Geotechnical Analysis and Levee Certification Report

North Shore Levee
Aberdeen and Hoquiam, Washington

For

KPFF Consulting Engineers, Inc.

April 26, 2017

GeoEngineers
Earth Science + Technology

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1.0 INTRODUCTION AND SCOPE OF SERVICES

This report provides geotechnical analysis for the City of Aberdeen North Shore Levee project in Aberdeen and Hoquiam, Washington. The City of Aberdeen (Aberdeen) and the City of Hoquiam (Hoquiam) are planning to construct approximately 5.6 miles of levees and floodwalls. The purpose of the project is to construct a Federal Emergency Management Agency (FEMA) accredited levee that will be considered by the National Flood Insurance Program in revising the flood insurance rate map (FIRM) for Aberdeen and Hoquiam. We previously completed a similar geotechnical report for an alternate levee alignment dated August 5, 2015.

The purpose of this report is to provide analysis demonstrating that the proposed levee and floodwall system will meet the geotechnical stability requirements of 44 Code of Federal Regulations (CFR) 65.10 based on the 100-year flood event. Additional requirements of 44 CFR 65.10 will be addressed in separate reports prepared by the team lead, KPFF Consulting Engineers (KPFF) and the team hydraulics engineer Watershed Science & Engineering (WSE). Our analysis is based on the Geotechnical Evaluation Guidance from the United States Army Corps of Engineers (USACE) Engineering Circular 1110-2-6067 "USACE Process for the National Flood Insurance Program (NFIP) Levee System Evaluation", USACE Engineering Manual 1110-2-1913 "Design and Construction of Levees", and sound engineering practices.

Our services have been provided in accordance with our agreement dated March 15, 2016. Our scope of services for the geotechnical analysis presented in this report includes:

- Reviewing existing subsurface data.
- Performing 18 subsurface explorations: 8 borings and 10 cone penetrometer tests (CPTs).
- Performing primary laboratory or index tests on representative soil samples including moisture contents, Atterberg Limits, and sieve analyses.
- Performing secondary strength and compressibility laboratory tests on representative soil samples.
- Performing stability and seepage analyses for 14 proposed levee cross sections under the three design conditions (end-of-construction, steady state seepage and rapid drawdown).
- Performing settlement analysis of the levee embankment to assess the potential settlement of the levee that could reduce freeboard over time.
- Developing geotechnical design recommendations for levee construction.
- Preparing this Geotechnical Analysis and Levee Certification Report summarizing the results of our exploration program, laboratory testing, analyses, and providing conclusions and recommendations.

2.0 DESIGN CONDITIONS

2.1. Design Hydraulic Conditions

Hydraulic conditions have been analyzed by WSE, and will be described in more detail in their accompanying report provided in the Conditional Letter of Map Revision (CLOMR) application.

The project is located between the Hoquiam and Wishkah rivers where they enter Grays Harbor and the Chehalis River. A Vicinity Map is provided as Figure 1. An overall Site Plan is presented in Figure 2 and an Index Sheet for the detailed site plans is presented in Figure 3. Detailed Site Plans are provided as Figures 4 through 12. The Hoquiam, Chehalis and Wishkah rivers are significantly tidally influenced within the project area. Hydraulic analysis has shown that variations in the water level in Grays Harbor influences predicted flood elevations more than variations in the flow of either the Hoquiam, Chehalis or Wishkah rivers. Accordingly, FEMA Base Flood Elevations (BFEs) in the project area have been determined based on coastal flooding criteria rather than riverine flooding.

The design stillwater BFE (100-year return period) within the project area has been determined to be Elevation 13.2 feet. Wave run up under a design storm has been predicted to be Elevation 14.2 feet. The top of the levees and floodwalls will be established at Elevation 15.2 feet. All elevations referenced in this report use the National American Vertical Datum of 1988 (NAVD88). The BFEs are based on coastal flooding and, as a result, are driven in a large part by the tide cycles. Accordingly, high water events that rise above the surrounding ground surface, at about Elevation 10 feet (NAVD88), are anticipated to recede within 4 to 6 hours.

2.2. Existing Site Conditions

The proposed alignment of the North Shore Levee is located within the cities of Aberdeen and Hoquiam on the north side of Grays Harbor and between the Hoquiam and Wishkah rivers. The proposed alignment extends through residential, commercial, and light industrial areas. Existing surface conditions are relatively flat and generally range between Elevation 10 and Elevation 15 feet (NAVD88).

Structures along Grays Harbor, the Wishkah River, and the Hoquiam River include automotive and railroad tracks and bridges, industrial buildings and abandoned timber piles that once supported riverbank structures. There are two highway bridges (Wishkah Street Bridge and Heron Street Bridge, both State Route 12), one residential street bridge (Youngs Street Bridge) and one railroad bridge (Puget Sound & Pacific Railroad) that cross the Wishkah River. One highway bridge crosses the Chehalis River (Highway 101) where it enters Grays Harbor. Two highway bridges (Simpson Avenue Bridge and Riverside Avenue Bridge, both Highway 101) cross the Hoquiam River. A seawall with riprap revetment at the base is also present along the Hoquiam River between these two bridges. In addition, old timber piles are present along the banks of the Wishkah River, Hoquiam River and in the harbor. The piles are generally located offshore and within the riverbank that is exposed during low tides.

2.3. Proposed Levee System

A 5.6-mile-long levee system consisting of a combination of earth embankment levees and various floodwalls (i.e., concrete, sheet pile, stop log closures) is proposed to provide flood protection for portions of Aberdeen and Hoquiam. The west end of the alignment consists of a 1.2-mile section on the left bank of the Hoquiam River. The center section of the alignment consists of a 3.2-mile long section between the Wishkah and Hoquiam rivers generally located parallel to the railroad tracks located inland of Grays Harbor. The east end of the alignment consists of a 1.2-mile section on the right bank of the Wishkah River. Both the eastern and western extents of the levee system will connect with natural high ground on the hills to the north of Aberdeen and Hoquiam. The levee system will intersect bridge approach embankments in three locations: the Riverside Avenue Bridge, the Heron Street Bridge, and the Wishkah Street Bridge. The crest elevation will be established at Elevation 15.2 feet. For our analysis, we have divided the proposed levee system into five reaches based on the observed subsurface conditions. These areas are shown on Figures

4 through 12 and are described in Table 1. Referenced project stationing has been estimated to the nearest 50 feet.

TABLE 1. LEVEE REACHES

Reach	Approximate Station Limits	Representative Cross Sections (Approximate Station)	General Description
Reach 1: Hoquiam Design Group	0+00 (High Ground Tie-In) to 80+00	1A (3+50), 1B (13+00), 1C (20+50), 1D (42+00), and 1E (57+00)	Reach 1 extends from the high ground tie-in at Broadway Avenue through residential neighborhoods and commercial and industrial areas generally along the Hoquiam River. The flood protection system will consist of earthen embankments, concrete and sheet pile floodwalls with stop log closures at some of the street intersections and modified existing bulkheads adjacent to Riverside Avenue.
Reach 2: Grays Harbor Design Group	80+00 to 120+00	2A (91+00), and 2B (100+50)	Reach 2 extends through industrial areas and is north of the railroad corridor. The flood protection system will consist of earthen embankments and concrete and sheet pile floodwalls with stop log closures at some of the street intersections.
Reach 3: Chehalis West Design Group	120+00 to 192+00	3A (155+00)	Reach 3 extends through industrial areas and is north of the railroad corridor. The flood protection system will consist of earthen embankments and concrete and sheet pile floodwalls with stop log closures at some of the street intersections.
Reach 4: Chehalis East Design Group	192+00 to 255+00	4A (192+50)	Reach 4 extends through industrial areas and is north of the railroad corridor. The flood protection system will consist of earthen embankments and concrete and sheet pile floodwalls with stop log closures at some of the street intersections.
Reach 5: Wishkah Design Group	225+00 to 297+50 (High Ground Tie-In)	5A (244+00), 5B (248+00), 5C (255+50), 5D (277+50), and 5E (291+00)	Reach 5 extends through residential neighborhoods, commercial, and industrial areas generally along the Wishkah River and ends at the high ground tie-in near Stewart Field. The flood protection system will consist of earthen embankments and concrete and sheet pile floodwalls with stop log closures at some of the street intersections.

3.0 LEVEE STRUCTURAL ANALYSIS

3.1. Embankment Protection and Scour

The BFE along Grays Harbor and along the Hoquiam, Chehalis and Wishkah rivers in the project area has been determined by WSE to be Elevation 13.2 feet. We understand from communication with WSE that this elevation is based on tidal flooding in Grays Harbor. In Reaches 2, 3, and 4, the North Shore Levee alignment is significantly inland from the water and wave run up or flowing flood water is not expected to

reach the levee. In Reaches 1 and 5, the levee is closer to the water, but the fetch is limited to the width of the Hoquiam and Wishkah rivers or a narrow section of Grays Harbor. Therefore, erosion from wind generated waves is not expected to be significant along the length of the proposed levee alignment and wave run-up on the levee prism or floodwalls is expected to be minor, if it occurs at all.

Modeling of the levee system by WSE indicates that shallow flooding along rivers might occur in the 100-year flood. Any overbank flows would be shallow and largely confined to street flooding less than 2 feet deep. Overbank flows from the Wishkah or Hoquiam rivers reaching the proposed levee are expected to have velocities of less than 0.9 feet per second. Based on our understanding of this potential hydraulic loading, it is our opinion that the proposed earth levees can be protected from erosion by maintaining a grass covering.

Two bridges cross the Wishkah River in the project area, the Wishkah Street Bridge and Heron Street Bridge. Washington State Department of Transportation (WSDOT) bridge inspection reports for these bridges were reviewed by WSE. These inspection reports include soundings of the river bottom. From this data, WSE concluded that the river bottom did not show a significant degradation in the riverbed elevation under either of the bridges, particularly in the most recent data from 1991 to 2011. The Chehalis River is regularly dredged by the USACE, indicating a long-term trend of natural aggradation of the river bottom. Based on this information, it is our opinion that the effects of long-term scour do not need to be included in our stability analyses.

3.2. Levee Crossings and Adjacent Structures

The impacts of adjacent structures on the levee, including roads, bridges, buildings, and utilities have been considered in our analysis. Structures that are constructed primarily of soil (i.e., roads, railroad embankments, and bridge approach embankments) were included in the stability analyses where appropriate. For example, where roads are located on top or adjacent to the levee or floodwall, the roadway is included in the analysis.

Significant structures that are adjacent to or cross the proposed levee alignment that are not constructed of soil include: the Wishkah Street Bridge (SR 12 West), the Heron Street Bridge (SR 12 East), multiple buildings between the bank of the Wishkah River and F Street, the railroad bridge, the Chehalis Bridge (SR 101), railroad embankments, the Simpson Avenue Bridge (SR 101), and the Riverside Avenue Bridge (SR 101). The bridge structures are confirmed, either through direct observation or review of as-built plans, to be supported on deep foundations. Structures supported on deep foundations will not interfere or add load to the levee structure or levee foundation. Accordingly, no additional structural analysis is warranted for these existing structures.

3.3. Embankment and Foundation Stability Analysis

3.3.1. Foundation Material Characteristics

3.3.1.1. *Geologic Setting*

The site is located on the north side of the Grays Harbor/Chehalis River. The geologic map "Geologic Map of the Humptulips Quadrangle and Adjacent Areas, Grays Harbor County, Washington" (Weldon W. Rau, 1986) indicates the soils at the site are Quaternary Deposits (Qd), which includes alluvium and glacial drift of alpine origin. The hills to the north of the western extent of the project area along the Hoquiam River where the high ground tie-in is located are mapped as the Montesano Formation (Tmss), which is described

as a medium- to fine grained sandstone and conglomerate. The Montesano Formation also borders a thin strip of the Quaternary Deposits along the edge of the Hoquiam River where Riverside Avenue is located.

3.3.1.2. *Subsurface Explorations*

Subsurface conditions along the proposed North Shore Levee alignment were explored by performing eight geotechnical borings using mud-rotary techniques, and advancing 10 Cone Penetrometer Tests (CPTs). The explorations occurred between July 25, 2016 and July 29, 2016. The locations of these explorations are shown on Figures 2 through 12. Additional details regarding our explorations and laboratory program are provided in Appendix A.

3.3.1.3. *Reviewed Subsurface Information*

We also reviewed existing subsurface information obtained internally and through a search of public records from WSDOT and the Washington Department of Natural Resources' Washington State Geologic Information Portal. Relevant documents included subsurface data and soils testing information from the 520 Pontoon Casting Facility, Aberdeen's Industrial Waterline investigation, and from design studies for the bridges that cross the Hoquiam, Chehalis and Wishkah rivers. A summary of the documents and the information used as reference and directly in our analysis is provided in Table 2.

TABLE 2. REVIEWED SUBSURFACE INFORMATION NEAR THE PROPOSED LEVEE

Document; Author	Date of Study	Pertinent Information
Geotechnical Analysis and Levee Certification Report – North Shore Levee; GeoEngineers, Inc.	August 2015	Subsurface soil conditions; consolidation lab test results; TXUU lab test results; index testing results including sieve analysis, moisture content determinations, and Atterberg limits
Aberdeen Industrial Waterline – Phase 2; Shannon & Wilson Inc.	March 2002	Subsurface soil conditions along Chehalis River and Port Industrial Road approximately from Wishkah River to 28th Street; index testing results including sieve analysis, moisture content determinations, and Atterberg limits; liquefaction analysis
Soils and Foundation Investigation Sanitary Sewer System Improvements for Aberdeen North of Chehalis River; Roger Lowe Associates	July 1977	Subsurface soil conditions; consolidation lab test results; TXUU lab test results; direct shear results; in-situ testing results (vane shear testing)
WSDOT – Simpson Ave Bridge	1976- 2004	Pile and drilled shaft foundation design plans, parameters and calculations including liquefaction analysis; subsurface conditions at the bridge crossing; in-situ testing results (vane shear testing); TXUU and TXCU lab testing data and results; index testing results including sieve analysis, moisture content determinations and Atterberg limits.
WSDOT – Aberdeen Hoquiam Couplet	1967-1997	Subsurface soil conditions; consolidation lab test results; TXUU and TXCU lab testing data and results

Document; Author	Date of Study	Pertinent Information
WSDOT – SR-101, OL-1680, SR 12 to SR 109 Aberdeen-Hoquiam EIS Scour Analysis – Grain Size Distribution	May 1994	Subsurface soil conditions; index testing results including sieve analysis, moisture content determinations, and Atterberg limits
Seismic Vulnerability Analysis of WSDOT Bridges Aberdeen, Washington; Shannon & Wilson, Inc.	June 1997	Bridge foundation plans for Aberdeen and Hoquiam; subsurface soil conditions; seismic evaluation; liquefaction analysis
SR 520 Pontoon Casting Facility, Aberdeen, Washington, Appendix A, Subsurface Explorations; Shannon & Wilson, Inc.	August 2010	Summary of strength test results from previous studies
Geotechnical Data Report, Volumes 1 & 2, SR 520 Pontoon Construction Design-Build Project, Aberdeen Log Yard; Landau Associates	August 2009	Index testing results; consolidation lab test results; TXUU and TXCU lab test results; in-situ testing results (pressure meter testing, vane shear testing, pilot infiltration testing)
Technical Memorandum, Preliminary Geotechnical Engineering Analyses, Civil Design Considerations, SR 520 Pontoon Construction Design/Build Project, Aberdeen Log Yard; Landau Associates	November 2009	Generalized soil profiles and descriptions of units modeled
Seismic Retrofit Study WSDOT SR 12/12S Wishkah River/Heron Street Bridge; Shannon & Wilson, Inc.	September 1999	Subsurface soil conditions along the Wishkah River at SR 12E Heron Street Bridge crossing
Preliminary Geotechnical Report, Seismic Retrofit Study WSDOT SR 101/115 Chehalis River Bridge; Shannon & Wilson Inc.	January 2000	Subsurface soil conditions along the Chehalis River at SR 101 Wishkah River Bridge crossing
Wishkah River Bridge #12/12N West Approach Replacement Foundation Report, WSDOT	November 1984	Subsurface soil conditions along the Wishkah River at SR 12W Wishkah River Bridge crossing

The reference material listed in Table 2 was reviewed for pertinent subsurface information to evaluate general geologic conditions and to evaluate site variability. A select number of the reviewed reference materials are used within this study in direct support of design soil properties and levee system analysis. The two subsurface soil studies referenced most in this report are the "Roger Lowe Associates, Soils and Foundation Investigation Sanitary Sewer System Improvements" report dated July 1977 and the GeoEngineers, Geotechnical Analysis and Levee Certification Report, North Shore Levee" dated August 2015. These studies are referred to in this report as the 1977 Lowe study and our 2015 study. The locations of explorations used directly to develop design soil properties are shown on Figures 2 through 12 and are included in Appendix B.

3.3.1.4. *Groundwater*

CPT data is interpreted to indicate a groundwater level at a depth of approximately 3 to 5 feet below the ground surface (bgs). Water levels in the borings could not be measured directly due to the drilling method used. Groundwater levels used during analysis are based on the anticipated flood conditions.

3.3.1.5. *Site Soils and Design Soil Parameters*

General

The site soils observed in our explorations consist of native alluvium typically overlain by a relatively thin (3- to 7-foot) layer of fill. The fill is thicker along the seawall bordering the Hoquiam River where up to 9.5 feet of fill was observed in explorations conducted for our 2015 study. We divided the project site into five general groups based on observed differences in alluvium soil type. These groups are: Hoquiam River (Reach 1), Grays Harbor (Reach 2), Chehalis River West (Reach 3), Chehalis River East (Reach 4), and Wishkah River (Reach 5).

Fill

Fill was observed in all reaches of the project, typically where the explorations were advanced in paved or previously developed areas. It is not clear how much fill is present in vacant lots or other undeveloped areas. The observed fill consisted of combinations of clay, silt, sand, gravel, organic matter, and small debris. Blow counts measured in the field within non-cohesive materials in this study as well as in our 2015 study are typically between 5 and 31. Blow counts measured in the field within cohesive materials in this study are typically between 0 and 3. In our explorations, the fill was consistently observed to be stronger than the underlying alluvium. The fill was also observed to be more permeable than the underlying alluvium except in portions of Reach 1 where the sea wall appears to be backfilled with clay on the landside. More permeable material at the landside ground surface has the effect of reducing hydraulic exit gradients and seepage under embankment levees or floodwalls will be managed by a cut off/inspection trench located on the flood side. Due to the variability in the location of the fill, we conservatively assumed that either no fill is present in our seepage and stability analyses or that the material properties for the fill are the same as the underlying alluvium.

Hoquiam River Alluvium (Reach 1)

The explorations in the project area near the Hoquiam River show a soil profile of interbedded alluvial fine grained soils (silts and clays) with various organics (grasses, logs, wood debris) overlain by approximately 1 to 9.5 feet of fill consisting of silt with organic matter, silty gravel with organic matter, silty gravel with sand, silty sand, silty sand with gravel, and lean clay with sand. The layering of the alluvial soils and organics varies along the length of the Hoquiam River, but generally can be divided into an upper layer of softer fine grained soils layers (upper alluvium), and a lower layer consisting of stiffer fine grained soils with intermittent layers of very loose to medium dense coarser grained soils (lower alluvium).

An exception to the general profile was observed in boring B-7, where a stiff clay layer is present to a depth of approximately 9.5 feet bgs behind the seawall along the Hoquiam River. The stiff clay generally overlies medium dense to dense silty sand to a depth of approximately 42.5 feet bgs. Below the silty sand, a very soft layer of silt and sandy silt is present to a depth of approximately 54 feet bgs and overlies what we interpret to be siltstone to the maximum depth explored for this boring. Boring B-7 indicates that a stiff clay soil is present immediately behind the seawall. the stiff clay is likely backfill placed and compacted behind the seawall during the seawall construction. Atterberg limits tests indicate that the fine-grained materials are high plasticity silts and clays. We did not consider the backfill material in our analysis and have based our design strength profile on data gathered from our other explorations, which we believe is conservative.

The upper alluvium generally consists of low plasticity silts (ML), and high plasticity silts (MH) with varying quantities of organics and sand particles. The consistency of the soils ranges from very soft to stiff. The upper alluvium generally extends from the ground surface to approximately Elevation -2 feet. Blow counts measured in the field for this material are generally between 1 and 2. Based on unconsolidated undrained triaxial (TXUU) testing, these cohesive materials have an undrained shear strength ranging from 205 pounds per square foot (psf) at approximately Elevation 0 feet to 881 psf at approximately Elevation 7 feet.

The lower alluvium includes layers of low plasticity silts (ML) and high plasticity silts (MH), with intermittent layers of silty sand and sand with silt. The consistency of the soils ranges from very soft to stiff, and very loose to medium dense. The lower alluvium is generally below approximately Elevation -2 feet. Blow counts measured in the field for this material are generally between 0 (weight of hammer) and 3 in the fine-grained alluvium and 0 (weight of hammer) and 24 in the coarse-grained alluvium. Based on TXUU testing the cohesive materials have an undrained shear strength ranging between 503 psf at approximately Elevation -10 feet and 1,435 psf at approximately Elevation -20 feet.

Data from the CPT explorations were also used to evaluate the soil strength properties using correlations presented by NCHRP Project 20-05 report. The correlation uses a bearing factor (N_{kt}) that is calibrated to the TXUU data. An N_{kt} ranging from 18 to 21 was determined to provide the best fit for calibrating the CPT data with the TXUU lab results. A range of N_{kt} considered typical is between 10 and 20. Higher ranges of N_{kt} tend to indicate higher plasticity soils and provide lower, more conservative estimates of undrained shear strength. Figure A-54 shows the calibrated CPT data, TXUU lab results, and strength properties used in design plotted against elevation for the Hoquiam River area (Reach 1).

The unit weight for alluvium was also evaluated from the CPT data using correlations published in the NCHRP project 20-05 report and calibrated to densities measured from Shelby tube samples. A unit weight of 102 and 109 pounds per cubic foot (pcf) was used for the upper and lower alluvium, respectively.

Grays Harbor Alluvium (Reach 2)

The explorations in the project area inland from Grays Harbor show a soil profile of alluvial silts and clays containing some sand and organics (i.e., peat and wood), interbedded with sand containing varying amounts of silt (i.e., SP, SP-SM, SM). We divided the soils into two groups: fine grained alluvium and sandy alluvium. Fine grained alluvium was typically present within the upper portion of the profile. Below the upper portion of the profile the fine grained and sandy alluvium soil units were observed in alternating layers throughout the depth of the explorations with more sandy alluvium at depth. As expected in an alluvial soil profile, the depth and thickness of the layers of soils varies along the length of the Grays Harbor and inland.

The fine-grained alluvium consists of sandy silt to clayey silt, high and low plasticity silts with organics as well as with interbeds of sensitive fine grained materials and organic material. Borings in Reach 2 indicate these units consist primarily of high plasticity silts (MH) and low plasticity silts (ML) typically with occasional organic matter (i.e., organic fibers/fragments and wood fragments), and trace amounts of sand. Interbeds of organic silts (OH) and organic matter were also observed.

The fine-grained alluvium was observed from the fill to approximately Elevation -16 feet. Blow counts measured in the field for this material are generally between 1 and 4. Based on TXUU testing these cohesive materials have an undrained shear strength ranging between 321 psf at approximately Elevation 2 feet

and 1,077 psf at approximately Elevation -10 feet. Data from the CPT explorations was also used to evaluate the soil strength properties using the same methods described for the Hoquiam alluvium. An N_{kt} ranging from 13 to 16 was determined to provide the best fit for calibrating the CPT data with the TXUU lab results from this study. Figure A-55 show the calibrated CPT data, TXUU lab results and strength properties of the fine-grained alluvium used in design plotted against elevation for the Grays Harbor area.

The sandy alluvium consists primarily of silty sand with cleaner layers of sand, observed to include organic matter (grass or wood) and interbeds of sandy silt. Blow counts between 0 (weight of hammer) and 6 were measured in the field for this material. Based on published correlations (Meyerhof 1956; Peck et al. 1974) for non-cohesive materials, the measured blow counts correspond to a friction angle of about 28 to 30 degrees. We used a friction angle of 29 degrees and a unit weight of 109 pcf to model the sandy alluvium in Reach 2.

Chehalis West Alluvium (Reach 3)

The explorations in the project area inland from Grays Harbor and along the mouth of the Chehalis River show a soil profile of alluvial silts and clays containing varying amounts of sand, gravel, and organics (i.e., peat and wood), as well as interbeds of organic matter and sand - typically silty sand - containing varying amounts of silt or clay (i.e., SP, SP-SM, SM). We divided the soils into two groups: fine grained alluvium and sandy alluvium. Fine grained alluvium was typically present throughout the profile with thicker sandy alluvium layering present approximately between Elevation -27 feet and -45 feet. As expected in an alluvial soil profile, the depth and thickness of the layers of soils varies along the length of the reach.

The fine-grained alluvium consists of interbedded layers of sandy silt to clayey silt, sensitive fine grained materials and organic material. Borings indicate these units consist of layers of organic silts (OH), organic layers (i.e., peat and wood logs), high plasticity silts (MH) and low plasticity silts (ML) varying amounts of sand, gravel and organic matter.

Soils reported in the 1977 Lowe study were consistent with the soils we observed within Reach 3. We used this lab and field testing program to help confirm the characteristics of the soils encountered in explorations conducted for this study and to calibrate CPT data collected within this reach.

