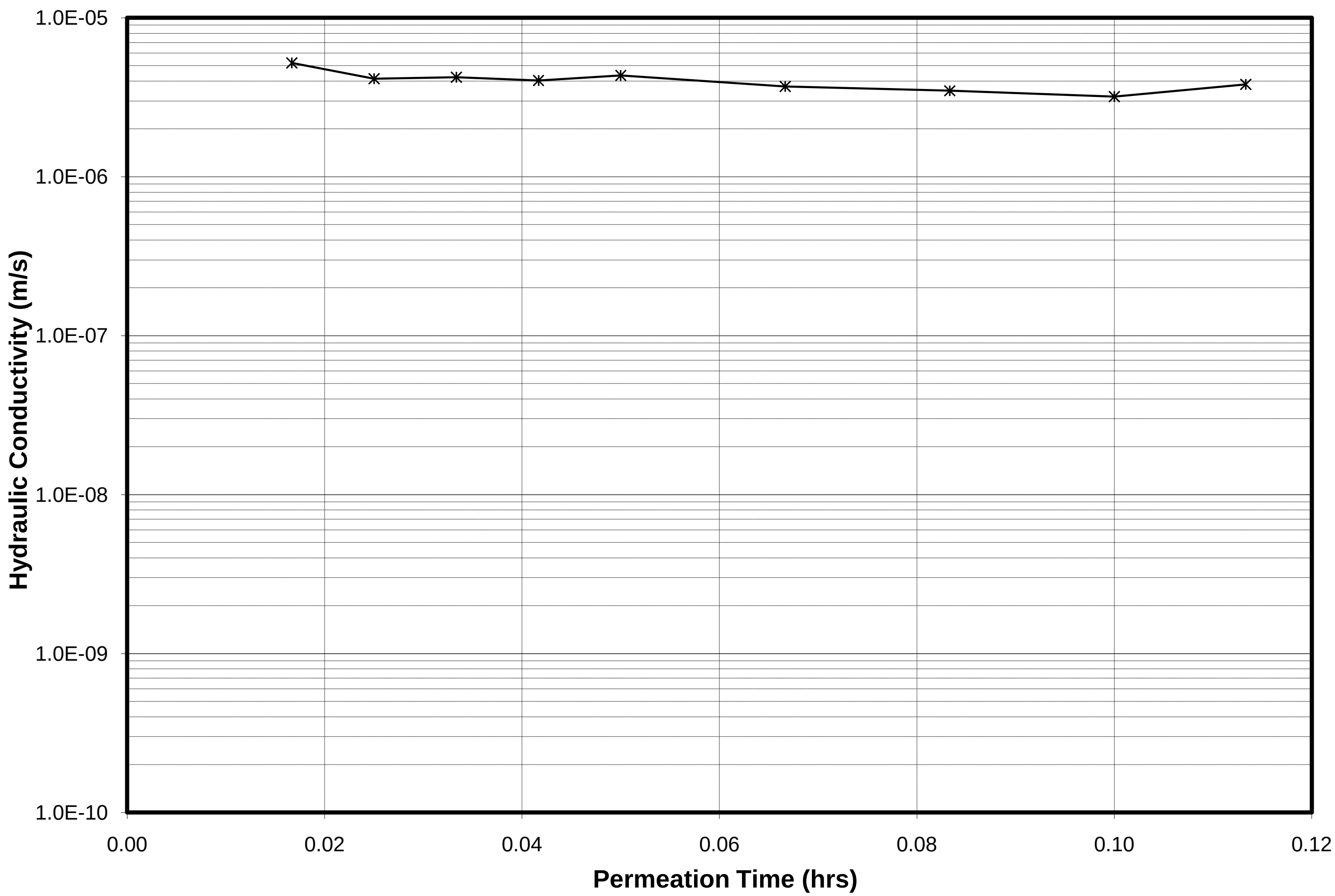
MEASURED DATA:

Read Time day	hr	min	Elapsed Time (hr)	Temp T (°C)	P_{cell} (psi)	P_{in} (psi)	P_{out} (psi)	V_{cell} (ml)	V_{in} (ml)	V_{out} (ml)	H_{cell} (m)	H_{in} (m)	H_{out} (m)	Head Loss h (m)	σ'_{max} (psi)	σ'_{min} (psi)	Inflow (ml)	Outflow (ml)	Storage (ml)	Cum. P.V.	Gradient (i)	K (m/sec)	R_T	k_{20} (m/sec)
1	0	0	0.00	22.6	49.4	47.0	45.0	0.0	79.0	5.0	0.000	0.371	0.024	1.688	4.3	1.9				0	25.0			
1	0	1	0.02	22.6	49.4	47.0	45.0	0.0	62.1	20.9	0.000	0.292	0.098	1.534	4.2	2.0	16.9	15.9	1.0	0.2225	22.7	5.5E-06	0.94	5.2E-06
1	0	1.5	0.03	22.6	49.4	47.0	45.0	0.0	56.0	27.0	0.000	0.263	0.127	1.476	4.1	2.0	6.1	6.1	0.0	0.3053	21.9	4.4E-06	0.94	4.1E-06
1	0	2	0.03	22.6	49.4	47.0	45.0	0.0	49.9	32.9	0.000	0.235	0.155	1.420	4.1	2.1	6.1	5.9	0.2	0.3867	21.0	4.5E-06	0.94	4.2E-06
1	0	2.5	0.04	22.6	49.4	47.0	45.0	0.0	44.5	38.5	0.000	0.209	0.181	1.368	4.0	2.1	5.4	5.6	-0.2	0.4614	20.3	4.3E-06	0.94	4.0E-06
1	0	3	0.05	22.6	49.4	47.0	45.0	0.0	38.3	43.7	0.000	0.180	0.205	1.315	4.0	2.1	6.2	5.2	1.0	0.5387	19.5	4.6E-06	0.94	4.3E-06
1	0	4	0.07	22.6	49.4	47.0	45.0	0.0	29.1	52.9	0.000	0.137	0.249	1.228	4.0	2.2	9.2	9.2	0.0	0.6635	18.2	3.9E-06	0.94	3.7E-06
1	0	5	0.08	22.6	49.4	47.0	45.0	0.0	21.0	61.0	0.000	0.099	0.287	1.152	3.9	2.3	8.1	8.1	0.0	0.7735	17.1	3.7E-06	0.94	3.5E-06
1	0	6	0.10	22.6	49.4	47.0	45.0	0.0	14.0	68.0	0.000	0.066	0.320	1.086	3.9	2.3	7.0	7.0	0.0	0.8684	16.1	3.4E-06	0.94	3.2E-06
1	0	6.8	0.11	22.6	49.4	47.0	45.0	0.0	7.7	74.3	0.000	0.036	0.349	1.027	3.8	2.3	6.3	6.3	0.0	0.9539	15.2	4.1E-06	0.94	3.8E-06
																							Average for last 4:	3.5E-06

HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-03)

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 NORTH 34TH STREET • SUITE 100
P.O. BOX 300303 • SEATTLE, WASHINGTON 98103
206-632-8020 FAX 206-695-6777

Project	Skagit River Levees	Job No.	21-1-21199-002		
Boring No.	DD17-3 Landward	Tested by	AKV	On	1/20/2010
Sample No.	S-2	Comp by	AKV	On	2/2/2010
Depth (ft)	5.9	Checked by	JFL	On	2/8/2010



HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-03)

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 NORTH 34TH STREET · SUITE 100
P.O. BOX 300303 · SEATTLE, WASHINGTON 98103
206-632-8020 FAX 206-695-6777

Project	Skagit River Levees	Job No.	21-1-21199-002		
Boring No.	DD17-3 Levee	Tested By	AKV	On	1/26/2010
Sample No.	S-5/S-6	Comp By	AKV	On	2/3/2010
Depth (ft)	12.5/15.0	Checked By	JFL	On	2/8/2010

WATER CONTENT DATA:

	Before Test	After Test
Pan No.	tin cup	Z-24
Wet+Tare	67.85	315.32
Dry+Tare	57.77	265.74
Tare	3.15	87.86
WC, %	18.5	27.9

DESCRIPTION:

Gray-brown, silty, fine SAND; SM

SPECIMEN DATA:

	Before Test	After Consol.	After Test
Height, m	0.0555	0.0552	0.0553
Diameter, m	0.0508	0.0508	0.0508
Wet Weight, g	199.22	198.42	227.46
Volume, ml	112.3	111.8	111.8
Area, m^2	0.00202	0.00202	0.00202
Wet Unit Wt, pcf	110.7	110.8	126.9
Dry Unit Wt, pcf	93.5	86.6	99.3
Est. Saturation,%	62.1	79.7	108.0

OTHER INFORMATION:

Burette Corr. Factor, BCF (vol. to height), 1ml = 0.0047 m

a = 2.13E-04 m^2

Specific Gravity ☑ Assumed ☐ Measured = 2.7

B-Coefficient = 0.95

Volume of Solid = 62.3 ml

Pore Volume (P.V.)= 50.0 ml

NOTE:

Sample comprised of
50% S-5, 50% S-6

FALLING-HEAD INCREASING TAILWATER LEVEL HYDRAULIC CONDUCTIVITY CALCULATION (METHOD C):

$$k = \frac{aL}{2At}\ln\left(\frac{h_1}{h_2}\right)$$

$$k_{20} = R_T k$$

a = cross-sectional area of standpipe, m^2
L = length of the sample, m
A = cross-sectional area of the sample, m^2
t = elapsed time between determination of h_1 and h_2, sec.

h_1 = head loss across the specimen at time t_1, m,
h_2 = head loss across the specimen at time t_2, m,
k_{20} = corrected hydraulic conductivity at temperature of 20 °C
R_T = correction factor for viscosity of water at various temperatures, T
= $2.2902(0.9842^T)/T^{0.1702}$

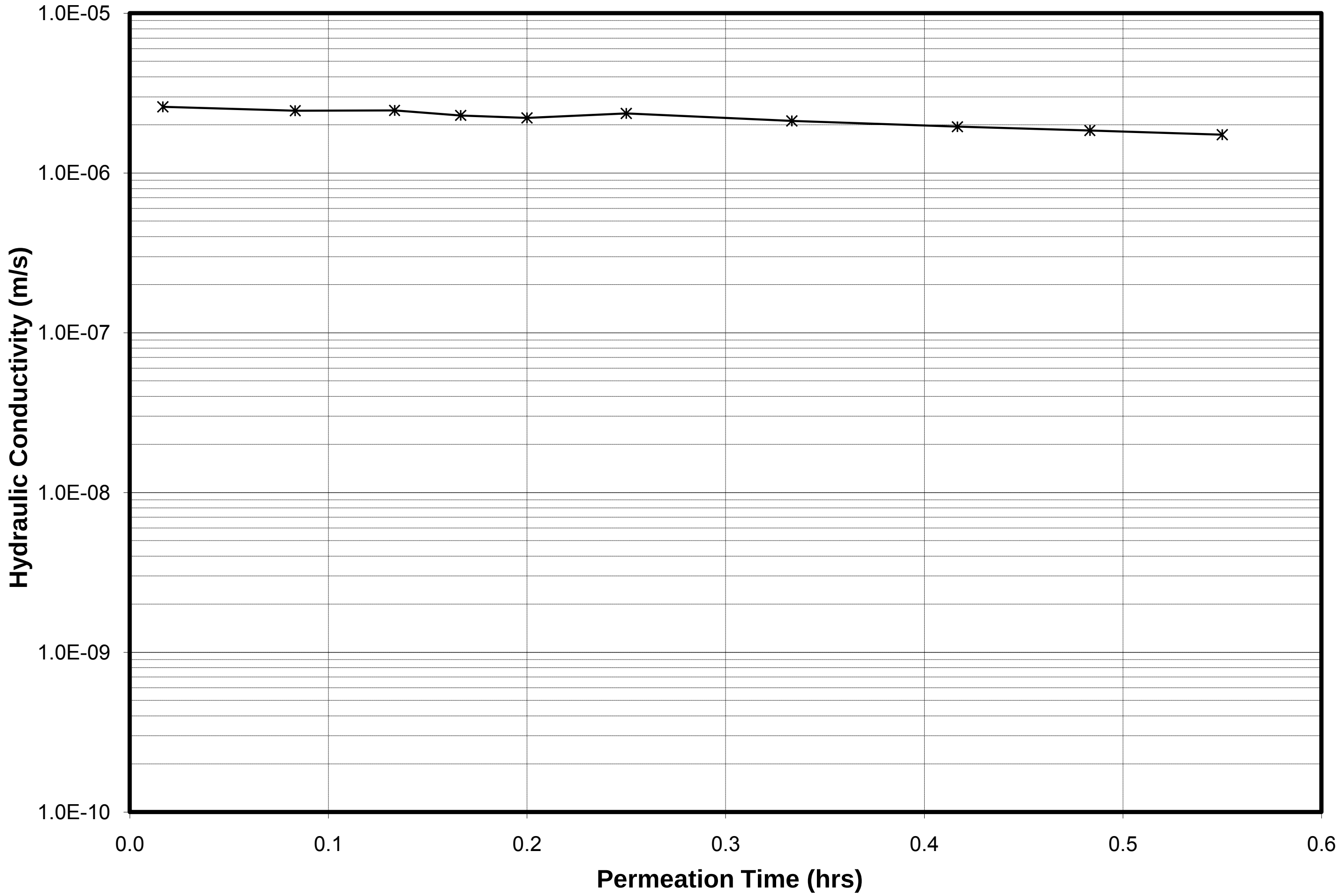
MEASURED DATA:

Read Time			Elapsed Time	Temp T	Pressure Readings			Burette Readings						Head Loss h	Effective Stresses		Calculated Flow Volumes				Gradient (i)	K	R_T	k_{20}
day	hr	min	(hr)	(°C)	P_{cell} (psi)	P_{in} (psi)	P_{out} (psi)	V_{cell} (ml)	V_{in} (ml)	V_{out} (ml)	H_{cell} (m)	H_{in} (m)	H_{out} (m)	(m)	σ'_{max} (psi)	σ'_{min} (psi)	Inflow (ml)	Outflow (ml)	Storage (ml)	Cum. P.V.		(m/sec)		(m/sec)
1	0	0	0.00	22.3	76.2	66.5	65.5	0.0	96.7	1.2	0.000	0.454	0.006	1.097	10.6	9.1				0	19.8			
1	0	1	0.02	22.3	76.2	66.5	65.5	0.0	89.8	7.1	0.000	0.422	0.033	1.037	10.6	9.1	6.9	5.9	1.0	0.1280	18.7	2.7E-06	0.947	2.6E-06
1	0	5	0.08	22.3	76.2	66.5	65.5	0.0	68.6	28.3	0.000	0.322	0.133	0.838	10.4	9.2	21.2	21.2	0.0	0.5520	15.1	2.6E-06	0.947	2.5E-06
1	0	8	0.13	22.3	76.2	66.5	65.5	0.0	55.4	41.5	0.000	0.260	0.195	0.714	10.3	9.3	13.2	13.2	0.0	0.8160	12.9	2.6E-06	0.947	2.5E-06
1	0	10	0.17	22.3	76.2	66.5	65.5	0.0	48.2	48.7	0.000	0.227	0.229	0.646	10.3	9.4	7.2	7.2	0.0	0.9600	11.6	2.4E-06	0.947	2.3E-06
1	0	12	0.20	22.3	76.2	66.5	65.5	0.0	41.9	55.0	0.000	0.197	0.259	0.587	10.3	9.4	6.3	6.3	0.0	1.0860	10.6	2.3E-06	0.947	2.2E-06
1	0	15	0.25	22.3	76.2	66.5	65.5	0.0	33.1	64.0	0.000	0.156	0.301	0.503	10.2	9.5	8.8	9.0	-0.2	1.2639	9.1	2.5E-06	0.947	2.4E-06
1	0	20	0.33	22.3	76.2	66.5	65.5	0.0	22.1	75.0	0.000	0.104	0.353	0.400	10.1	9.6	11.0	11.0	0.0	1.4839	7.2	2.2E-06	0.947	2.1E-06
1	0	25	0.42	22.3	76.2	66.5	65.5	0.0	14.0	83.1	0.000	0.066	0.391	0.324	10.1	9.6	8.1	8.1	0.0	1.6459	5.8	2.1E-06	0.947	1.9E-06
1	0	29	0.48	22.3	76.2	66.5	65.5	0.0	8.9	88.2	0.000	0.042	0.415	0.276	10.0	9.6	5.1	5.1	0.0	1.7479	5.0	2.0E-06	0.947	1.8E-06
1	0	33	0.55	22.3	76.2	66.5	65.5	0.0	4.8	92.3	0.000	0.023	0.434	0.237	10.0	9.7	4.1	4.1	0.0	1.8299	4.3	1.8E-06	0.947	1.7E-06
																							Average for last 4:	1.9E-06

HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-03)

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 NORTH 34TH STREET • SUITE 100
P.O. BOX 300303 • SEATTLE, WASHINGTON 98103
206-632-8020 FAX 206-695-6777

Project	Skagit River Levees	Job No.	21-1-21199-002		
Boring No.	DD17-3 Levee	Tested by	AKV	On	1/26/2010
Sample No.	S-5/S-6	Comp by	AKV	On	2/3/2010
Depth (ft)	12.5/15.0	Checked by	JFL	On	2/8/2010



HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-03)

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 NORTH 34TH STREET • SUITE 100
P.O. BOX 300303 • SEATTLE, WASHINGTON 98103
206-632-8020 FAX 206-695-6777

Project	Skagit River Levees		Job No.	21-1-21199-002		
Boring No.	DD22-1 Landward		Tested By	AKV	On	1/28/2010
Sample No.	S-1		Comp By	AKV	On	2/3/2010
Depth (ft)	2.5		Checked By	JFL	On	2/8/2010

WATER CONTENT DATA:

	Before Test	After Test
Pan No.	tin cup	Z-24
Wet+Tare	46.81	199.06
Dry+Tare	40.61	179.95
Tare	2.94	103.16
WC, %	16.5	24.9

DESCRIPTION:

Brown, silty, fine SAND; trace of organics; SM

SPECIMEN DATA:

	Before Test	After Consol.	After Test
Height, m	0.0483	0.0483	0.0482
Diameter, m	0.0369	0.0369	0.0369
Wet Weight, g	89.95	89.25	95.90
Volume, ml	51.5	51.5	51.4
Area, m^2	0.00107	0.00107	0.00107
Wet Unit Wt, pcf	109.0	108.1	116.4
Dry Unit Wt, pcf	93.6	86.6	93.2
Est. Saturation,%	55.5	71.0	83.1

OTHER INFORMATION:

Burette Corr. Factor, BCF (vol. to height), 1ml = 0.0047 m

a = 2.13E-04 m^2

Specific Gravity ☑ Assumed ☐ Measured = 2.7

B-Coefficient = 0.95

Volume of Solid = 28.6 ml

Pore Volume (P.V.)= 22.9 ml

NOTE:

FALLING-HEAD INCREASING TAILWATER LEVEL HYDRAULIC CONDUCTIVITY CALCULATION (METHOD C):

$$k = \frac{aL}{2At}\ln\left(\frac{h_1}{h_2}\right)$$

$$k_{20} = R_T k$$

a = cross-sectional area of standpipe, m^2
L = length of the sample, m
A = cross-sectional area of the sample, m^2
t = elapsed time between determination of h_1 and h_2, sec.

h_1 = head loss across the specimen at time t_1, m,
h_2 = head loss across the specimen at time t_2, m,
k_{20} = corrected hydraulic conductivity at temperature of 20 °C
R_T = correction factor for viscosity of water at various temperatures, T
= $2.2902(0.9842^T)/T^{0.1702}$

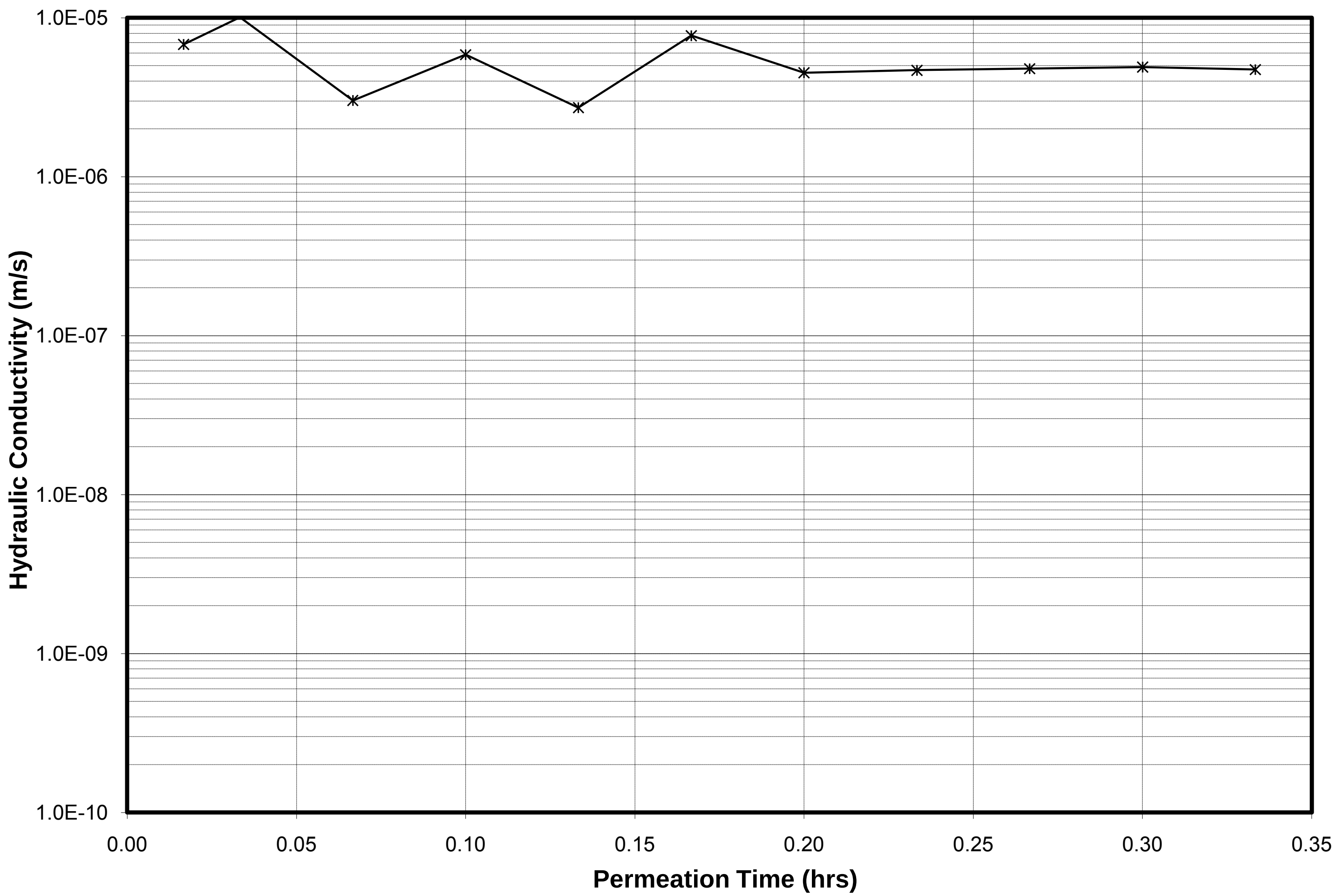
MEASURED DATA:

Read Time			Elapsed Time	Temp T	Pressure Readings			Burette Readings						Head Loss h	Effective Stresses		Calculated Flow Volumes				Gradient (i)	K	R_T	k_{20}
day	hr	min	(hr)	(°C)	P_{cell} (psi)	P_{in} (psi)	P_{out} (psi)	V_{cell} (ml)	V_{in} (ml)	V_{out} (ml)	H_{cell} (m)	H_{in} (m)	H_{out} (m)	(m)	σ'_{max} (psi)	σ'_{min} (psi)	Inflow (ml)	Outflow (ml)	Storage (ml)	Cum. P.V.		(m/sec)		(m/sec)
1	0	0	0.00	22.4	65.2	56.5	55.5	0.0	95.2	6.6	0.000	0.447	0.031	1.072	9.6	8.1				0	22.2			
1	0	1	0.02	22.4	65.2	56.5	55.5	0.0	85.1	16.1	0.000	0.400	0.076	0.980	9.5	8.1	10.1	9.5	0.6	0.4278	20.3	7.2E-06	0.944	6.8E-06
1	0	2	0.03	22.4	65.2	56.5	55.5	0.0	72.1	29.1	0.000	0.339	0.137	0.858	9.4	8.2	13.0	13.0	0.0	0.9953	17.8	1.1E-05	0.944	1.0E-05
1	0	4	0.07	22.4	65.2	56.5	55.5	0.0	65.1	36.1	0.000	0.306	0.170	0.792	9.4	8.3	7.0	7.0	0.0	1.3008	16.4	3.2E-06	0.944	3.0E-06
1	0	6	0.10	22.4	65.2	56.5	55.5	0.0	53.0	48.2	0.000	0.249	0.227	0.678	9.3	8.3	12.1	12.1	0.0	1.8290	14.1	6.2E-06	0.944	5.9E-06
1	0	8	0.13	22.4	65.2	56.5	55.5	0.0	48.0	53.2	0.000	0.226	0.250	0.631	9.3	8.4	5.0	5.0	0.0	2.0473	13.1	2.9E-06	0.944	2.7E-06
1	0	10	0.17	22.4	65.2	56.5	55.5	0.0	36.1	66.1	0.000	0.170	0.311	0.515	9.2	8.5	11.9	12.9	-1.0	2.5886	10.7	8.2E-06	0.944	7.7E-06
1	0	12	0.20	22.4	65.2	56.5	55.5	0.0	29.8	72.1	0.000	0.140	0.339	0.457	9.1	8.5	6.3	6.0	0.3	2.8570	9.5	4.8E-06	0.944	4.5E-06
1	0	14	0.23	22.4	65.2	56.5	55.5	0.0	23.9	77.5	0.000	0.112	0.364	0.404	9.1	8.5	5.9	5.4	0.5	3.1037	8.4	5.0E-06	0.944	4.7E-06
1	0	16	0.27	22.4	65.2	56.5	55.5	0.0	18.8	82.6	0.000	0.088	0.388	0.356	9.1	8.6	5.1	5.1	0.0	3.3263	7.4	5.1E-06	0.944	4.8E-06
1	0	18	0.30	22.4	65.2	56.5	55.5	0.0	14.2	87.2	0.000	0.067	0.410	0.312	9.0	8.6	4.6	4.6	0.0	3.5271	6.5	5.2E-06	0.944	4.9E-06
1	0	20	0.33	22.4	65.2	56.5	55.5	0.0	10.3	91.1	0.000	0.048	0.428	0.276	9.0	8.6	3.9	3.9	0.0	3.6973	5.7	5.0E-06	0.944	4.7E-06
																							Average for last 4:	4.8E-06

HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-03)

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 NORTH 34TH STREET · SUITE 100
P.O. BOX 300303 · SEATTLE, WASHINGTON 98103
206-632-8020 FAX 206-695-6777

Project	Skagit River Levees	Job No.	21-1-21199-002		
Boring No.	DD22-1 Landward	Tested by	AKV	On	1/28/2010
Sample No.	S-1	Comp by	AKV	On	2/3/2010
Depth (ft)	2.5	Checked by	JFL	On	2/8/2010



HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-03)

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 NORTH 34TH STREET • SUITE 100
P.O. BOX 300303 • SEATTLE, WASHINGTON 98103
206-632-8020 FAX 206-695-6777

Project	Skagit River Levees	Job No.	21-1-21199-002		
Boring No.	DD22-1 Levee	Tested By	AKV	On	1/26/2010
Sample No.	S-6/S-7/S-4	Comp By	AKV	On	2/3/2010
Depth (ft)	15.0/17.5/10.0	Checked By	JFL	On	2/8/2010

WATER CONTENT DATA:

	Before Test	After Test
Pan No.	tin cup	Z-24
Wet+Tare	78.02	305.78
Dry+Tare	63.93	258.77
Tare	3.06	101.81
WC, %	23.1	30.0

DESCRIPTION:

Brown, silty, fine SAND; SM

SPECIMEN DATA:

	Before Test	After Consol.	After Test
Height, m	0.0536	0.0536	0.0535
Diameter, m	0.0508	0.0508	0.0508
Wet Weight, g	193.67	193.07	203.97
Volume, ml	108.5	108.4	108.3
Area, m^2	0.00202	0.00202	0.00202
Wet Unit Wt, pcf	111.4	111.1	117.6
Dry Unit Wt, pcf	90.4	85.5	90.5
Est. Saturation,%	72.4	83.3	93.8

OTHER INFORMATION:

Burette Corr. Factor, BCF (vol. to height), 1ml = 0.0047 m

a = 2.13E-04 m^2

Specific Gravity ☑ Assumed ☐ Measured = 2.7

B-Coefficient = 0.95

Volume of Solid = 58.2 ml

Pore Volume (P.V.)= 50.3 ml

NOTE:

Sample comprised of
45% S-6, 45% S-7,
10% S-4

FALLING-HEAD INCREASING TAILWATER LEVEL HYDRAULIC CONDUCTIVITY CALCULATION (METHOD C):

$$k = \frac{aL}{2At}\ln\left(\frac{h_1}{h_2}\right)$$

$$k_{20} = R_T k$$

a = cross-sectional area of standpipe, m^2
L = length of the sample, m
A = cross-sectional area of the sample, m^2
t = elapsed time between determination of h_1 and h_2, sec.

h_1 = head loss across the specimen at time t_1, m,
h_2 = head loss across the specimen at time t_2, m,
k_{20} = corrected hydraulic conductivity at temperature of 20 °C
R_T = correction factor for viscosity of water at various temperatures, T
= $2.2902(0.9842^T)/T^{0.1702}$

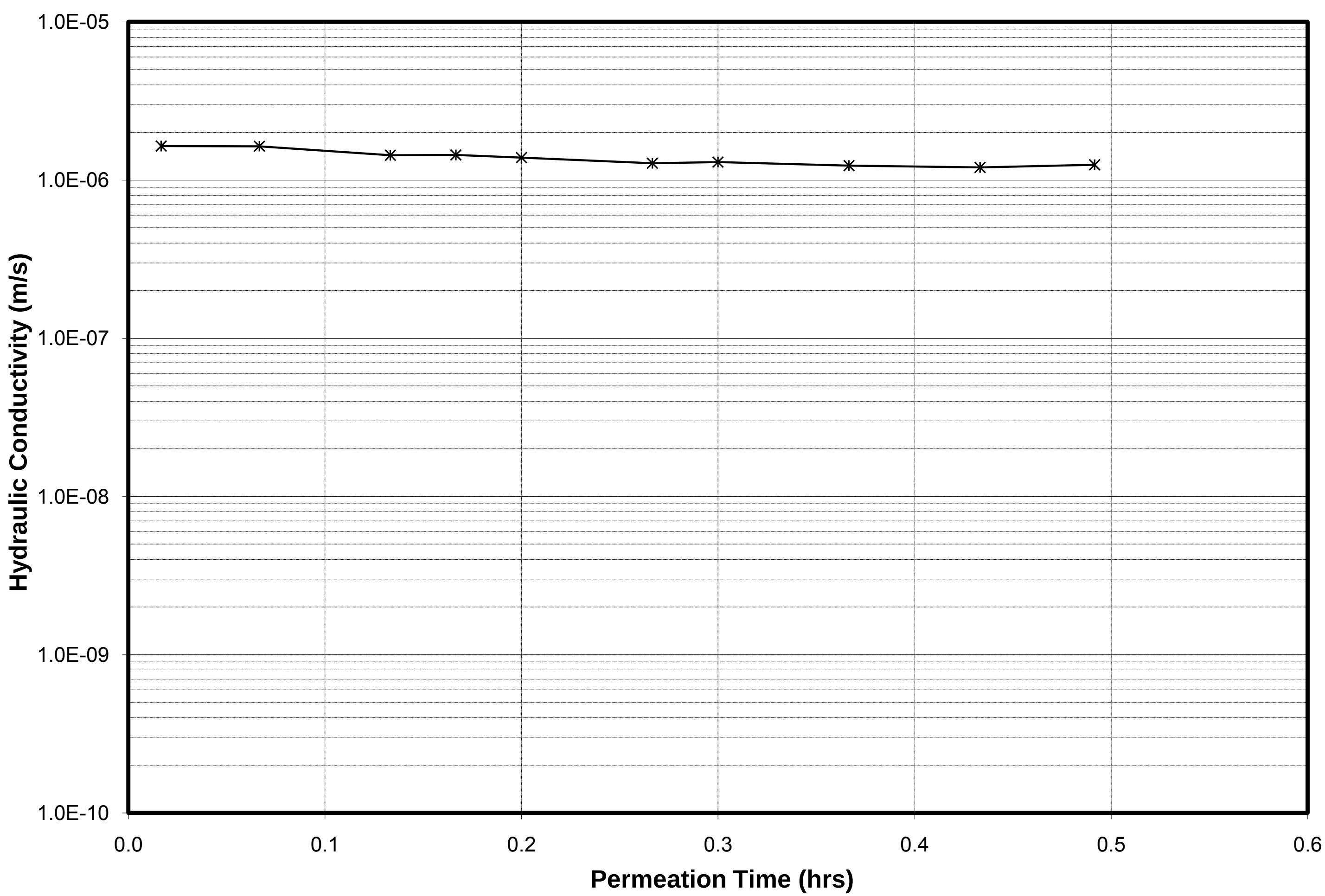
MEASURED DATA:

Read Time			Elapsed Time	Temp T	Pressure Readings			Burette Readings						Head Loss h	Effective Stresses		Calculated Flow Volumes				Gradient (i)	*K*	R_T	k_{20}
day	hr	min	(hr)	(°C)	P_{cell} (psi)	P_{in} (psi)	P_{out} (psi)	V_{cell} (ml)	V_{in} (ml)	V_{out} (ml)	H_{cell} (m)	H_{in} (m)	H_{out} (m)	(m)	σ'_{max} (psi)	σ'_{min} (psi)	Inflow (ml)	Outflow (ml)	Storage (ml)	Cum. P.V.		(m/sec)		(m/sec)
1	0	0	0.00	22.3	68.2	61.5	60.5	0.0	99.5	0.8	0.000	0.468	0.004	1.114	7.6	6.0				0	20.8			
1	0	1	0.02	22.3	68.2	61.5	60.5	0.0	95.1	5.0	0.000	0.447	0.024	1.074	7.6	6.1	4.4	4.2	0.2	0.0856	20.0	1.7E-06	0.947	1.6E-06
1	0	4	0.07	22.3	68.2	61.5	60.5	0.0	83.2	17.0	0.000	0.391	0.080	0.961	7.5	6.1	11.9	12.0	-0.1	0.3233	17.9	1.7E-06	0.947	1.6E-06
1	0	8	0.13	22.3	68.2	61.5	60.5	0.0	70.7	29.3	0.000	0.332	0.138	0.845	7.4	6.2	12.5	12.3	0.2	0.5700	15.8	1.5E-06	0.947	1.4E-06
1	0	10	0.17	22.3	68.2	61.5	60.5	0.0	65.1	35.0	0.000	0.306	0.165	0.792	7.4	6.3	5.6	5.7	-0.1	0.6824	14.8	1.5E-06	0.947	1.4E-06
1	0	12	0.20	22.3	68.2	61.5	60.5	0.0	60.0	40.1	0.000	0.282	0.188	0.744	7.4	6.3	5.1	5.1	0.0	0.7839	13.9	1.5E-06	0.947	1.4E-06
1	0	16	0.27	22.3	68.2	61.5	60.5	0.0	51.2	48.5	0.000	0.241	0.228	0.663	7.3	6.4	8.8	8.4	0.4	0.9550	12.4	1.4E-06	0.947	1.3E-06
1	0	18	0.30	22.3	68.2	61.5	60.5	0.0	47.2	52.5	0.000	0.222	0.247	0.625	7.3	6.4	4.0	4.0	0.0	1.0346	11.7	1.4E-06	0.947	1.3E-06
1	0	22	0.37	22.3	68.2	61.5	60.5	0.0	40.2	59.5	0.000	0.189	0.280	0.559	7.2	6.4	7.0	7.0	0.0	1.1739	10.4	1.3E-06	0.947	1.2E-06
1	0	26	0.43	22.3	68.2	61.5	60.5	0.0	34.1	65.6	0.000	0.160	0.308	0.502	7.2	6.5	6.1	6.1	0.0	1.2952	9.4	1.3E-06	0.947	1.2E-06
1	0	30	0.49	22.3	68.2	61.5	60.5	0.0	29.1	70.6	0.000	0.137	0.332	0.455	7.2	6.5	5.0	5.0	0.0	1.3947	8.5	1.3E-06	0.947	1.3E-06
																							Average for last 4:	1.2E-06

HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-03)

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 NORTH 34TH STREET • SUITE 100
P.O. BOX 300303 • SEATTLE, WASHINGTON 98103
206-632-8020 FAX 206-695-6777

Project	Skagit River Levees	Job No.	21-1-21199-002		
Boring No.	DD22-1 Levee	Tested by	AKV	On	1/26/2010
Sample No.	S-6/S-7/S-4	Comp by	AKV	On	2/3/2010
Depth (ft)	15.0/17.5/10.0	Checked by	JFL	On	2/8/2010



HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-03)

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 NORTH 34TH STREET • SUITE 100
P.O. BOX 300303 • SEATTLE, WASHINGTON 98103
206-632-8020 FAX 206-695-6777

Project	Skagit River Levees	Job No.	21-1-21199-002		
Boring No.	DD22-2 Landward	Tested By	AKV	On	1/20/2010
Sample No.	S-2	Comp By	AKV	On	2/2/2010
Depth (ft)	5.3	Checked By	JFL	On	2/8/2010

WATER CONTENT DATA:

	Before Test	After Test
Pan No.	tin cup	Z-24
Wet+Tare	119.83	309.96
Dry+Tare	79.21	234.52
Tare	2.98	103.09
WC, %	53.3	57.4

DESCRIPTION:

Gray, slightly clayey SILT; orange mottling and oxidation; ML

SPECIMEN DATA:

	Before Test	After Consol.	After Test
Height, m	0.0618	0.0613	0.0615
Diameter, m	0.0511	0.0511	0.0511
Wet Weight, g	206.24	205.54	206.87
Volume, ml	126.4	125.5	125.8
Area, m^2	0.00205	0.00205	0.00205
Wet Unit Wt, pcf	101.8	102.2	102.6
Dry Unit Wt, pcf	66.4	64.9	65.2
Est. Saturation,%	93.6	97.2	97.8

OTHER INFORMATION:

Burette Corr. Factor, BCF (vol. to height), 1ml = 0.0047 m

a = 2.13E-04 m^2

Specific Gravity ☑ Assumed ☐ Measured = 2.7

B-Coefficient = 0.98

Volume of Solid = 49.8 ml

Pore Volume (P.V.)= 76.6 ml

NOTE:

FALLING-HEAD INCREASING TAILWATER LEVEL HYDRAULIC CONDUCTIVITY CALCULATION (METHOD C):

$$k = \frac{aL}{2At}\ln\left(\frac{h_1}{h_2}\right)$$

$$k_{20} = R_T k$$

a = cross-sectional area of standpipe, m^2

L = length of the sample, m

A = cross-sectional area of the sample, m^2

t = elapsed time between determination of h_1 and h_2, sec.

h_1 = head loss across the specimen at time t_1, m,

h_2 = head loss across the specimen at time t_2, m,

k_{20} = corrected hydraulic conductivity at temperature of 20 °C

R_T = correction factor for viscosity of water at various temperatures, T = $2.2902(0.9842^T)/T^{0.1702}$

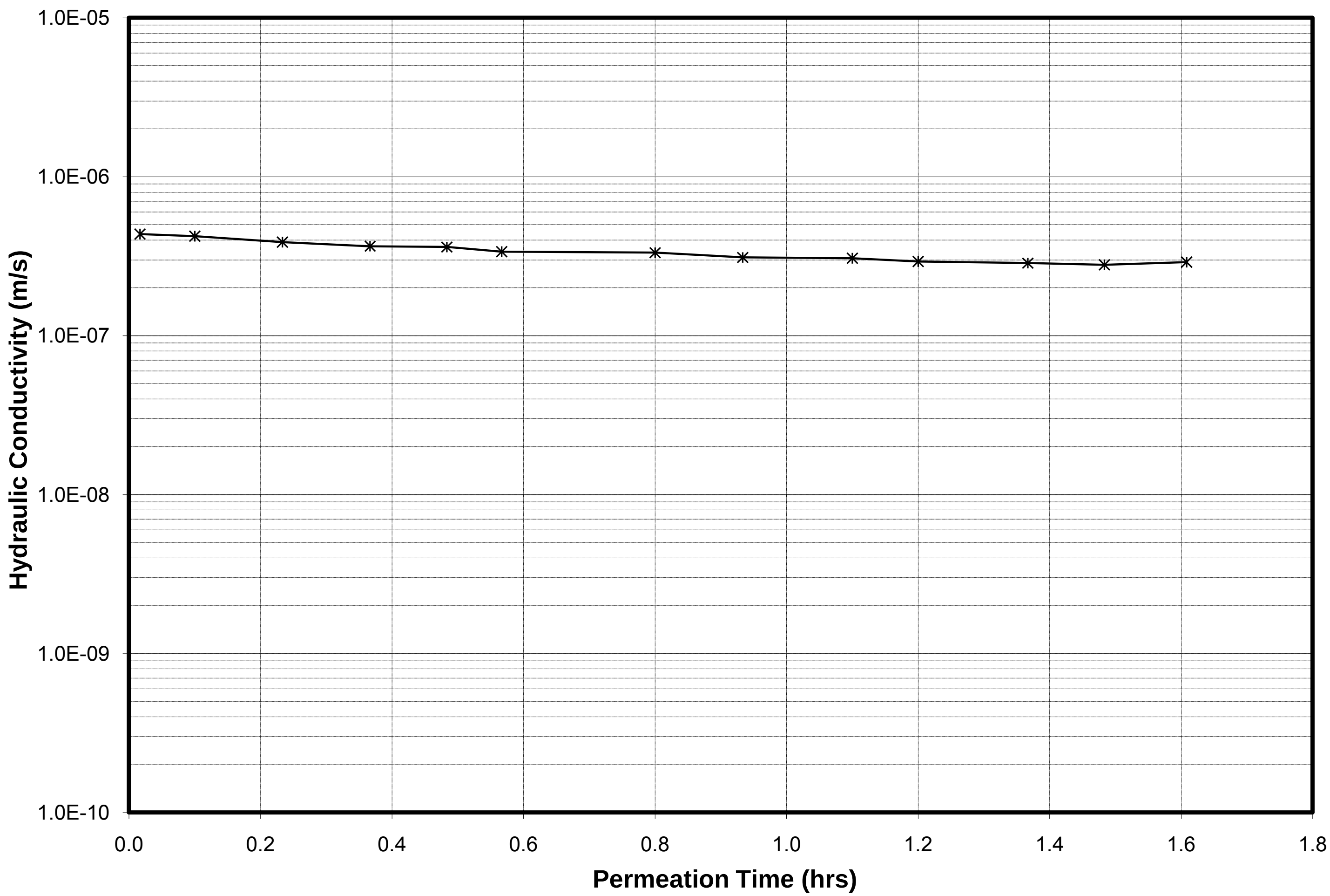
MEASURED DATA:

Read Time			Elapsed Time	Temp T	Pressure Readings P_{cell}	P_{in}	P_{out}	Burette Readings V_{cell}	V_{in}	V_{out}	H_{cell}	H_{in}	H_{out}	Head Loss h	Effective Stresses σ'_{max}	σ'_{min}	Calculated Flow Volumes Inflow	Outflow	Storage	Cum. P.V.	Gradient (i)	K	R_T	k_{20}
day	hr	min	(hr)	(°C)	(psi)	(psi)	(psi)	(ml)	(ml)	(ml)	(m)	(m)	(m)	(m)	(psi)	(psi)	(ml)	(ml)	(ml)			(m/sec)		(m/sec)
1	0	0	0.00	22.5	34.0	32.0	30.0	0.0	99.1	2.9	0.000	0.466	0.014	1.798	3.9	1.3				0	29.1			
1	0	1	0.02	22.5	34.0	32.0	30.0	0.0	97.0	4.1	0.000	0.456	0.019	1.782	3.9	1.4	2.1	1.2	0.9	0.0215	28.9	4.6E-07	0.942	4.4E-07
1	0	6	0.10	22.5	34.0	32.0	30.0	0.0	89.3	12.0	0.000	0.420	0.056	1.709	3.8	1.4	7.7	7.9	-0.2	0.1234	27.7	4.5E-07	0.942	4.2E-07
1	0	14	0.23	22.5	34.0	32.0	30.0	0.0	78.5	22.9	0.000	0.369	0.108	1.607	3.8	1.5	10.8	10.9	-0.1	0.2650	26.0	4.1E-07	0.942	3.9E-07
1	0	22	0.37	22.5	34.0	32.0	30.0	0.0	68.9	32.6	0.000	0.324	0.153	1.516	3.7	1.5	9.6	9.7	-0.1	0.3909	24.6	3.9E-07	0.942	3.7E-07
1	0	29	0.48	22.5	34.0	32.0	30.0	0.0	60.9	40.4	0.000	0.286	0.190	1.442	3.6	1.6	8.0	7.8	0.2	0.4941	23.4	3.8E-07	0.942	3.6E-07
1	0	34	0.57	22.5	34.0	32.0	30.0	0.0	56.0	45.6	0.000	0.263	0.214	1.395	3.6	1.6	4.9	5.2	-0.3	0.5600	22.6	3.6E-07	0.942	3.4E-07
1	0	48	0.80	22.5	34.0	32.0	30.0	0.0	42.8	58.6	0.000	0.201	0.275	1.272	3.5	1.7	13.2	13.0	0.2	0.7310	20.6	3.5E-07	0.942	3.3E-07
1	0	56	0.93	22.5	34.0	32.0	30.0	0.0	36.3	65.1	0.000	0.171	0.306	1.210	3.5	1.8	6.5	6.5	0.0	0.8158	19.6	3.3E-07	0.942	3.1E-07
1	1	6	1.10	22.5	34.0	32.0	30.0	0.0	28.7	72.7	0.000	0.135	0.342	1.139	3.4	1.8	7.6	7.6	0.0	0.9150	18.4	3.3E-07	0.942	3.1E-07
1	1	12	1.20	22.5	34.0	32.0	30.0	0.0	24.6	76.9	0.000	0.116	0.361	1.100	3.4	1.8	4.1	4.2	-0.1	0.9692	17.8	3.1E-07	0.942	2.9E-07
1	1	22	1.37	22.5	34.0	32.0	30.0	0.0	18.2	83.4	0.000	0.086	0.392	1.039	3.4	1.9	6.4	6.5	-0.1	1.0534	16.8	3.0E-07	0.942	2.9E-07
1	1	29	1.48	22.5	34.0	32.0	30.0	0.0	14.0	87.6	0.000	0.066	0.412	1.000	3.3	1.9	4.2	4.2	0.0	1.1082	16.2	3.0E-07	0.942	2.8E-07
1	1	37	1.61	22.5	34.0	32.0	30.0	0.0	9.5	92.1	0.000	0.045	0.433	0.958	3.3	1.9	4.5	4.5	0.0	1.1670	15.5	3.1E-07	0.942	2.9E-07
																						Average for last 4:		2.9E-07

HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-03)

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 NORTH 34TH STREET • SUITE 100
P.O. BOX 300303 • SEATTLE, WASHINGTON 98103
206-632-8020 FAX 206-695-6777

Project	Skagit River Levees	Job No.	21-1-21199-002		
Boring No.	DD22-2 Landward	Tested by	AKV	On	1/20/2010
Sample No.	S-2	Comp by	AKV	On	2/2/2010
Depth (ft)	5.3	Checked by	JFL	On	2/8/2010



HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-03)

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 NORTH 34TH STREET • SUITE 100
P.O. BOX 300303 • SEATTLE, WASHINGTON 98103
206-632-8020 FAX 206-695-6777

Project	Skagit River Levees	Job No.	21-1-21199-002		
Boring No.	DD22-2 Landward	Tested By	AKV	On	1/27/2010
Sample No.	S-13	Comp By	AKV	On	2/2/2010
Depth (ft)	41.2	Checked By	JFL	On	2/8/2010

WATER CONTENT DATA:

	Before Test	After Test
Pan No.	tin cup	Z-24
Wet+Tare	129.49	317.29
Dry+Tare	97.10	264.52
Tare	3.01	102.51
WC, %	34.4	32.6

DESCRIPTION:
Gray-brown, silty, fine SAND; SM

SPECIMEN DATA:

	Before Test	After Consol.	After Test
Height, m	0.0612	0.0606	0.0606
Diameter, m	0.0535	0.0535	0.0535
Wet Weight, g	218.29	216.99	214.78
Volume, ml	137.7	136.3	136.2
Area, m^2	0.00225	0.00225	0.00225
Wet Unit Wt, pcf	98.9	99.3	98.4
Dry Unit Wt, pcf	73.6	74.9	74.2
Est. Saturation,%	72.1	70.4	69.3

OTHER INFORMATION:

Burette Corr. Factor, BCF (vol. to height), 1ml = 0.0047 m
a = 2.13E-04 m^2
Specific Gravity ☑ Assumed ☐ Measured = 2.7
B-Coefficient = 0.97
Volume of Solid = 60.1 ml
Pore Volume (P.V.)= 77.5 ml

NOTE:
Probable migration of fines during testing.