The fine-grained alluvium is generally present throughout the soil profile. Blow counts measured in the field for this material are generally between 2 and 9. Based on TXUU testing performed in our 2015 study, the cohesive soils within Reach 3 have an undrained shear strength of approximately 593 psf at approximately Elevation -1.5 feet. The undrained shear strength measured in our 2015 study is consistent with TXUU results from the 1977 Lowe study. Data from the CPT explorations was used to evaluate the soil strength properties using the same methods described earlier. An N_{kt} ranging from 13 to 15 was determined to provide the best fit for calibrating the CPT data with the TXUU lab results from this study as well as the lab results presented in our 2015 study, Shannon & Wilson (2009), and the 1977 Lowe study. Figure A-56 shows the calibrated CPT data, TXUU lab results, field vane shear test results (1977 Lowe study), and the strength properties of the fine-grained alluvium used in design plotted against elevation for the Western portion of the levee system along the Chehalis River (Reach 3). Figure A-57 shows this same data plus data from the Shannon and Wilson Study for the WSDOT Pontoon Casting Facility.

The sandy alluvium consists primarily of silty sand, and sand with silt. A typical blow count of 20 was measured in the field for this material. Based on published correlations (Meyerhof 1956; Peck et al. 1974)

for non-cohesive materials, the measured blow counts correspond to a friction angle of about 30 to 36 degrees. We used a friction angle of 33 degrees and a unit weight of 107 pcf to model the sandy alluvium in Reach 3.

Chehalis East Alluvium (Reach 4)

The explorations in the project area along the Chehalis River show a soil profile of alluvial silts and clays containing varying amounts of sand, gravel, and organics (i.e., peat and wood), as well as interbeds of organic matter and sand containing varying amounts of silt (i.e., SP, SP-SM, SM). We divided the soils into two groups: fine grained alluvium and sandy alluvium. Fine grained alluvium was typically present throughout the profile with thicker layers of sandy alluvium layering present below about Elevation -22 feet. As expected in an alluvial soil profile, the general depth and thickness of the layers varies along the length of the reach.

The fine-grained alluvium consists of interbedded layers of sandy silt to clayey silt, sensitive fine grained materials and organic material. Borings from our 2015 study in Reach 4 indicate these units consist of layers of organic silts (OH), organic layers (i.e., peat and wood debris [PT/WD]), high plasticity silts (MH) and low plasticity silts (ML) with varying amounts of sand and organic material.

Soils reported in 1977 Lowe study were consistent with the soils encountered within Reach 4 from our 2015 study. Because of the similarity in the observed soils, data from the 1977 Lowe study was used in part to calibrate CPT data collected within this reach.

The fine-grained alluvium is generally present throughout the soil profile as previously mentioned. Blow counts measured in the field for this material are generally between 0 (weight of hammer) and 5. Based on TXUU testing performed in our 2015 study, the cohesive materials have an undrained shear strength of approximately 593 psf approximately at Elevation -15 feet. The undrained shear strength measured in the 2015 study is consistent with TXUU results from the 1977 Lowe study. Data from the 2015 CPT explorations was used to evaluate the soil strength properties using the same methods described for the other reaches. An N_{kt} generally ranging from 13 to 24 was determined to provide the best fit for calibrating the CPT data with the TXUU lab results from this study as well as the lab results from our 2015 study and the 1977 Lowe study. Figure A-58 shows the calibrated CPT data, TXUU lab results (from our 2015 study and from the 1977 Lowe study), and strength properties of the fine-grained alluvium used in design plotted against elevation for the eastern portion of the levee system along the Chehalis River area.

The sandy alluvium consists primarily of silty sand, and sand with silt, but was also observed to include small lenses of silt or organic matter (grass). Blow counts typically between 6 and 12 were measured in the field for this material. Based on published correlations (Meyerhof 1956; Peck et al. 1974) for non-cohesive materials, the measured blow counts correspond to a friction angle of about 30 to 36 degrees. We used a friction angle of 30 degrees and a unit weight of 99 pcf to model the sandy alluvium in Reach 4.

Wishkah River Alluvium (Reach 5)

The explorations in the project area along the Wishkah River show a soil profile of interbedded alluvial fine grained soils (silts and clays) with various organics (grasses, logs, wood debris) overlain by approximately 2.5 to 4.5 feet of a granular fill. The layering of the alluvial soils and organics varies along the length of the Wishkah River, but generally can be divided into an upper layer of fine grained soils with significant amounts

of organics (upper alluvium), and a lower layer consisting primarily of fine grained soils and clays with less organics (lower alluvium). Atterberg limits tests indicate that the fine-grained materials are high plasticity silts and clays.

The upper alluvium consists of high plasticity silts (MH), organic silts and clays (OH), wood debris/logs, and peat (PT). The upper alluvium extends from the ground surface to approximately Elevation -2 feet. Blow counts measured in the field for this material are generally between 0 (weight of hammer) and 4. Based on TXUU testing, these cohesive materials have an undrained shear strength ranging from 256 psf at approximately Elevation 2 feet to 519 psf at approximately Elevation 7 feet.

The lower alluvium includes layers of high plasticity silts (MH), fat clay (CH), organic silt (OH), wood debris, and peat (PT). The lower alluvium is generally below Elevation -2 feet. Blow counts measured in the field for this material are between 0 (weight of hammer) and 3. Based on TXUU testing these cohesive materials have an undrained shear strength ranging between 222 psf at approximately Elevation -19 feet and 641 psf at approximately Elevation -18 feet.

Data from the CPT explorations was used to evaluate the soil strength properties of the alluvium as described previously for the other reaches. An N_{kt} ranging from 12 to 21 was determined to provide the best fit for calibrating the CPT data with the TXUU lab results. Figure A-59 show the calibrated CPT data, TXUU lab results (from our 2015 study, and from the 1977 Lowe study), and strength properties of the fine-grained alluvium used in design plotted against elevation for the portion of the levee system along the Wishkah River area.

The unit weight for alluvium was also evaluated from the CPT data using correlations published in the NCHRP project 20-05 report and calibrated to densities measured from Shelby tube samples. A unit weight of 93 and 94 pcf was used for the upper and lower alluvium, respectively.

Levee Embankment Fill

Levee embankment fill placed as part of this project will be a silty/clayey sand. Specific recommendations for levee embankment fill have been provided in our report "Preliminary Design and Construction Recommendations Floodwalls and Embankment Levees North Shore Levee Aberdeen and Hoquiam, Washington" dated April 26, 2017. In addition to meeting the more stringent specification, we recommend this material also meet the requirements of WSDOT Standard Specification 9-03.14(3) (Common Borrow). The WSDOT Geotechnical Design Manual (GDM) presumes that common borrow has a friction angle between 30 and 34 degrees and a unit weight between 115 and 130 pcf. We used a friction angle of 34 degrees and a unit weight of 120 pcf to model the levee embankment fill.

3.4. Embankment Seepage

3.4.1. Seepage Analysis Method

Groundwater flow through each design section was analyzed using the computer program Seep/W (GEO-SLOPE International, Ltd., 2012). Seep/W is used to analyze a numerical groundwater flow model using groundwater flow equations with the finite-element method. We used the program to model the proposed levee sections as a 2-dimensional cross section. The design sections were analyzed under steady state conditions to estimate seepage and uplift forces. Alluvial foundation soils were assumed to be fully saturated.

Horizontal hydraulic conductivity or K_h values for the soils were selected based on correlations with coefficient of consolidation measurements, soil classifications, and field observations using guidance from existing literature (Powers, et al. 2007). Observations from the explorations were also used to estimate the anisotropy, or hydraulic conductivity ratio (horizontal hydraulic conductivity divided by vertical hydraulic conductivity, K_h/K_v), for the generalized soil unit. The hydraulic conductivity at saturation (K-Sat), hydraulic conductivity ratio (K_h/K_v), volumetric water content (θ), coefficient of volume compressibility (m_v), used in the analyses are shown on the output Figures S-1A through S-5E.

For our analysis, we assumed that the groundwater on the land side of the levee is located at the ground surface and that steady state seepage develops in the profile. The base flood is tidally influenced and, therefore, is not likely to persist for more than about 6 hours. Based on these factors, it is our opinion that it is unlikely that full steady state seepage conditions will develop in the levee. Accordingly, we consider our analysis to be conservative.

3.4.2. Analysis Results

The simulated head equipotentials for the design sections are shown in Figures S-1A through S-5E. The color shading in the figures represents the regions between the equipotentials. Where multiple cross sections were evaluated in a reach, the critical cross section with regard to seepage forces and seepage flow is reported in Table 3.

TABLE 3. SEEPAGE SUMMARY

Analysis Reach (Location)	Critical Section	Seepage per 100 feet of Levee (ft^3/hr)	Vertical Exit Gradient at Landside Toe (ft/ft)	Exit Velocity at Landside Toe (ft/sec)
Reach 1 (0+00 to 80+00)	1C (20+50)	$8.75x10^{-5}$	0.40	$7.08x10^{-10}$
Reach 2 (80+00 to 120+00)	2A (91+00)	$3.06x10^{-4}$	0.30	$3.58x10^{-10}$
Reach 3 (120+00 to 192+00)	3A (155+00)	$2.66x10^{-2}$	0.36	$7.29x10^{-8}$
Reach 4 (192+00 to 255+00)	4A (192+50)	$8.58x10^{-3}$	0.14	$1.83x10^{-8}$
Reach 5 (225+00 to 297+50)	5C (255+50)	$7.90x10^{-4}$	0.31	$5.21x10^{-10}$

As shown above, the maximum exit velocity is estimated to be $7.29x10^{-8}$ ft/s, or more than an order of magnitude below the transport velocity for silt or clay. The maximum vertical exit gradient is estimated to be 0.40, below the USACE's recommended limit of 0.5. Accordingly, it is our opinion that the risk of piping, boiling, or soil transport due to seepage forces is low.

The analyzed section for Reach 3 is based on a typical levee prism with a 10-foot crest, 2H:1V slopes, and an existing ground surface Elevation of 11 feet. There are areas within Reach 3 where the existing ground surface is lower than Elevation 11 feet, resulting in a taller levee segment. Predicted vertical exit gradients for these taller segments can approach or exceed the recommended limit of 0.5 and will, therefore, require some modification to the typical levee cross section. Based on our analysis, modifying the typical cross

section by either adding a soil drain on the land side, flattening the landside slope to about 3H:1V, or increasing the crest width to about 15 feet will reduce exit gradients to below 0.5. We understand that one or a combination of these solutions will be incorporated into the final design.

Some seepage through the levee may occur during high water periods in localized areas of higher permeability. The seepage does not necessarily affect the stability of the levee provided that the seepage does not heave or transport soil (piping). Levee monitoring or "levee patrols" during high water periods must check the toe areas of the levees for seepage areas.

Measures for controlling detrimental seepage or piping during flood fighting are described in the USACE manual "Levee Owner's Manual for Non-Federal Flood Control Works". If piping or sediment transport is observed during high water periods, these measures must be quickly enacted. We recommend that these measures be included in the "Operations and Maintenance Manual" and that the individuals designated for high water levee monitoring be familiar with the requirements of the monitoring program.

3.5. Embankment Stability

3.5.1. Analysis Method

Slope stability analyses are completed using the computer program SLOPE/W (GEO-SLOPE International, Ltd., 2012). SLOPE/W evaluates the stability of numerous trial shear surfaces using a vertical slice limit-equilibrium method. This method compares the ratio of forces and moments driving slope movement versus forces and moments resisting slope movement for each trial shear surface, and presents the result as the factor of safety. The program then sorts the trial shear surfaces and identifies the surface with the lowest factor of safety, or the "critical" shear surface. We assumed a circular arc failure surface and used the Morgenstern-Price method to calculate the forces. The failure surface was optimized using an algorithm within the SLOPE/W program.

We evaluated the proposed embankments for the following USACE design cases:

1. **End of Construction.** The end of construction case is based on the current condition of existing levees or the post-construction condition of improved levees. The water level in the river is assumed to be at Mean Lower Low Water (MLLW) flow for this analysis at Elevation 1.6 feet NAVD88.
2. **Steady State Seepage.** The levee stability is evaluated under flood conditions assuming a river level at the BFE and assuming that seepage through the levee has achieved a steady state as modeled in the Seep/W analysis. We evaluated the stability for both the river side and the land side of the levee.
3. **Drawdown.** The levee stability under drawdown conditions is evaluated using an undrained strength analysis using piezometric lines derived from a parent Seep/W analysis. The analysis is completed by first assuming steady state seepage has developed through the levee at flood stage and then conservatively assuming the piezometric line follows the ground surface on the waterside of the levee/floodwall in a drawdown condition to the elevation of MLLW, Elevation 1.6 feet NAVD88.

For the purposes of levee analysis, only shear surfaces that would result in a risk of a levee breach are considered. Shear surfaces that would reduce the crest of the levee to less than 10 feet of undisturbed material are considered to be a risk to the levee. Shear surfaces that did not encroach on this 10-foot crest width would not affect the function of the levee and are, therefore, considered a riverbank maintenance issue rather than a levee stability issue.

Seismic stability of the levee system was considered during preliminary evaluations of levees proposed in this area. We evaluated the site based on the United States Geological Survey (USGS) predicted seismic loading for a 108-year return period event. The largest contribution to this seismic hazard is from the Cascadia Subduction Zone (CSZ) located off the coast of Washington and about 30 to 40 kilometers from the site. This fault is predicted to be capable of generating a 9.0 magnitude earthquake and is also predicted to trigger a significant tsunami that could inundate the areas surrounding Grays Harbor. The proposed levee is not intended to protect against the effects of a tsunami. The estimated average recurrence interval for this event is currently under debate and the estimated ranges vary significantly. But, the average recurrence interval is generally accepted to be greater than about 250 years.

The preliminary seismic evaluations indicated that soil liquefaction and/or loss of soil strength due to cyclic softening during the 108-year return period event is possible throughout the City and along the proposed levee alignment. Where the levee alignment is located adjacent to Grays Harbor or either the Chehalis, Wishkah, or Hoquiam rivers, this loss of soil strength could in turn lead to lateral spreading of the ground surface. Moving the levee inland, away from the riverbanks would result in placing a significant portion of Hoquiam and Aberdeen outside of the flood protection zone. Preventing or limiting loss of soil strength and lateral spread by ground improvement would likely require some form of cementitious ground improvement, such as jet grout, extending well beyond the footprint of the proposed levee. In our opinion, installing this amount of ground improvement within an existing urban area would be impractical.

Based on these factors, Hoquiam and Aberdeen have determined that constructing a levee system capable of withstanding such a significant seismic event was not consistent with their overall approach to risk and disaster management. Hoquiam and Aberdeen have elected to design the levee only for the predicted 100-year flood and not for seismic events. Hoquiam and Aberdeen intend to manage the potential for seismic damage of the levee by repairing damage after significant seismic events as needed. Details of the repair plan are provided in the "Levee Operations and Maintenance Manual" that is included in the CLOMR submittal.

3.5.2. Slope Stability Analysis Results

The results of the slope stability analyses are provided in Figures 1A-1 through 5E-3. An error message of "E996" indicates a factor of safety that is too large to accurately calculate (i.e., sliding uphill). An error message of "E984" indicates that critical slip surfaces intersect the structure and, therefore, global stability does not control. Table 4 summarizes the results of our analyses. The four significant digits reported in the figures and the three significant digits reported in the table are included to provide a comparison between different cross sections, it does not represent the precision of the analysis.

TABLE 4. SLOPE STABILITY ANALYSIS RESULTS

Levee Reach	Approximate Station	Figure Series	Calculated Factor of Safety			
			End of Construction	Critical Flood Stage		Sudden Drawdown
			Water Side	Waterside	Landside	Water Side
USACE Recommended Factor of Safety			1.3	1.4	1.4	1.0
1	3+50	1A	1.25	2.00	>5	1.25
1	13+00	1B	1.93	2.85	4.08	1.93

Levee Reach	Approximate Station	Figure Series	Calculated Factor of Safety			
			End of Construction	Critical Flood Stage		Sudden Drawdown
			Water Side	Waterside	Landside	Water Side
USACE Recommended Factor of Safety			1.3	1.4	1.4	1.0
1	20+50	1C	1.34	1.96	>5	1.35
1	42+00	1D	1.47	2.38	>5	1.47
1	57+00	1E	1.69	2.82	3.22	1.71
2	91+00	2A	2.06	3.03	3.39	2.05
2	100+50	2B	3.00	>5	4.36	2.97
3	155+00	3A	3.54	4.80	3.32	3.57
4	192+5-	4A	4.37	>5	>5	4.36
5	244+00	5A	1.17	1.93	>5	1.16
5	248+00	5B	1.13	1.95	>5	1.13
5	255+50	5C	1.67	3.13	>5	1.68
5	277+50	5D	1.59	3.53	4.16	1.59
5	291+00	5E	1.33	2.31	>5	1.33

The proposed levee cross sections we analyzed meet or exceed USACE recommended minimum factors of safety in all cases except the End of Construction case for Sections 1A, 5A, and 5B. In all these cases, the calculated factor of safety is greater than 1.1 but less than the recommended 1.3. The intent of the End of Construction case is to evaluate the potential for embankments to produce a bearing failure before the excess pore water pressure in the foundation soils have dissipated.

In levee Section 1A consists of a sheet pile wall installed near the riverbank and no new fill is proposed in this area. The levee section in the areas around 5A and 5B is relatively low (on the order of 2 feet of fill) and will not result in a significant new load on the soil. The relatively low factor of safety is a result of the adjacent steep river banks. We have chosen these analysis cross sections based on the steepest observed riverbanks in the area and have analyzed then using the lower end of the observe soil strengths. This conservatism is inherent in the analysis method. Additionally, should this type of slope instability occur, it would be during construction and could be managed by repairing the segment and modifying the construction sequence. These segments constitute less than 600 feet of the 5.6-mile levee alignment. Based on these considerations, it is our opinion that the calculated factor of safety is appropriate for these conditions.

We also evaluated a gap analysis of proposed sheet pile walls in accordance with USACE Engineering Circular EC 1110-2-6066 “Engineering and Design: Design of I-Walls.” In all locations where sheet piles will be used, the landside is relatively flat and the factor of safety against this type of failure is greater than 5.0.

3.6. Floodwalls

Floodwalls were included in our seepage and slope stability models to evaluate the global stability of the walls and the foundations. The evaluation of the internal stability of the wall, including evaluation for overturning and sliding will be provided by KPFF.

3.7. Settlement

Settlement analyses of the levee system were completed using the computer program Settle3D (Rocscience Inc. 2014). Settle3D evaluates the settlement using a computer model of different soil layers with compression properties. The model uses a Boussinesq soil stress distribution to calculate soil loading that induces initial elastic settlement and primary consolidation settlement. Secondary compression, or creep, was not included in our settlement analysis.

We evaluated settlement using soil properties determined from the results of our consolidations tests, correlations with moisture content, and the results of consolidation tests from previous studies. For each soil profile we estimated a high and low value for the compression index (Cc). These values were used to provide a range of predicted settlements.

We evaluated settlements using a time dependent consolidation analysis. We used coefficients of consolidation (Cv) based on the consolidation test results. We also performed a sensitivity analysis where we varied the coefficient of consolidation. The variations in predicted settlement at different times due to changes in the coefficient of consolidation were much less than the variations that were a result of the different compression indexes. Accordingly, we determined that the results were not sensitive to the coefficient of consolidation and did not vary this parameter in our analyses.

We calculated the predicted settlement for a typical embankment section in the Wishkah (Reach 5) design profile. This design profile contains the most compressible layers and is where settlement is expected to be critical. We also calculated the predicted settlement for five time stages: Instantaneous (only includes elastic settlement), 2 months, 1 year, 10 years and 100 years. The results of our analyses and the input values we used are presented in our output results in Appendix C. A summary of our results is provided in Table 5.

TABLE 5. SETTLEMENT ANALYSIS RESULTS

Months	Low Estimate (inches)	High Estimate (Inches)
2	2.0	2.6
12	2.8	3.7
120	4.2	5.4
1,200	4.5	5.8

The settlement that is predicted between 0 and 2 months is expected to occur during construction and can be managed by placing additional fill during construction. The settlement that is predicted to occur between two months and one year (12 months) could be managed by scheduling a follow-up minor regrading project. In roadways, this may require repairing cracks and repaving. The additional settlement that occurs beyond one year (120 and 1,200 months) is the predicted long-term settlement. This settlement should be accounted for by overbuilding embankments so that freeboard is maintained for the entire certification

period. The floodwalls, unlike an embankment levee, cannot be added to easily during construction. In this case, preloading should be considered where floodwalls will be used in conjunction with earth fills.

We recommend that settlement monitoring points be used to evaluate the rate and amount of settlement that occurs during construction. This data can then be used to refine the model and adjustments to the finished design grade can be made during construction.

4.0 CONCLUSIONS

We conclude, based on the results of our analyses, that the proposed Aberdeen North Shore Levee as currently envisioned will meet the geotechnical requirements of 44 CFR 65.10 and USACE Engineering Circular EC 1110-2-6067 "USACE Process for the National Flood Insurance Program (NFIP) Levee System Evaluation" for the 100-year (1-percent-annual-chance) design flood and will provide protection over the certification period of 10 years provided that maintenance is performed, as recommended, on a regular and timely basis.

The recommendations and analysis included in this report are considered to be final based on the available information (60 Percent Plans), but may change based on modifications to the levee design made during final design or based on different soil conditions observed during construction. We must be retained to monitor the geotechnical aspects of levee construction in order to confirm that soil conditions in the field are as we assumed in our analysis and we must be given an opportunity to revise our recommendations as needed. At the completion of the project, we will provide a Levee Certification Letter documenting our observations and additional recommendations for submittal with the final LOMR application.

5.0 LIMITATIONS

We have prepared this report for the exclusive use of KPFF Consulting Engineers, Inc. KPFF may distribute copies of this report to the City of Aberdeen, the City's authorized agents, and regulatory agencies including FEMA and FEMA's designated reviewers, as may be required for the project.

Levee certification within the context of this report follows the definition provided in 44 CFR 65.2, which states that "certification by a registered professional engineer or other party does not constitute a warranty or guarantee of performance, expressed or implied. Certification of data is a statement that the data is accurate to the best of the certifier's knowledge. Certification of analyses is a statement that the analyses have been performed correctly and in accordance with sound engineering practices."

Qualified engineering and construction practices can help mitigate flooding risks, but they cannot completely eliminate those risks. Favorable performance of structures in the recent past provides useful information for anticipating likely near-term future performance, but it cannot predict or imply a certainty of similar long-term performance. Levee systems require periodic inspection to confirm that all critical components continue functioning as intended. Confirmation that design flood flows and/or elevations have not significantly changed also requires the periodic review of design criteria and other potential contributing factors including, but not limited to, changes in surrounding development, weather patterns, system operational policies, or sedimentation.

The conclusions are recommendations presented in this report are based on an assumed subsurface profile developed through interpolation between widely spaced subsurface investigations and review of preliminary (60-percent) project plans. GeoEngineers must be involved with the final design and construction of the project to confirm that our recommendations are being properly interpreted and that soil conditions are consistent with our assumptions.

Prior geotechnical borings and other subsurface data by others, if any, presented in our reports are for the sake of completeness only; they should not be relied upon without confirmation from the originator of such data.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in the field of geotechnical engineering in this area at the time this report was prepared. The conclusions, recommendations, and opinions presented in this report are based on our professional knowledge, judgment and experience. No warranty or other conditions, express or implied, should be understood.

Please refer to Appendix D titled "Report Limitations and Guidelines for Use" for additional information pertaining to use of this report.