FALLING-HEAD INCREASING TAILWATER LEVEL HYDRAULIC CONDUCTIVITY CALCULATION (METHOD C):

$$k = \frac{aL}{2At}\ln\left(\frac{h_1}{h_2}\right)$$

$$k_{20} = R_T k$$

a = cross-sectional area of standpipe, m^2
L = length of the sample, m
A = cross-sectional area of the sample, m^2
t = elapsed time between determination of h_1 and h_2, sec.

h_1 = head loss across the specimen at time t_1, m,
h_2 = head loss across the specimen at time t_2, m,
k_{20} = corrected hydraulic conductivity at temperature of 20 °C
R_T = correction factor for viscosity of water at various temperatures, T
= $2.2902(0.9842^T)/T^{0.1702}$

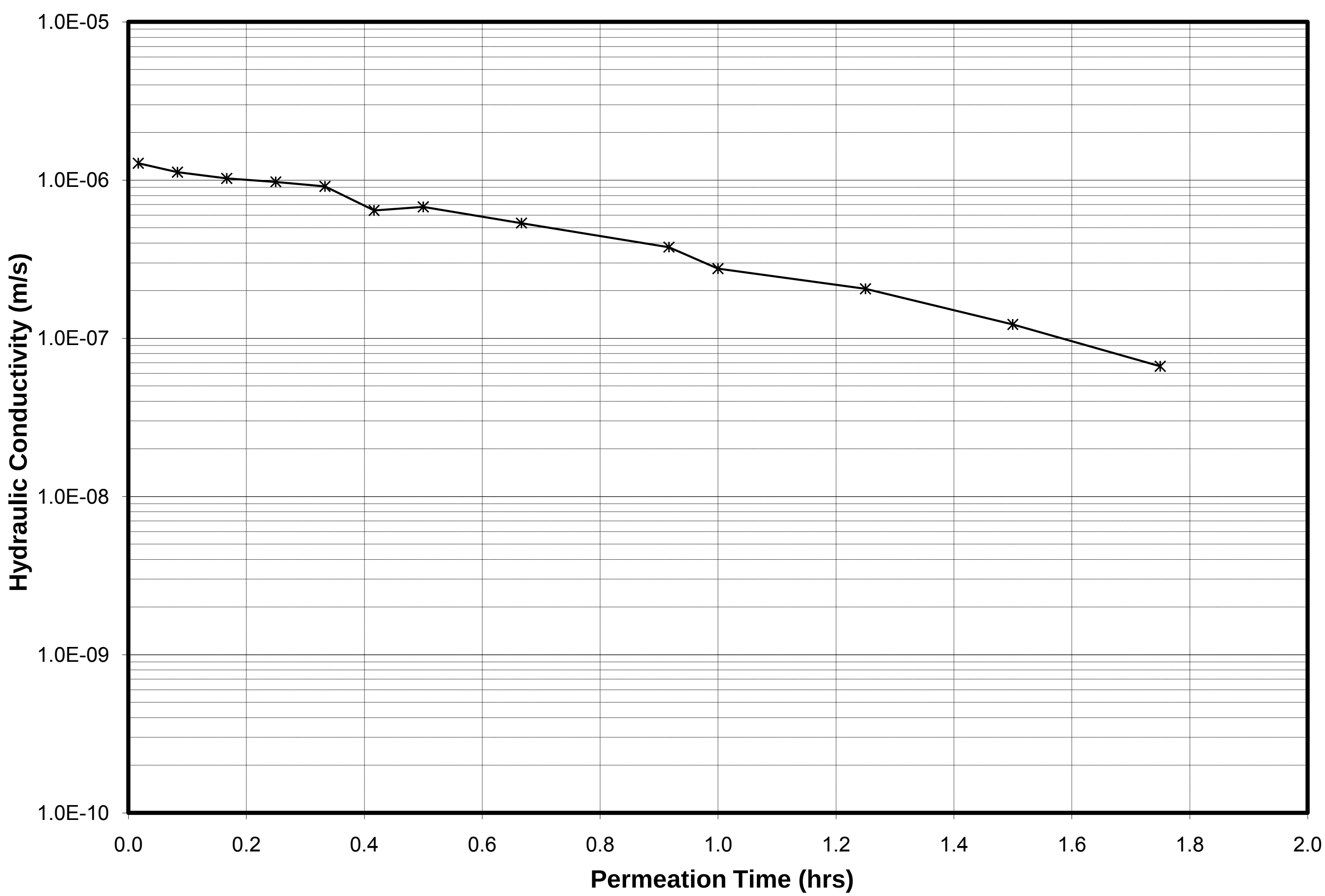
MEASURED DATA:

Read Time			Elapsed Time	Temp T	Pressure Readings			Burette Readings						Head Loss h	Effective Stresses		Calculated Flow Volumes				Gradient (i)	K	R_T	k_{20}
					P_{cell}	P_{in}	P_{out}	V_{cell}	V_{in}	V_{out}	H_{cell}	H_{in}	H_{out}		σ'_{max}	σ'_{min}	Inflow	Outflow	Storage	Cum.				
day	hr	min	(hr)	(°C)	(psi)	(psi)	(psi)	(ml)	(ml)	(ml)	(m)	(m)	(m)	(m)	(psi)	(psi)	(ml)	(ml)	(ml)	P.V.		(m/sec)		(m/sec)
1	0	0	0.00	22.4	54.5	36.5	35.5	0.0	99.0	4.2	0.000	0.465	0.020	1.088	18.9	17.3				0	17.8			
1	0	1	0.02	22.4	54.5	36.5	35.5	0.0	95.6	7.2	0.000	0.449	0.034	1.058	18.9	17.4	3.4	3.0	0.4	0.0413	17.3	1.4E-06	0.944	1.3E-06
1	0	5	0.08	22.4	54.5	36.5	35.5	0.0	84.9	17.6	0.000	0.399	0.083	0.959	18.8	17.4	10.7	10.4	0.3	0.1774	15.7	1.2E-06	0.944	1.1E-06
1	0	10	0.17	22.4	54.5	36.5	35.5	0.0	74.1	28.5	0.000	0.348	0.134	0.857	18.7	17.5	10.8	10.9	-0.1	0.3173	14.0	1.1E-06	0.944	1.0E-06
1	0	15	0.25	22.4	54.5	36.5	35.5	0.0	65.2	38.1	0.000	0.306	0.179	0.770	18.7	17.6	8.9	9.6	-0.7	0.4366	12.6	1.0E-06	0.944	9.8E-07
1	0	20	0.33	22.4	54.5	36.5	35.5	0.0	57.0	45.5	0.000	0.268	0.214	0.697	18.6	17.6	8.2	7.4	0.8	0.5373	11.4	9.7E-07	0.944	9.1E-07
1	0	25	0.42	22.4	54.5	36.5	35.5	0.0	52.2	50.8	0.000	0.245	0.239	0.649	18.6	17.7	4.8	5.3	-0.5	0.6024	10.6	6.8E-07	0.944	6.4E-07
1	0	30	0.50	22.4	54.5	36.5	35.5	0.0	47.5	56.0	0.000	0.223	0.263	0.603	18.5	17.7	4.7	5.2	-0.5	0.6662	9.8	7.2E-07	0.944	6.8E-07
1	0	40	0.67	22.4	54.5	36.5	35.5	0.0	40.1	62.8	0.000	0.188	0.295	0.536	18.5	17.7	7.4	6.8	0.6	0.7578	8.7	5.7E-07	0.944	5.4E-07
1	0	55	0.92	22.4	54.5	36.5	35.5	0.0	33.5	69.5	0.000	0.157	0.327	0.473	18.4	17.8	6.6	6.7	-0.1	0.8436	7.7	4.0E-07	0.944	3.8E-07
1	1	0	1.00	22.4	54.5	36.5	35.5	0.0	32.0	71.0	0.000	0.150	0.334	0.459	18.4	17.8	1.5	1.5	0.0	0.8630	7.5	2.9E-07	0.944	2.8E-07
1	1	15	1.25	22.4	54.5	36.5	35.5	0.0	28.8	74.2	0.000	0.135	0.349	0.429	18.4	17.8	3.2	3.2	0.0	0.9042	7.0	2.2E-07	0.944	2.1E-07
1	1	30	1.50	22.4	54.5	36.5	35.5	0.0	27.0	76.0	0.000	0.127	0.357	0.412	18.4	17.8	1.8	1.8	0.0	0.9275	6.7	1.3E-07	0.944	1.2E-07
1	1	45	1.75	22.4	54.5	36.5	35.5	0.0	26.1	77.0	0.000	0.123	0.362	0.403	18.4	17.8	0.9	1.0	-0.1	0.9397	6.6	7.1E-08	0.944	6.7E-08
																							Average for last 4:	4.7E-07

HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-03)

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 NORTH 34TH STREET • SUITE 100
P.O. BOX 300303 • SEATTLE, WASHINGTON 98103
206-632-8020 FAX 206-695-6777

Project	Skagit River Levees	Job No.	21-1-21199-002		
Boring No.	DD22-2 Landward	Tested by	AKV	On	1/27/2010
Sample No.	S-13	Comp by	AKV	On	2/2/2010
Depth (ft)	41.2	Checked by	JFL	On	2/8/2010



HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-03)

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 NORTH 34TH STREET • SUITE 100
P.O. BOX 300303 • SEATTLE, WASHINGTON 98103
206-632-8020 FAX 206-695-6777

Project	Skagit River Levees		Job No.	21-1-21199-002		
Boring No.	DD22-2 Levee		Tested By	AKV	On	1/20/2010
Sample No.	S-7		Comp By	AKV	On	2/2/2010
Depth (ft)	18.3		Checked By	JFL	On	2/5/2010

WATER CONTENT DATA:

	Before Test	After Test
Pan No.	tin cup	Z-24
Wet+Tare	123.72	311.18
Dry+Tare	88.52	255.09
Tare	3.05	102.19
WC, %	41.2	36.7

DESCRIPTION:

Gray-brown, fine sandy SILT; ML

SPECIMEN DATA:

	Before Test	After Consol.	After Test
Height, m	0.0583	0.0580	0.0582
Diameter, m	0.0502	0.0502	0.0502
Wet Weight, g	211.21	210.21	208.99
Volume, ml	115.3	114.7	115.2
Area, m^2	0.00198	0.00198	0.00198
Wet Unit Wt, pcf	114.3	114.4	113.2
Dry Unit Wt, pcf	81.0	83.7	82.8
Est. Saturation,%	102.9	97.7	95.7

OTHER INFORMATION:

Burette Corr. Factor, BCF (vol. to height), 1ml = 0.0047 m

a = 2.13E-04 m^2

Specific Gravity ☑ Assumed ☐ Measured = 2.7

B-Coefficient = 0.96

Volume of Solid = 55.4 ml

Pore Volume (P.V.)= 59.9 ml

NOTE:

FALLING-HEAD INCREASING TAILWATER LEVEL HYDRAULIC CONDUCTIVITY CALCULATION (METHOD C):

$$k = \frac{aL}{2At}\ln\left(\frac{h_1}{h_2}\right)$$

$$k_{20} = R_T k$$

a = cross-sectional area of standpipe, m^2
L = length of the sample, m
A = cross-sectional area of the sample, m^2
t = elapsed time between determination of h_1 and h_2, sec.

h_1 = head loss across the specimen at time t_1, m,
h_2 = head loss across the specimen at time t_2, m,
k_{20} = corrected hydraulic conductivity at temperature of 20 °C
R_T = correction factor for viscosity of water at various temperatures, T
= $2.2902(0.9842^T)/T^{0.1702}$

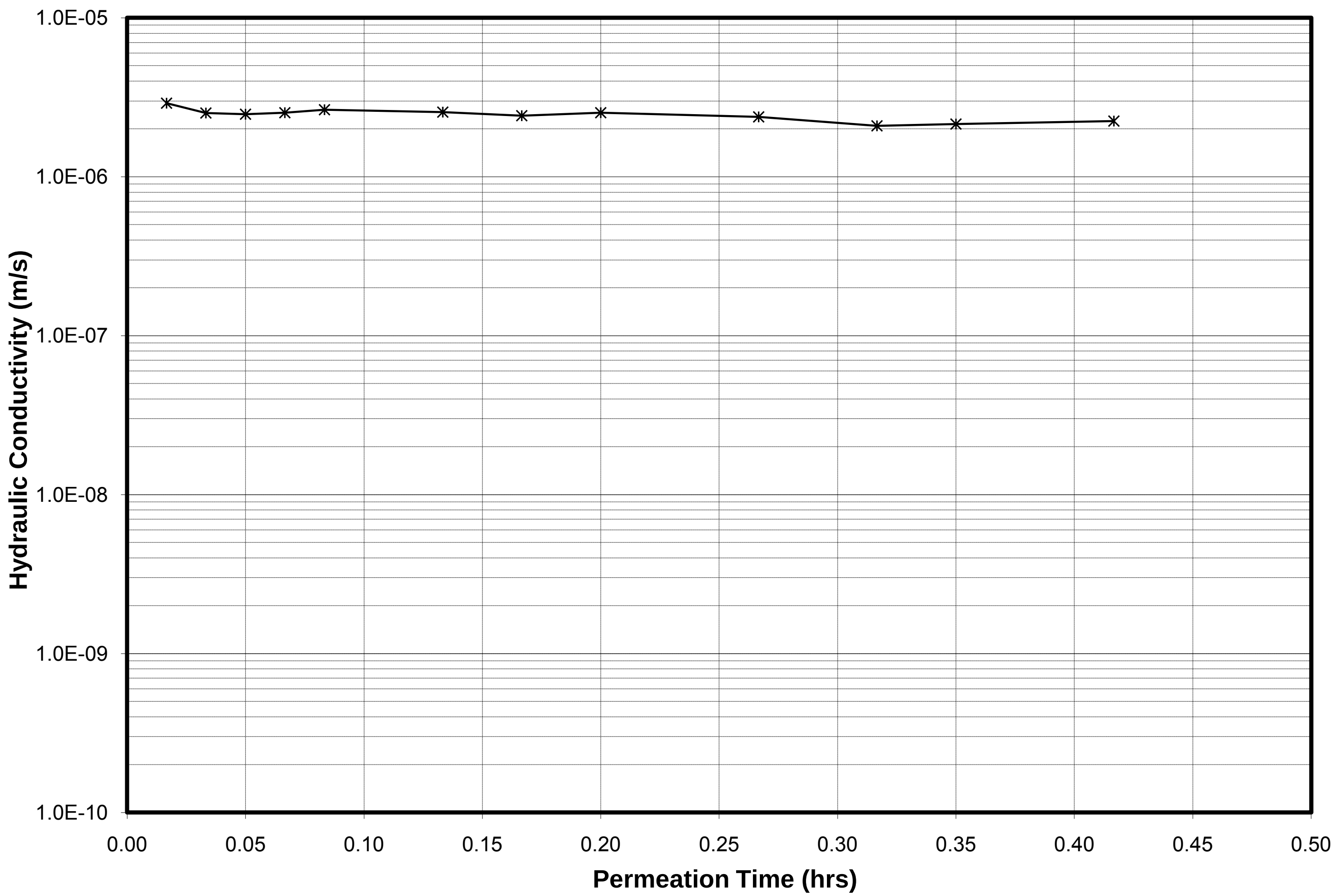
MEASURED DATA:

Read Time			Elapsed Time	Temp T	Pressure Readings			Burette Readings						Head Loss h	Effective Stresses		Calculated Flow Volumes				Gradient (i)	*K*	R_T	k_{20}
					P_{cell}	P_{in}	P_{out}	V_{cell}	V_{in}	V_{out}	H_{cell}	H_{in}	H_{out}		σ'_{max}	σ'_{min}	Inflow	Outflow	Storage	Cum. P.V.				
day	hr	min	(hr)	(°C)	(psi)	(psi)	(psi)	(ml)	(ml)	(ml)	(m)	(m)	(m)	(m)	(psi)	(psi)	(ml)	(ml)	(ml)			(m/sec)		(m/sec)
1	0	0	0.00	22.6	39.2	31.5	30.5	0.0	97.4	1.0	0.000	0.458	0.005	1.099	8.6	7.0				0	18.9			
1	0	1	0.02	22.6	39.2	31.5	30.5	0.0	90.6	7.6	0.000	0.426	0.036	1.036	8.6	7.1	6.8	6.6	0.2	0.1119	17.8	3.1E-06	0.94	2.9E-06
1	0	2	0.03	22.6	39.2	31.5	30.5	0.0	85.0	13.0	0.000	0.400	0.061	0.984	8.5	7.1	5.6	5.4	0.2	0.2038	16.9	2.7E-06	0.94	2.5E-06
1	0	3	0.05	22.6	39.2	31.5	30.5	0.0	79.9	18.2	0.000	0.376	0.086	0.935	8.5	7.2	5.1	5.2	-0.1	0.2898	16.1	2.6E-06	0.94	2.5E-06
1	0	4	0.07	22.6	39.2	31.5	30.5	0.0	74.8	23.1	0.000	0.352	0.109	0.888	8.5	7.2	5.1	4.9	0.2	0.3733	15.2	2.7E-06	0.94	2.5E-06
1	0	5	0.08	22.6	39.2	31.5	30.5	0.0	69.9	28.1	0.000	0.329	0.132	0.842	8.4	7.2	4.9	5.0	-0.1	0.4559	14.4	2.8E-06	0.94	2.6E-06
1	0	8	0.13	22.6	39.2	31.5	30.5	0.0	57.0	41.0	0.000	0.268	0.193	0.721	8.3	7.3	12.9	12.9	0.0	0.6714	12.4	2.7E-06	0.94	2.5E-06
1	0	10	0.17	22.6	39.2	31.5	30.5	0.0	49.8	48.2	0.000	0.234	0.227	0.653	8.3	7.4	7.2	7.2	0.0	0.7916	11.2	2.6E-06	0.94	2.4E-06
1	0	12	0.20	22.6	39.2	31.5	30.5	0.0	43.0	55.0	0.000	0.202	0.259	0.589	8.2	7.4	6.8	6.8	0.0	0.9052	10.1	2.7E-06	0.94	2.5E-06
1	0	16	0.27	22.6	39.2	31.5	30.5	0.0	32.1	66.2	0.000	0.151	0.311	0.485	8.2	7.5	10.9	11.2	-0.3	1.0897	8.3	2.5E-06	0.94	2.4E-06
1	0	19	0.32	22.6	39.2	31.5	30.5	0.0	25.5	72.0	0.000	0.120	0.338	0.427	8.1	7.5	6.6	5.8	0.8	1.1933	7.3	2.2E-06	0.94	2.1E-06
1	0	21	0.35	22.6	39.2	31.5	30.5	0.0	21.9	76.0	0.000	0.103	0.357	0.391	8.1	7.6	3.6	4.0	-0.4	1.2567	6.7	2.3E-06	0.94	2.1E-06
1	0	25	0.42	22.6	39.2	31.5	30.5	0.0	15.1	83.1	0.000	0.071	0.391	0.326	8.1	7.6	6.8	7.1	-0.3	1.3728	5.6	2.4E-06	0.94	2.2E-06
																							Average for last 4:	2.2E-06

HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-03)

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
400 NORTH 34TH STREET • SUITE 100
P.O. BOX 300303 • SEATTLE, WASHINGTON 98103
206-632-8020 FAX 206-695-6777

Project	Skagit River Levees	Job No.	21-1-21199-002		
Boring No.	DD22-2 Levee	Tested by	AKV	On	1/20/2010
Sample No.	S-7	Comp by	AKV	On	2/2/2010
Depth (ft)	18.3	Checked by	JFL	On	2/5/2010



APPENDIX D

LIQUEFACTION FACTOR OF SAFETY ANALYSES

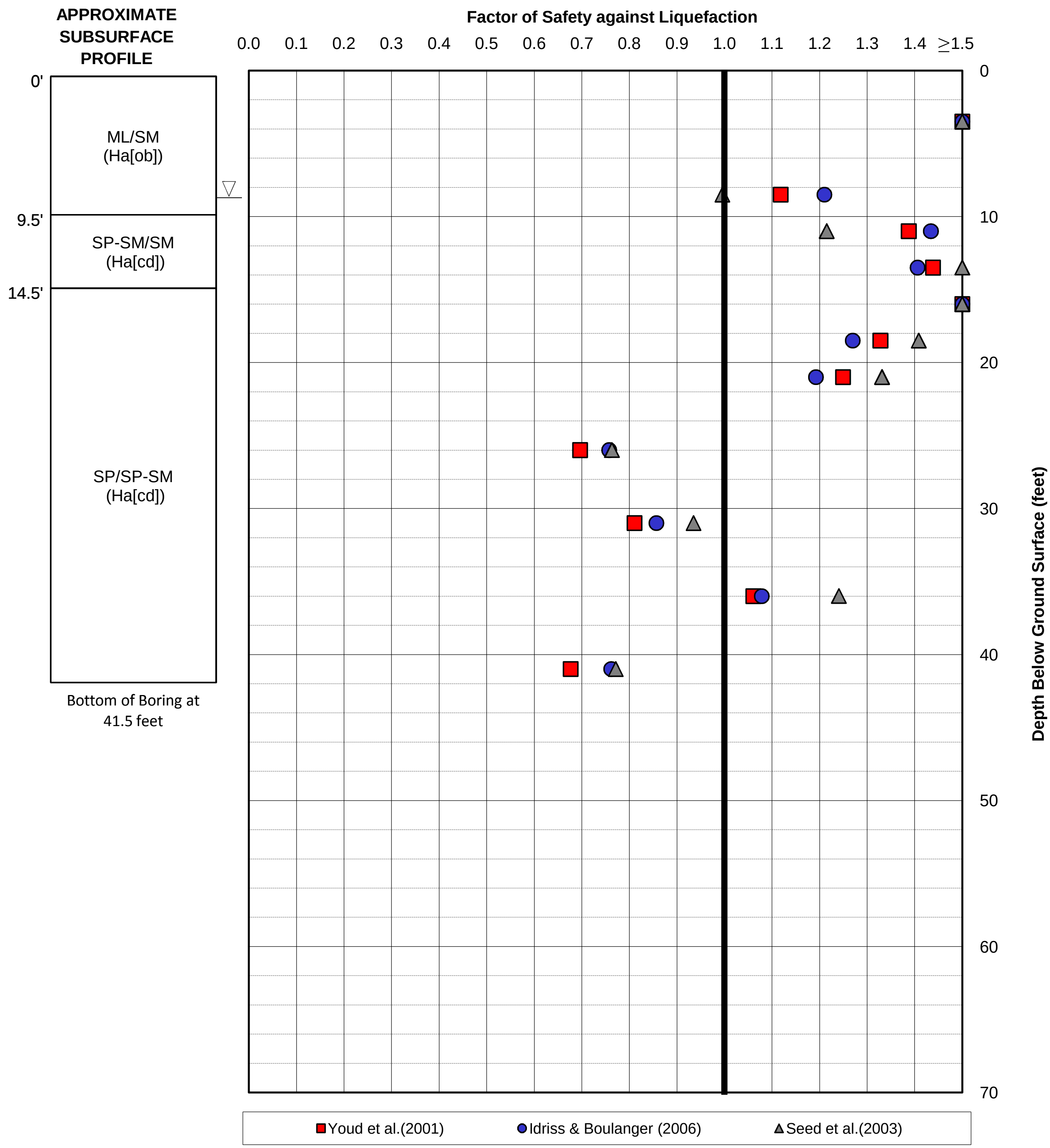
APPENDIX D

LIQUEFACTION FACTOR OF SAFETY ANALYSES

TABLE OF CONTENTS

FIGURES

FIGURES (cont.)



NOTES

1. See main text for references.
2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
3. Calculation of factors of safety based on M = 6.6, PGA = 0.20g

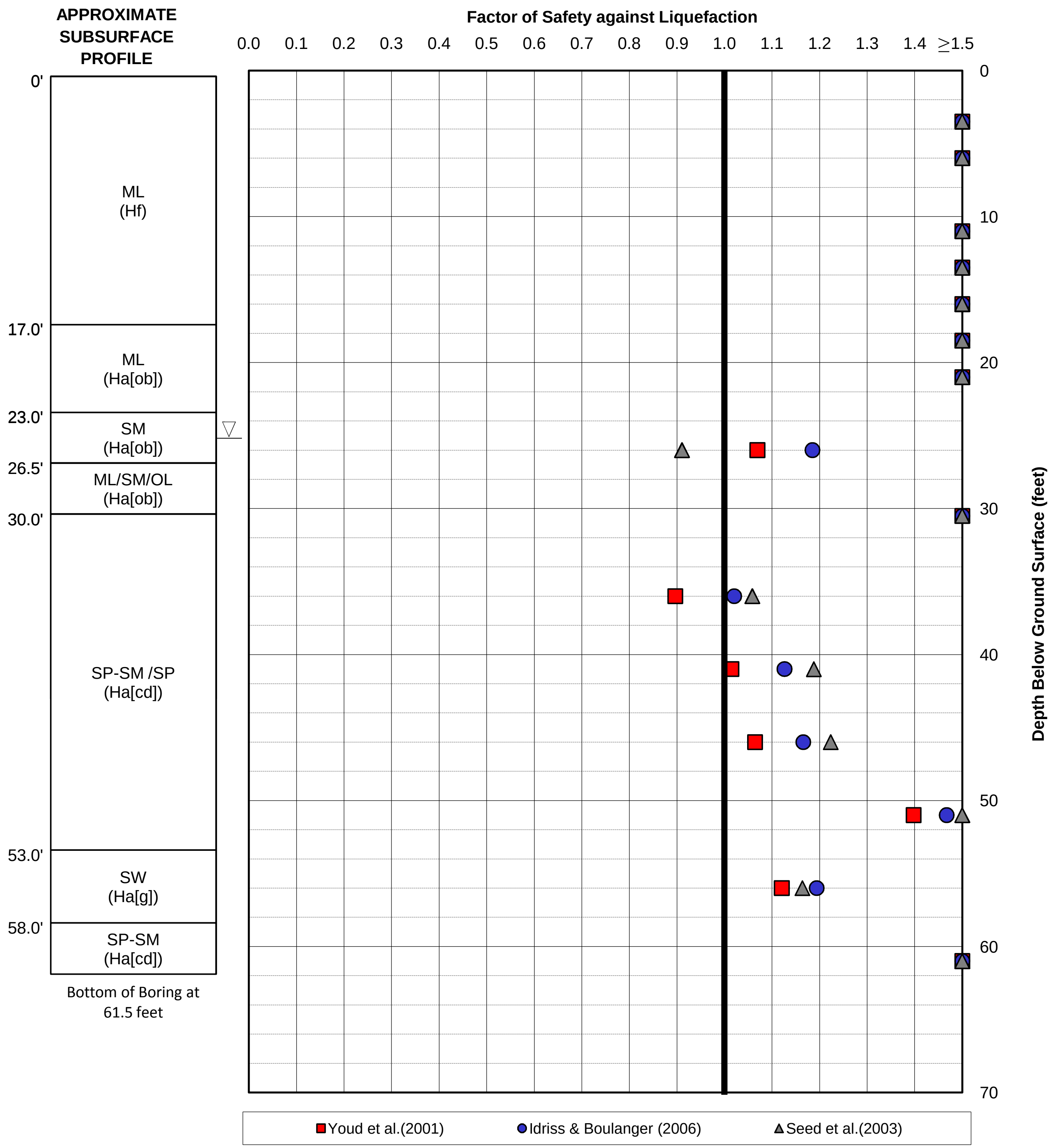
Skagit River Levee General Investigation
Skagit County, Washington

RESULTS OF LIQUEFACTION ANALYSES
BORING DD1-1 LANDWARD
144-YR RETURN PERIOD (OBE)

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. D-1



NOTES

1. See main text for references.
2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
3. Calculation of factors of safety based on M = 6.6, PGA = 0.20g

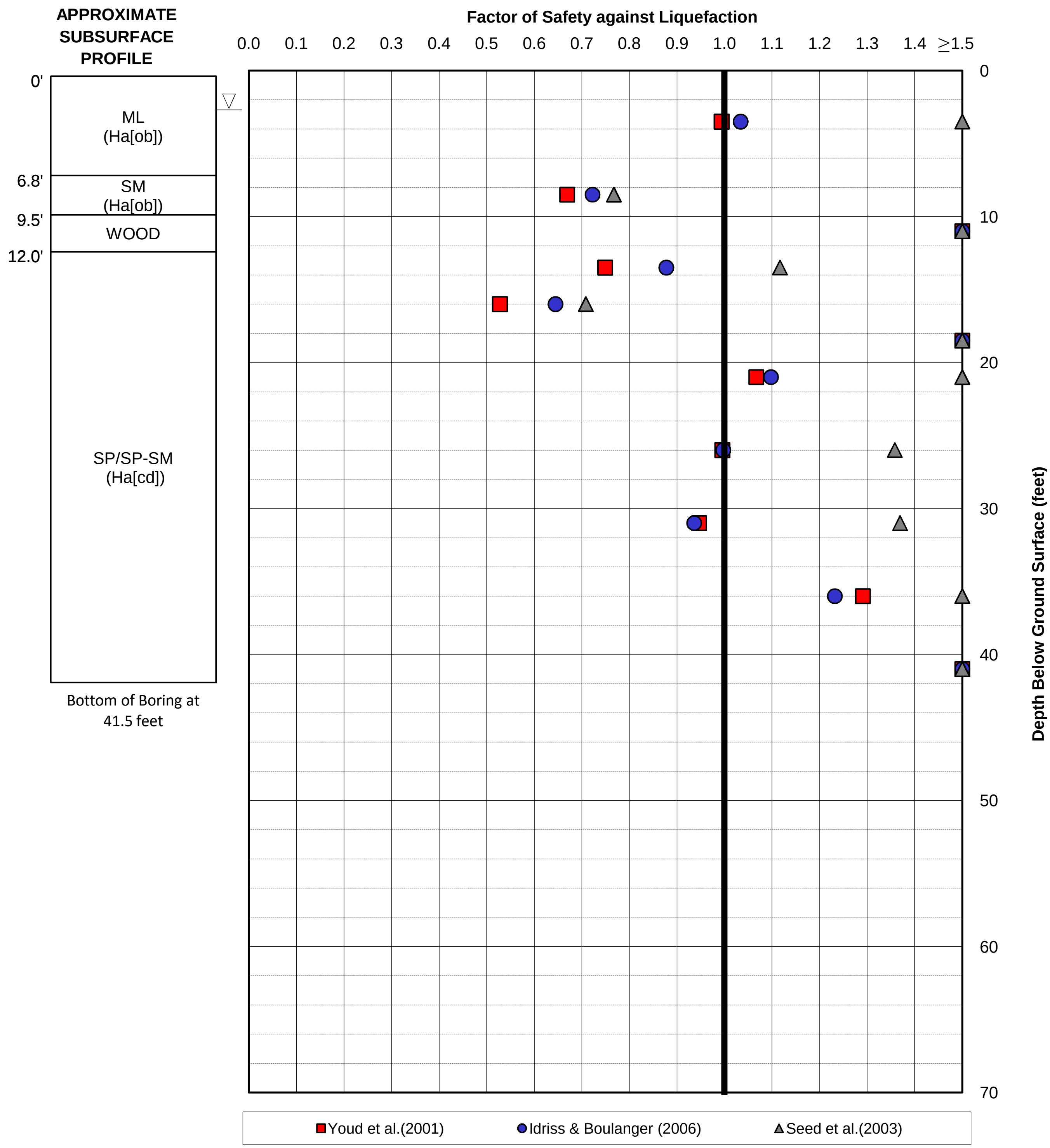
Skagit River Levee General Investigation
Skagit County, Washington

RESULTS OF LIQUEFACTION ANALYSES
BORING DD1-1 LEVEE
144-YR RETURN PERIOD (OBE)

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. D-2



NOTES

1. See main text for references.
2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
3. Calculation of factors of safety based on M = 6.6, PGA = 0.20g

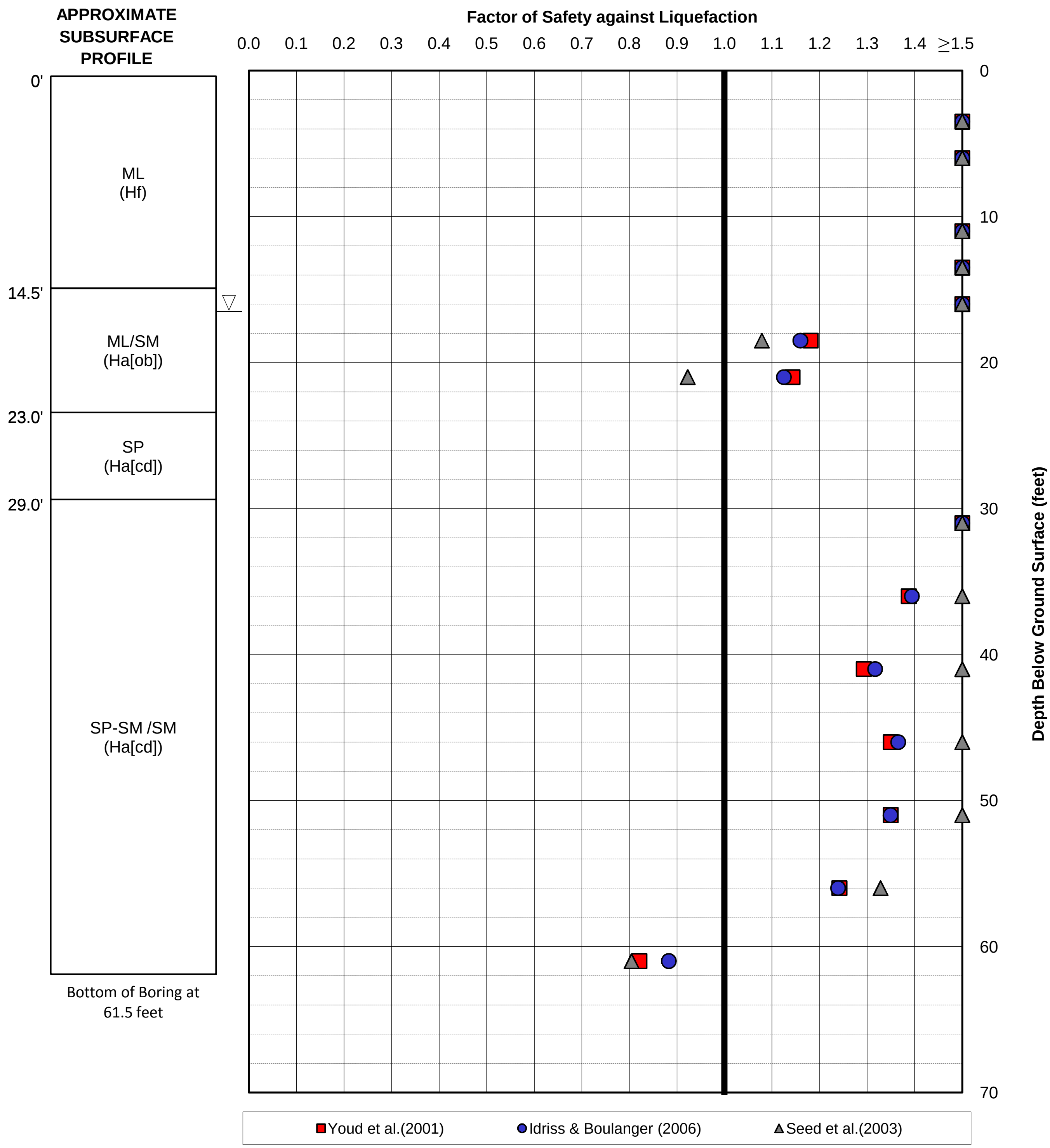
Skagit River Levee General Investigation
Skagit County, Washington

RESULTS OF LIQUEFACTION ANALYSES
BORING DD1-2 LANDWARD
144-YR RETURN PERIOD (OBE)

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. D-3



NOTES

1. See main text for references.
2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
3. Calculation of factors of safety based on M = 6.6, PGA = 0.20g

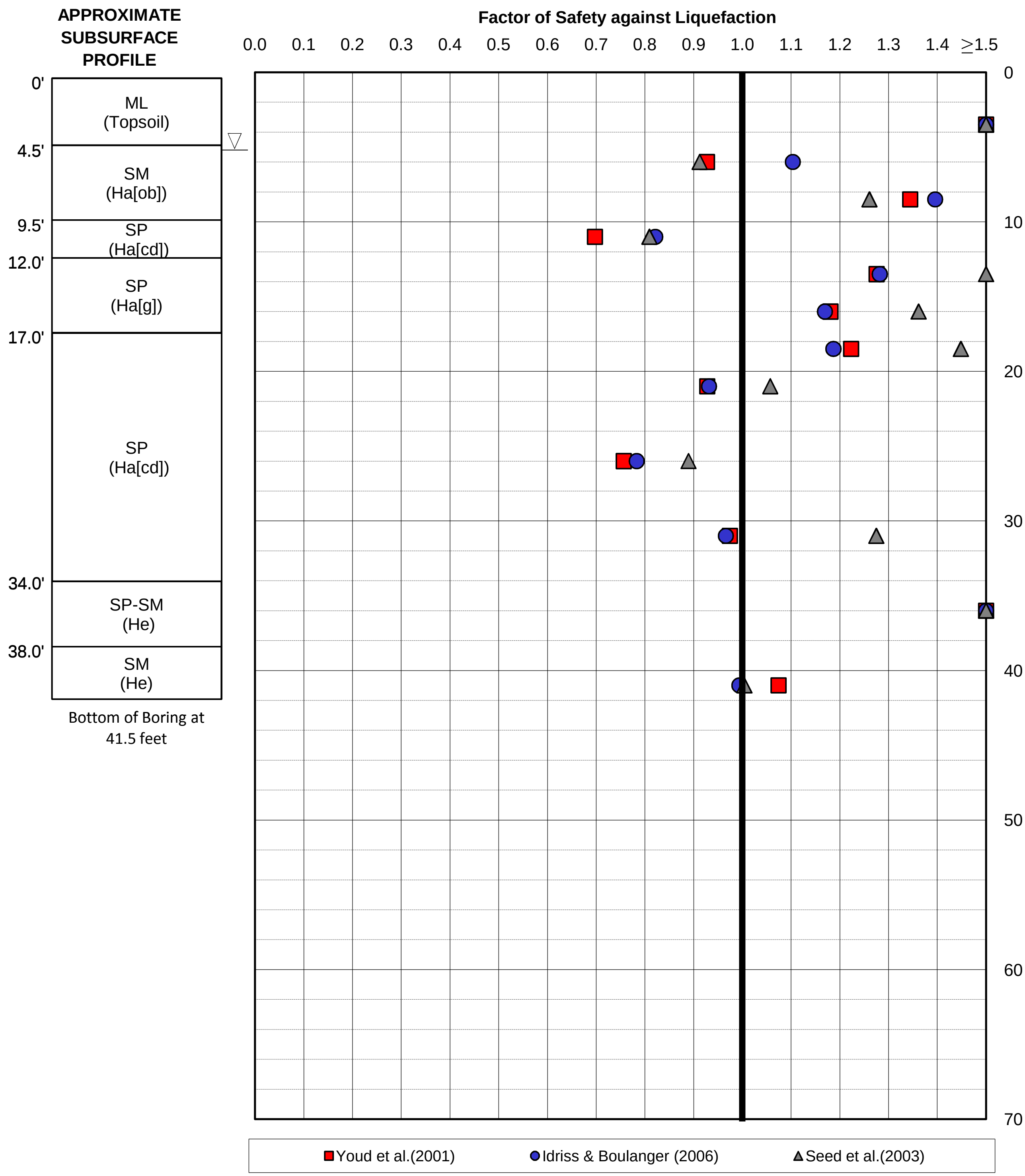
Skagit River Levee General Investigation
Skagit County, Washington

RESULTS OF LIQUEFACTION ANALYSES
BORING DD1-2 LEVEE
144-YR RETURN PERIOD (OBE)

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. D-4



NOTES

1. See main text for references.
2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
3. Calculation of factors of safety based on M = 6.6, PGA = 0.20g

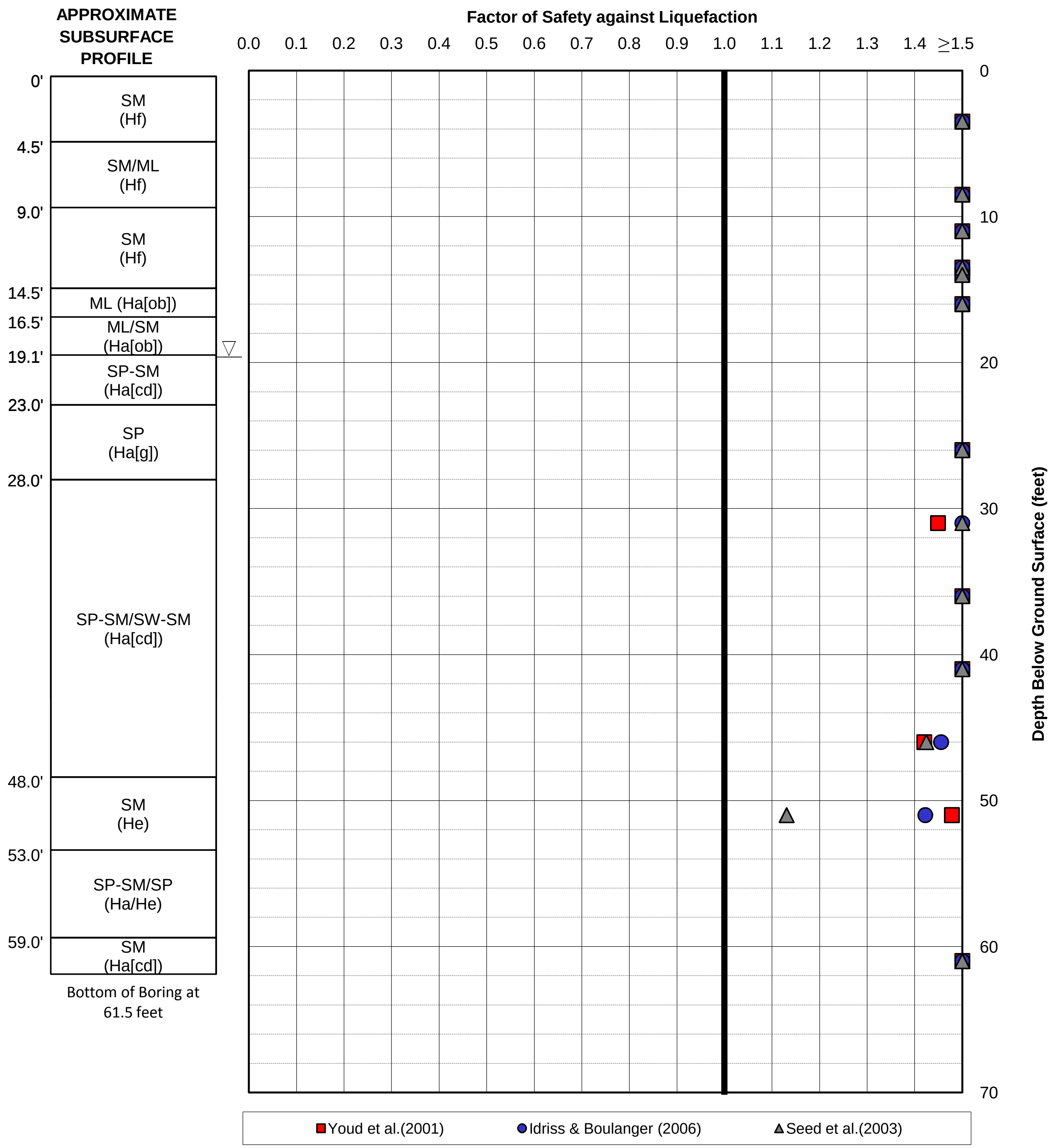
Skagit River Levee General Investigation
Skagit County, Washington

RESULTS OF LIQUEFACTION ANALYSES
BORING DD3-1 LANDWARD
144-YR RETURN PERIOD (OBE)

June 2010 | 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. D-5



NOTES

1. See main text for references.
2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
3. Calculation of factors of safety based on M = 6.6, PGA = 0.20g

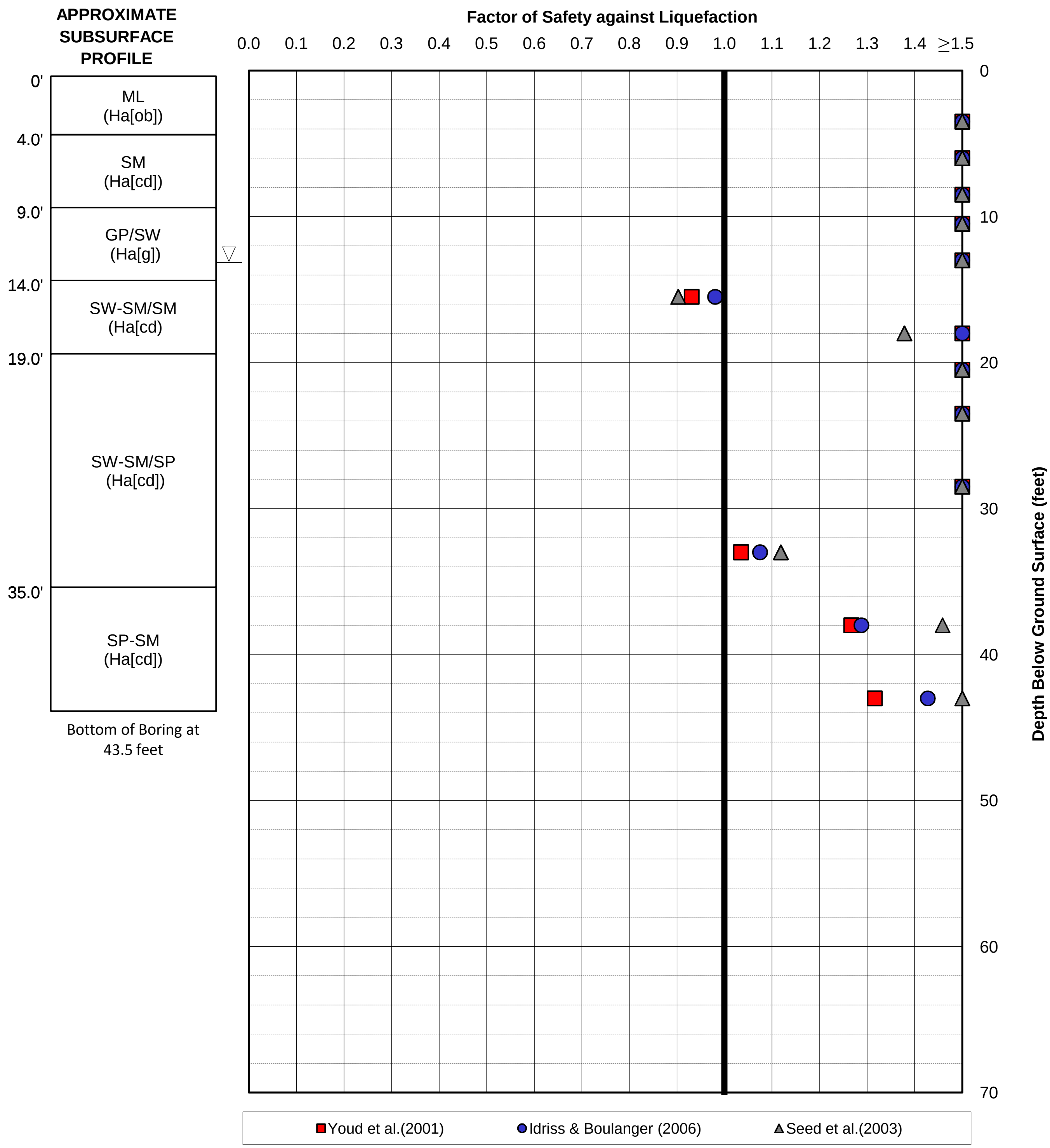
Skagit River Levee General Investigation
Skagit County, Washington

RESULTS OF LIQUEFACTION ANALYSES
BORING DD3-1 LEVEE
144-YR RETURN PERIOD (OBE)

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. D-6



NOTES

1. See main text for references.
2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
3. Calculation of factors of safety based on M = 6.6, PGA = 0.20g

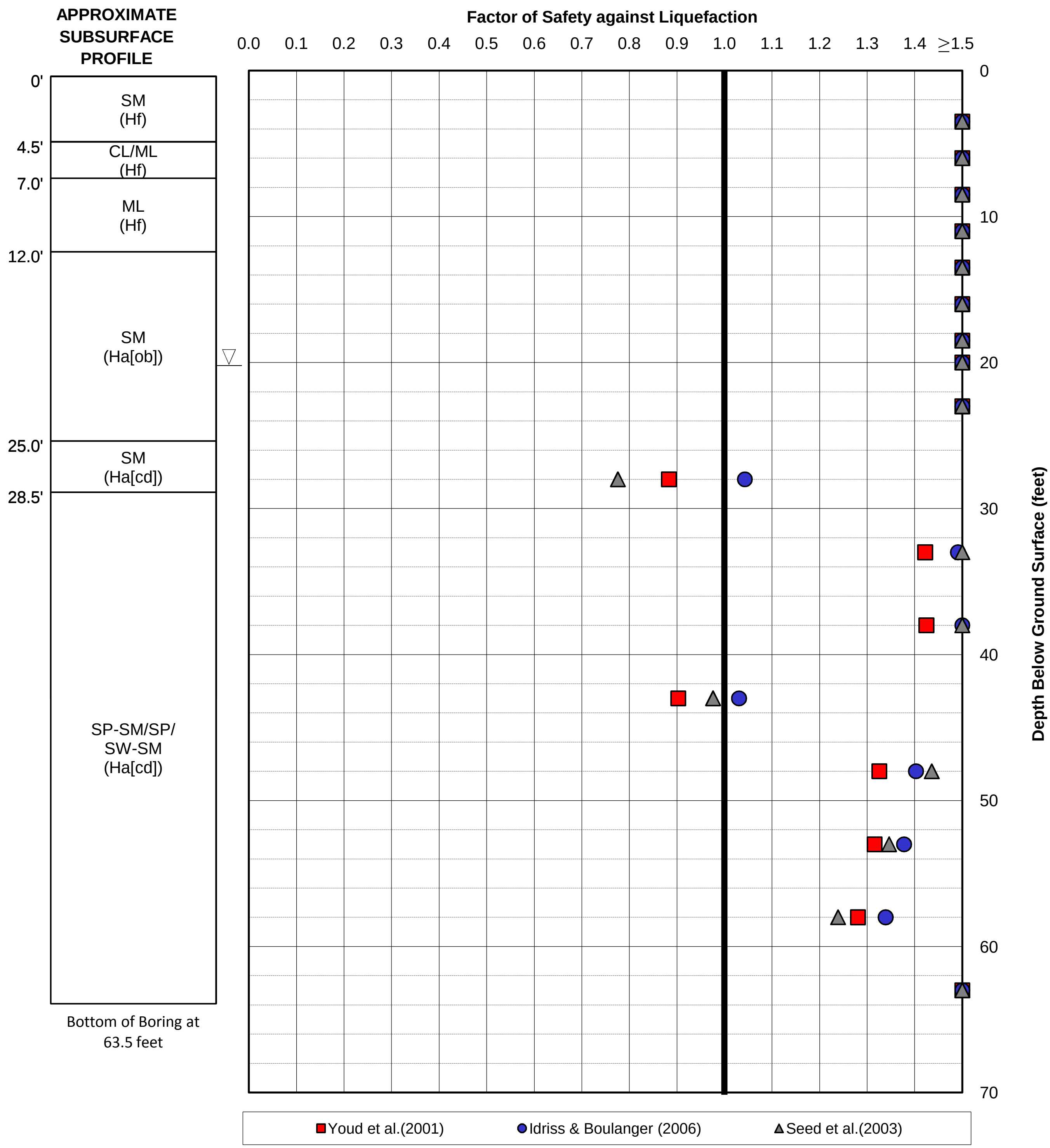
Skagit River Levee General Investigation
Skagit County, Washington