6.0 REFERENCES

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Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: Mapbox Open Street Map, 2015
Projection: NAD 1983 2011 StatePlane Washington South FIPS 4602 Ft US

Vicinity Map

North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure 1

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Notes:

1. The locations of all features shown are approximate.
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Data Source: Aerial from ESRI, 2015

Projection: NAD 1983 StatePlane Washington South FIPS 4602 Feet

Legend

Levee System Alignment

Approximate Location of CPT

- GeoEngineers, 2016
- GeoEngineers, 2015

Approximate Location of Boring

- GeoEngineers, 2016
- GeoEngineers, 2015
- WSDOT, 2010
- Shannon and Wilson, 1999
- WSDOT, 1983
- WSDOT, 1976
- Lowe, 1977
- WSDOT, 1968
- WSDOT, 1952

N W E S

1,500 0 1,500

Feet

Site Plan

North Shore Levee
Aberdeen and Hoqium, Washington

GeoEngineers

Figure 2

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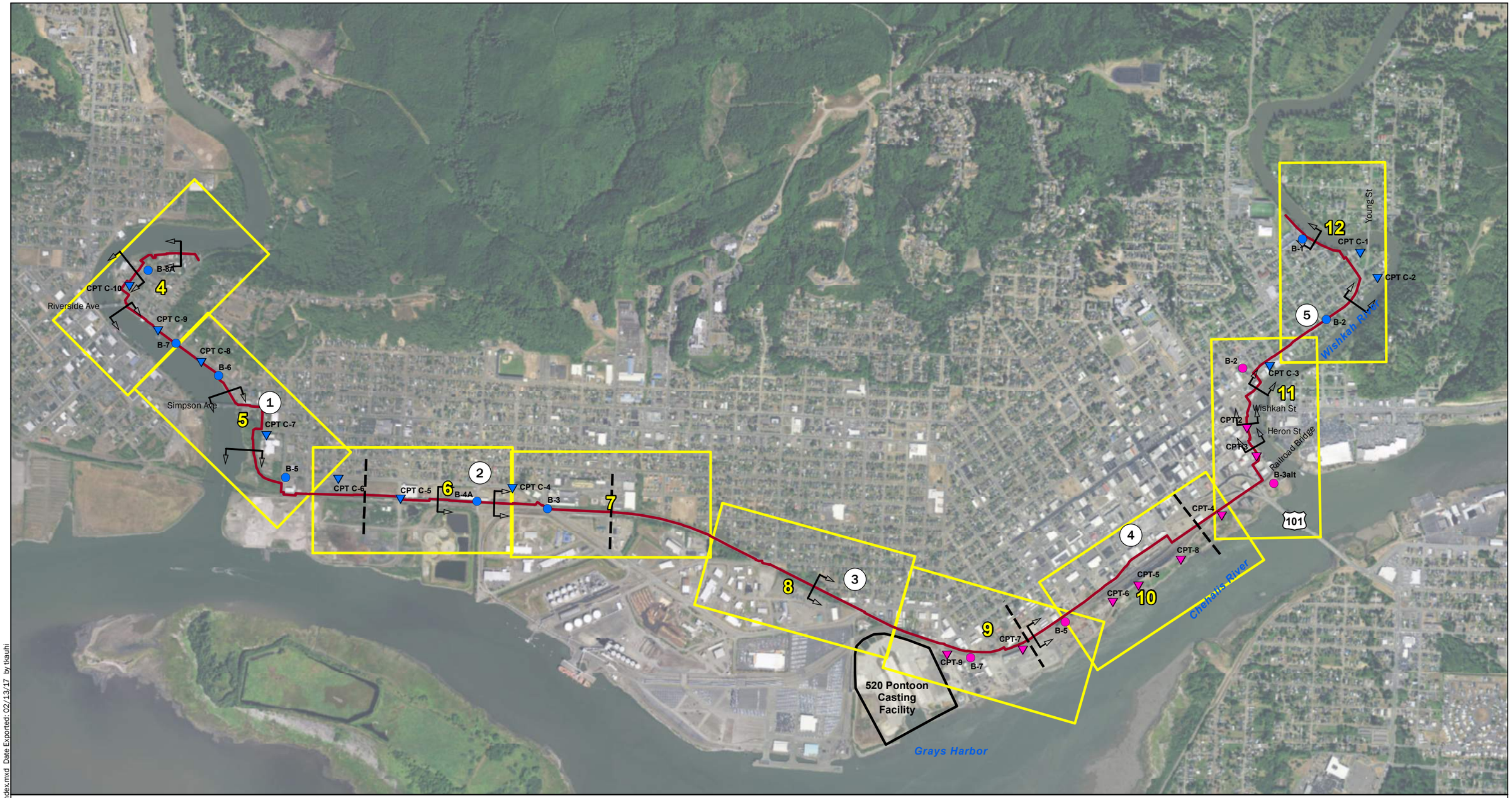

Notes:

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Data Source: Aerial from ESRI, 2015

Projection: NAD 1983 StatePlane Washington South FIPS 4602 Feet

Legend

Approximate Location of CPT

- GeoEngineers, 2016
- GeoEngineers, 2015

Approximate Location of Boring

- GeoEngineers, 2016
- GeoEngineers, 2015

- Levee System Alignment
- (1) Reach Number
- Division Between Reaches
- 1 Page Index
- Analysis Cross Section Location

N W E S

1,500 0 1,500

Feet

Index Sheet

North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure 3

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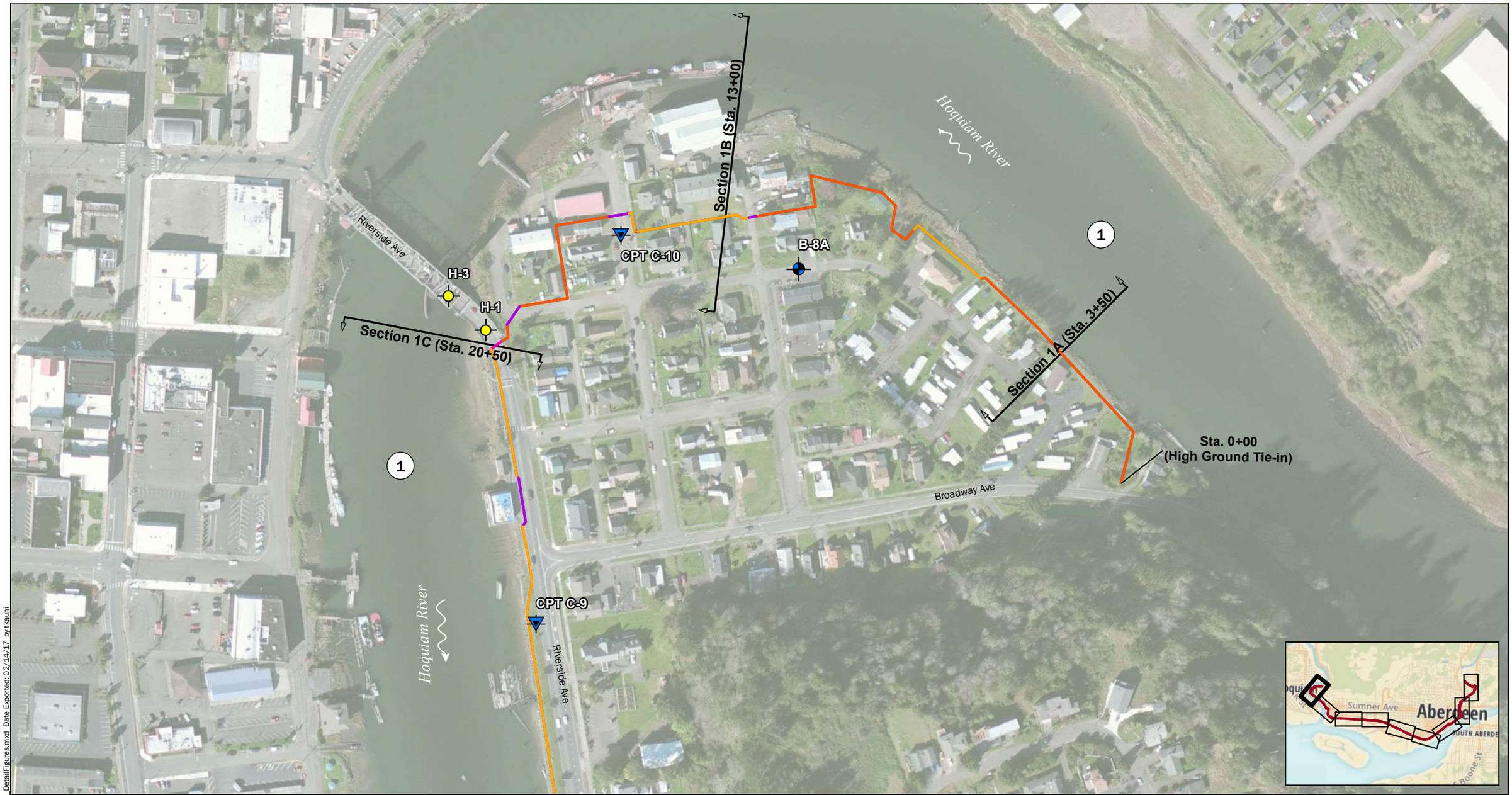

Notes:

1. The locations of all features shown are approximate.
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Data Source: Aerial from ESRI, 2010

Projection: NAD 1983 StatePlane Washington South FIPS 4602 Feet

Legend

- (1) Reach Number
- Sheet Pile Wall
- Concrete Wall
- Stoplog Closure
- Existing Embankment

Approximate Location of Boring

- GeoEngineers, 2016
- WSDOT, 1968

Approximate Location of CPT

- GeoEngineers, 2016

- Division Between Reaches
- Analysis Cross Section Location

200 0 200

Feet

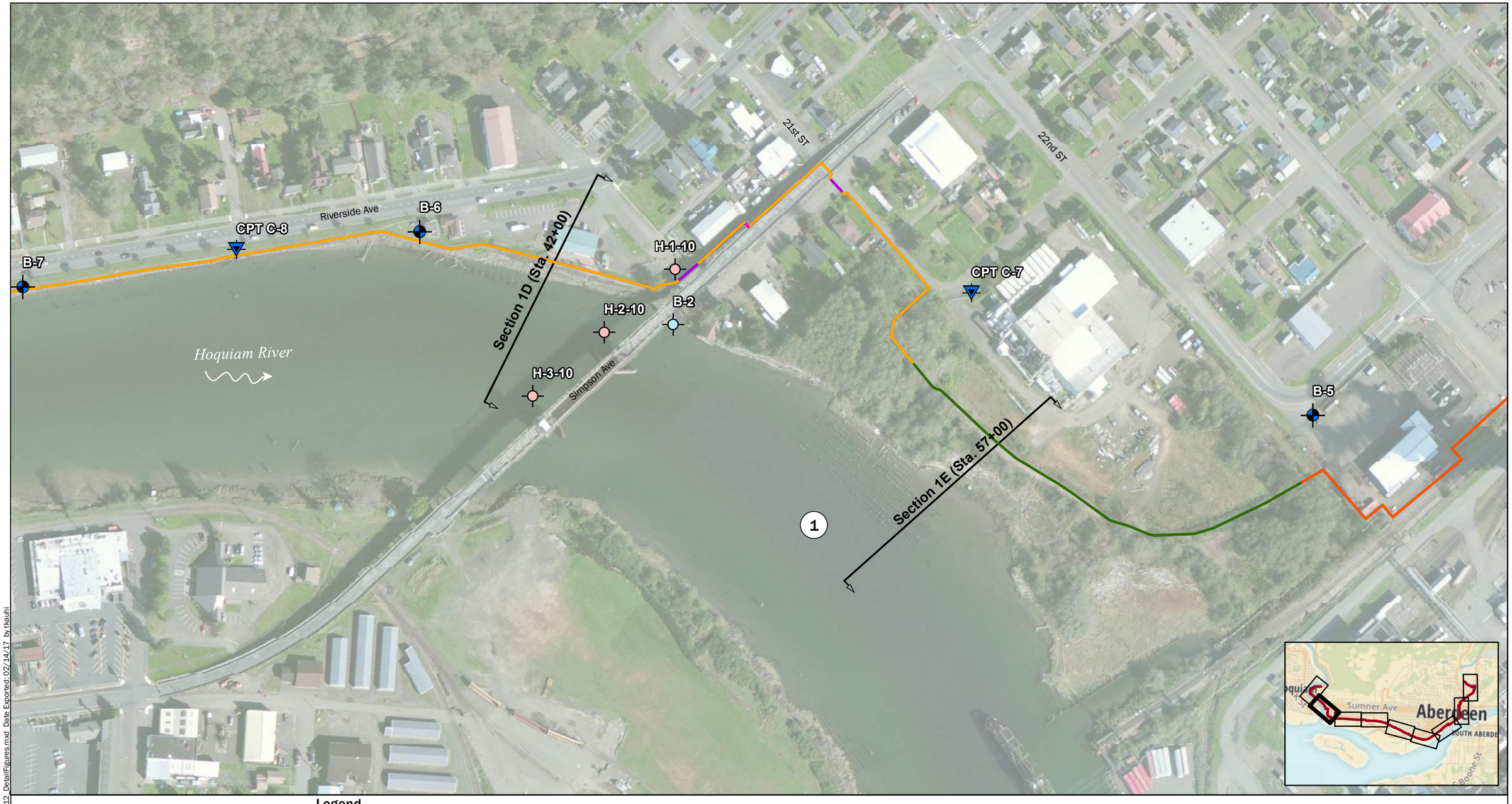
Detailed Site Plan

North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure 4

P:\0\02010086\GIS\MXDs\020100801_F04-12_DetailFigures.mxd Date Exported: 02/14/17 by tkauhi



Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: Aerial from ESRI, 2010

Projection: NAD 1983 StatePlane Washington South FIPS 4602 Feet

Legend

- (1) Reach Number
- Sheet Pile Wall
- Earthen Dike
- Concrete Wall
- Stoplog Closure
- Existing Embankment

Approximate Location of Boring

- GeoEngineers, 2016
- WSDOT, 2010
- WSDOT, 1976

Approximate Location of CPT

- GeoEngineers, 2016

- Division Between Reaches
- Analysis Cross Section Location

200 0 200
Feet

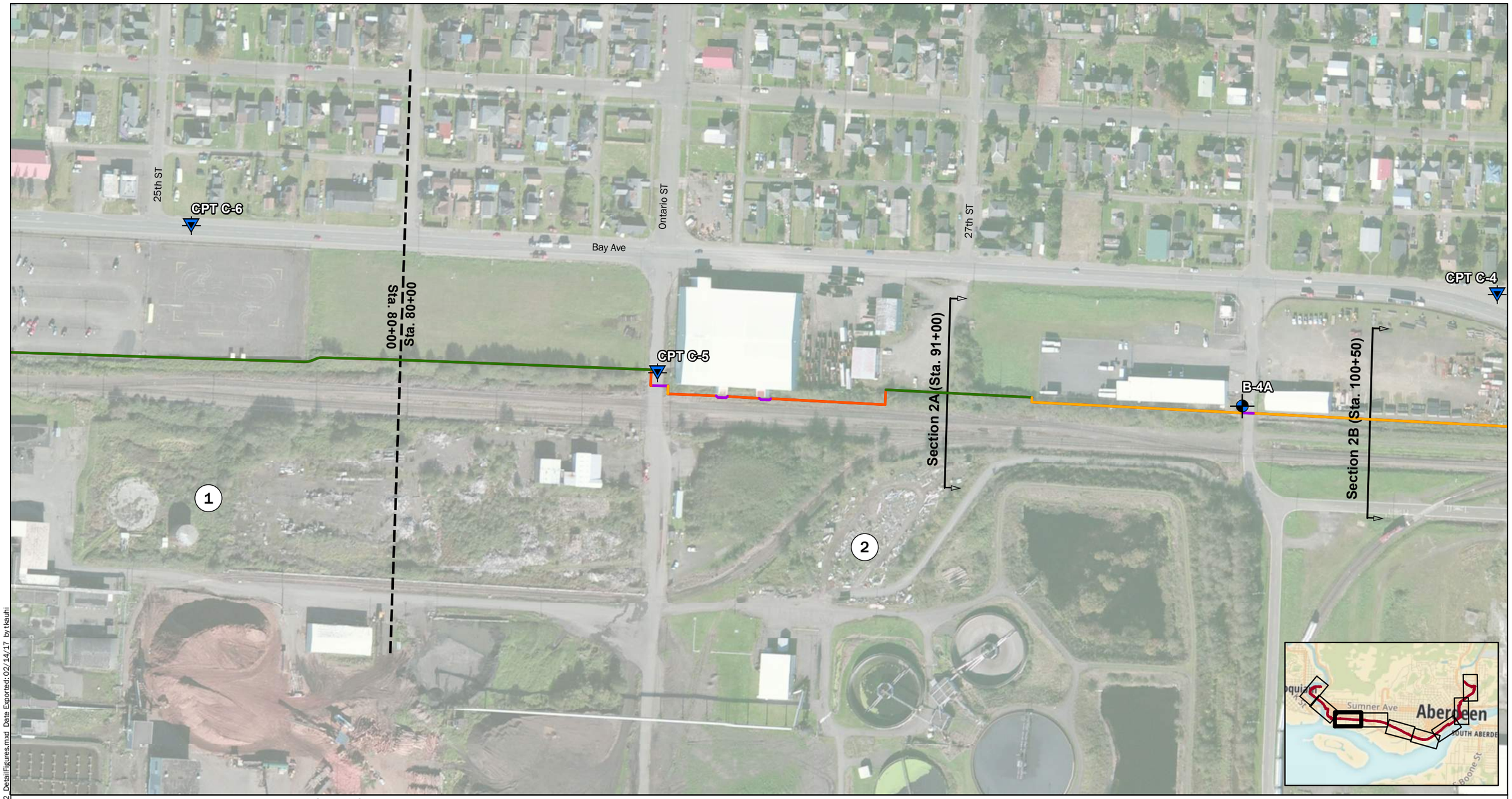
Detailed Site Plan

Northside Levee
Aberdeen, Washington

GeoEngineers

Figure 5

P:\0\0201006\GIS\MXDs\0201006801_F04-12_DetailFigures.mxd Date Exported: 02/14/17 by tkauhi



Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: Aerial from ESRI, 2010

Projection: NAD 1983 StatePlane Washington South FIPS 4602 Feet

Legend

- (1) Reach Number
- Sheet Pile Wall
- Earthen Dike
- Concrete Wall
- Stoplog Closure

Approximate Location of Boring

- GeoEngineers, 2016

Approximate Location of CPT

- GeoEngineers, 2016

- Division Between Reaches
- Analysis Cross Section Location

N W E S

200 0 200

Feet

Detailed Site Plan

Northside Levee
Aberdeen, Washington

GeoEngineers

Figure 6

P:\0\02010081GIS\MXDs\020100801_F04-12_DetailFigures.mxd Date Exported: 02/14/17 by tkauhi

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: Aerial from ESRI, 2010

Projection: NAD 1983 StatePlane Washington South FIPS 4602 Feet

Legend

(1) Reach Number

Earthen Dike
Concrete Wall
Stoplog Closure

Approximate Location of Boring
GeoEngineers, 2016
Lowe, 1977

Approximate Location of CPT
GeoEngineers, 2016

Division Between Reaches
Analysis Cross Section Location

N W E S

200 0 200
Feet

Detailed Site Plan

Northside Levee
Aberdeen, Washington

GeoEngineers

Figure 7

P:\O\0201008\GIS\MXDs\0201008O1_F04-12_DetailFigures.mxd Date Exported: 02/14/17 by hkuhl

Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: Aerial from ESRI, 2010

Projection: NAD 1983 StatePlane Washington South FIPS 4602 Feet

Legend

- (1) Reach Number
- Sheet Pile Wall
- Earthen Dike
- Concrete Wall
- Stoplog Closure
- **Approximate Location of Boring**
- Lowe, 1977
- Division Between Reaches
- Analysis Cross Section Location

N E S W

200 0 200

Feet

Detailed Site Plan

Northside Levee
Aberdeen, Washington

GeoEngineers

Figure 8

P:\0\0201008\GIS\MXDs\0201008_F04-12_DetailFigures.mxd Date Exported: 02/14/17 by tkauhi

Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: Aerial from ESRI, 2010

Projection: NAD 1983 StatePlane Washington South FIPS 4602 Feet

Legend

- (1) Reach Number
- Sheet Pile Wall
- Earthen Dike
- Concrete Wall
- Stoplog Closure

Approximate Location of Boring

- GeoEngineers, 2015
- Lowe, 1977

Approximate Location of CPT

- GeoEngineers, 2015

- Division Between Reaches
- Analysis Cross Section Location

N E S W

200 0 200

Feet

Detailed Site Plan

Northside Levee
Aberdeen, Washington

GeoEngineers

Figure 9

P:\0\0201008\GIS\MXDs\0201008_F04-12_DetailFigures.mxd Date Exported: 02/14/17 by tkauhi

Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: Aerial from ESRI, 2010

Projection: NAD 1983 StatePlane Washington South FIPS 4602 Feet

Legend

(1) Reach Number

Sheet Pile Wall
Earthen Dike
Concrete Wall
Stoplog Closure
Existing Embankment

Approximate Location of Boring

GeoEngineers, 2015
Lowe, 1977

Approximate Location of CPT

GeoEngineers, 2015

Division Between Reaches
Analysis Cross Section Location

200 0 200
Feet

Detailed Site Plan

Northside Levee
Aberdeen, Washington

GeoEngineers

Figure 10

P:\0\02010086\GIS\MXDs\020100801_F04-12_DetailFigures.mxd Date Exported: 02/14/17 by tkauhi

RB-220
CPT C-3
Wishkah River
Section 5C (Sta. 255+50)
5
Wishkah St
Heron St
B-1
11
Section 5B (Sta. 248+00)
Section 5A (Sta. 244+00)
CPT-3
B-2
RB-215
B-1
C-1
CPT-2
Railroad Bridge
Wishkah River
Chehalis River
B-309
B-3alt
H-10-52
101
H-6-52
5
Sumner Ave
Aberdeen

P:\0\0201006\GIS\MXDs\020100901_F11_DetailFigures.mxd Date Exported: 02/14/17 by kauhi

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: Aerial from ESRI, 2010

Projection: NAD 1983 StatePlane Washington South FIPS 4602 Feet

Legend

(1) Reach Number

Sheet Pile Wall
Earthen Dike
Concrete Wall
Stoplog Closure
Existing Embankment

Approximate Location of Boring

GeoEngineers, 2015
WSDOT; 1952, 1983 or 1999
Lowe, 1977

Approximate Location of CPT

GeoEngineers, 2016
GeoEngineers, 2015

Division Between Reaches
Analysis Cross Section Location

N E S W

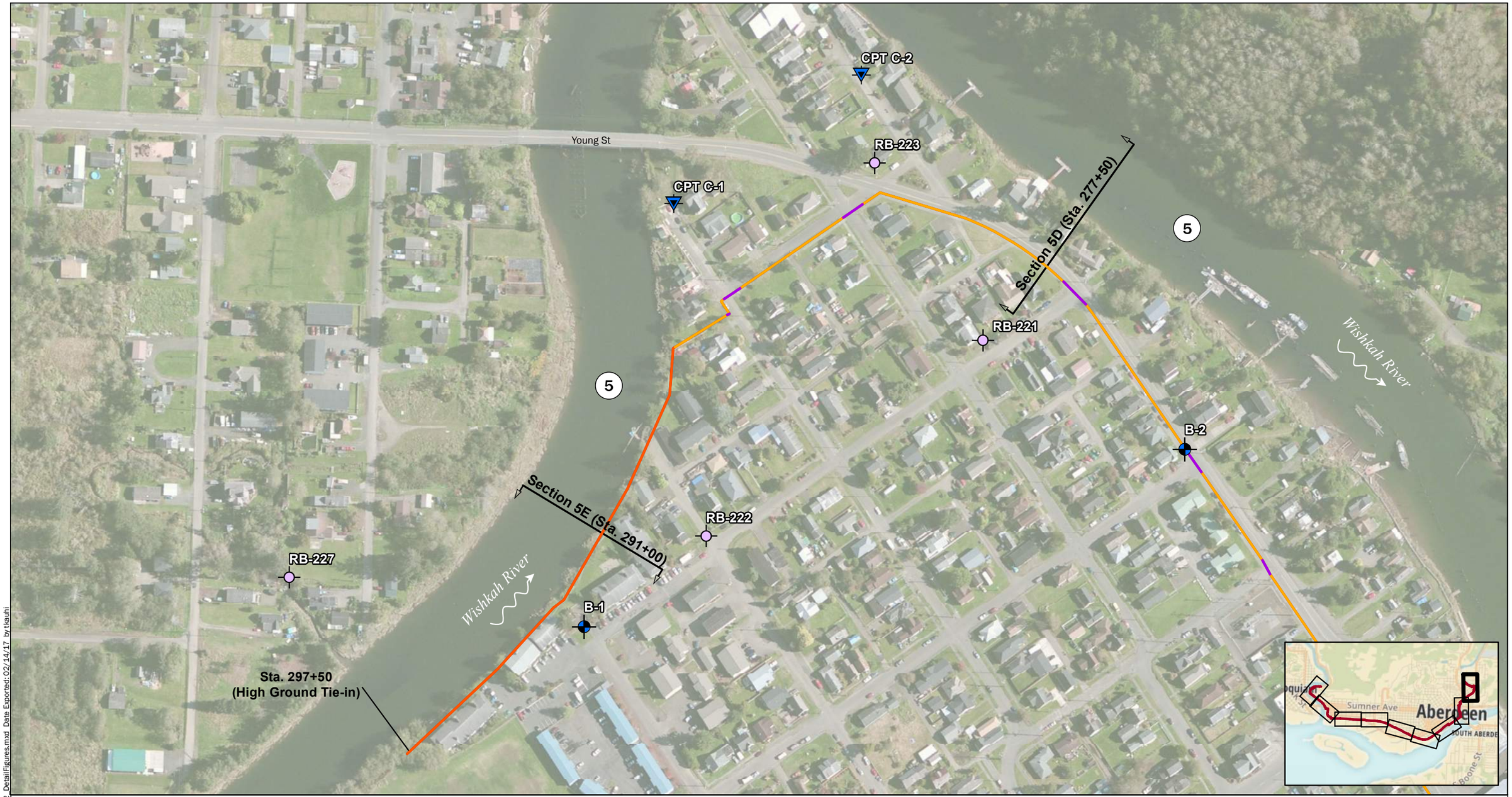
200 0 200
Feet

Detailed Site Plan

Northside Levee
Aberdeen, Washington

GeoEngineers

Figure 11



Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: Aerial from ESRI, 2010

Projection: NAD 1983 StatePlane Washington South FIPS 4602 Feet

Legend

- (1) Reach Number
- Sheet Pile Wall
- Concrete Wall
- Stoplog Closure

Approximate Location of Boring

- GeoEngineers, 2016
- Lowe, 1977

Approximate Location of CPT

- GeoEngineers, 2016

- Division Between Reaches
- Analysis Cross Section Location

N W E S

200 0 200

Feet

Detailed Site Plan

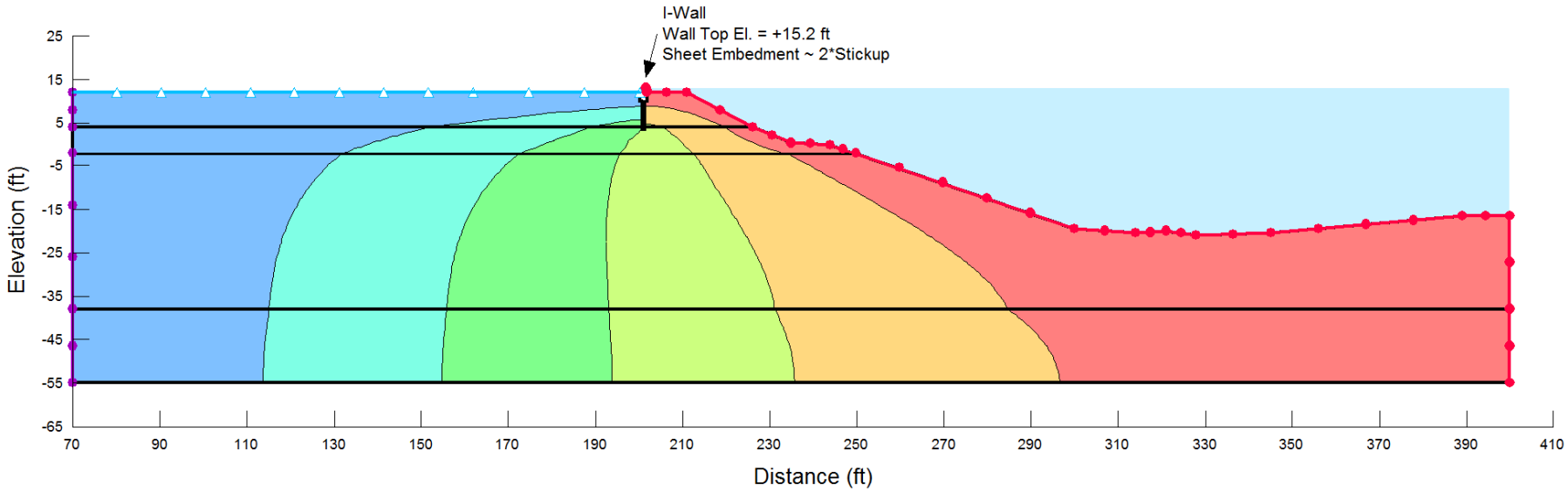
Northside Levee
Aberdeen, Washington

GeoEngineers

Figure 12

P:\0\0201008\GIS\MXDs\0201008I_F04-12_DetailFigures.mxd Date Exported: 02/14/17 by: tlauhi