RESULTS OF LIQUEFACTION ANALYSES
BORING DD17-1 LANDWARD
144-YR RETURN PERIOD (OBE)

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. D-7



NOTES

1. See main text for references.
2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
3. Calculation of factors of safety based on M = 6.6, PGA = 0.20g

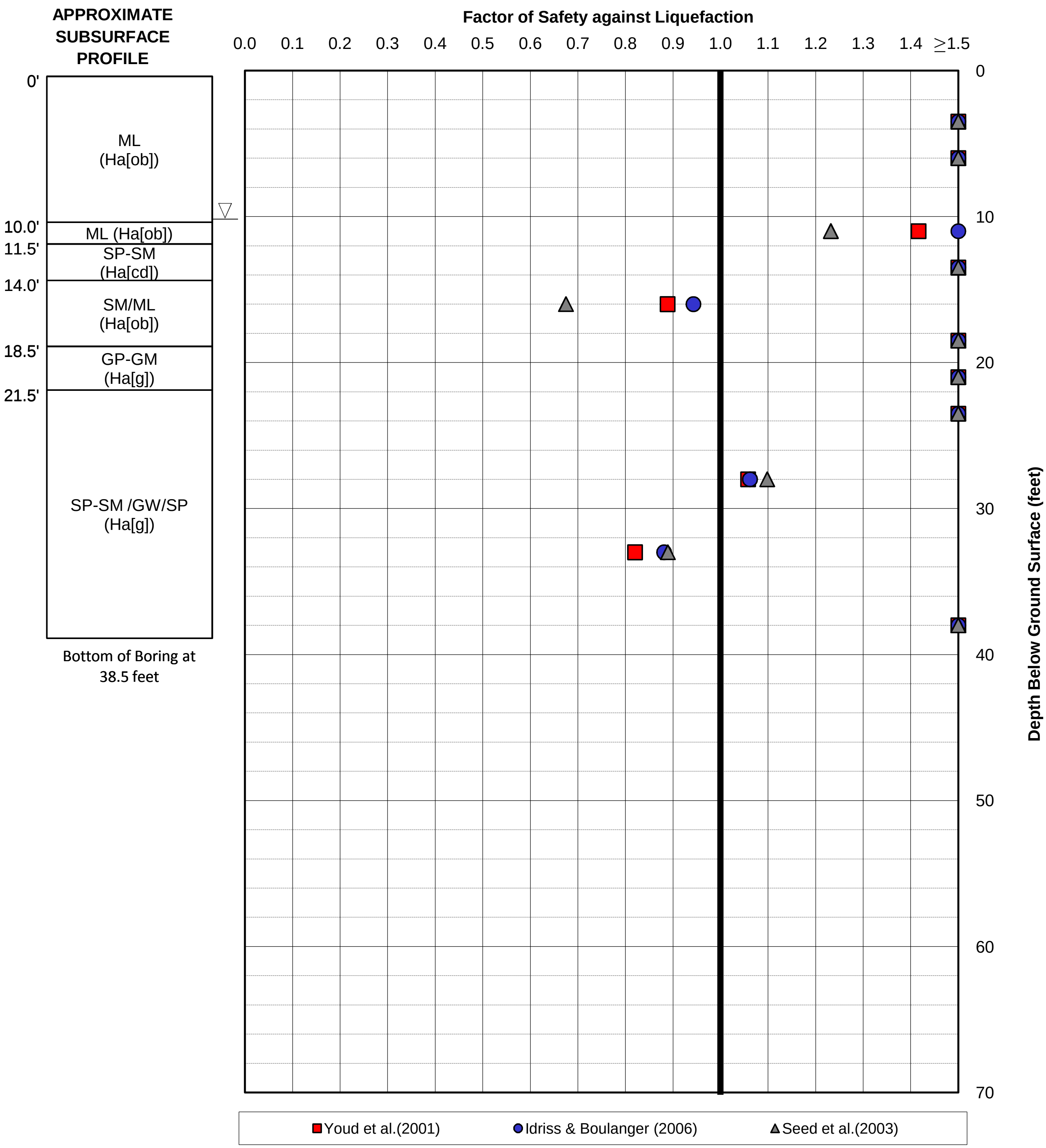
Skagit River Levee General Investigation
Skagit County, Washington

RESULTS OF LIQUEFACTION ANALYSES
BORING DD17-1 LEVEE
144-YR RETURN PERIOD (OBE)

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. D-8



NOTES

1. See main text for references.
2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
3. Calculation of factors of safety based on M = 6.6, PGA = 0.20g

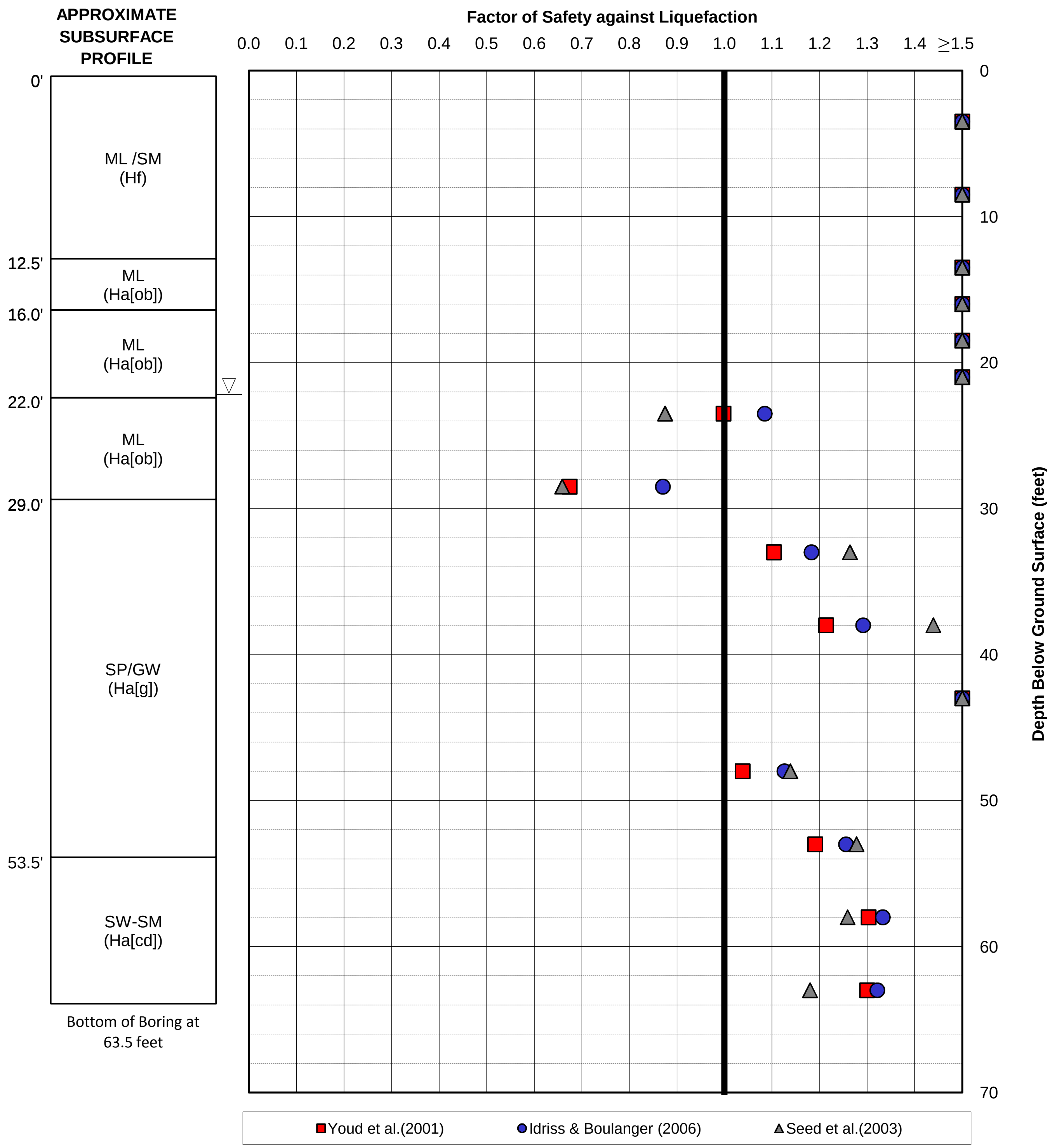
Skagit River Levee General Investigation
Skagit County, Washington

RESULTS OF LIQUEFACTION ANALYSES
BORING DD17-2 LANDWARD
144-YR RETURN PERIOD (OBE)

June 2010 | 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. D-9



NOTES

1. See main text for references.
2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
3. Calculation of factors of safety based on M = 6.6, PGA = 0.20g

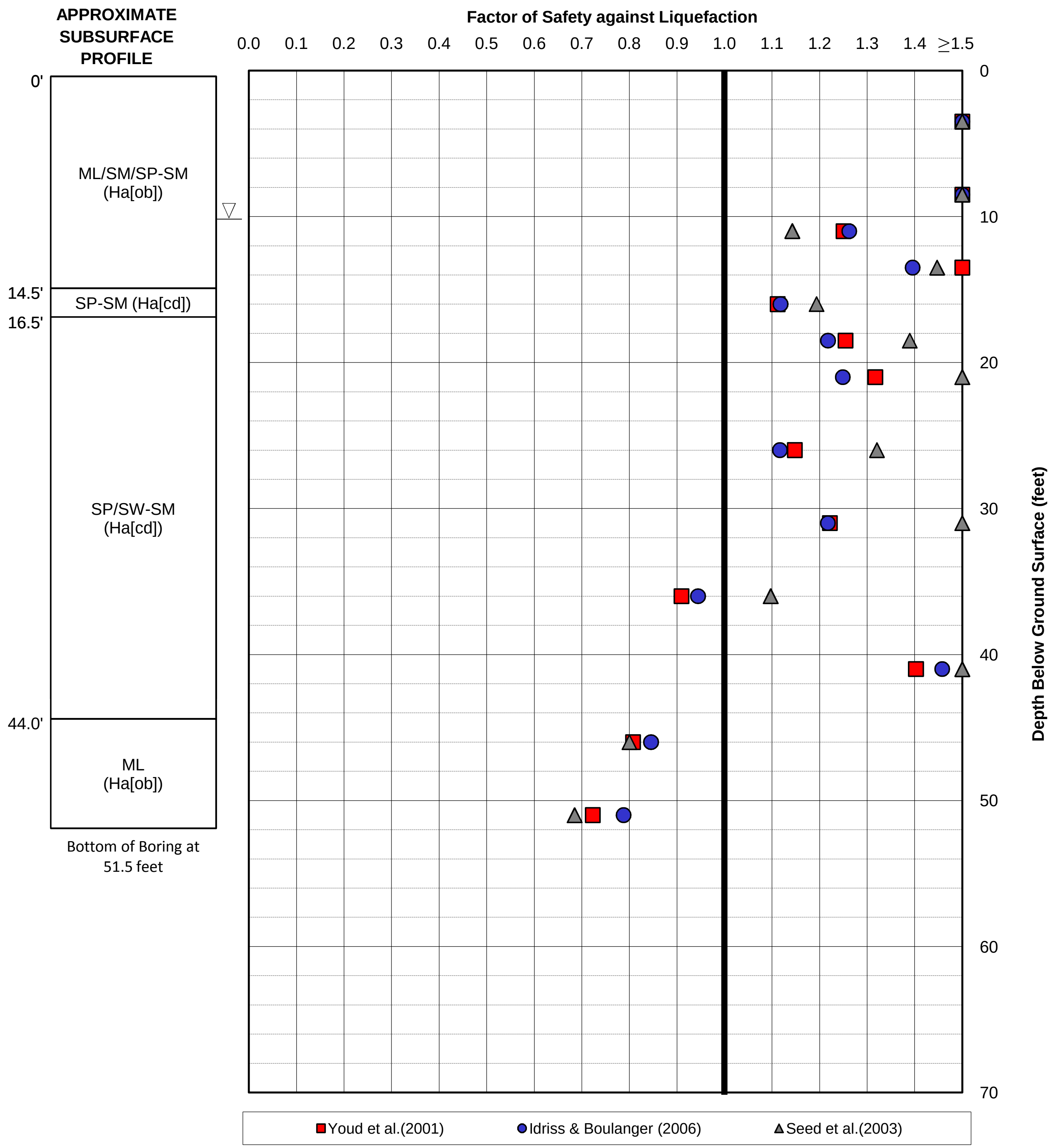
Skagit River Levee General Investigation
Skagit County, Washington

RESULTS OF LIQUEFACTION ANALYSES
BORING DD17-2 LEVEE
144-YR RETURN PERIOD (OBE)

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. D-10



NOTES

1. See main text for references.
2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
3. Calculation of factors of safety based on M = 6.6, PGA = 0.20g

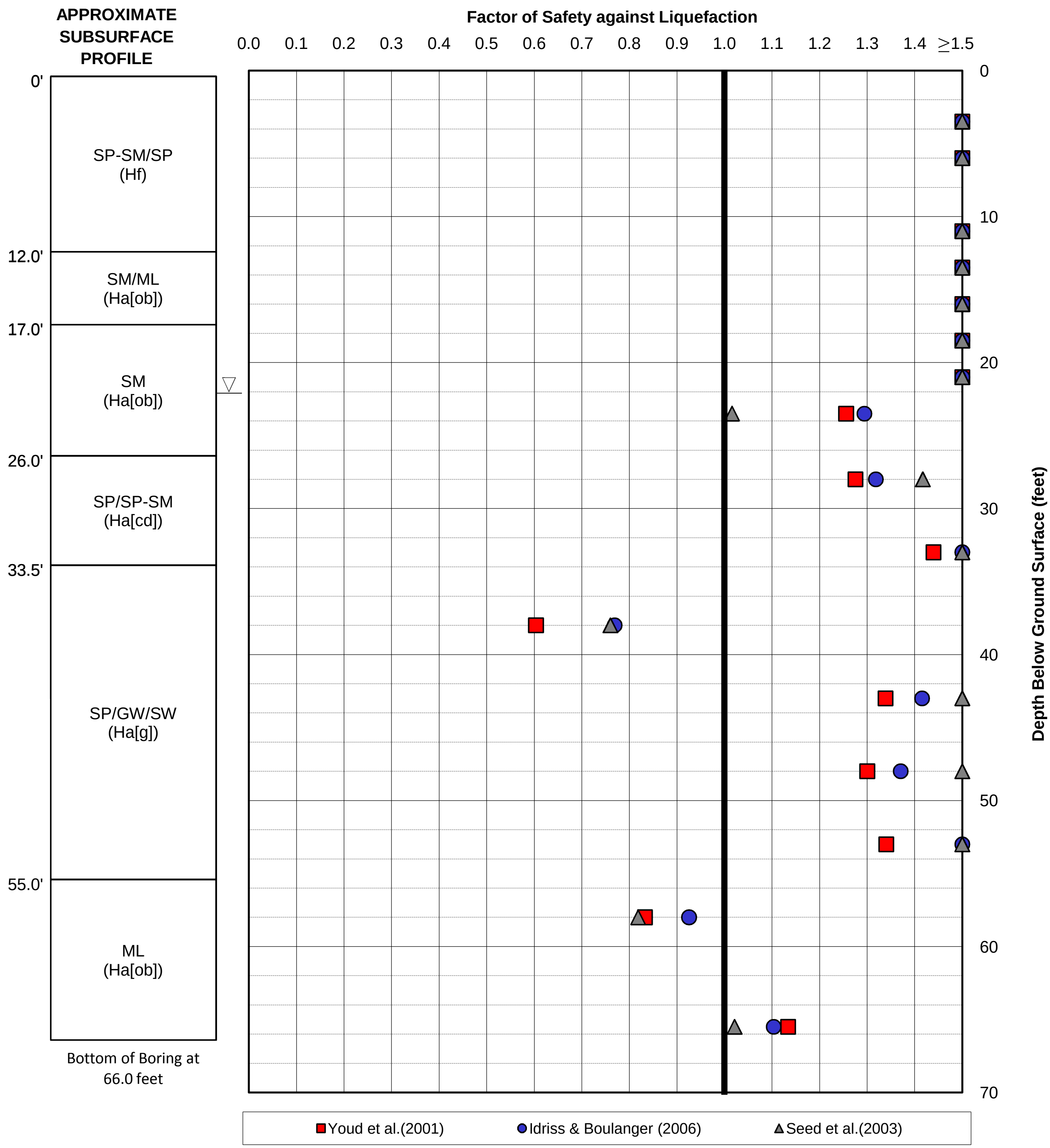
Skagit River Levee General Investigation
Skagit County, Washington

RESULTS OF LIQUEFACTION ANALYSES
BORING DD17-3 LANDWARD
144-YR RETURN PERIOD (OBE)

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. D-11



NOTES

1. See main text for references.
2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
3. Calculation of factors of safety based on M = 6.6, PGA = 0.20g

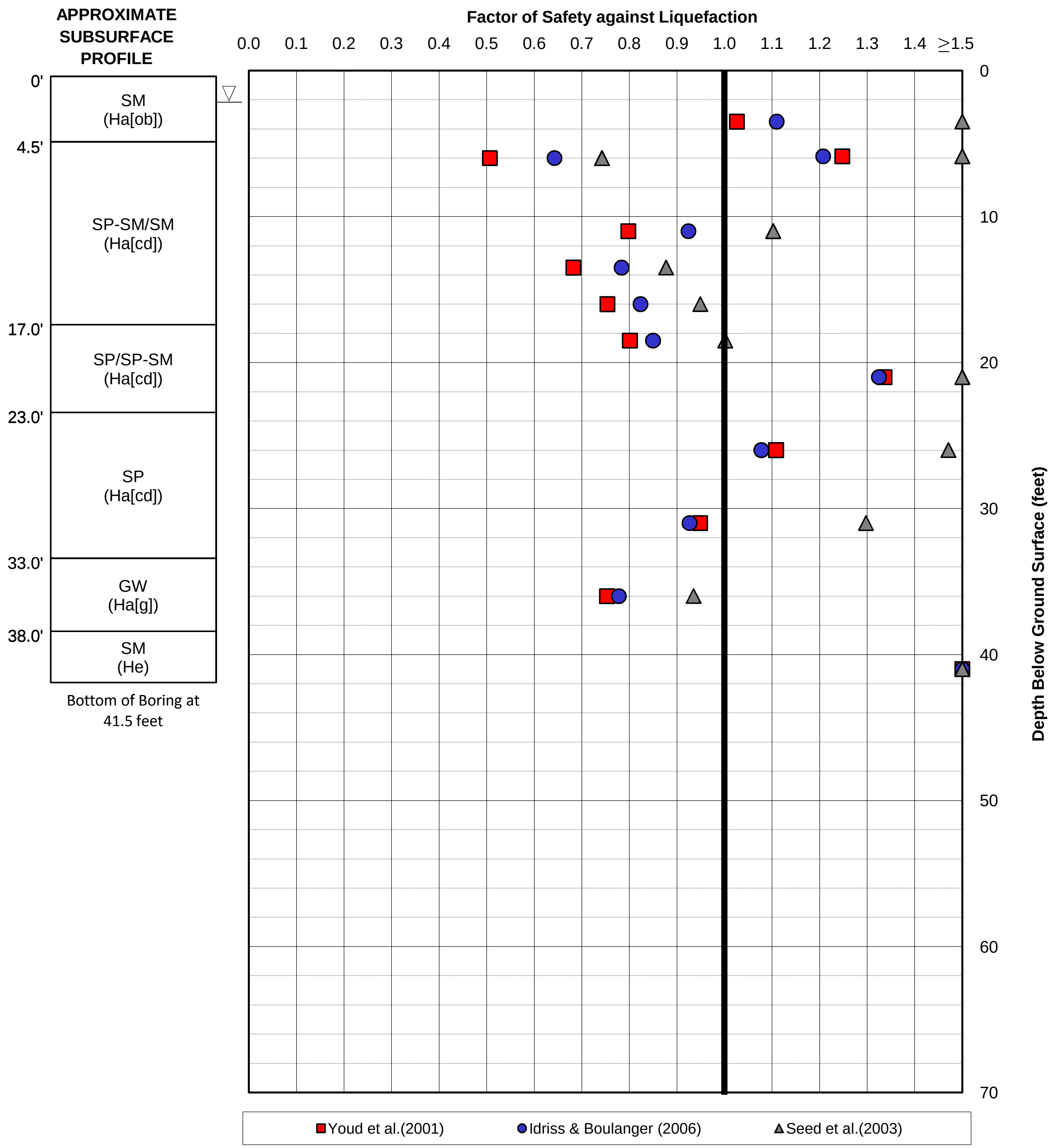
Skagit River Levee General Investigation
Skagit County, Washington

RESULTS OF LIQUEFACTION ANALYSES
BORING DD17-3 LEVEE
144-YR RETURN PERIOD (OBE)

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. D-12



NOTES

1. See main text for references.
2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
3. Calculation of factors of safety based on M = 6.6, PGA = 0.20g

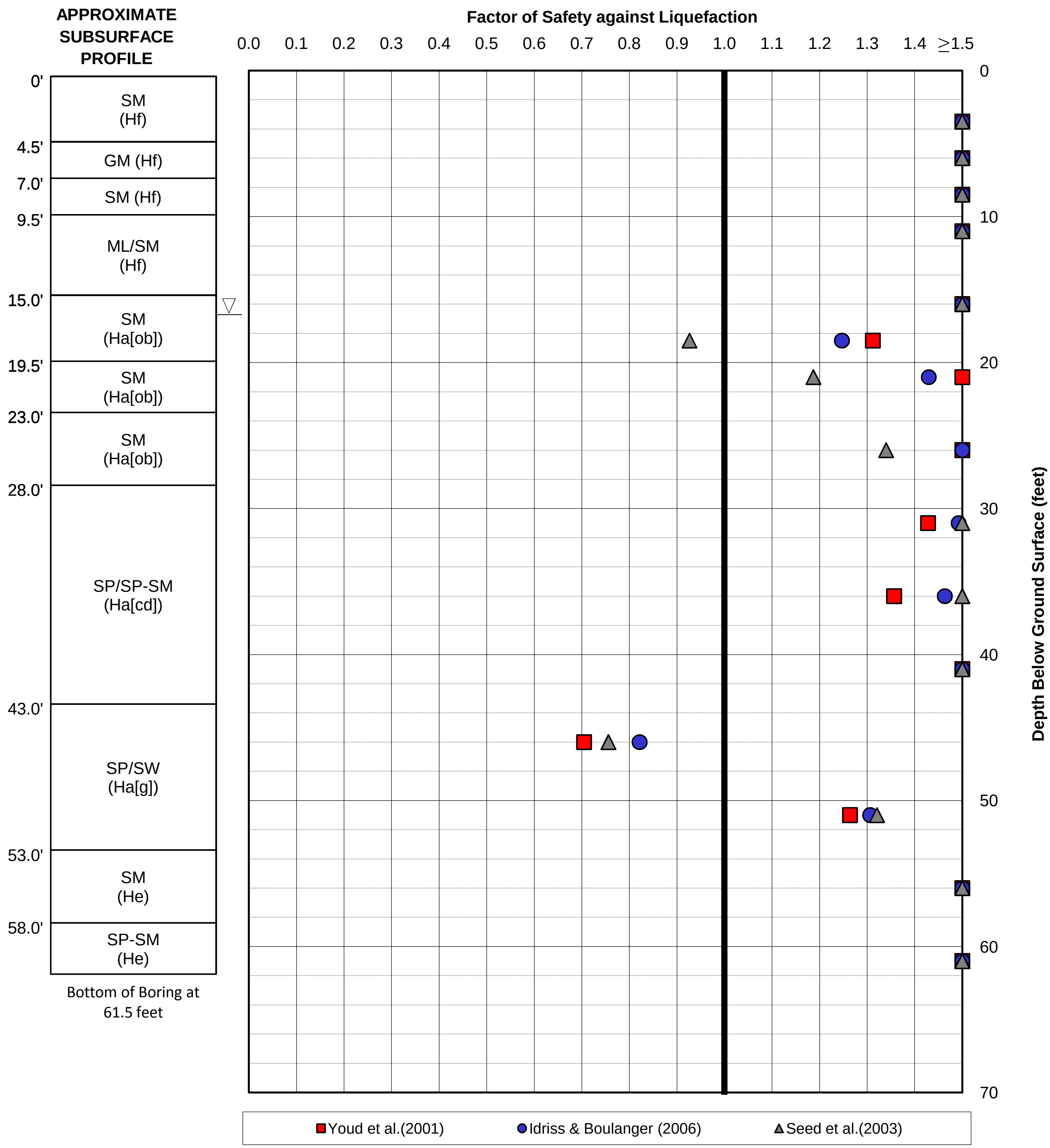
Skagit River Levee General Investigation
Skagit County, Washington