Name: I-Wall (Concrete) Model: Interface K-Transpose: 0 ft/sec K-Normal: 0 ft/sec
Name: I-Wall (Steel Sheets) Model: Interface K-Transpose: 0 ft/sec K-Normal: 0 ft/sec
Name: 12.0 to 4.0 ft Model: Saturated Only K-Sat: 2.04e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.63 ft³/ft³ Mv: 2.574e-005 /psf
Name: 4.0 to -2.0 ft Model: Saturated Only K-Sat: 3.33e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.66 ft³/ft³ Mv: 4.189e-005 /psf
Name: -2.0 to -38.0 ft Model: Saturated Only K-Sat: 6.6e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.68 ft³/ft³ Mv: 8.305e-005 /psf
Name: -38.0 to -55.0 ft Model: Saturated Only K-Sat: 2.21e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.61 ft³/ft³ Mv: 2.657e-005 /psf



See report text for additional explanation

Seep/W Steady State Seepage (Station 3+50)

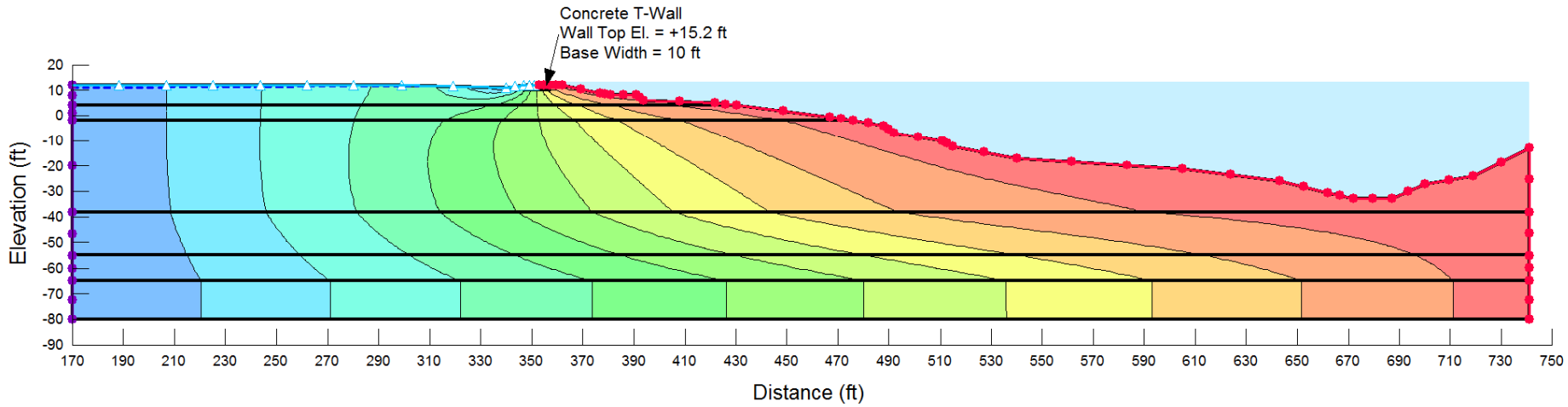
North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure S-1A

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Concrete T-Wall Model: Interface K-Transpose: 0 ft/sec K-Normal: 0 ft/sec
Name: 12.0 to 4.0 ft Model: Saturated Only K-Sat: 2.04e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.63 ft³/ft³ Mv: 2.574e-005 /psf
Name: 4.0 to -2.0 ft Model: Saturated Only K-Sat: 3.33e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.66 ft³/ft³ Mv: 4.189e-005 /psf
Name: -2.0 to -38.0 ft Model: Saturated Only K-Sat: 6.6e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.68 ft³/ft³ Mv: 8.305e-005 /psf
Name: -38.0 to -55.0 ft Model: Saturated Only K-Sat: 2.21e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.61 ft³/ft³ Mv: 2.657e-005 /psf
Name: -55.0 to -65 ft (assumed soil properties based on above layer) Model: Saturated Only K-Sat: 2.21e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.61 ft³/ft³ Mv: 2.657e-005 /psf
Name: -65.0 to -80.0 ft (from WSDOT boring logs for 6th Ave Bridge) Model: Saturated Only K-Sat: 3e-007 ft/sec Ky'/Kx' Ratio: 0.75 Rotation: 0 ° Volumetric Water Content: 0.4 ft³/ft³ Mv: 3.5e-005 /psf



See report text for additional explanation

Seep/W Steady State Seepage (Station 13+00)

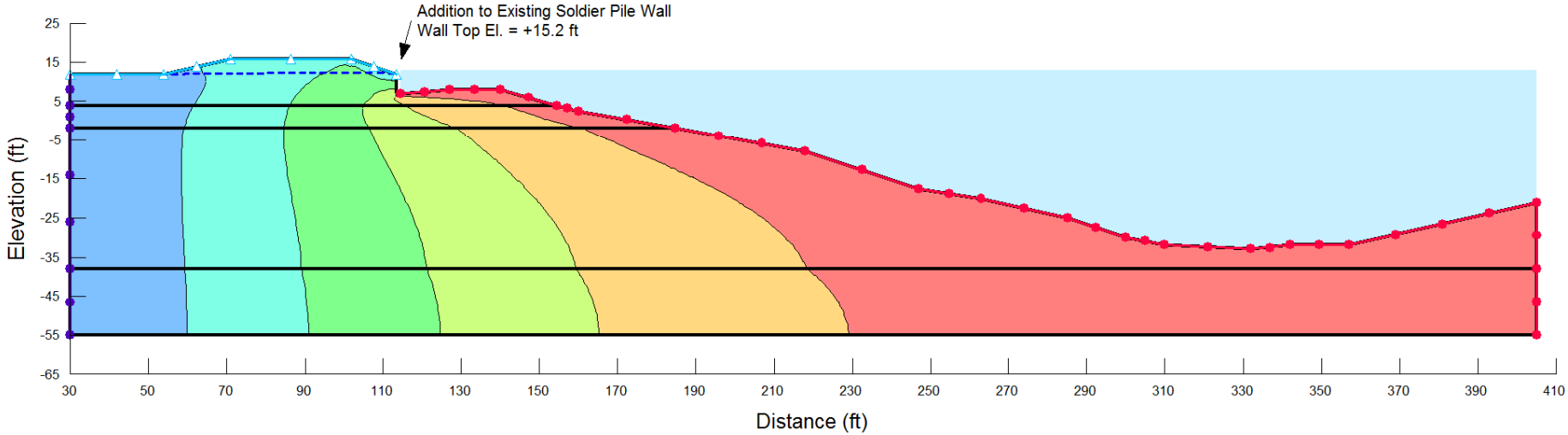
North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure S-1B

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Soldier Pile Wall Model: Interface K-Transpose: 0 ft/sec K-Normal: 0 ft/sec
Name: 12.0 to 4.0 ft Model: Saturated Only K-Sat: 2.04e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.63 ft³/ft³ Mv: 2.574e-005 /psf
Name: 4.0 to -2.0 ft Model: Saturated Only K-Sat: 3.33e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.66 ft³/ft³ Mv: 4.189e-005 /psf
Name: -2.0 to -38.0 ft Model: Saturated Only K-Sat: 6.6e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.68 ft³/ft³ Mv: 8.305e-005 /psf
Name: -38.0 to -55.0 ft Model: Saturated Only K-Sat: 2.21e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.61 ft³/ft³ Mv: 2.657e-005 /psf



See report text for additional explanation

Seep/W Steady State Seepage (Station 20+50)

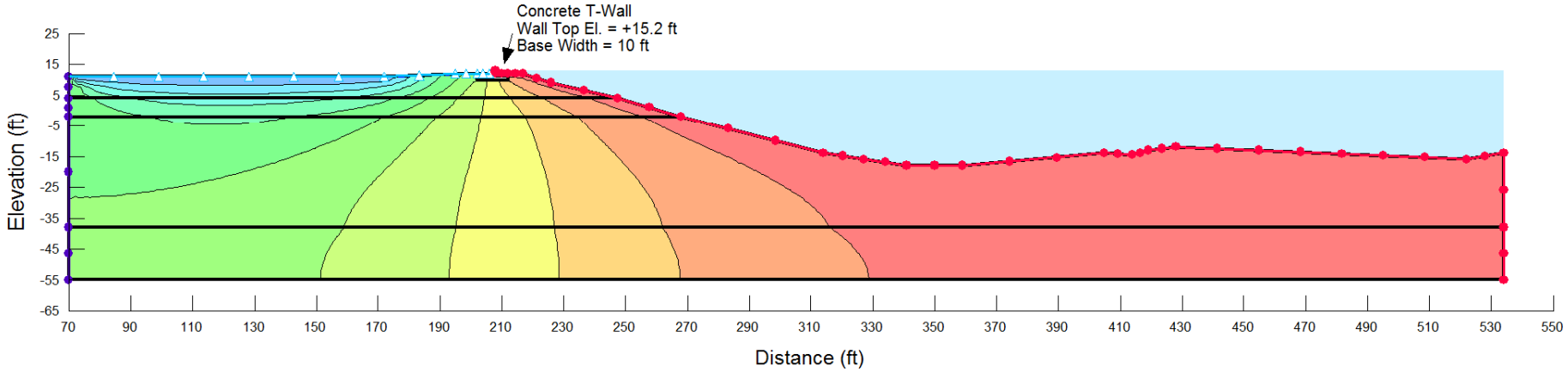
North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure S-1C

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Concrete T-Wall Model: Interface K-Transpose: 0 ft/sec K-Normal: 0 ft/sec
Name: 12.0 to 4.0 ft Model: Saturated Only K-Sat: 2.04e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.63 ft³/ft³ Mv: 2.574e-005 /psf
Name: 4.0 to -2.0 ft Model: Saturated Only K-Sat: 3.33e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.66 ft³/ft³ Mv: 4.189e-005 /psf
Name: -2.0 to -38.0 ft Model: Saturated Only K-Sat: 6.6e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.68 ft³/ft³ Mv: 8.305e-005 /psf
Name: -38.0 to -55.0 ft Model: Saturated Only K-Sat: 2.21e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.61 ft³/ft³ Mv: 2.657e-005 /psf



See report text for additional explanation

Seep/W Steady State Seepage (Station 42+00)

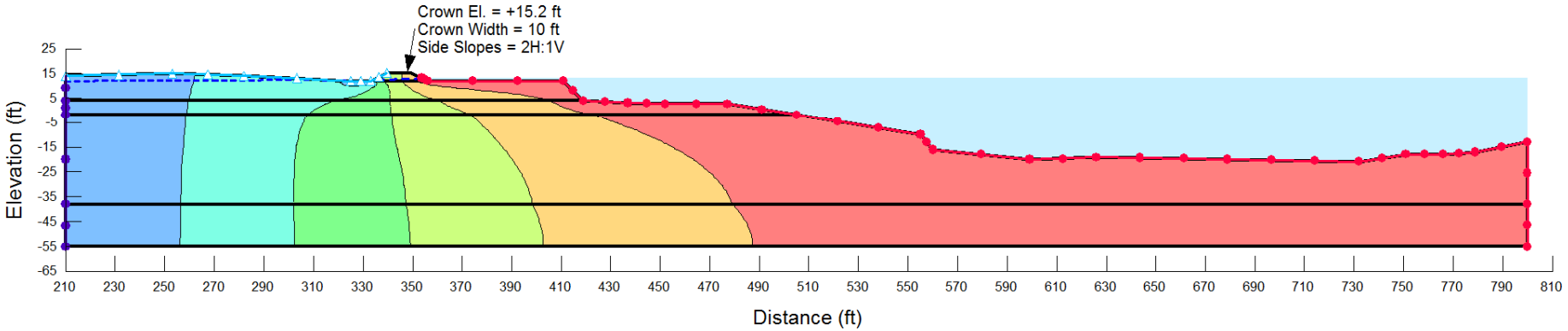
North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure S-1D

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Embankment Fill Model: Saturated Only K-Sat: 2.4e-007 ft/sec Ky'/Kx' Ratio: 0.75 Rotation: 0 ° Volumetric Water Content: 0.5 ft³/ft³ Mv: 3e-005 /psf
Name: 12.0 to 4.0 ft Model: Saturated Only K-Sat: 2.04e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.63 ft³/ft³ Mv: 2.574e-005 /psf
Name: 4.0 to -2.0 ft Model: Saturated Only K-Sat: 3.33e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.66 ft³/ft³ Mv: 4.189e-005 /psf
Name: -2.0 to -38.0 ft Model: Saturated Only K-Sat: 6.6e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.68 ft³/ft³ Mv: 8.305e-005 /psf
Name: -38.0 to -55.0 ft Model: Saturated Only K-Sat: 2.21e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.61 ft³/ft³ Mv: 2.657e-005 /psf



See report text for additional explanation

Seep/W Steady State Seepage (Station 57+00)

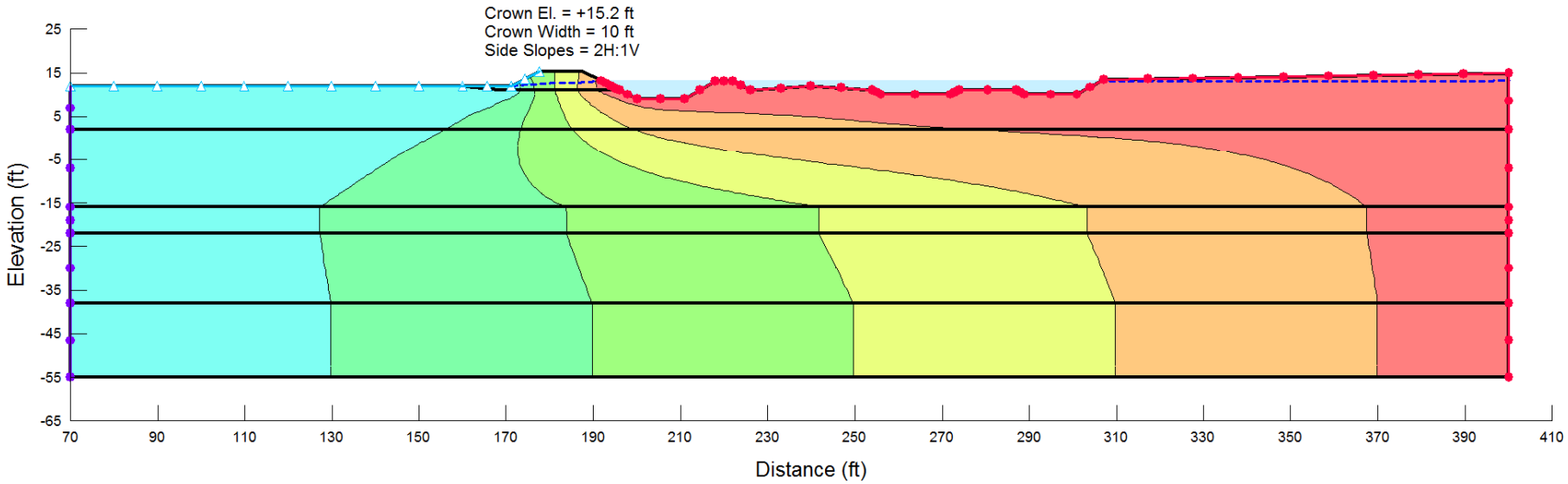
North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure S-1E

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Embankment Fill Model: Saturated Only K-Sat: 2.4e-007 ft/sec Ky'/Kx' Ratio: 0.75 Rotation: 0 ° Volumetric Water Content: 0.5 ft³/ft³ Mv: 3e-005 /psf
Name: 12.0 to 2.0 ft Model: Saturated Only K-Sat: 2.24e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.66 ft³/ft³ Mv: 2.703e-005 /psf
Name: 2.0 to -16.0 ft Model: Saturated Only K-Sat: 1.62e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.64 ft³/ft³ Mv: 2.044e-005 /psf
Name: -16.0 to -22.0 ft Model: Saturated Only K-Sat: 2.7e-007 ft/sec Ky'/Kx' Ratio: 0.75 Rotation: 0 ° Volumetric Water Content: 0.48 ft³/ft³ Mv: 3.735e-005 /psf
Name: -22.0 to -38.0 ft Model: Saturated Only K-Sat: 1.09e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.58 ft³/ft³ Mv: 1.314e-005 /psf
Name: -38.0 to -55.0 ft Model: Saturated Only K-Sat: 1.65e-007 ft/sec Ky'/Kx' Ratio: 0.75 Rotation: 0 ° Volumetric Water Content: 0.48 ft³/ft³ Mv: 2.279e-005 /psf



See report text for additional explanation

Seep/W Steady State Seepage (Station 91+00)

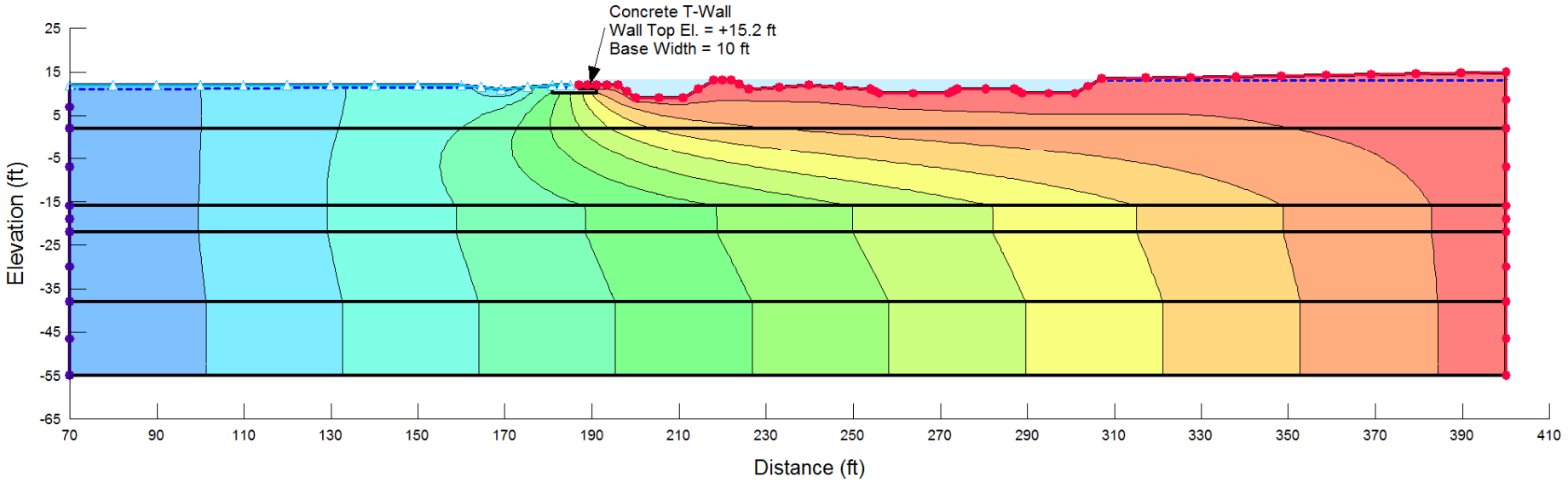
North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure S-2A

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Concrete T-Wall Model: Interface K-Transpose: 0 ft/sec K-Normal: 0 ft/sec
Name: 12.0 to 2.0 ft Model: Saturated / Unsaturated K-Function: 12.0 to 2.0 ft Hyd K Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Vol. WC. Function: 12.0 to 2.0 ft Vol WC
Name: 2.0 to -16.0 ft Model: Saturated / Unsaturated K-Function: 2.0 to -16.0 ft Hyd K Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Vol. WC. Function: 2.0 to -16.0 ft Vol WC
Name: -16.0 to -22.0 ft Model: Saturated / Unsaturated K-Function: -16.0 to -22.0 ft Ky'/Kx' Ratio: 0.75 Rotation: 0 ° Vol. WC. Function: -16.0 to -22.0 ft Vol WC
Name: -22.0 to -38.0 ft Model: Saturated / Unsaturated K-Function: -22.0 to -38.0 ft Hyd K Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Vol. WC. Function: -22.0 to -38.0 ft Vol WC
Name: -38.0 to -55.0 ft Model: Saturated / Unsaturated K-Function: -38.0 to -55.0 ft Hyd K Ky'/Kx' Ratio: 0.75 Rotation: 0 ° Vol. WC. Function: -38.0 to -55.0 ft Vol WC



See report text for additional explanation

Seep/W Steady State Seepage (Station 100+50)

North Shore Levee
Aberdeen and Hoquiam, Washington

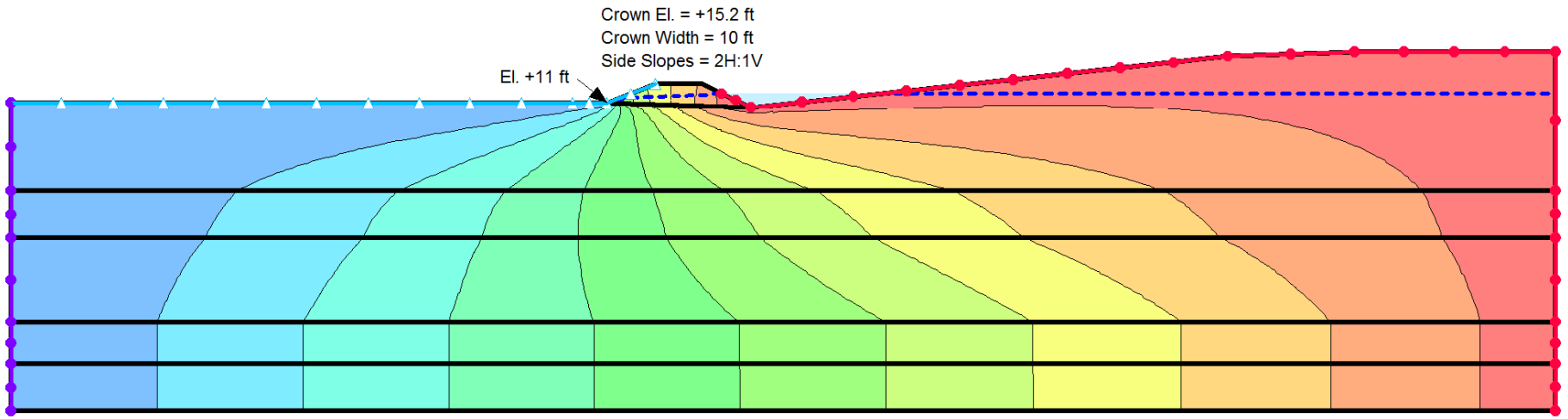
GeoEngineers

Figure S-2B

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Embankment Fill Model: Saturated Only K-Sat: 2.4e-007 ft/sec Ky'/Kx' Ratio: 0.75 Rotation: 0 ° Volumetric Water Content: 0.5 ft³/ft³ Mv: 3e-005 /psf
Name: 12.0 to -8.0 ft Model: Saturated Only K-Sat: 1.42e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.55 ft³/ft³ Mv: 1.791e-005 /psf
Name: -8.0 to -18.0 ft Model: Saturated Only K-Sat: 2.76e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.53 ft³/ft³ Mv: 3.48e-005 /psf
Name: -18.0 to -36.0 ft Model: Saturated Only K-Sat: 1.36e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.52 ft³/ft³ Mv: 1.508e-005 /psf
Name: -36.0 to -45.0 ft Model: Saturated Only K-Sat: 2.15e-007 ft/sec Ky'/Kx' Ratio: 0.75 Rotation: 0 ° Volumetric Water Content: 0.47 ft³/ft³ Mv: 2.974e-005 /psf
Name: -45.0 to -55.0 ft Model: Saturated Only K-Sat: 1.36e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.54 ft³/ft³ Mv: 1.572e-005 /psf