RESULTS OF LIQUEFACTION ANALYSES
BORING DD22-1 LANDWARD
144-YR RETURN PERIOD (OBE)

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. D-13



NOTES

1. See main text for references.
2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
3. Calculation of factors of safety based on M = 6.6, PGA = 0.20g

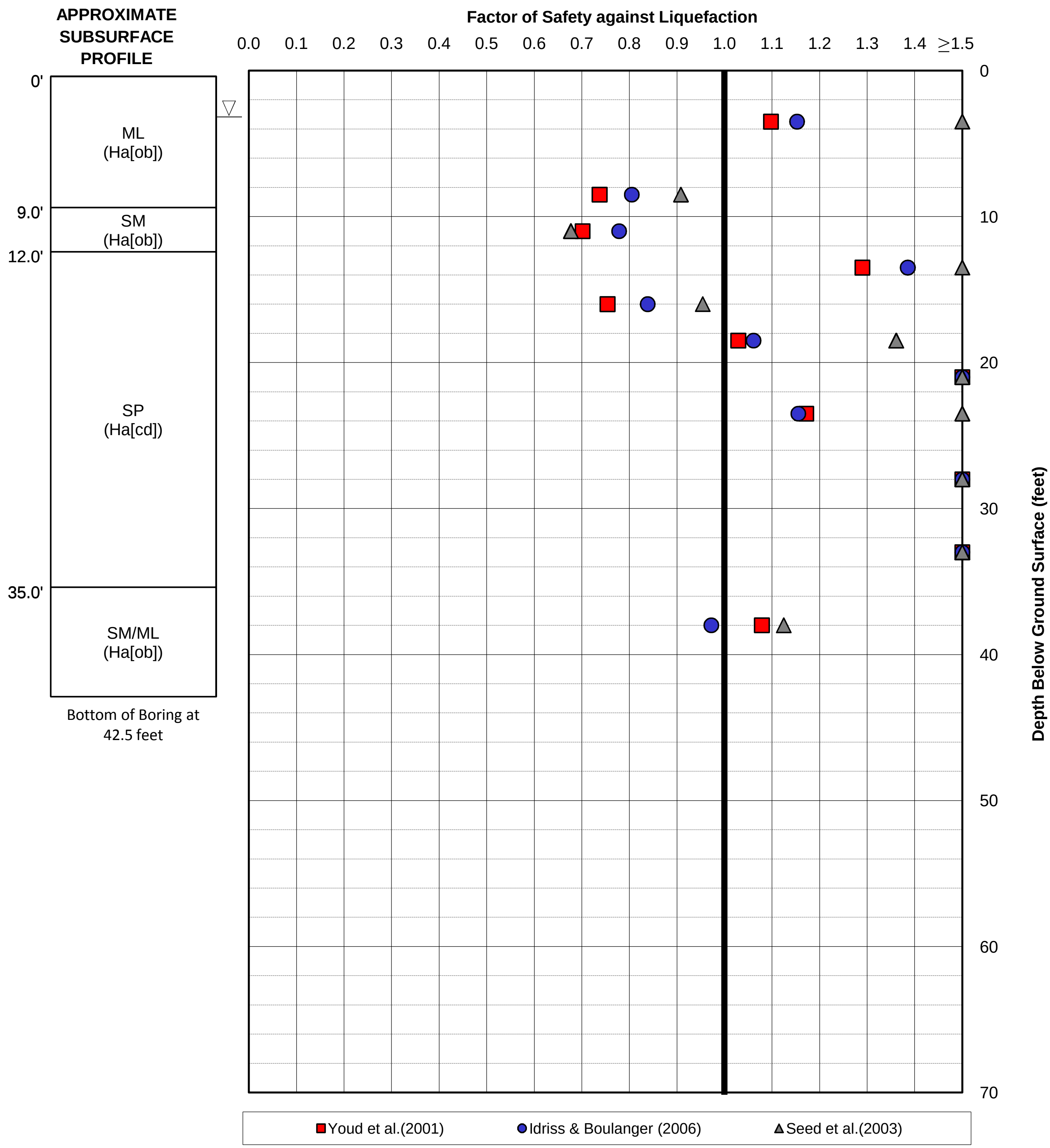
Skagit River Levee General Investigation
Skagit County, Washington

RESULTS OF LIQUEFACTION ANALYSES
BORING DD22-1 LEVEE
144-YR RETURN PERIOD (OBE)

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. D-14



NOTES

1. See main text for references.
2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
3. Calculation of factors of safety based on M = 6.6, PGA = 0.20g

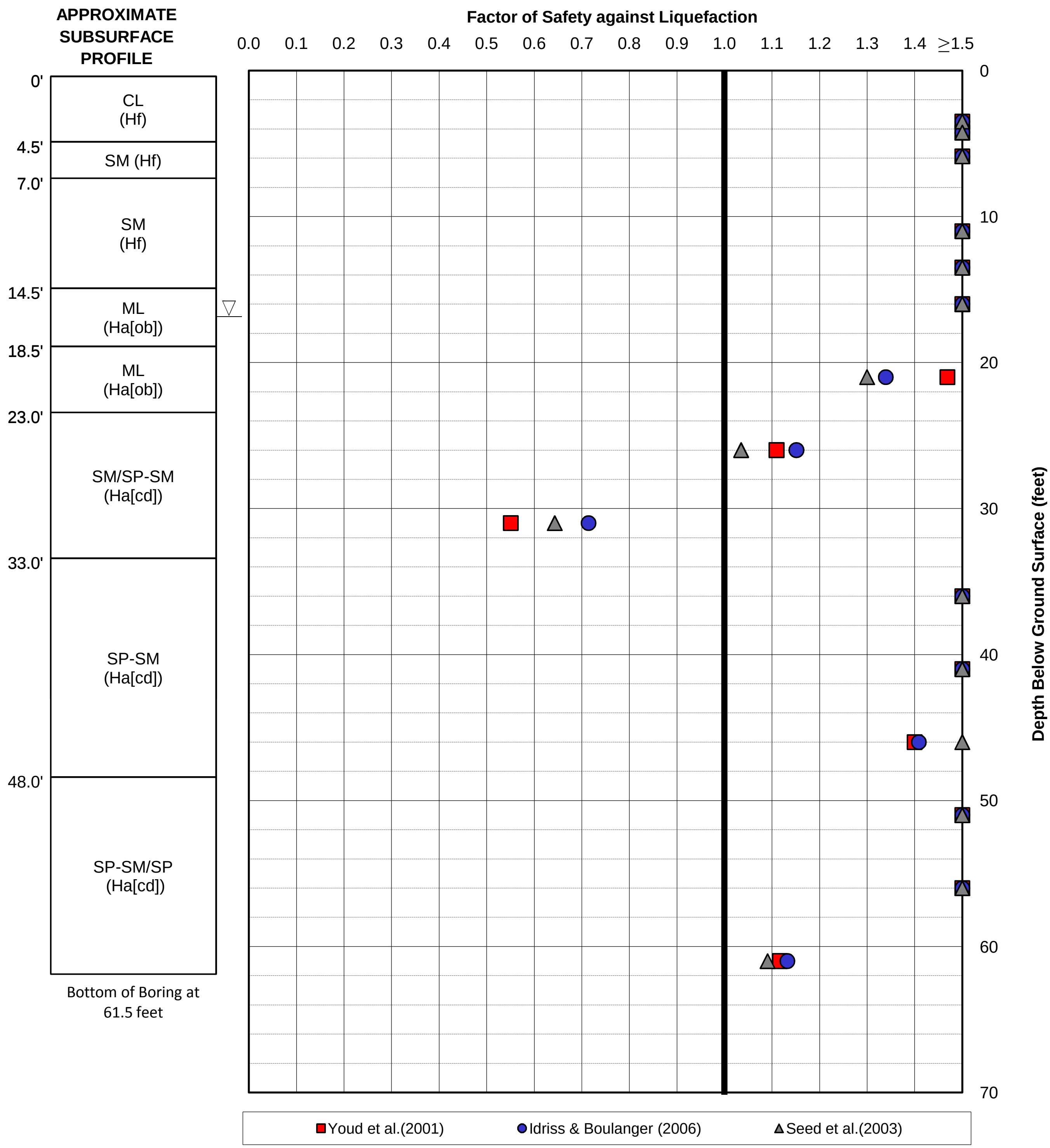
Skagit River Levee General Investigation
Skagit County, Washington

RESULTS OF LIQUEFACTION ANALYSES
BORING DD22-2 LANDWARD
144-YR RETURN PERIOD (OBE)

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. D-15



NOTES

1. See main text for references.
2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
3. Calculation of factors of safety based on M = 6.6, PGA = 0.20g

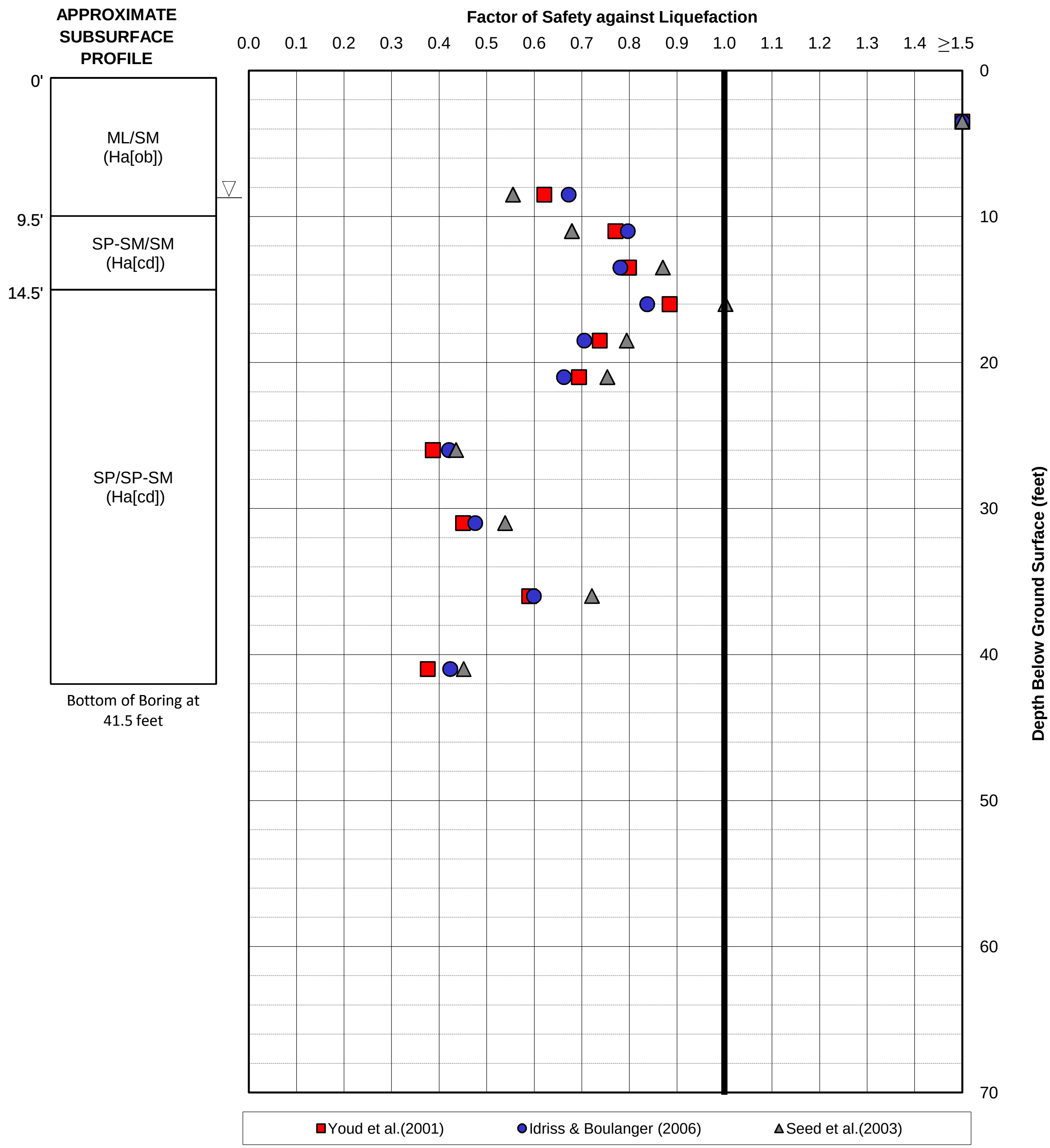
Skagit River Levee General Investigation
Skagit County, Washington

RESULTS OF LIQUEFACTION ANALYSES
BORING DD22-2 LEVEE
144-YR RETURN PERIOD (OBE)

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. D-16



NOTES

1. See main text for references.
2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
3. Calculation of factors of safety based on M = 6.6, PGA = 0.36g

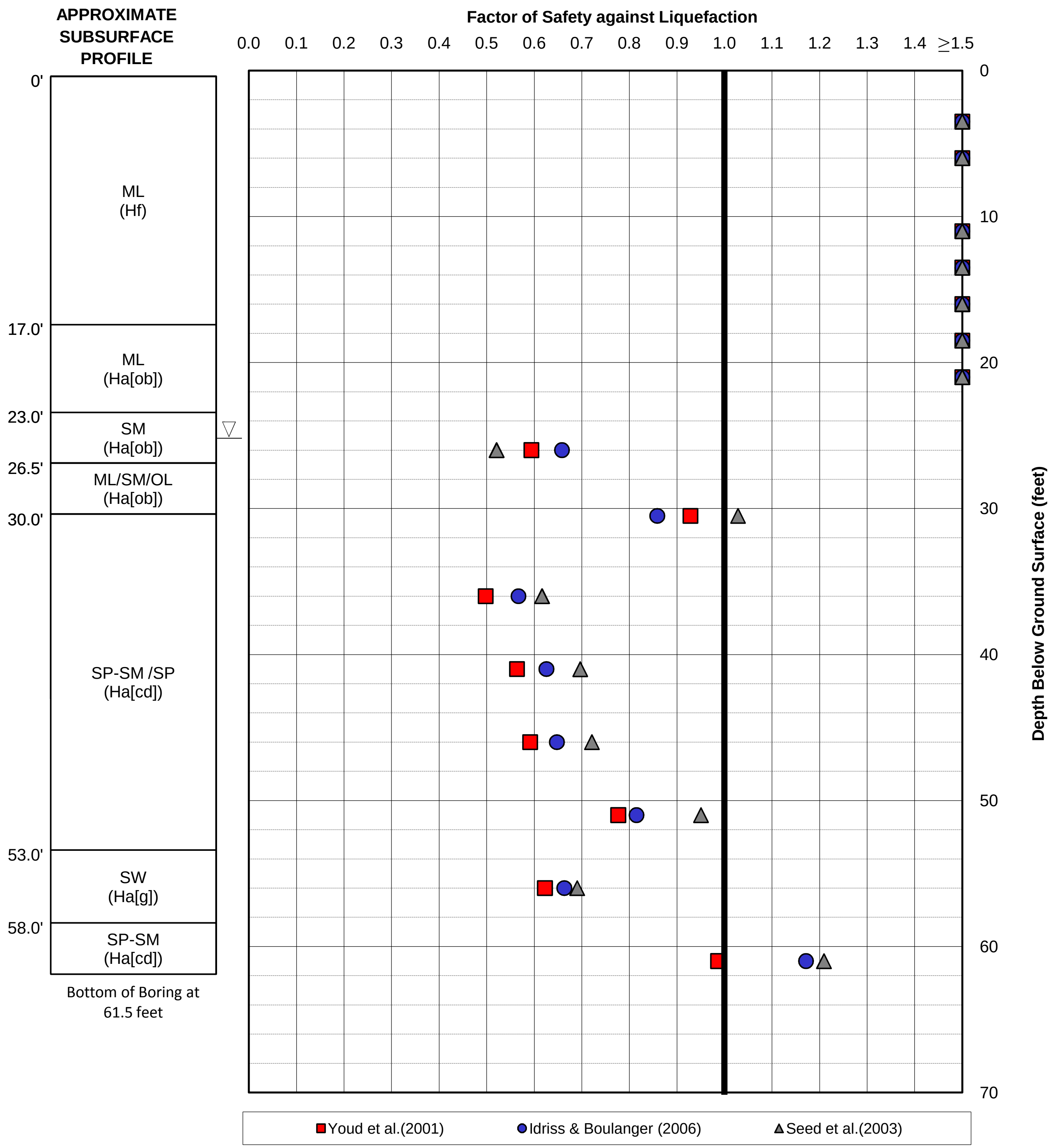
Skagit River Levee General Investigation
Skagit County, Washington

RESULTS OF LIQUEFACTION ANALYSES
BORING DD1-1 LANDWARD
975-YR RETURN PERIOD

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. D-17



NOTES

1. See main text for references.
2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
3. Calculation of factors of safety based on M = 6.6, PGA = 0.36g

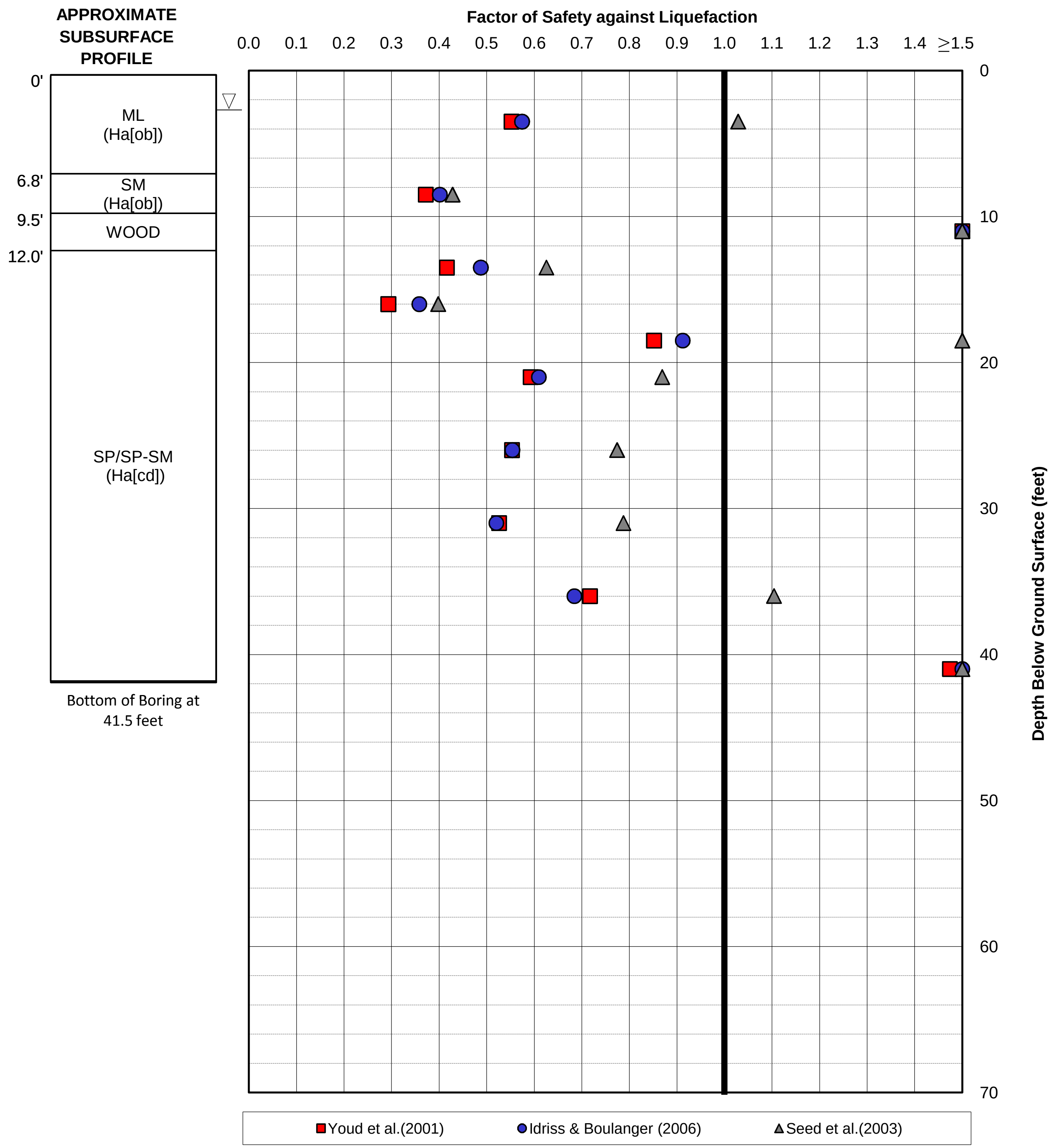
Skagit River Levee General Investigation
Skagit County, Washington

RESULTS OF LIQUEFACTION ANALYSES
BORING DD1-1 LEVEE
975-YR RETURN PERIOD

June 2010 | 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. D-18



NOTES

1. See main text for references.
2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
3. Calculation of factors of safety based on M = 6.6, PGA = 0.36g

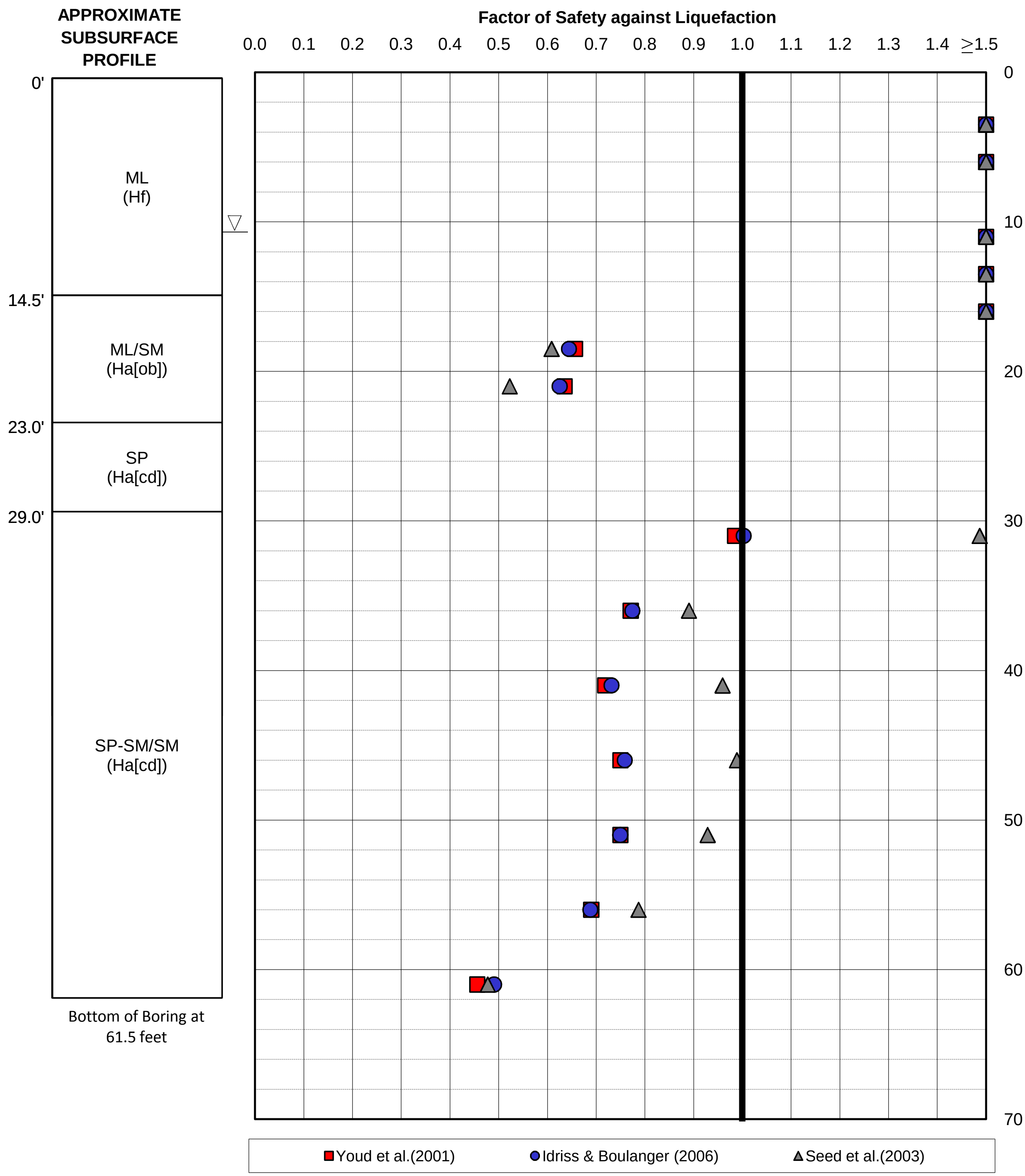
Skagit River Levee General Investigation
Skagit County, Washington