F of S:



See report text for additional explanation

Seep/W Steady State Seepage (Station 155+00)

North Shore Levee
Aberdeen and Hoquiam, Washington

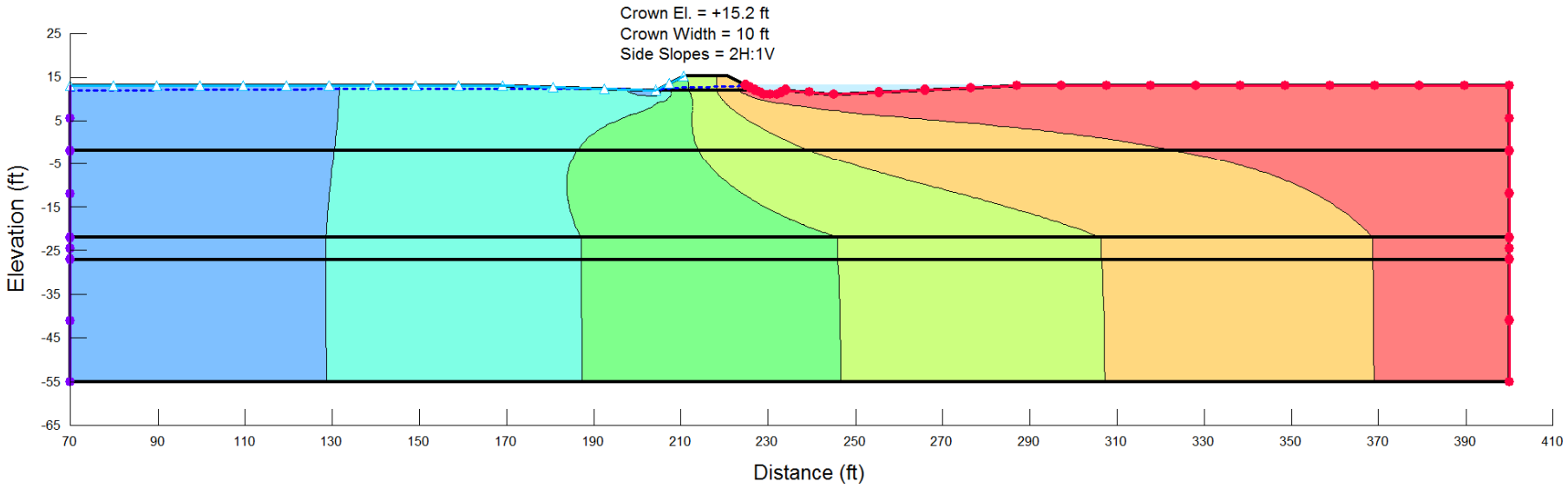
GeoEngineers

Figure S-3A

0201-008-01 Date Exported: 2/17/17

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Embankment Fill Model: Saturated Only K-Sat: 2.4e-007 ft/sec Ky'/Kx' Ratio: 0.75 Rotation: 0 ° Volumetric Water Content: 0.5 ft³/ft³ Mv: 3e-005 /psf
Name: 12.0 to -2.0 ft Model: Saturated Only K-Sat: 1.56e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.67 ft³/ft³ Mv: 2.402e-005 /psf
Name: -2.0 to -22.0 ft Model: Saturated Only K-Sat: 1.37e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.55 ft³/ft³ Mv: 1.896e-005 /psf
Name: -22.0 to -27.0 ft Model: Saturated Only K-Sat: 3.11e-007 ft/sec Ky'/Kx' Ratio: 0.75 Rotation: 0 ° Volumetric Water Content: 0.45 ft³/ft³ Mv: 4.31e-005 /psf
Name: -27.0 to -55.0 ft Model: Saturated Only K-Sat: 1.46e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.48 ft³/ft³ Mv: 1.613e-005 /psf



See report text for additional explanation

Seep/W Steady State Seepage (Station 192+50)

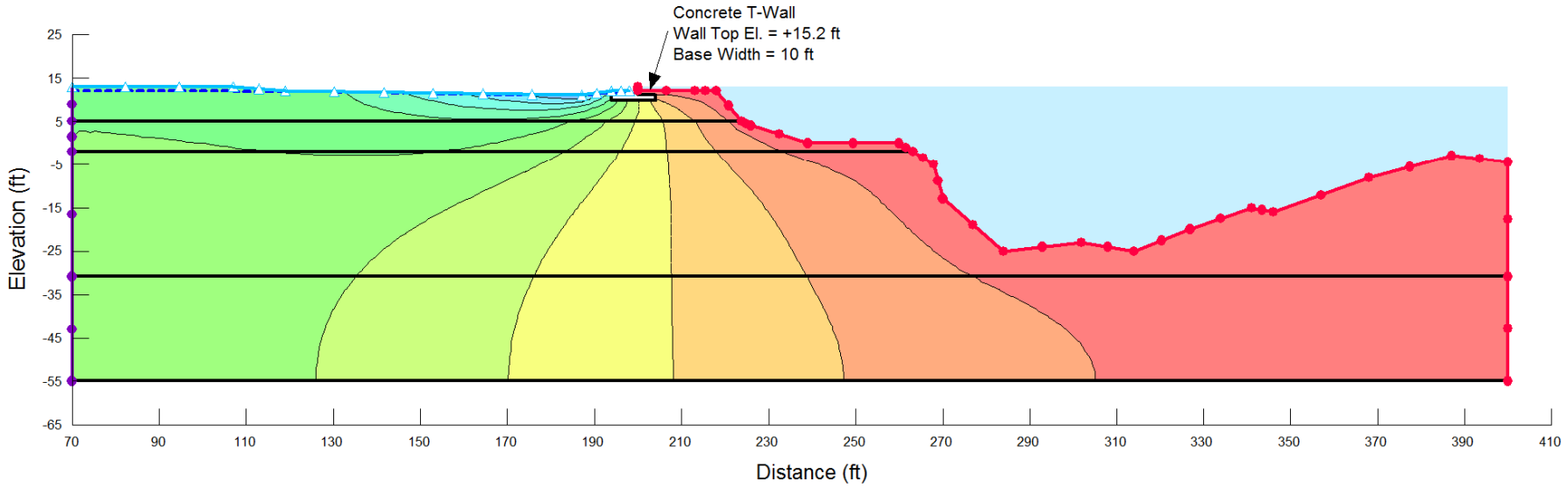
North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure S-4A

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Concrete T-Wall Model: Interface K-Transpose: 0 ft/sec K-Normal: 0 ft/sec
Name: 12.0 to 5.0 ft Model: Saturated Only K-Sat: 2.41e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.69 ft³/ft³ Mv: 2.899e-005 /psf
Name: 5.0 ft to -2.0 ft Model: Saturated Only K-Sat: 5.32e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.84 ft³/ft³ Mv: 9.208e-005 /psf
Name: -2.0 ft to -31.0 ft Model: Saturated Only K-Sat: 4.63e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.69 ft³/ft³ Mv: 5.572e-005 /psf
Name: -31.0 to -55.0 ft Model: Saturated Only K-Sat: 4.14e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.59 ft³/ft³ Mv: 5.214e-005 /psf



See report text for additional explanation

Seep/W Steady State Seepage (Station 244+00)

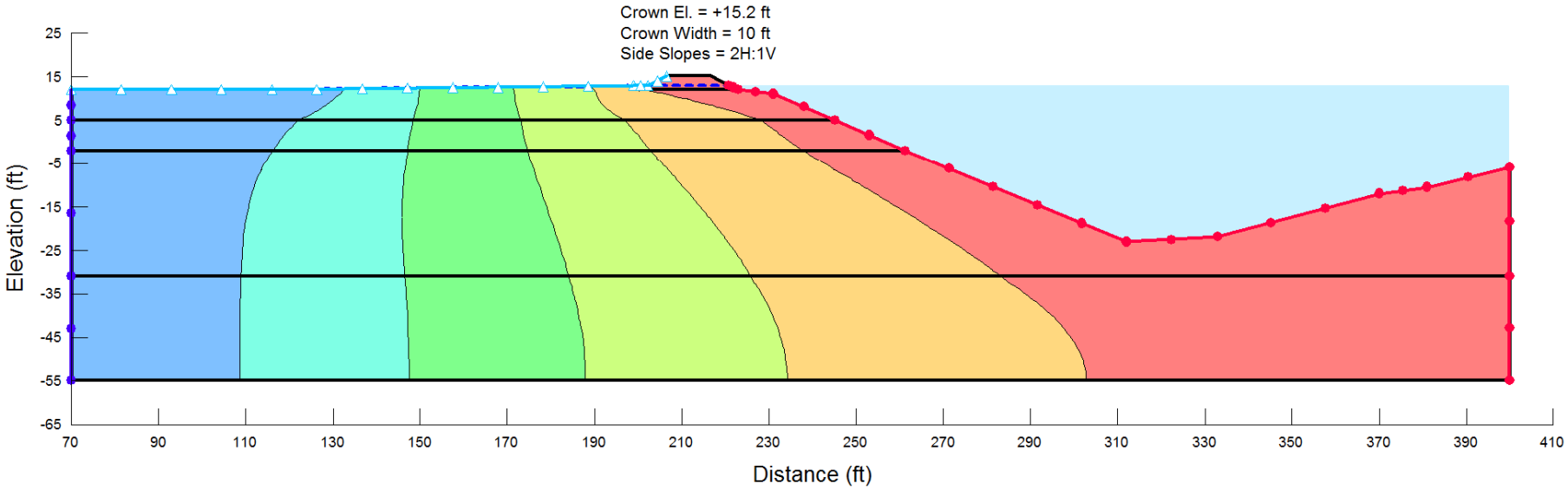
North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure S-5A

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Embankment Fill Model: Saturated Only K-Sat: 2.4e-007 ft/sec Ky'/Kx' Ratio: 0.75 Rotation: 0 ° Volumetric Water Content: 0.5 ft³/ft³ Mv: 3e-005 /psf
Name: 12.0 to 5.0 ft Model: Saturated Only K-Sat: 2.41e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.69 ft³/ft³ Mv: 2.899e-005 /psf
Name: 5.0 to -2.0 ft Model: Saturated Only K-Sat: 5.32e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.84 ft³/ft³ Mv: 9.208e-005 /psf
Name: -2.0 to -31.0 ft Model: Saturated Only K-Sat: 4.63e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.69 ft³/ft³ Mv: 5.572e-005 /psf
Name: -31.0 to -55.0 ft Model: Saturated Only K-Sat: 4.14e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.59 ft³/ft³ Mv: 5.214e-005 /psf



See report text for additional explanation

Seep/W Steady State Seepage (Station 248+00)

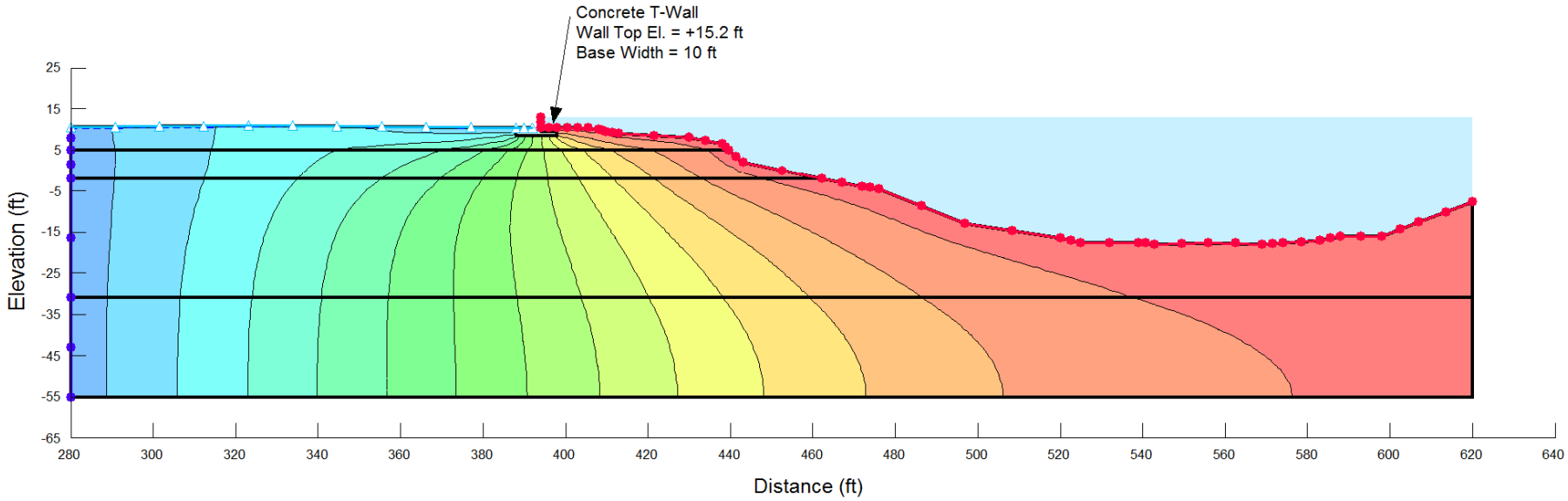
North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure S-5B

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Concrete T-Wall Model: Interface K-Transpose: 0 ft/sec K-Normal: 0 ft/sec
Name: 12.0 to 5.0 ft Model: Saturated Only K-Sat: 2.41e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.69 ft³/ft³ Mv: 2.899e-005 /psf
Name: 5.0 to -2.0 ft Model: Saturated Only K-Sat: 5.32e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.84 ft³/ft³ Mv: 9.208e-005 /psf
Name: -2.0 to -31.0 ft Model: Saturated Only K-Sat: 4.63e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.69 ft³/ft³ Mv: 5.572e-005 /psf
Name: -31.0 to -55.0 ft Model: Saturated Only K-Sat: 4.14e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.59 ft³/ft³ Mv: 5.214e-009 /psf



See report text for additional explanation

Seep/W Steady State Seepage (Station 255+50)

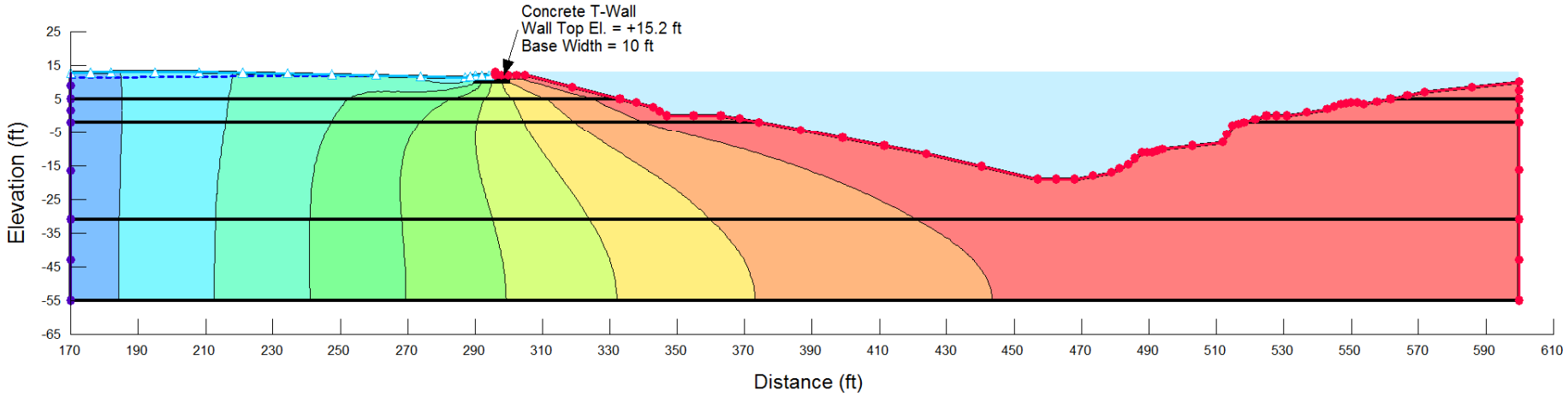
North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure S-5C

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Concrete T-Wall Model: Interface K-Transpose: 0 ft/sec K-Normal: 0 ft/sec
Name: 12.0 to 5.0 ft Model: Saturated Only K-Sat: 2.41e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.69 ft³/ft³ Mv: 2.899e-005 /psf
Name: 5.0 ft to -2.0 ft Model: Saturated Only K-Sat: 5.32e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.84 ft³/ft³ Mv: 9.208e-005 /psf
Name: -2.0 to -31.0 ft Model: Saturated Only K-Sat: 4.63e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.69 ft³/ft³ Mv: 5.572e-005 /psf
Name: -31.0 to -55.0 ft Model: Saturated Only K-Sat: 4.14e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.59 ft³/ft³ Mv: 5.214e-005 /psf



See report text for additional explanation

Seep/W Steady State Seepage (Station 277+50)

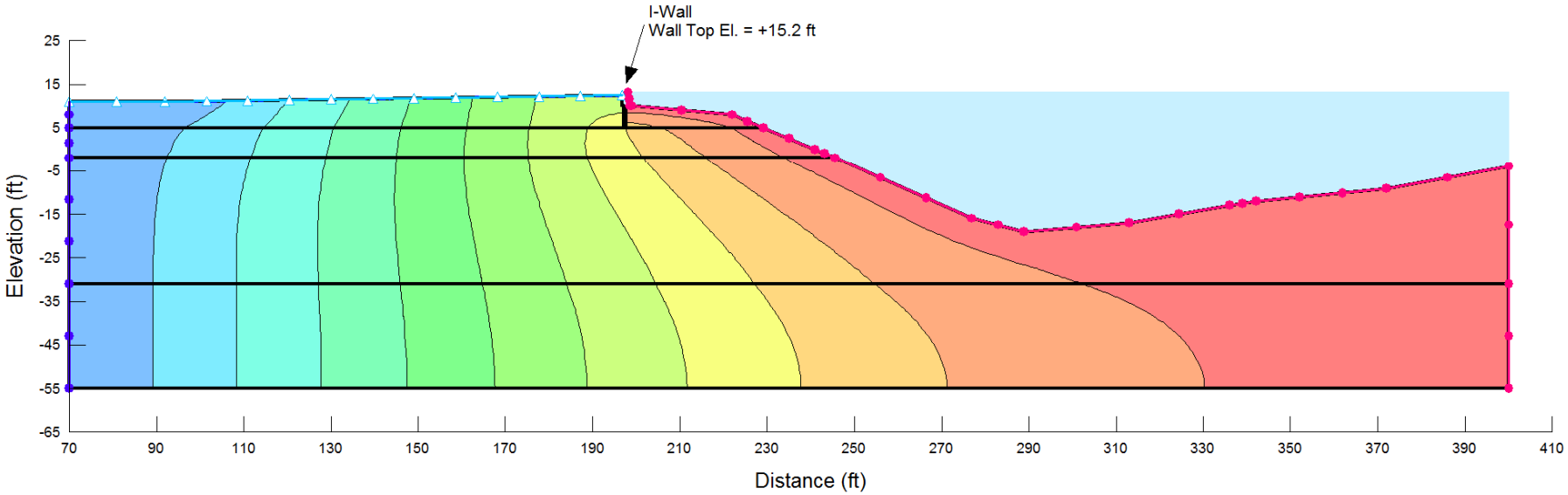
North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure S-5D

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: I-Wall (Concrete) Model: Interface K-Transpose: 0 ft/sec K-Normal: 0 ft/sec
Name: I-Wall (Steel Sheets) Model: Interface K-Transpose: 0 ft/sec K-Normal: 0 ft/sec
Name: 12.0 to 5.0 ft Model: Saturated Only K-Sat: 2.41e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.69 ft³/ft³ Mv: 2.899e-005 /psf
Name: 5.0 ft to -2.0 ft Model: Saturated Only K-Sat: 5.32e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.84 ft³/ft³ Mv: 9.208e-005 /psf
Name: -2.0 to -31.0 ft Model: Saturated Only K-Sat: 4.63e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.69 ft³/ft³ Mv: 5.572e-005 /psf
Name: -31.0 to -55.0 ft Model: Saturated Only K-Sat: 4.14e-009 ft/sec Ky'/Kx' Ratio: 0.2 Rotation: 0 ° Volumetric Water Content: 0.59 ft³/ft³ Mv: 5.214e-005 /psf



See report text for additional explanation

Seep/W Steady State Seepage (Station 291+00)

North Shore Levee
Aberdeen and Hoquiam, Washington

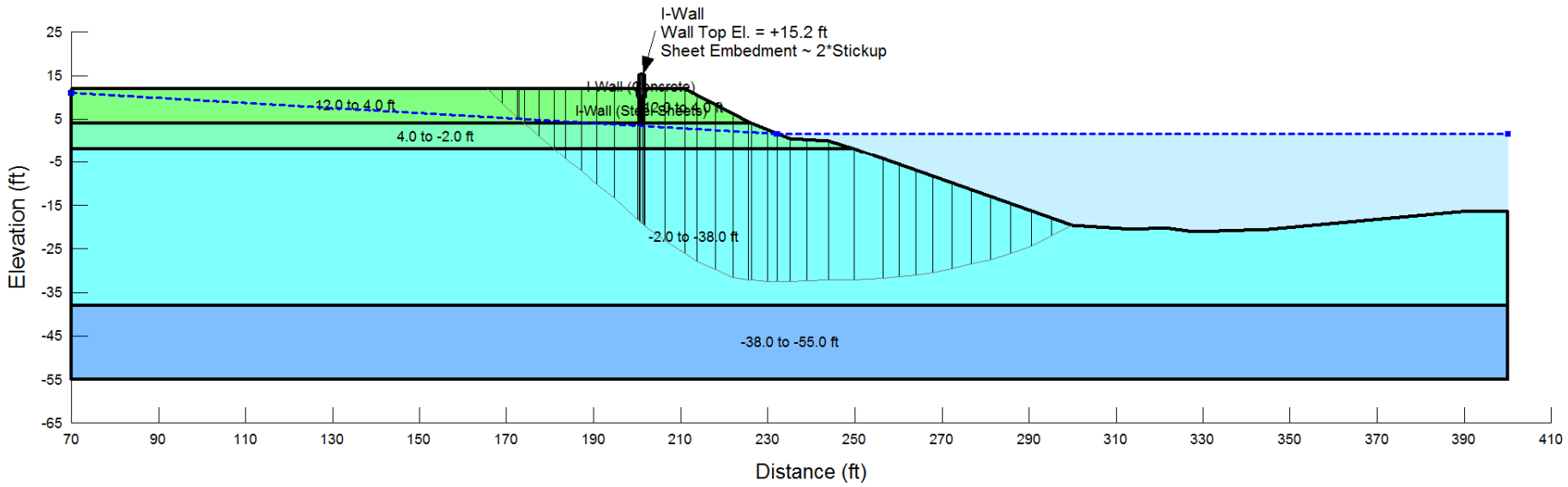
GeoEngineers

Figure S-5E

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: I-Wall (Concrete) Model: High Strength Unit Weight: 145 pcf
Name: I-Wall (Steel Sheets) Model: High Strength Unit Weight: 484 pcf
Name: 12.0 to 4.0 ft Model: Mohr-Coulomb Unit Weight: 102 pcf Cohesion': 260 psf Phi': 0 °
Name: 4.0 to -2.0 ft Model: Mohr-Coulomb Unit Weight: 102 pcf Cohesion': 260 psf Phi': 0 °
Name: -2.0 to -38.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 260 psf C-Rate of Change: 7.925 psf/ft C-Maximum: 545 psf
Name: -38.0 to -55.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 545 psf C-Rate of Change: 7.925 psf/ft C-Maximum: 680 psf

F of S: 1.245



Slope/W Stability – End of Construction (Station 3+50)

North Shore Levee
Aberdeen and Hoquiam, Washington

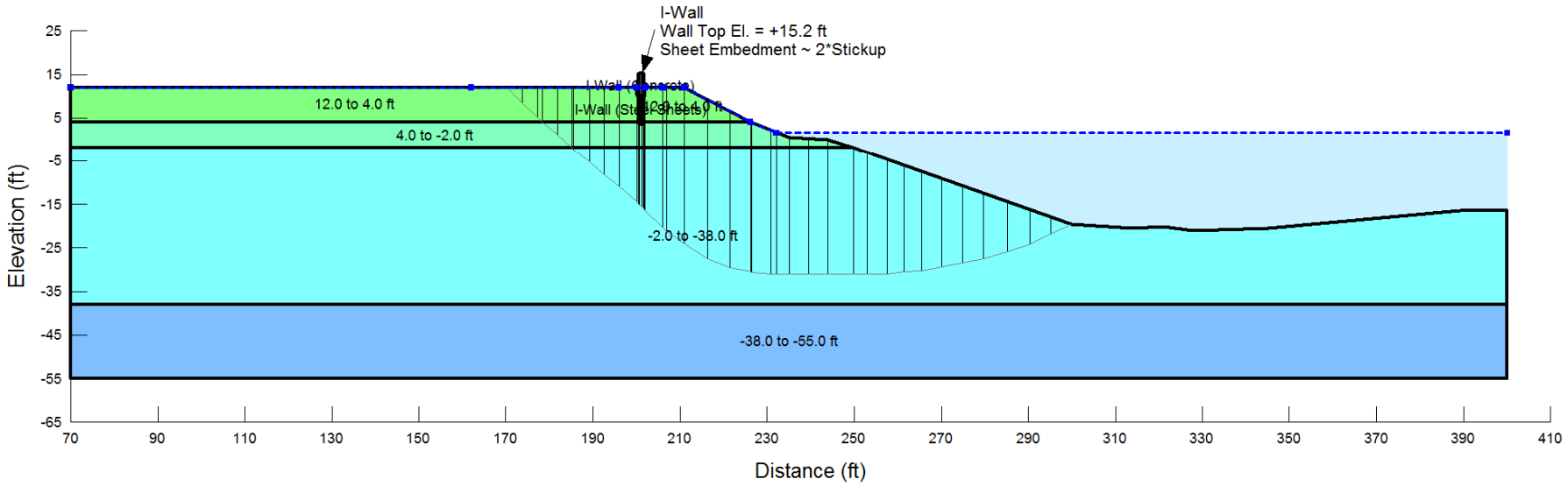
GeoEngineers

Figure 1A-1

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: I-Wall (Concrete) Model: High Strength Unit Weight: 145 pcf
Name: I-Wall (Steel Sheets) Model: High Strength Unit Weight: 484 pcf
Name: 12.0 to 4.0 ft Model: Mohr-Coulomb Unit Weight: 102 pcf Cohesion': 260 psf Phi': 0 °
Name: 4.0 to -2.0 ft Model: Mohr-Coulomb Unit Weight: 102 pcf Cohesion': 260 psf Phi': 0 °
Name: -2.0 to -38.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 260 psf C-Rate of Change: 7.925 psf/ft C-Maximum: 545 psf
Name: -38.0 to -55.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 545 psf C-Rate of Change: 7.925 psf/ft C-Maximum: 680 psf