RESULTS OF LIQUEFACTION ANALYSES
BORING DD1-2 LANDWARD
975-YR RETURN PERIOD

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. D-19



NOTES

1. See main text for references.
2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
3. Calculation of factors of safety based on M = 6.6, PGA = 0.36g

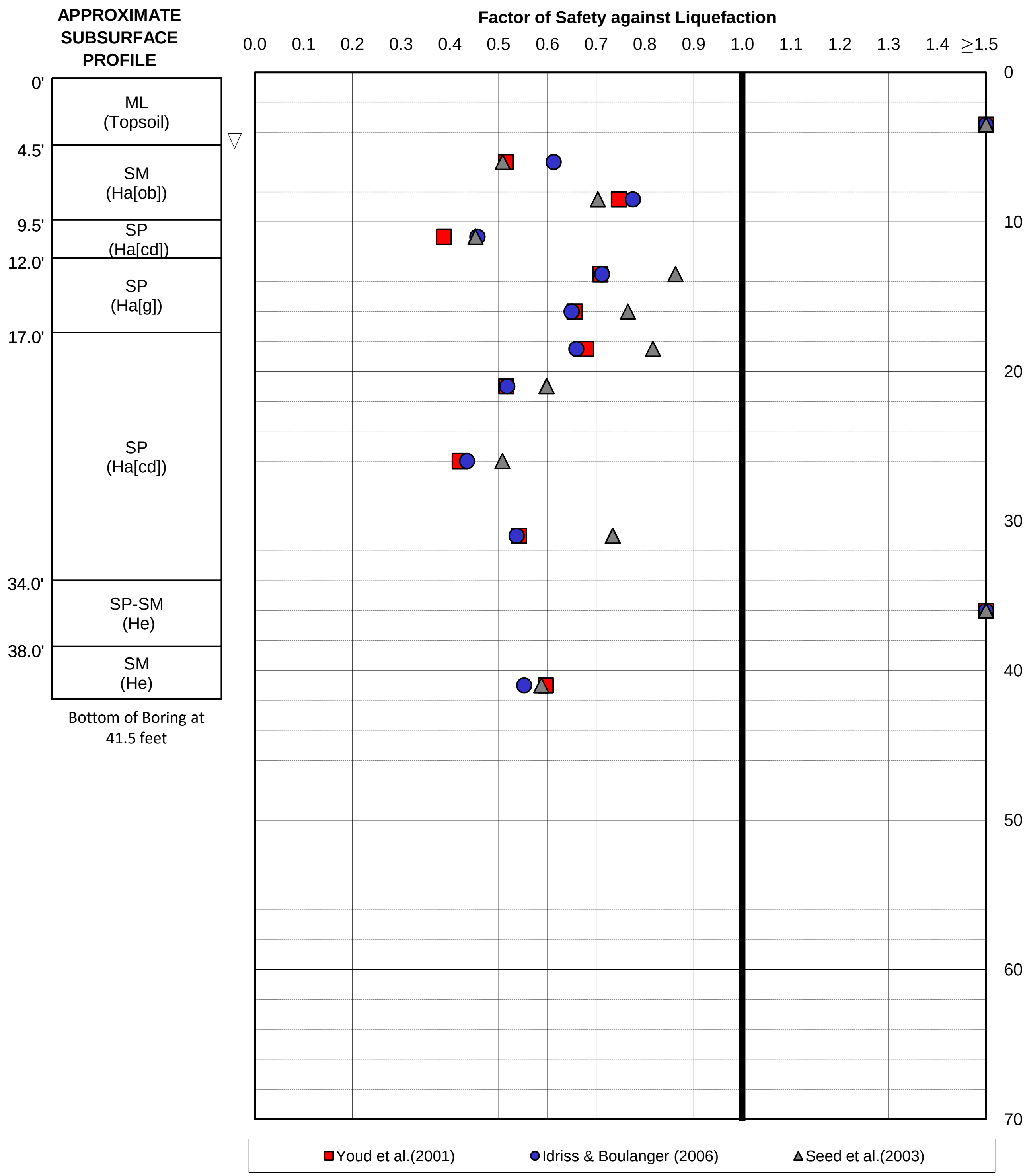
Skagit River Levee General Investigation
Skagit County, Washington

RESULTS OF LIQUEFACTION ANALYSES
BORING DD1-2 LEVEE
975-YR RETURN PERIOD

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. D-20



NOTES

1. See main text for references.
2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
3. Calculation of factors of safety based on M = 6.6, PGA = 0.36g

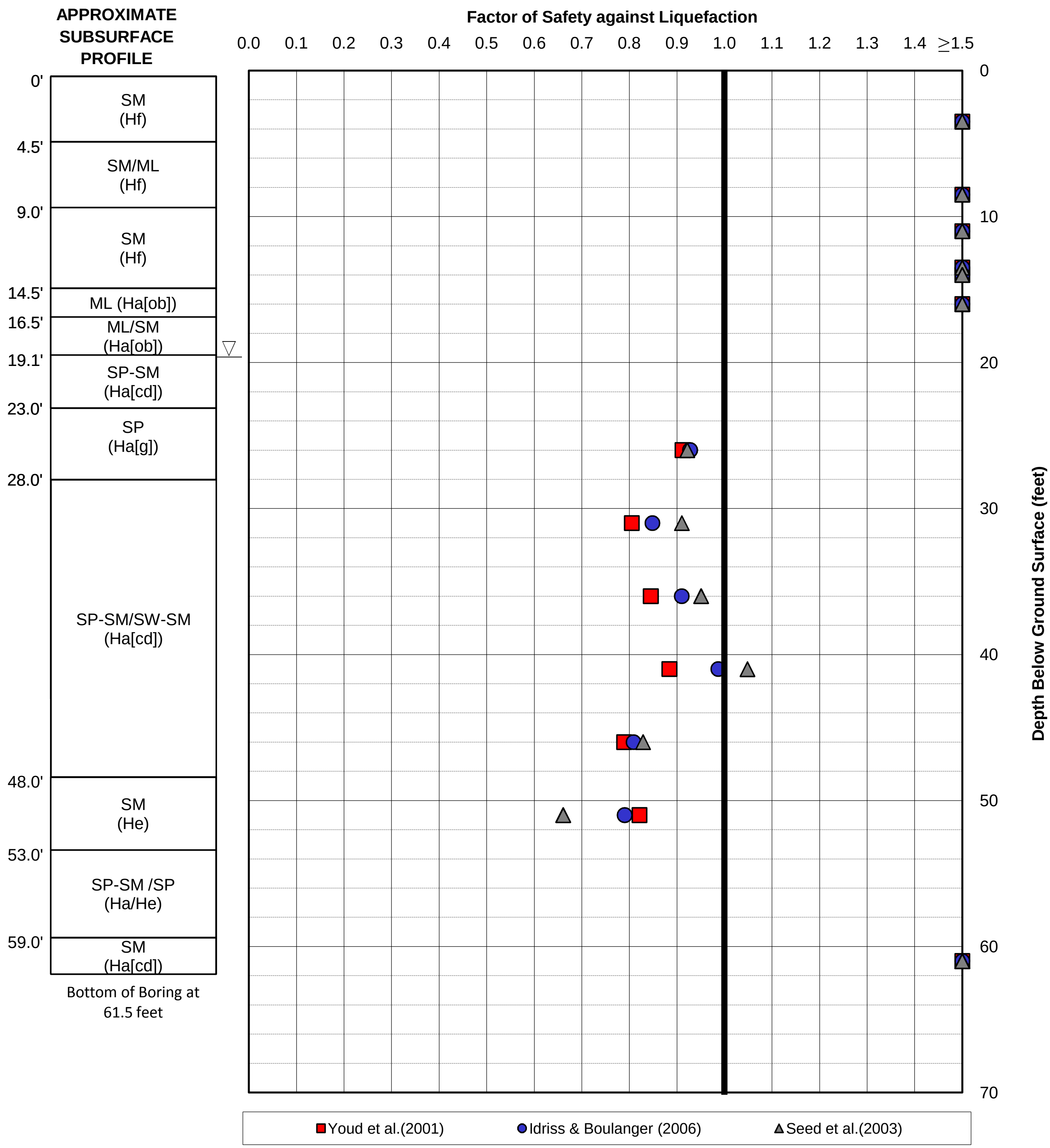
Skagit River Levee General Investigation
Skagit County, Washington

RESULTS OF LIQUEFACTION ANALYSES
BORING DD3-1 LANDWARD
975-YR RETURN PERIOD

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. D-21



NOTES

1. See main text for references.
2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
3. Calculation of factors of safety based on M = 6.6, PGA = 0.36g

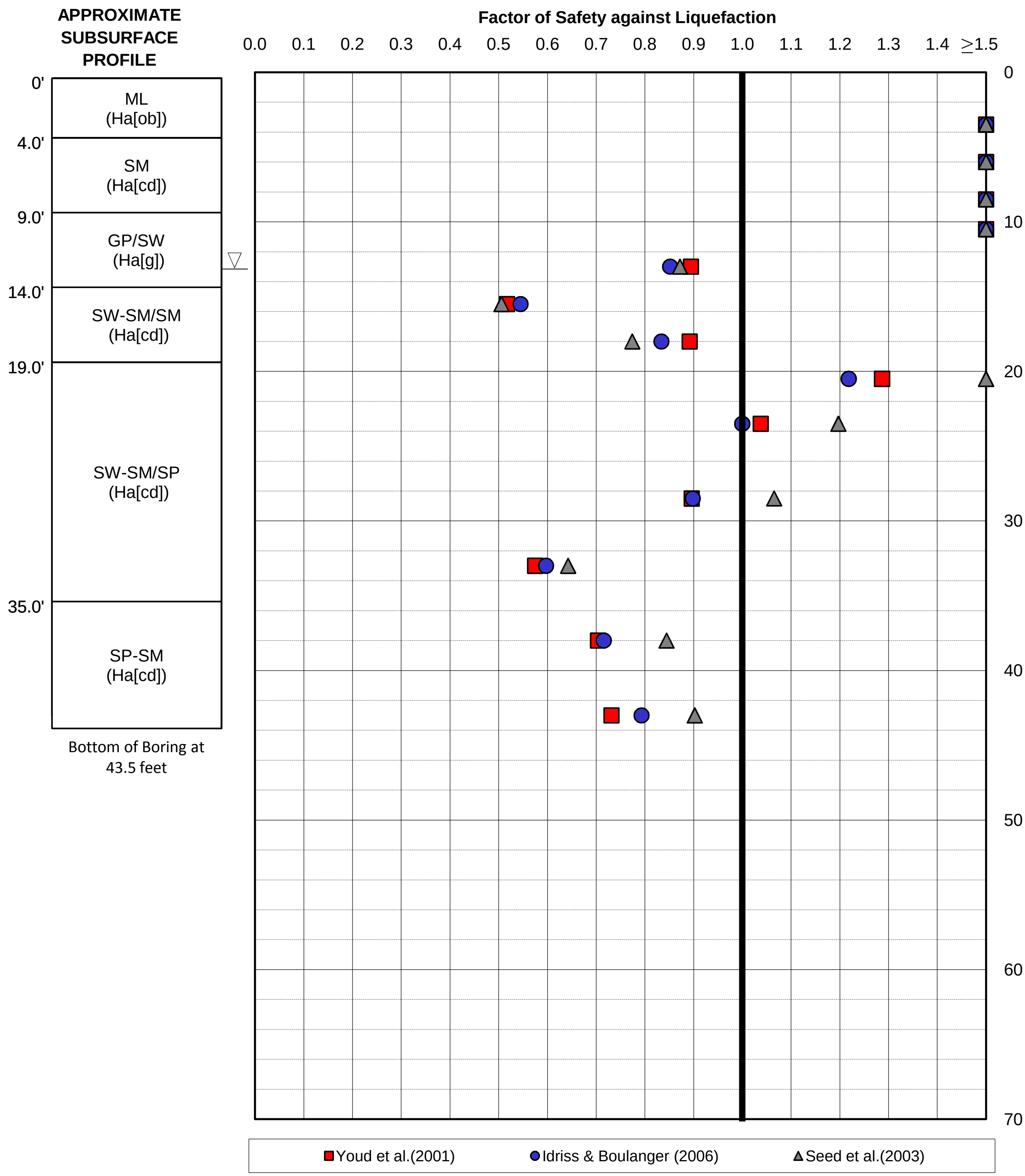
Skagit River Levee General Investigation
Skagit County, Washington

RESULTS OF LIQUEFACTION ANALYSES
BORING DD3-1 LEVEE
975-YR RETURN PERIOD

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. D-22



NOTES

1. See main text for references.
2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
3. Calculation of factors of safety based on M = 6.6, PGA = 0.36g

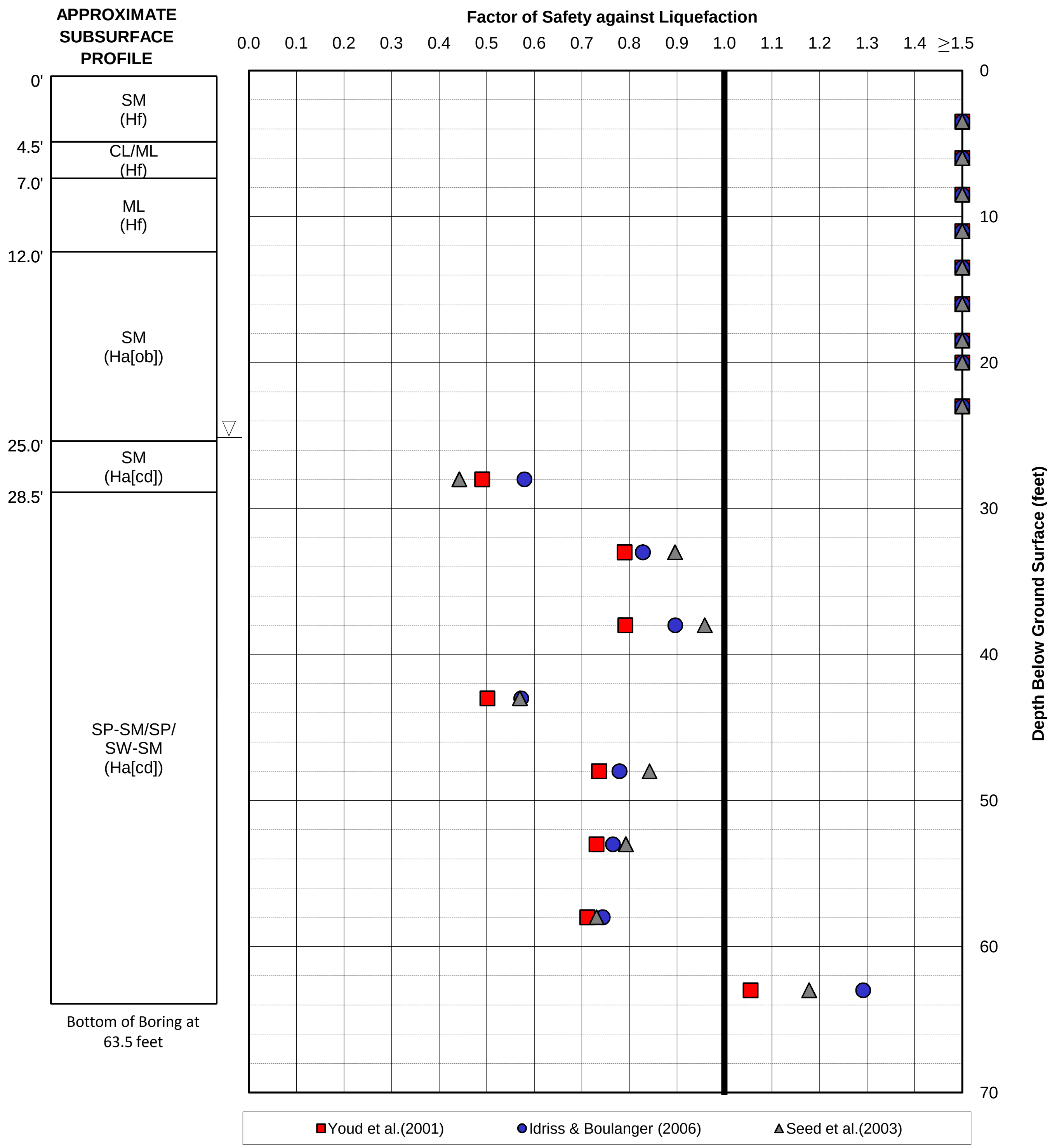
Skagit River Levee General Investigation
Skagit County, Washington

RESULTS OF LIQUEFACTION ANALYSES
BORING DD17-1 LANDWARD
975-YR RETURN PERIOD

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. D-23



NOTES

1. See main text for references.
2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
3. Calculation of factors of safety based on M = 6.6, PGA = 0.36g

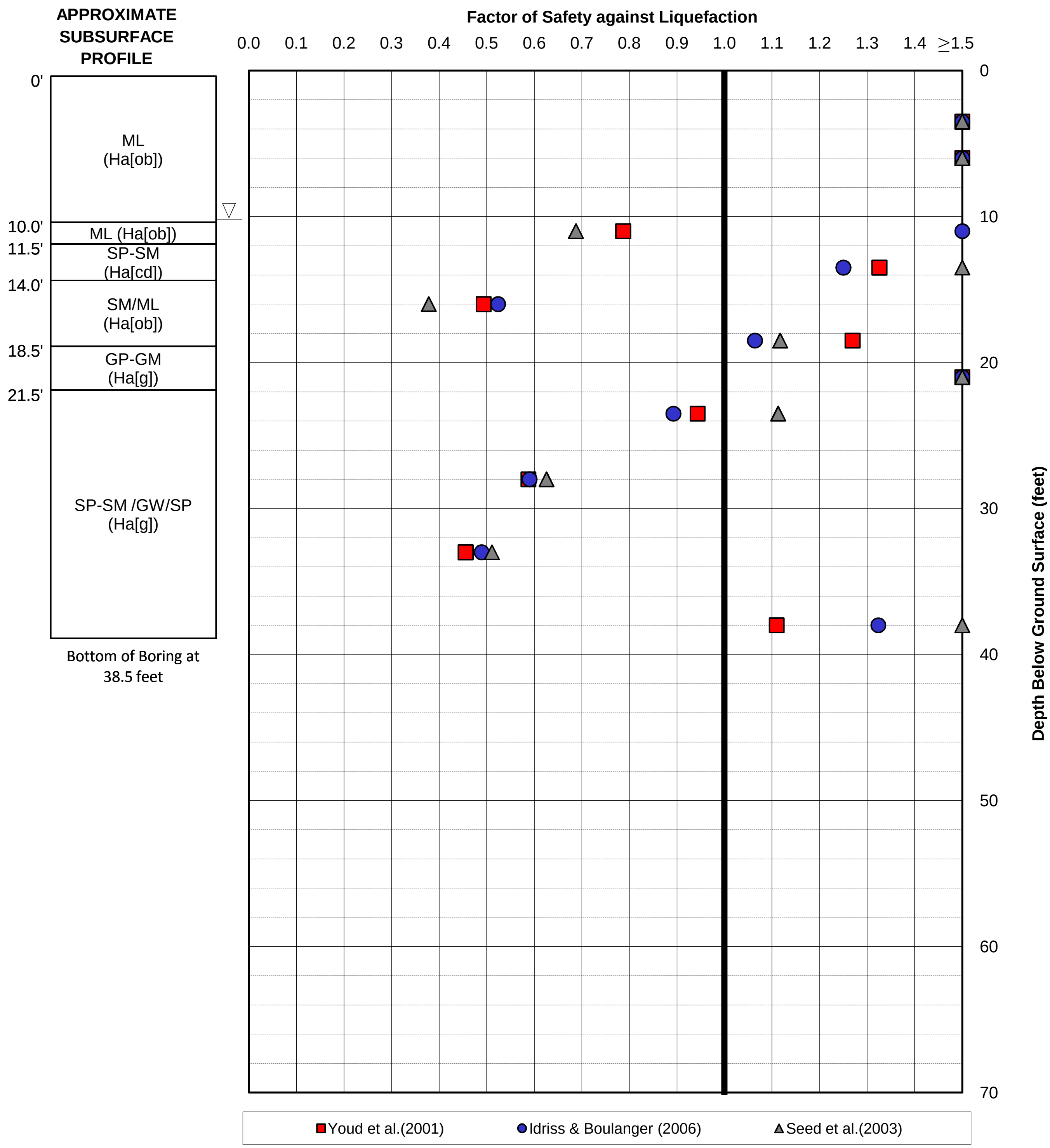
Skagit River Levee General Investigation
Skagit County, Washington

RESULTS OF LIQUEFACTION ANALYSES
BORING DD17-1 LEVEE
975-YR RETURN PERIOD

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. D-24



NOTES

1. See main text for references.
2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
3. Calculation of factors of safety based on M = 6.6, PGA = 0.36g

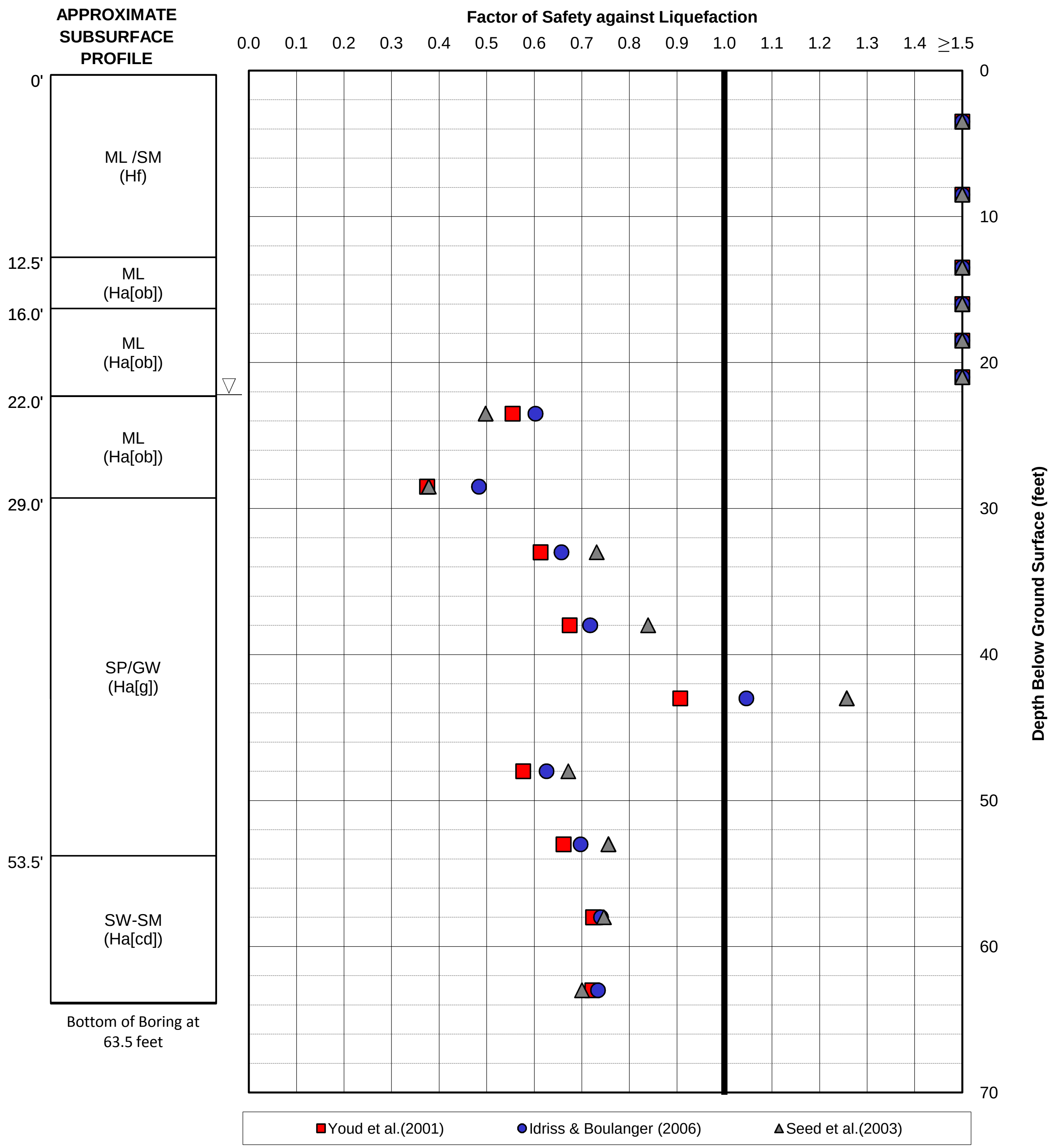
Skagit River Levee General Investigation
Skagit County, Washington

RESULTS OF LIQUEFACTION ANALYSES
BORING DD17-2 LANDWARD
975-YR RETURN PERIOD

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. D-25



NOTES

1. See main text for references.
2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
3. Calculation of factors of safety based on M = 6.6, PGA = 0.36g