F of S: 1.245



Slope/W Stability – Sudden Drawdown (Station 3+50)

North Shore Levee
Aberdeen and Hoquiam, Washington

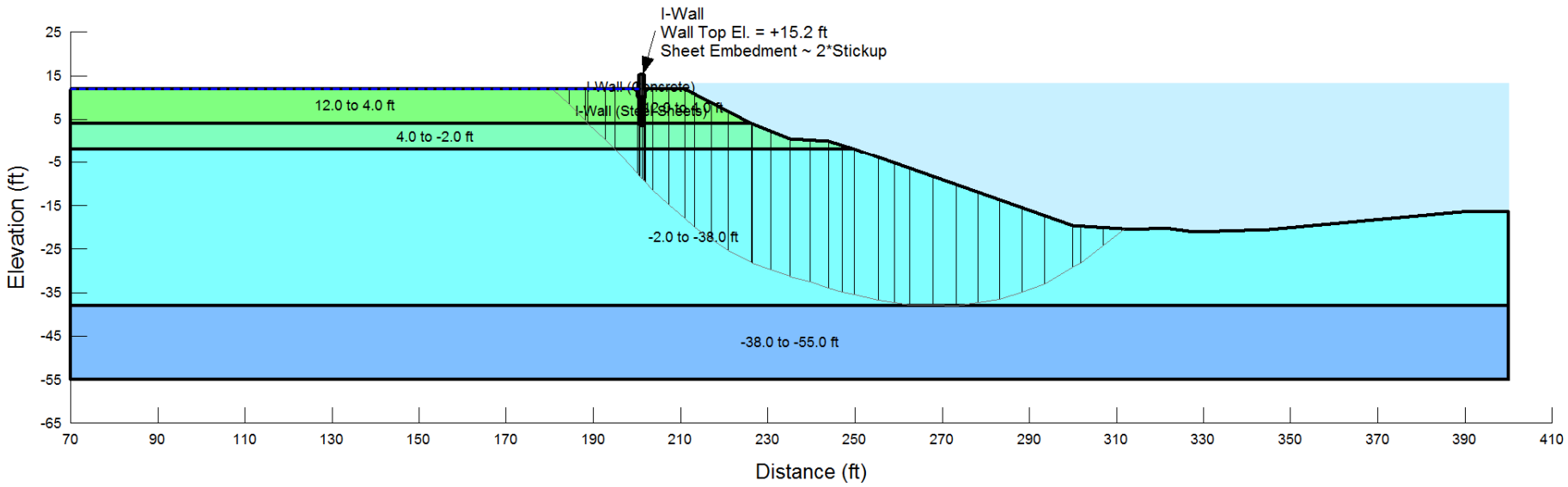
GeoEngineers

Figure 1A-2

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: I-Wall (Concrete) Model: High Strength Unit Weight: 145 pcf
Name: I-Wall (Steel Sheets) Model: High Strength Unit Weight: 484 pcf
Name: 12.0 to 4.0 ft Model: Mohr-Coulomb Unit Weight: 102 pcf Cohesion': 260 psf Phi': 0 °
Name: 4.0 to -2.0 ft Model: Mohr-Coulomb Unit Weight: 102 pcf Cohesion': 260 psf Phi': 0 °
Name: -2.0 to -38.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 260 psf C-Rate of Change: 7.925 psf/ft C-Maximum: 545 psf
Name: -38.0 to -55.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 545 psf C-Rate of Change: 7.925 psf/ft C-Maximum: 680 psf

F of S: 1.990



Slope/W Stability – Critical Flood State – Waterside (Station 3+50)

North Shore Levee
Aberdeen and Hoquiam, Washington

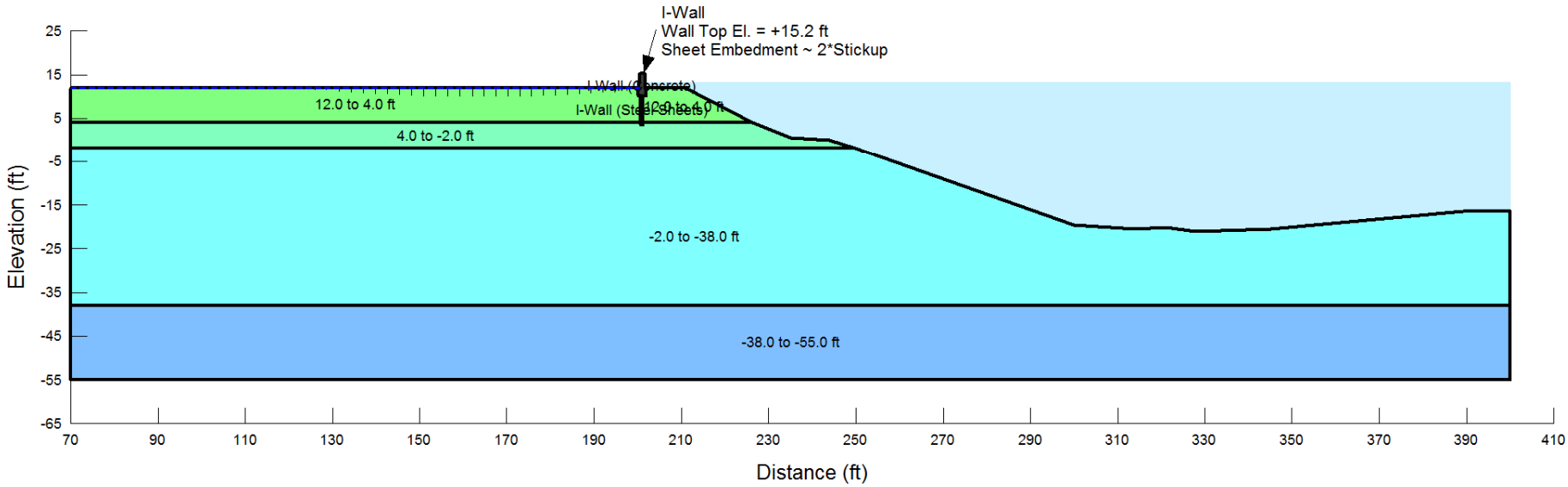
GeoEngineers

Figure 1A-3WS

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: I-Wall (Concrete) Model: High Strength Unit Weight: 145 pcf
Name: I-Wall (Steel Sheets) Model: High Strength Unit Weight: 484 pcf
Name: 12.0 to 4.0 ft Model: Mohr-Coulomb Unit Weight: 102 pcf Cohesion': 260 psf Phi': 0 °
Name: 4.0 to -2.0 ft Model: Mohr-Coulomb Unit Weight: 102 pcf Cohesion': 260 psf Phi': 0 °
Name: -2.0 to -38.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 260 psf C-Rate of Change: 7.925 psf/ft C-Maximum: 545 psf
Name: -38.0 to -55.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 545 psf C-Rate of Change: 7.925 psf/ft C-Maximum: 680 psf

F of S: E984



Slope/W Stability – Critical Flood Stage – Landside (Station 3+50)

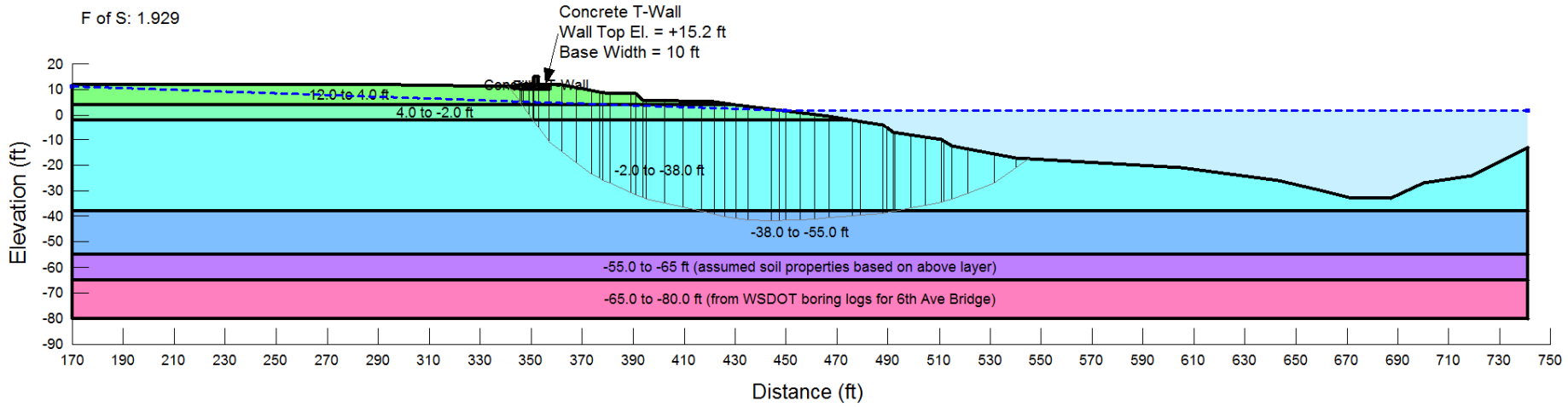
North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure 1A-3LS

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Concrete T-Wall Model: High Strength Unit Weight: 145 pcf
Name: Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: 12.0 to 4.0 ft Model: Mohr-Coulomb Unit Weight: 102 pcf Cohesion': 260 psf Phi': 0 °
Name: 4.0 to -2.0 ft Model: Mohr-Coulomb Unit Weight: 102 pcf Cohesion': 260 psf Phi': 0 °
Name: -2.0 to -38.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 260 psf C-Rate of Change: 7.925 psf/ft C-Maximum: 545 psf
Name: -38.0 to -55.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 545 psf C-Rate of Change: 7.925 psf/ft C-Maximum: 680 psf
Name: -55.0 to -65 ft (assumed soil properties based on above layer) Model: Mohr-Coulomb Unit Weight: 109 pcf Cohesion': 680 psf Phi': 0 °
Name: -65.0 to -80.0 ft (from WSDOT boring logs for 6th Ave Bridge) Model: Bedrock (Impenetrable)



Slope/W Stability – End of Construction (Station 13+00)

North Shore Levee
Aberdeen and Hoquiam, Washington

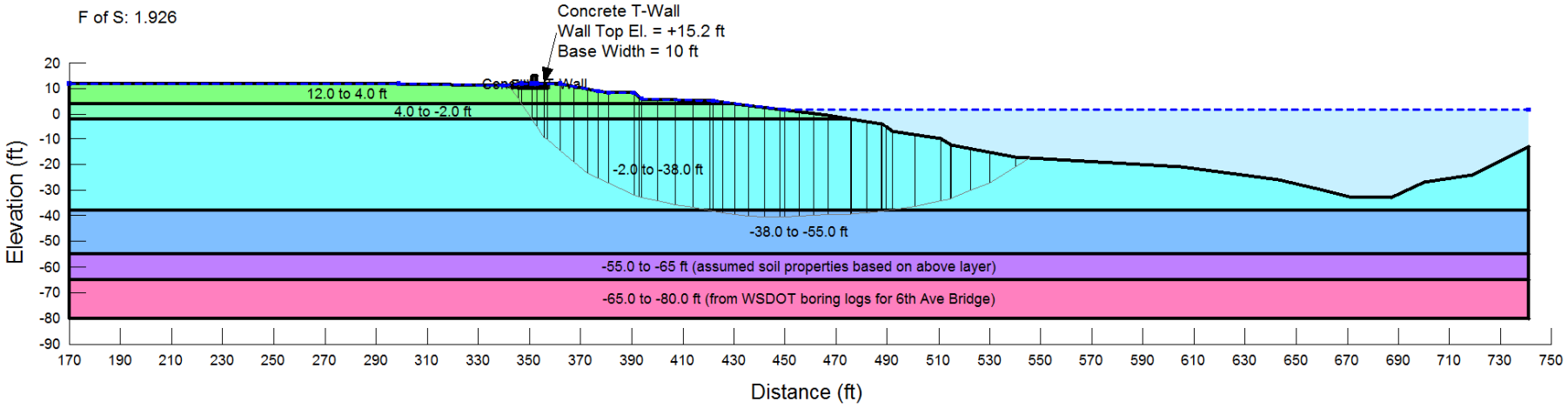
GeoEngineers

Figure 1B-1

0201-008-01 Date Exported: 02/10/17

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Concrete T-Wall Model: High Strength Unit Weight: 145 pcf
Name: Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: 12.0 to 4.0 ft Model: Mohr-Coulomb Unit Weight: 102 pcf Cohesion': 260 psf Phi': 0 °
Name: 4.0 to -2.0 ft Model: Mohr-Coulomb Unit Weight: 102 pcf Cohesion': 260 psf Phi': 0 °
Name: -2.0 to -38.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 260 psf C-Rate of Change: 7.925 psf/ft C-Maximum: 545 psf
Name: -38.0 to -55.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 545 psf C-Rate of Change: 7.925 psf/ft C-Maximum: 680 psf
Name: -55.0 to -65 ft (assumed soil properties based on above layer) Model: Mohr-Coulomb Unit Weight: 109 pcf Cohesion': 680 psf Phi': 0 °
Name: -65.0 to -80.0 ft (from WSDOT boring logs for 6th Ave Bridge) Model: Bedrock (Impenetrable)



Slope/W Stability – Sudden Drawdown (Station 13+00)

North Shore Levee
Aberdeen and Hoquiam, Washington

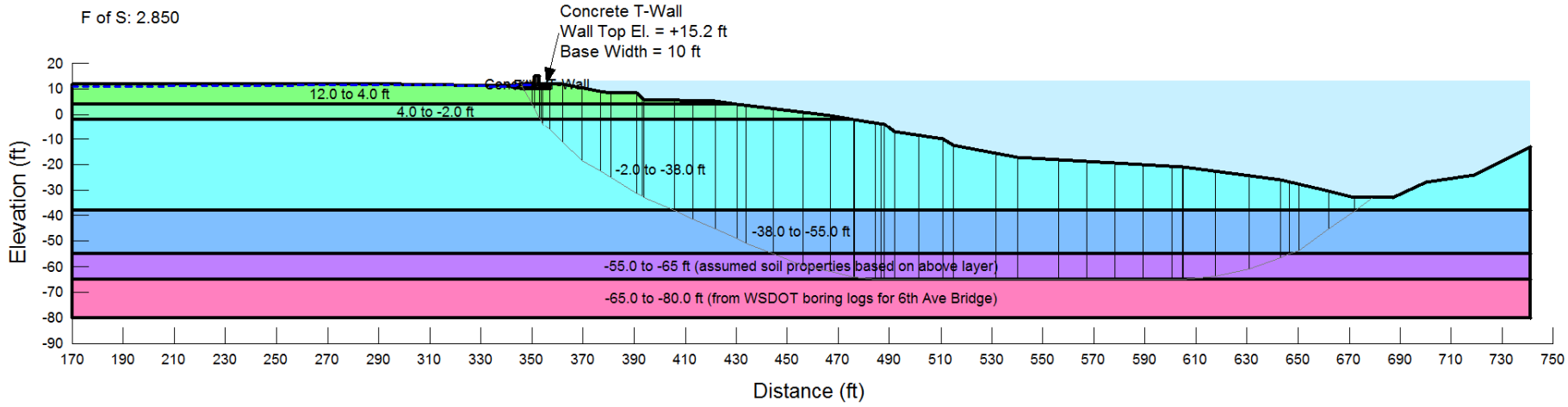
GeoEngineers

Figure 1B-2

0201-008-01 Date Exported: 02/10/17

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Concrete T-Wall Model: High Strength Unit Weight: 145 pcf
Name: Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: 12.0 to 4.0 ft Model: Mohr-Coulomb Unit Weight: 102 pcf Cohesion': 260 psf Phi': 0 °
Name: 4.0 to -2.0 ft Model: Mohr-Coulomb Unit Weight: 102 pcf Cohesion': 260 psf Phi': 0 °
Name: -2.0 to -38.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 260 psf C-Rate of Change: 7.925 psf/ft C-Maximum: 545 psf
Name: -38.0 to -55.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 545 psf C-Rate of Change: 7.925 psf/ft C-Maximum: 680 psf
Name: -55.0 to -65 ft (assumed soil properties based on above layer) Model: Mohr-Coulomb Unit Weight: 109 pcf Cohesion': 680 psf Phi': 0 °
Name: -65.0 to -80.0 ft (from WSDOT boring logs for 6th Ave Bridge) Model: Bedrock (Impenetrable)



Slope/W Stability – Critical Flood State – Waterside (Station 13+00)

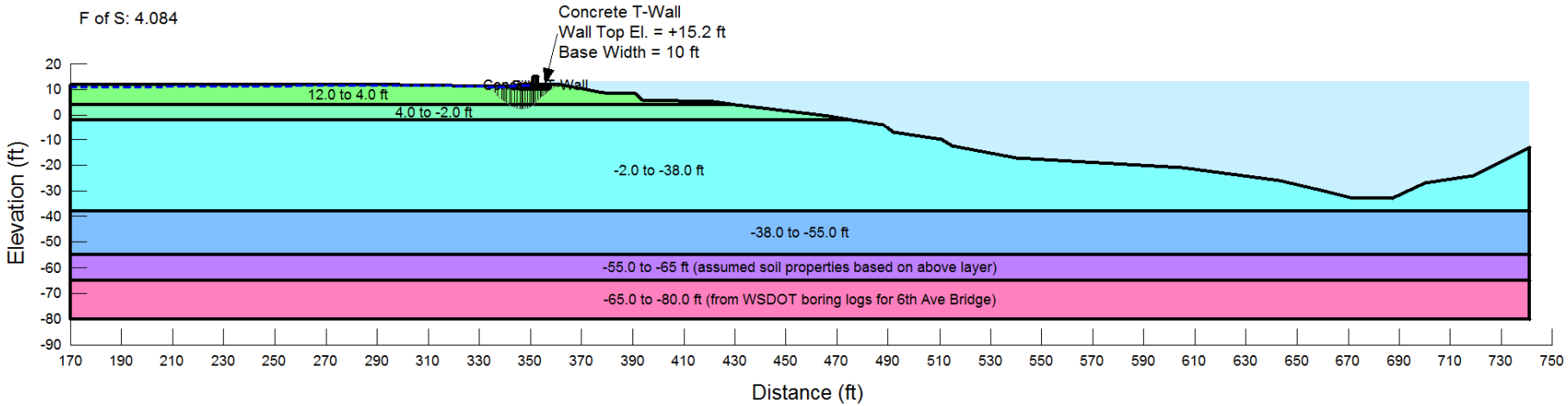
North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure 1B-3WS

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Concrete T-Wall Model: High Strength Unit Weight: 145 pcf
Name: Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: 12.0 to 4.0 ft Model: Mohr-Coulomb Unit Weight: 102 pcf Cohesion': 260 psf Phi': 0 °
Name: 4.0 to -2.0 ft Model: Mohr-Coulomb Unit Weight: 102 pcf Cohesion': 260 psf Phi': 0 °
Name: -2.0 to -38.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 260 psf C-Rate of Change: 7.925 psf/ft C-Maximum: 545 psf
Name: -38.0 to -55.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 545 psf C-Rate of Change: 7.925 psf/ft C-Maximum: 680 psf
Name: -55.0 to -65 ft (assumed soil properties based on above layer) Model: Mohr-Coulomb Unit Weight: 109 pcf Cohesion': 680 psf Phi': 0 °
Name: -65.0 to -80.0 ft (from WSDOT boring logs for 6th Ave Bridge) Model: Bedrock (Impenetrable)



Slope/W Stability – Critical Flood Stage – Landside (Station 13+00)

North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

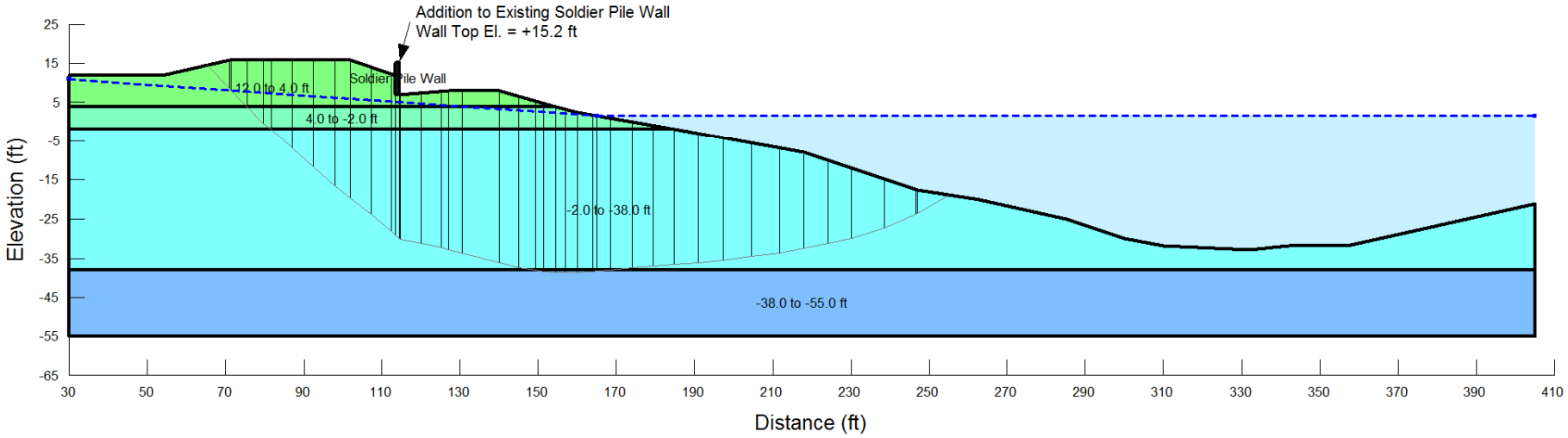
Figure 1B-3LS

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

0201-008-01 Date Exported: 02/10/17

Name: Soldier Pile Wall Model: High Strength Unit Weight: 484 pcf
Name: 12.0 to 4.0 ft Model: Mohr-Coulomb Unit Weight: 102 pcf Cohesion': 260 psf Phi': 0 °
Name: 4.0 to -2.0 ft Model: Mohr-Coulomb Unit Weight: 102 pcf Cohesion': 260 psf Phi': 0 °
Name: -2.0 to -38.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 260 psf C-Rate of Change: 7.925 psf/ft C-Maximum: 545 psf
Name: -38.0 to -55.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 545 psf C-Rate of Change: 7.925 psf/ft C-Maximum: 680 psf

F of S: 1.338



Slope/W Stability – End of Construction (Station 20+50)

North Shore Levee
Aberdeen and Hoquiam, Washington

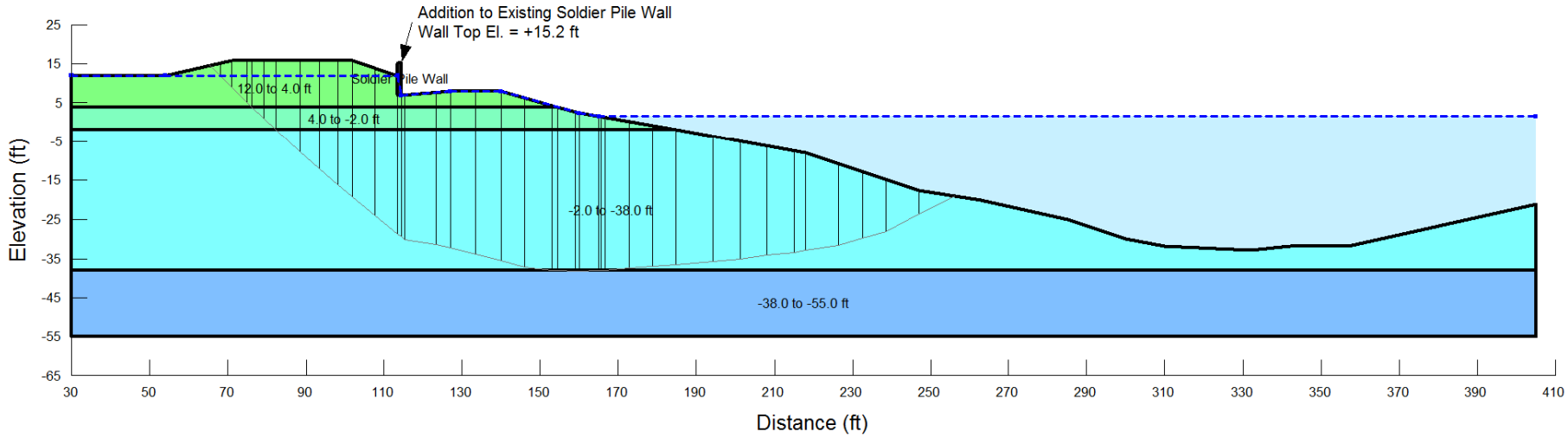
GeoEngineers

Figure 1C-1

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Soldier Pile Wall Model: High Strength Unit Weight: 484 pcf
Name: 12.0 to 4.0 ft Model: Mohr-Coulomb Unit Weight: 102 pcf Cohesion': 260 psf Phi': 0 °
Name: 4.0 to -2.0 ft Model: Mohr-Coulomb Unit Weight: 102 pcf Cohesion': 260 psf Phi': 0 °
Name: -2.0 to -38.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 260 psf C-Rate of Change: 7.925 psf/ft C-Maximum: 545 psf
Name: -38.0 to -55.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 545 psf C-Rate of Change: 7.925 psf/ft C-Maximum: 680 psf

F of S: 1.347



Slope/W Stability – Sudden Drawdown (Station 13+00)

North Shore Levee
Aberdeen and Hoquiam, Washington

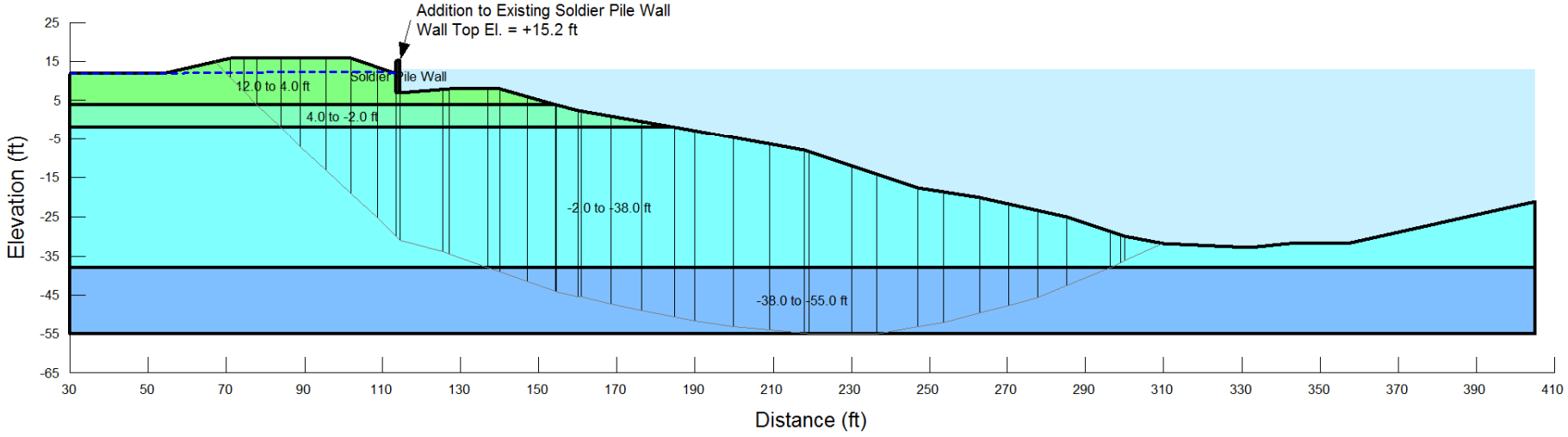
GeoEngineers

Figure 1C-2

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Soldier Pile Wall Model: High Strength Unit Weight: 484 pcf
Name: 12.0 to 4.0 ft Model: Mohr-Coulomb Unit Weight: 102 pcf Cohesion': 260 psf Phi': 0 °
Name: 4.0 to -2.0 ft Model: Mohr-Coulomb Unit Weight: 102 pcf Cohesion': 260 psf Phi': 0 °
Name: -2.0 to -38.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 260 psf C-Rate of Change: 7.925 psf/ft C-Maximum: 545 psf
Name: -38.0 to -55.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 545 psf C-Rate of Change: 7.925 psf/ft C-Maximum: 680 psf

F of S: 1.956



Slope/W Stability – Critical Flood State – Waterside (Station 13+00)

North Shore Levee
Aberdeen and Hoquiam, Washington

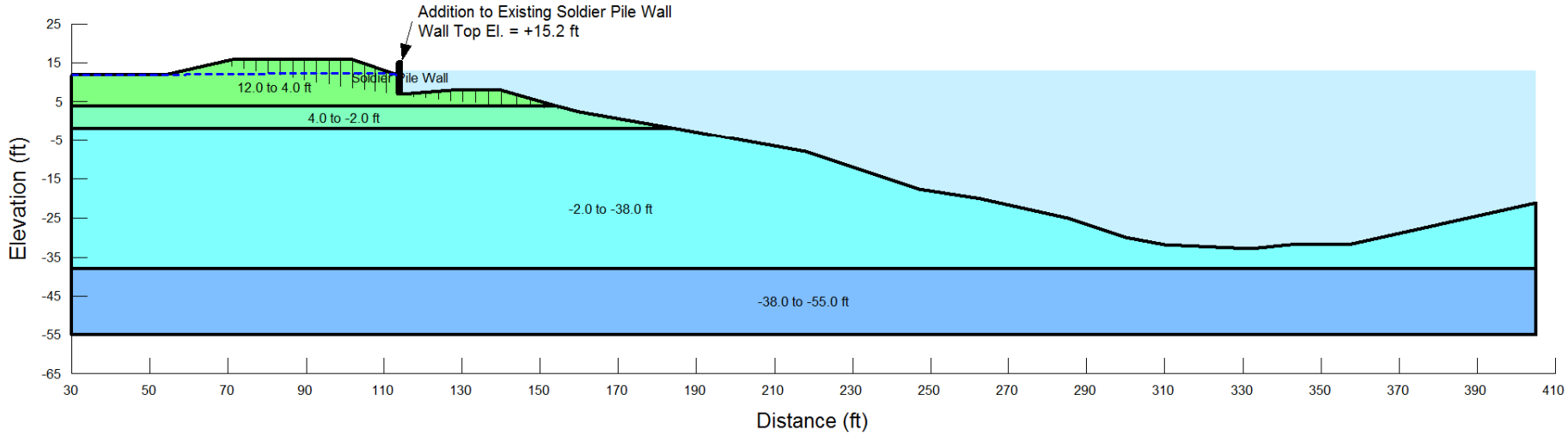
GeoEngineers

Figure 1C-3WS

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Soldier Pile Wall Model: High Strength Unit Weight: 484 pcf
Name: 12.0 to 4.0 ft Model: Mohr-Coulomb Unit Weight: 102 pcf Cohesion': 260 psf Phi': 0 °
Name: 4.0 to -2.0 ft Model: Mohr-Coulomb Unit Weight: 102 pcf Cohesion': 260 psf Phi': 0 °
Name: -2.0 to -38.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 260 psf C-Rate of Change: 7.925 psf/ft C-Maximum: 545 psf
Name: -38.0 to -55.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 545 psf C-Rate of Change: 7.925 psf/ft C-Maximum: 680 psf

F of S: E984



Slope/W Stability – Critical Flood Stage – Landside (Station 13+00)

North Shore Levee
Aberdeen and Hoquiam, Washington

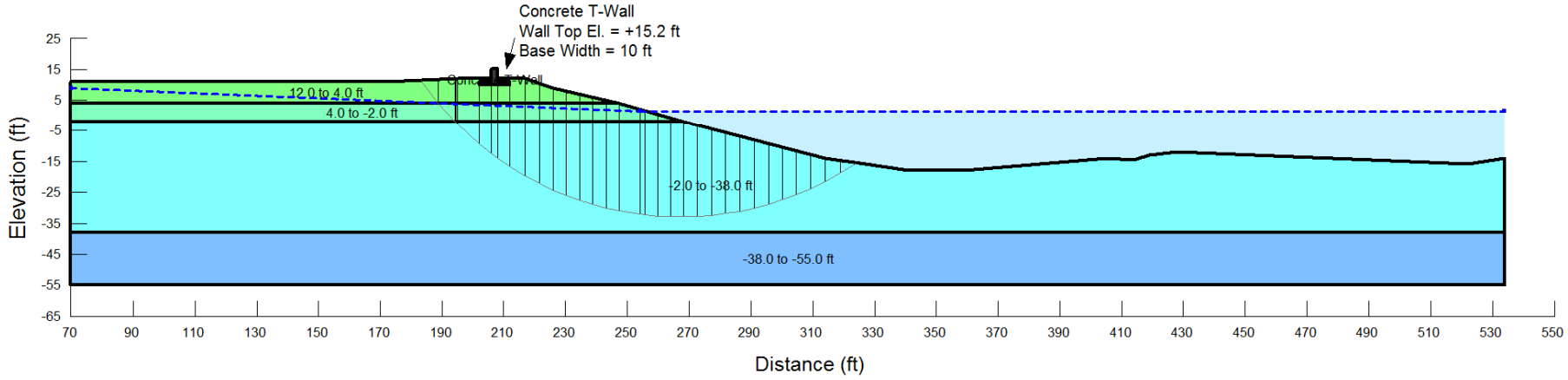
GeoEngineers

Figure 1C-3LS

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Concrete T-Wall Model: High Strength Unit Weight: 145 pcf
Name: 12.0 to 4.0 ft Model: Mohr-Coulomb Unit Weight: 102 pcf Cohesion': 260 psf Phi': 0 °
Name: 4.0 to -2.0 ft Model: Mohr-Coulomb Unit Weight: 102 pcf Cohesion': 260 psf Phi': 0 °
Name: -2.0 to -38.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 260 psf C-Rate of Change: 7.925 psf/ft C-Maximum: 545 psf
Name: -38.0 to -55.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 545 psf C-Rate of Change: 7.925 psf/ft C-Maximum: 680 psf

F of S: 1.473



Slope/W Stability – End of Construction (Station 42+00)

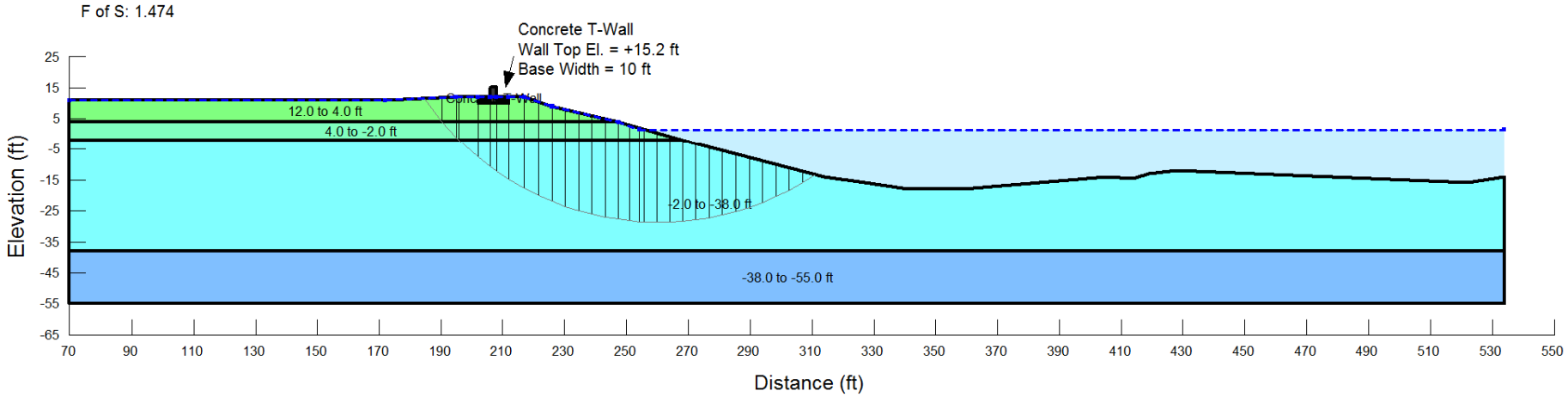
North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure 1D-1

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Concrete T-Wall Model: High Strength Unit Weight: 145 pcf
Name: 12.0 to 4.0 ft Model: Mohr-Coulomb Unit Weight: 102 pcf Cohesion': 260 psf Phi': 0 °
Name: 4.0 to -2.0 ft Model: Mohr-Coulomb Unit Weight: 102 pcf Cohesion': 260 psf Phi': 0 °
Name: -2.0 to -38.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 260 psf C-Rate of Change: 7.925 psf/ft C-Maximum: 545 psf
Name: -38.0 to -55.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 545 psf C-Rate of Change: 7.925 psf/ft C-Maximum: 680 psf



Slope/W Stability – Sudden Drawdown (Station 42+00)

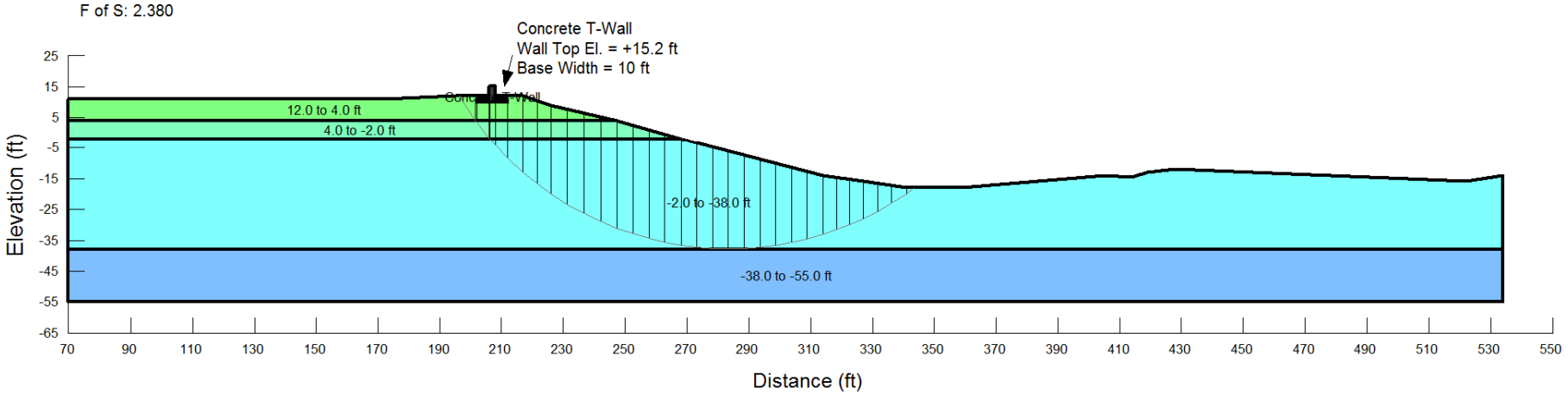
North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure 1D-2

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Concrete T-Wall Model: High Strength Unit Weight: 145 pcf
Name: 12.0 to 4.0 ft Model: Mohr-Coulomb Unit Weight: 102 pcf Cohesion': 260 psf Phi': 0 °
Name: 4.0 to -2.0 ft Model: Mohr-Coulomb Unit Weight: 102 pcf Cohesion': 260 psf Phi': 0 °
Name: -2.0 to -38.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 260 psf C-Rate of Change: 7.925 psf/ft C-Maximum: 545 psf
Name: -38.0 to -55.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 545 psf C-Rate of Change: 7.925 psf/ft C-Maximum: 680 psf



Slope/W Stability – Critical Flood State – Waterside (Station 42+00)

North Shore Levee
Aberdeen and Hoquiam, Washington

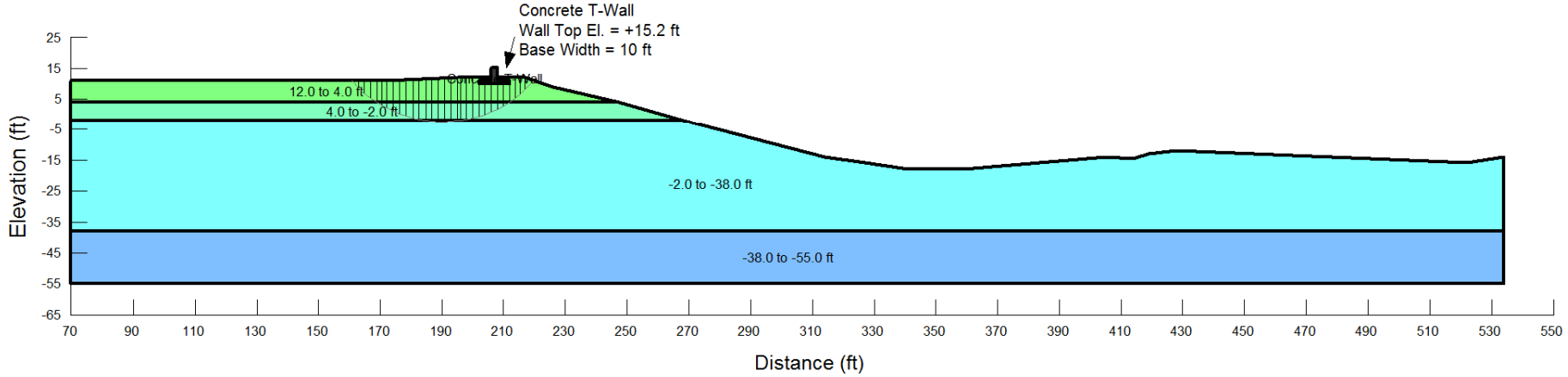
GeoEngineers

Figure 1D-3WS

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Concrete T-Wall Model: High Strength Unit Weight: 145 pcf
Name: 12.0 to 4.0 ft Model: Mohr-Coulomb Unit Weight: 102 pcf Cohesion': 260 psf Phi': 0 °
Name: 4.0 to -2.0 ft Model: Mohr-Coulomb Unit Weight: 102 pcf Cohesion': 260 psf Phi': 0 °
Name: -2.0 to -38.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 260 psf C-Rate of Change: 7.925 psf/ft C-Maximum: 545 psf
Name: -38.0 to -55.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 545 psf C-Rate of Change: 7.925 psf/ft C-Maximum: 680 psf

F of S: 8.133



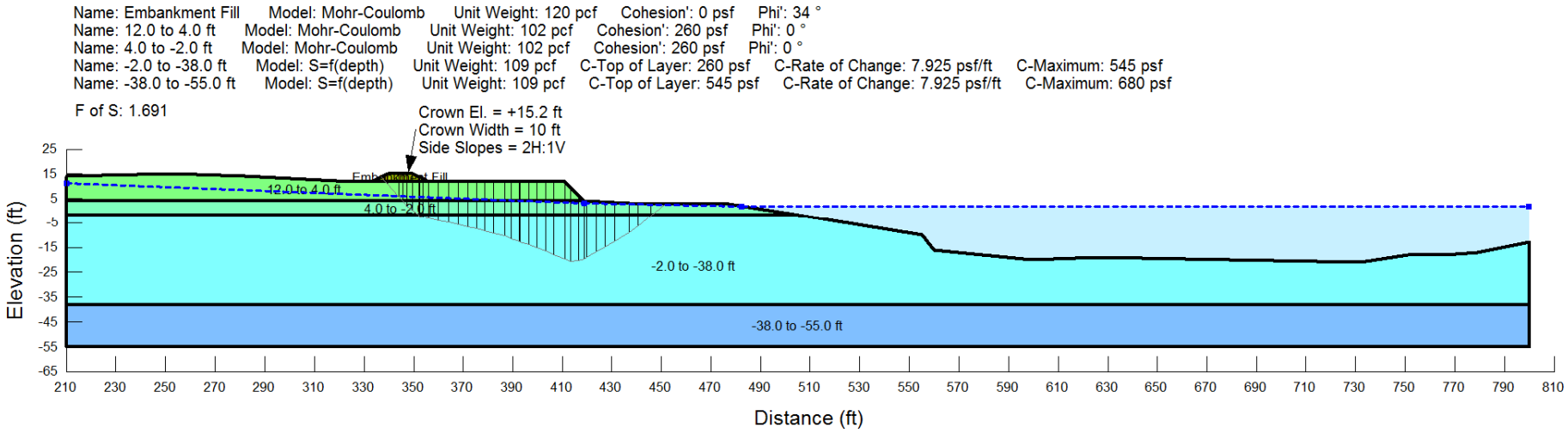
Slope/W Stability – Critical Flood Stage – Landside (Station 42+00)

North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure 1D-3LS

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.



Slope/W Stability – End of Construction (Station 57+00)

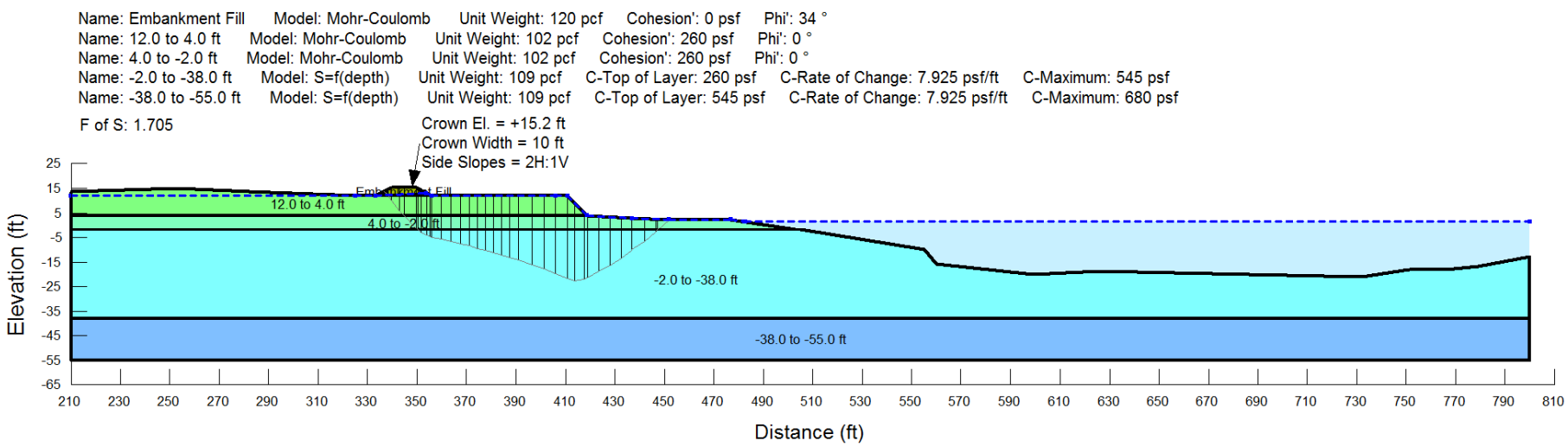
North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure 1E-1

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Embankment Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: 12.0 to 4.0 ft Model: Mohr-Coulomb Unit Weight: 102 pcf Cohesion': 260 psf Phi': 0 °
Name: 4.0 to -2.0 ft Model: Mohr-Coulomb Unit Weight: 102 pcf Cohesion': 260 psf Phi': 0 °
Name: -2.0 to -38.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 260 psf C-Rate of Change: 7.925 psf/ft C-Maximum: 545 psf
Name: -38.0 to -55.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 545 psf C-Rate of Change: 7.925 psf/ft C-Maximum: 680 psf



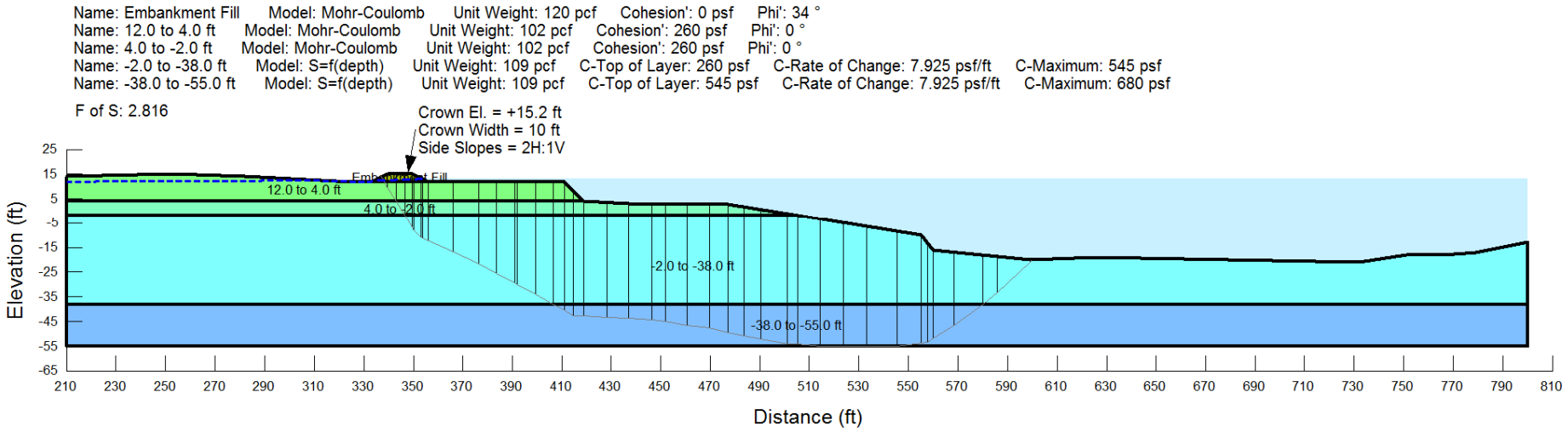
Slope/W Stability – Sudden Drawdown (Station 57+00)

North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure 1E-2

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.