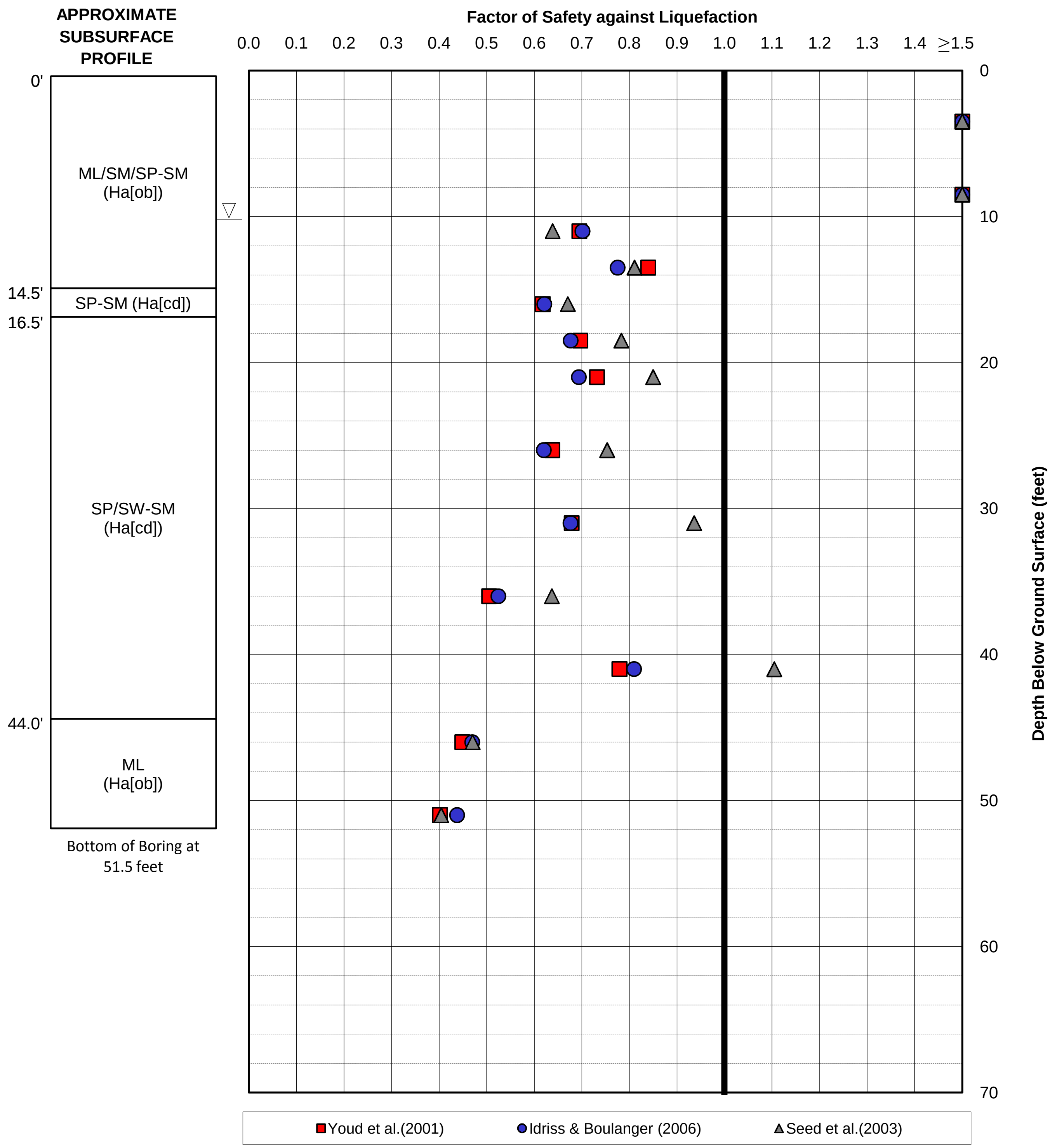
Skagit River Levee General Investigation
Skagit County, Washington

RESULTS OF LIQUEFACTION ANALYSES
BORING DD17-2 LEVEE
975-YR RETURN PERIOD

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. D-26



NOTES

1. See main text for references.
2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
3. Calculation of factors of safety based on M = 6.6, PGA = 0.36g

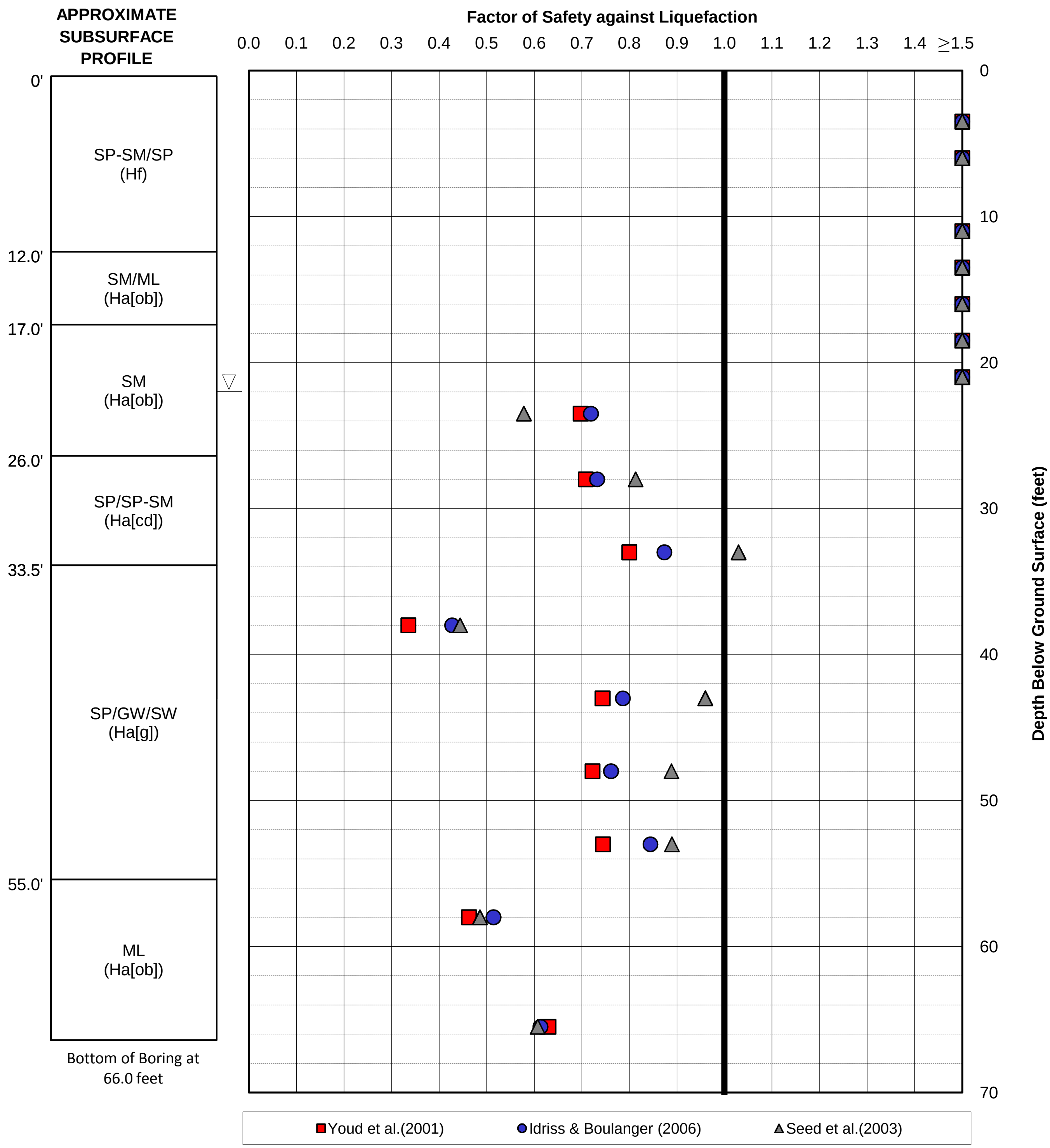
Skagit River Levee General Investigation
Skagit County, Washington

RESULTS OF LIQUEFACTION ANALYSES
BORING DD17-3 LANDWARD
975-YR RETURN PERIOD

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. D-27



NOTES

1. See main text for references.
2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
3. Calculation of factors of safety based on M = 6.6, PGA = 0.36g

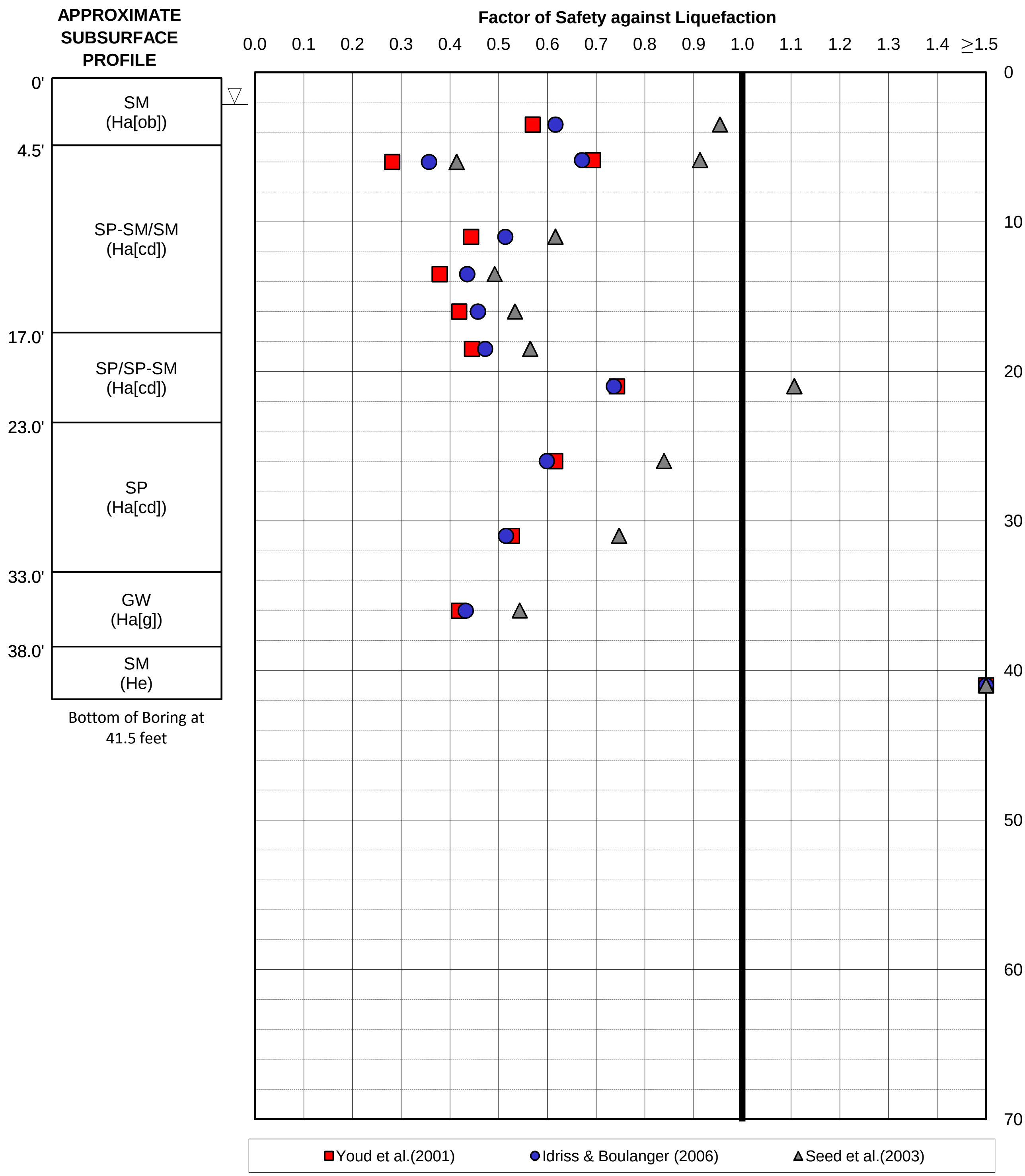
Skagit River Levee General Investigation
Skagit County, Washington

RESULTS OF LIQUEFACTION ANALYSES
BORING DD17-3 LEVEE
975-YR RETURN PERIOD

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. D-28



NOTES

1. See main text for references.
2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
3. Calculation of factors of safety based on M = 6.6, PGA = 0.36g

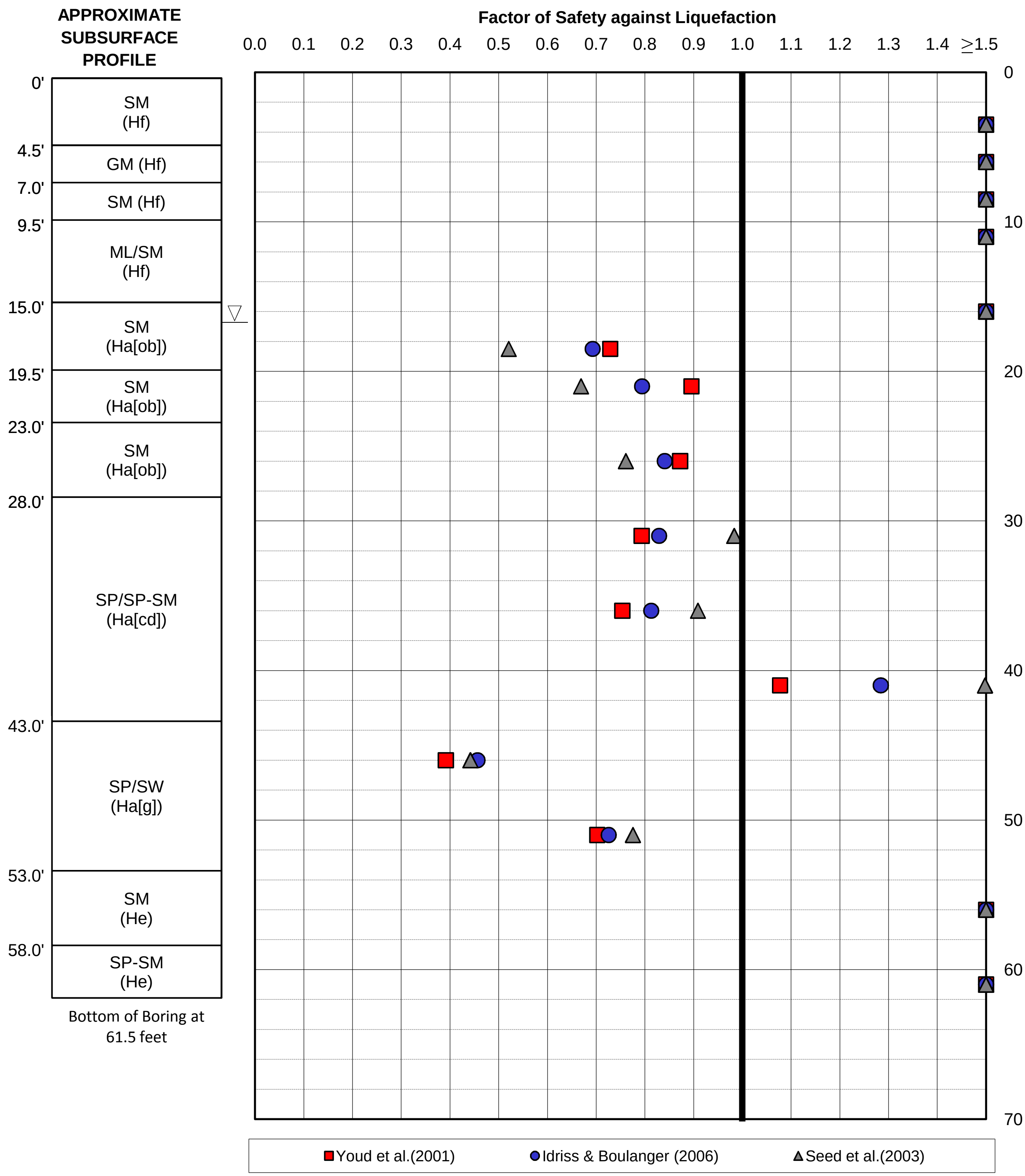
Skagit River Levee General Investigation
Skagit County, Washington

RESULTS OF LIQUEFACTION ANALYSES
BORING DD22-1 LANDWARD
975-YR RETURN PERIOD

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. D-29



NOTES

1. See main text for references.
2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
3. Calculation of factors of safety based on M = 6.6, PGA = 0.36g

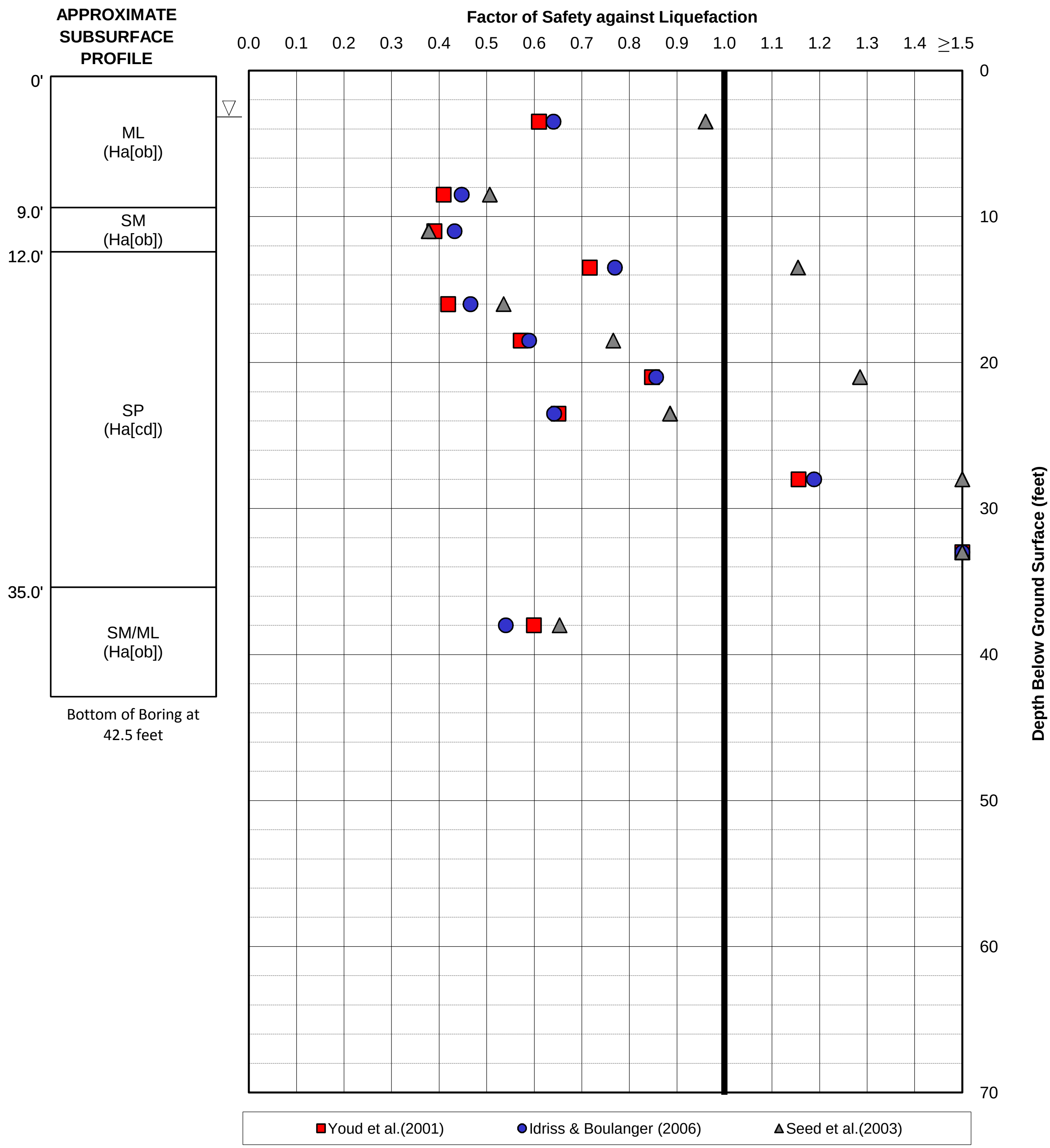
Skagit River Levee General Investigation
Skagit County, Washington

RESULTS OF LIQUEFACTION ANALYSES
BORING DD22-1 LEVEE
975-YR RETURN PERIOD

June 2010 | 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. D-30



NOTES

1. See main text for references.
2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
3. Calculation of factors of safety based on M = 6.6, PGA = 0.36g

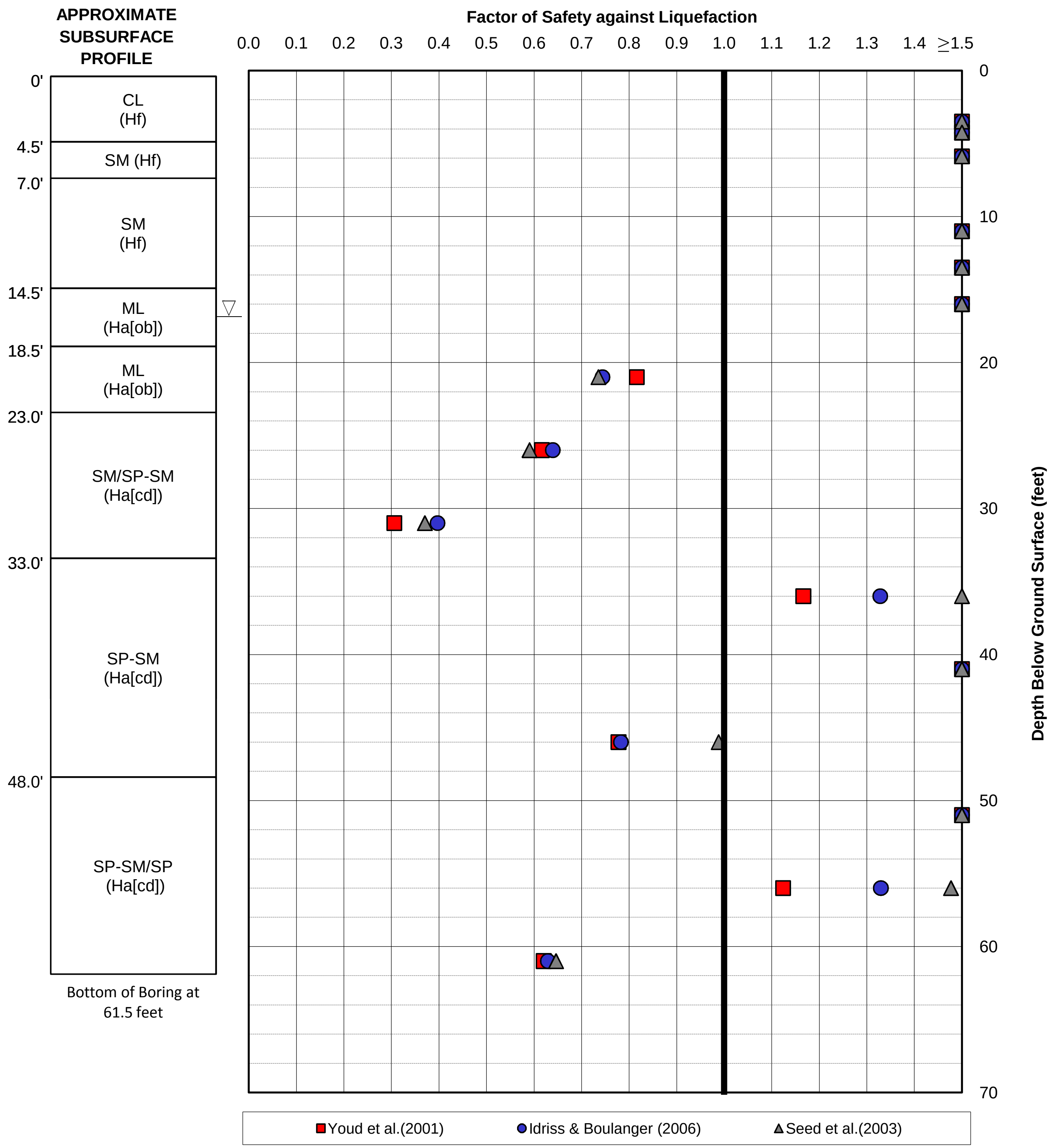
Skagit River Levee General Investigation
Skagit County, Washington

RESULTS OF LIQUEFACTION ANALYSES
BORING DD22-2 LANDWARD
975-YR RETURN PERIOD

June 2010 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. D-31



NOTES

1. See main text for references.
2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
3. Calculation of factors of safety based on M = 6.6, PGA = 0.36g

Skagit River Levee General Investigation
Skagit County, Washington

RESULTS OF LIQUEFACTION ANALYSES
BORING DD22-2 LEVEE
975-YR RETURN PERIOD

June 2010 | 21-1-21199-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. D-32

APPENDIX E

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL/ENVIRONMENTAL REPORT

Date: June 18, 2010
To: Mr. Daniel E. Johnson
U.S. Army Corps of Engineers,
Seattle District

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 which 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