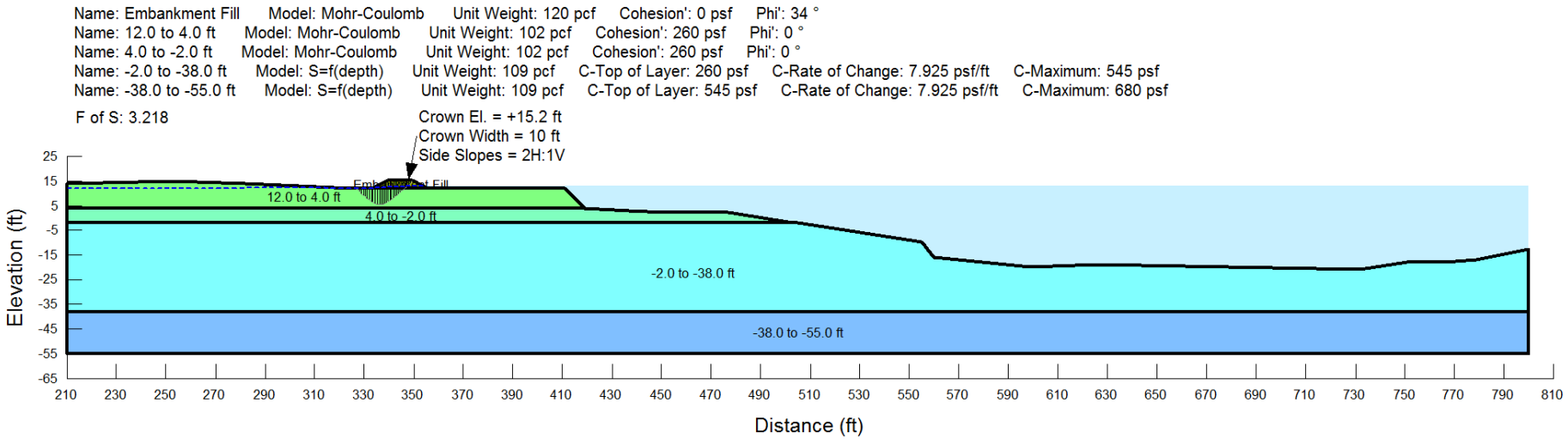
Slope/W Stability – Critical Flood State – Waterside (Station 57+00)

North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure 1E-3WS

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.



Slope/W Stability – Critical Flood Stage – Landside (Station 57+00)

North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

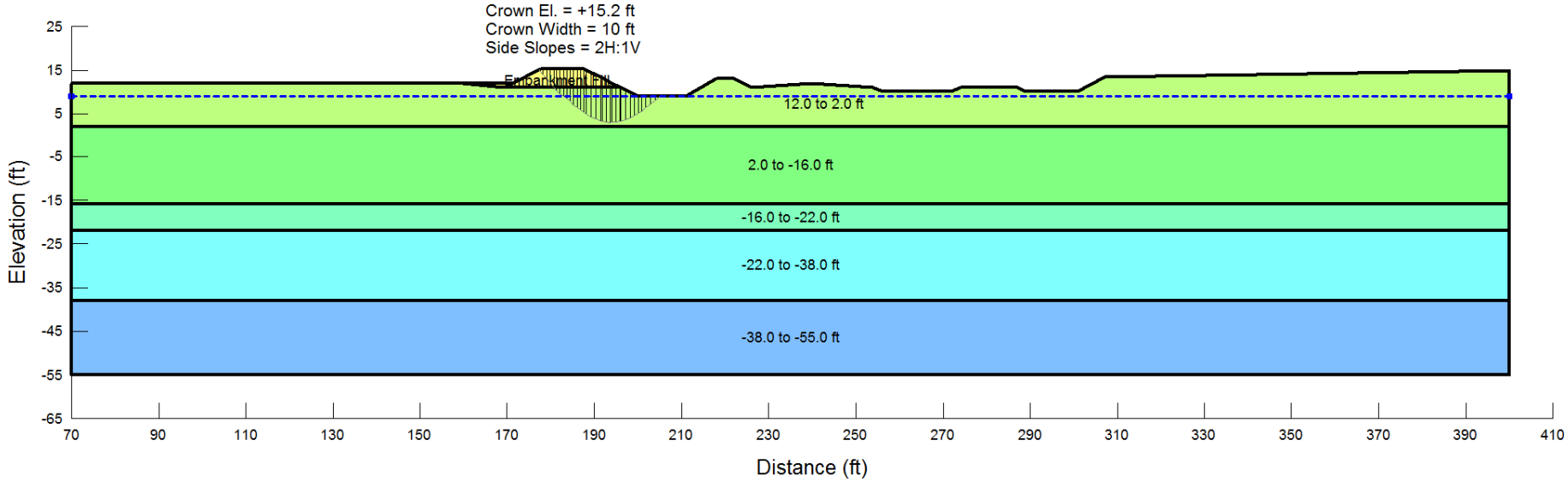
Figure 1E-3LS

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

0201-008-01 Date Exported: 02/10/17

Name: Embankment Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: 12.0 to 2.0 ft Model: Mohr-Coulomb Unit Weight: 97 pcf Cohesion': 280 psf Phi': 0 °
Name: 2.0 to -16.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 280 psf C-Rate of Change: 27.778 psf/ft C-Maximum: 780 psf
Name: -16.0 to -22.0 ft Model: Mohr-Coulomb Unit Weight: 109 pcf Cohesion': 0 psf Phi': 29 °
Name: -22.0 to -38.0 ft Model: Mohr-Coulomb Unit Weight: 109 pcf Cohesion': 1,000 psf Phi': 0 °
Name: -38.0 to -55.0 ft Model: Mohr-Coulomb Unit Weight: 109 pcf Cohesion': 0 psf Phi': 29 °

F of S: 2.058



Slope/W Stability – End of Construction (Station 91+00)

North Shore Levee
Aberdeen and Hoquiam, Washington

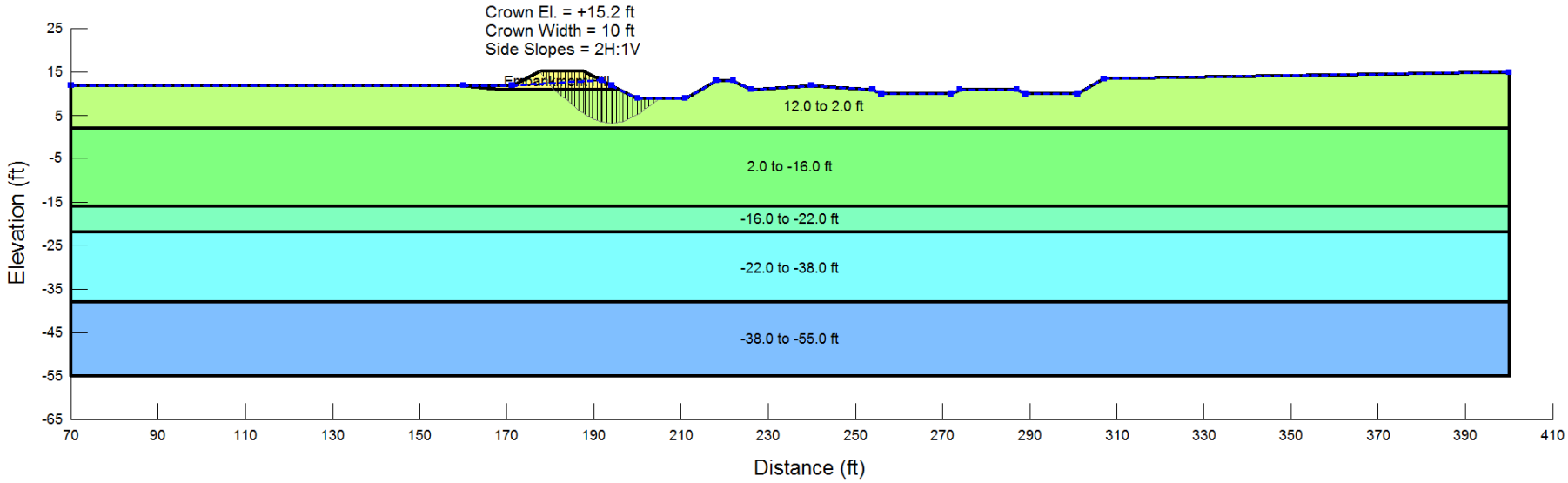
GeoEngineers

Figure 2A-1

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Embankment Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: 12.0 to 2.0 ft Model: Mohr-Coulomb Unit Weight: 97 pcf Cohesion': 280 psf Phi': 0 °
Name: 2.0 to -16.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 280 psf C-Rate of Change: 27.778 psf/ft C-Maximum: 780 psf
Name: -16.0 to -22.0 ft Model: Mohr-Coulomb Unit Weight: 109 pcf Cohesion': 0 psf Phi': 29 °
Name: -22.0 to -38.0 ft Model: Mohr-Coulomb Unit Weight: 109 pcf Cohesion': 1,000 psf Phi': 0 °
Name: -38.0 to -55.0 ft Model: Mohr-Coulomb Unit Weight: 109 pcf Cohesion': 0 psf Phi': 29 °

F of S: 2.054



Slope/W Stability – Sudden Drawdown (Station 91+00)

North Shore Levee
Aberdeen and Hoquiam, Washington

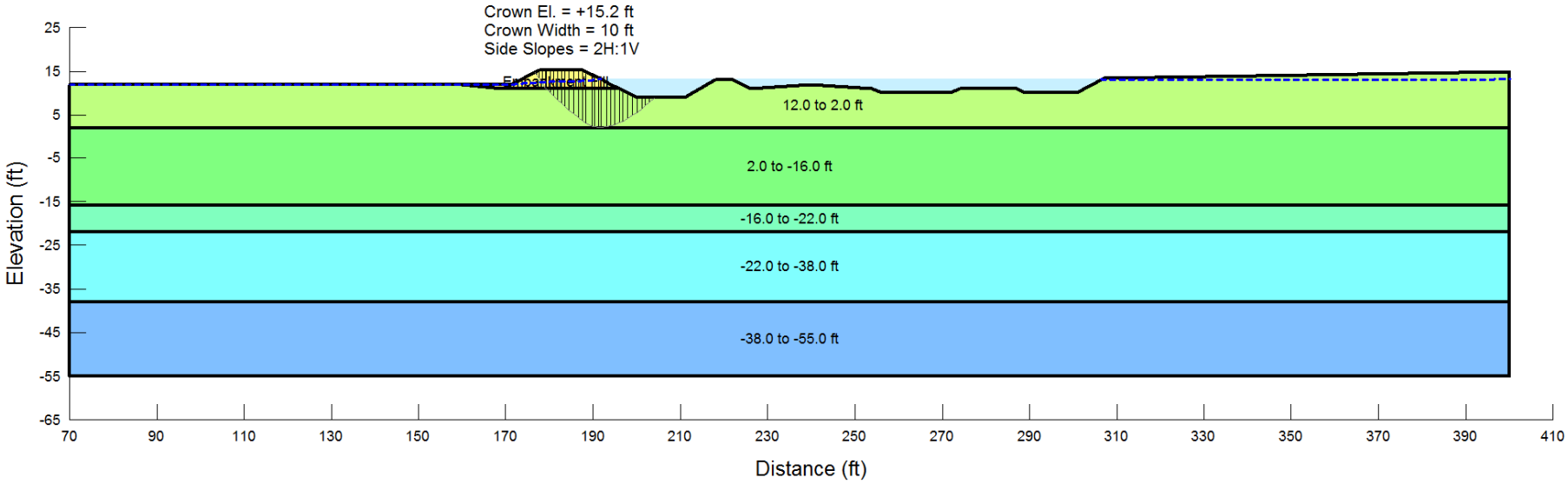
GeoEngineers

Figure 2A-2

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Embankment Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: 12.0 to 2.0 ft Model: Mohr-Coulomb Unit Weight: 97 pcf Cohesion': 280 psf Phi': 0 °
Name: 2.0 to -16.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 280 psf C-Rate of Change: 27.778 psf/ft C-Maximum: 780 psf
Name: -16.0 to -22.0 ft Model: Mohr-Coulomb Unit Weight: 109 pcf Cohesion': 0 psf Phi': 29 °
Name: -22.0 to -38.0 ft Model: Mohr-Coulomb Unit Weight: 109 pcf Cohesion': 1,000 psf Phi': 0 °
Name: -38.0 to -55.0 ft Model: Mohr-Coulomb Unit Weight: 109 pcf Cohesion': 0 psf Phi': 29 °

F of S: 3.032



Slope/W Stability – Critical Flood State – Waterside (Station 91+00)

North Shore Levee
Aberdeen and Hoquiam, Washington

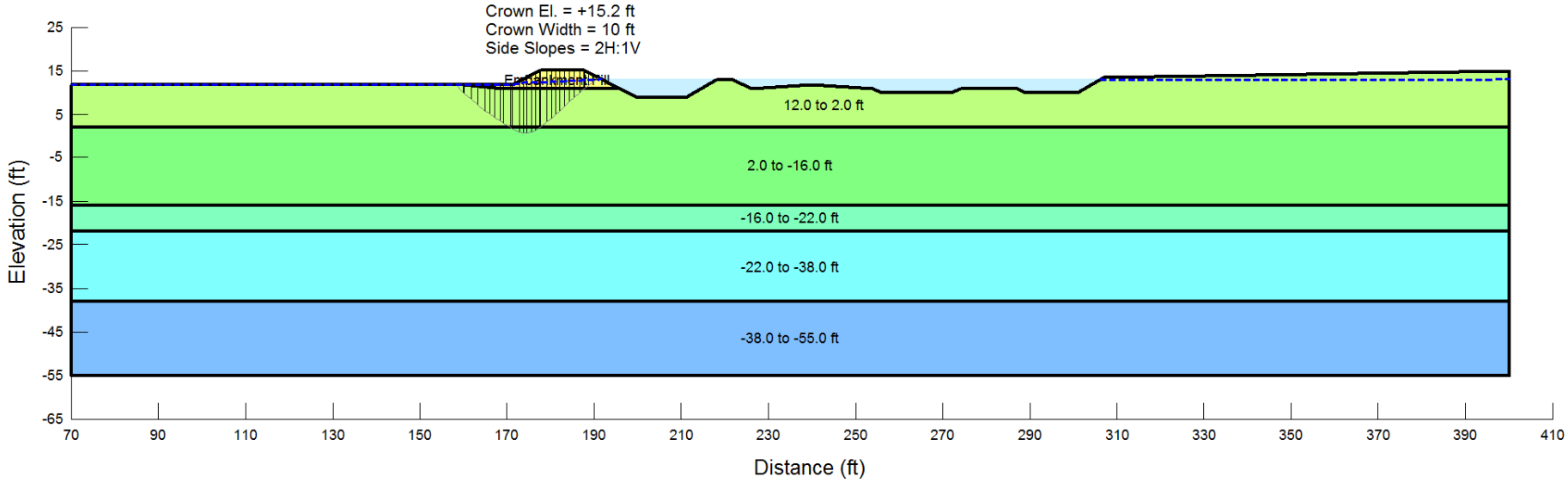
GeoEngineers

Figure 2A-3WS

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Embankment Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: 12.0 to 2.0 ft Model: Mohr-Coulomb Unit Weight: 97 pcf Cohesion': 280 psf Phi': 0 °
Name: 2.0 to -16.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 280 psf C-Rate of Change: 27.778 psf/ft C-Maximum: 780 psf
Name: -16.0 to -22.0 ft Model: Mohr-Coulomb Unit Weight: 109 pcf Cohesion': 0 psf Phi': 29 °
Name: -22.0 to -38.0 ft Model: Mohr-Coulomb Unit Weight: 109 pcf Cohesion': 1,000 psf Phi': 0 °
Name: -38.0 to -55.0 ft Model: Mohr-Coulomb Unit Weight: 109 pcf Cohesion': 0 psf Phi': 29 °

F of S: 3.389



Slope/W Stability – Critical Flood Stage – Landside (Station 91+00)

North Shore Levee
Aberdeen and Hoquiam, Washington

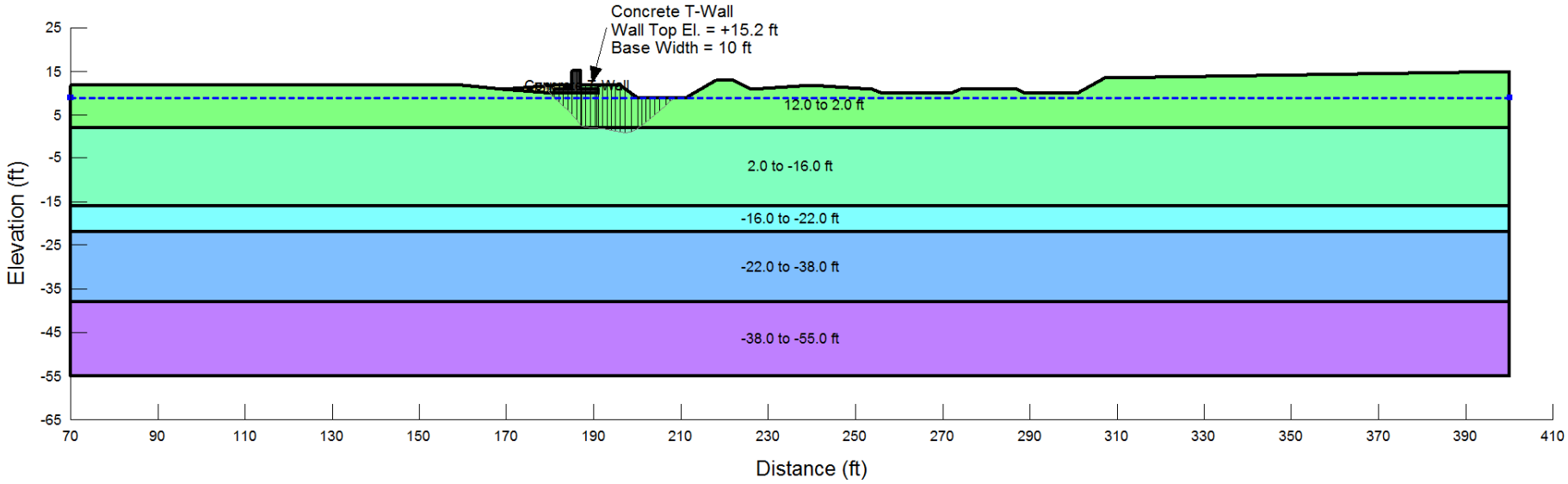
GeoEngineers

Figure 2A-3LS

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Concrete T-Wall Model: High Strength Unit Weight: 145 pcf
Name: Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: 12.0 to 2.0 ft Model: Mohr-Coulomb Unit Weight: 97 pcf Cohesion': 280 psf Phi': 0 °
Name: 2.0 to -16.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 280 psf C-Rate of Change: 27.78 psf/ft C-Maximum: 780 psf
Name: -16.0 to -22.0 ft Model: Mohr-Coulomb Unit Weight: 109 pcf Cohesion': 0 psf Phi': 29 °
Name: -22.0 to -38.0 ft Model: Mohr-Coulomb Unit Weight: 109 pcf Cohesion': 1,000 psf Phi': 0 °
Name: -38.0 to -55.0 ft Model: Mohr-Coulomb Unit Weight: 109 pcf Cohesion': 0 psf Phi': 29 °

F of S: 2.999



Slope/W Stability – End of Construction (Station 100+50)

North Shore Levee
Aberdeen and Hoquiam, Washington

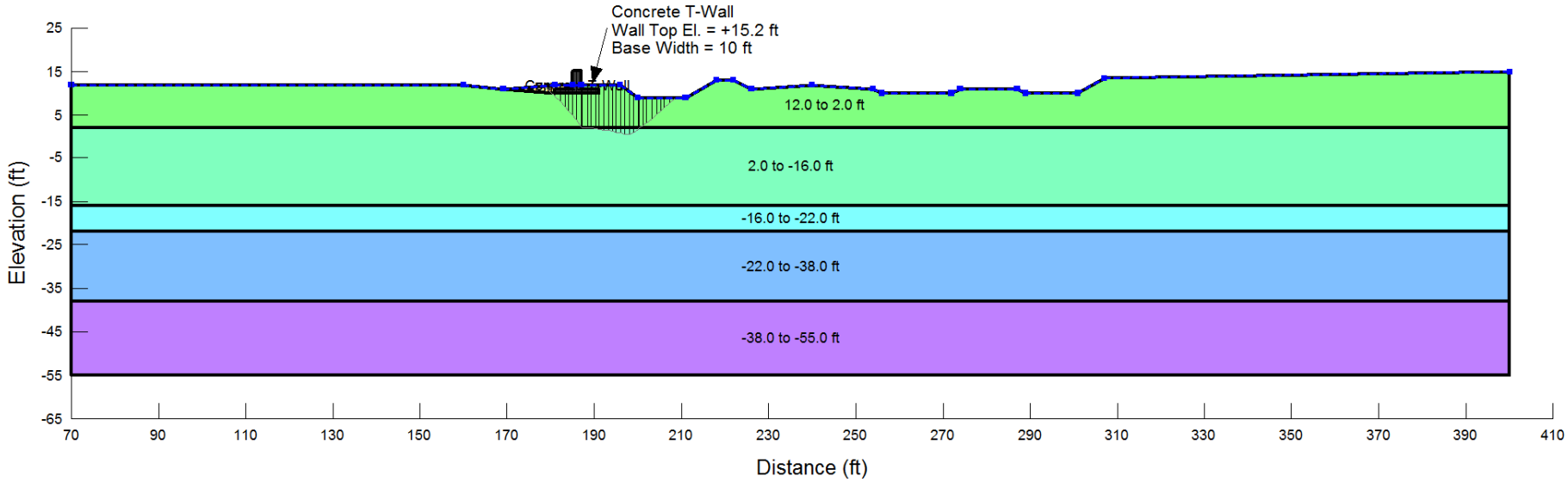
GeoEngineers

Figure 2B-1

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Concrete T-Wall Model: High Strength Unit Weight: 145 pcf
Name: Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: 12.0 to 2.0 ft Model: Mohr-Coulomb Unit Weight: 97 pcf Cohesion': 280 psf Phi': 0 °
Name: 2.0 to -16.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 280 psf C-Rate of Change: 27.78 psf/ft C-Maximum: 780 psf
Name: -16.0 to -22.0 ft Model: Mohr-Coulomb Unit Weight: 109 pcf Cohesion': 0 psf Phi': 29 °
Name: -22.0 to -38.0 ft Model: Mohr-Coulomb Unit Weight: 109 pcf Cohesion': 1,000 psf Phi': 0 °
Name: -38.0 to -55.0 ft Model: Mohr-Coulomb Unit Weight: 109 pcf Cohesion': 0 psf Phi': 29 °

F of S: 2.974



Slope/W Stability – Sudden Drawdown (Station 100+50)

North Shore Levee
Aberdeen and Hoquiam, Washington

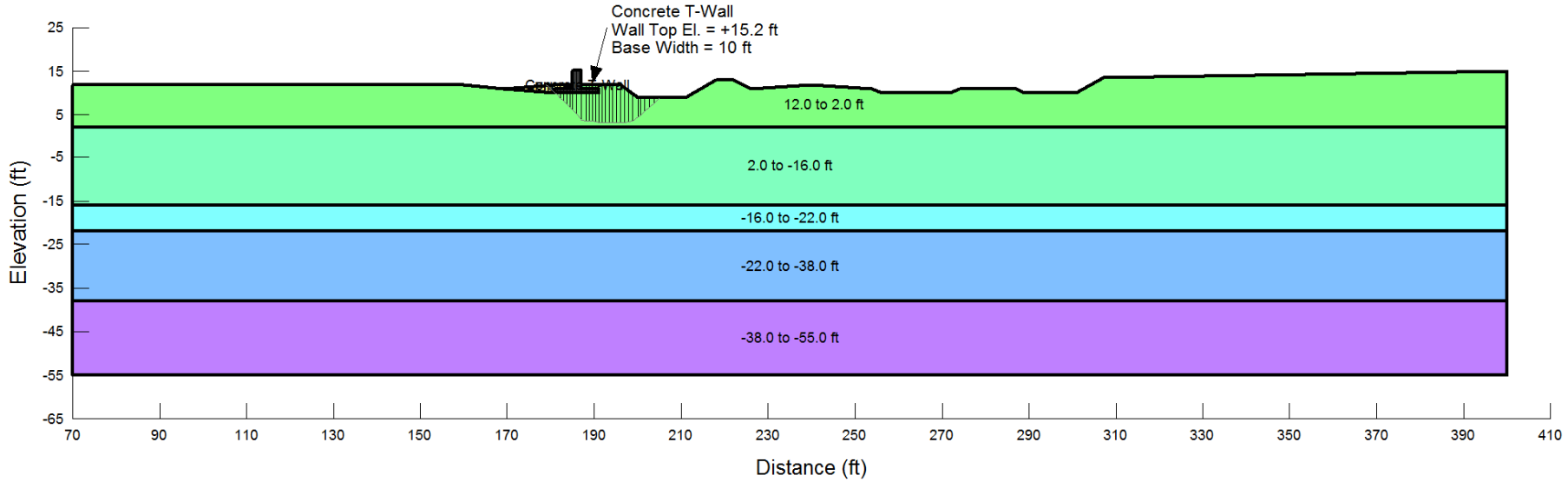
GeoEngineers

Figure 2B-2

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Concrete T-Wall Model: High Strength Unit Weight: 145 pcf
Name: Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: 12.0 to 2.0 ft Model: Mohr-Coulomb Unit Weight: 97 pcf Cohesion': 280 psf Phi': 0 °
Name: 2.0 to -16.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 280 psf C-Rate of Change: 27.78 psf/ft C-Maximum: 780 psf
Name: -16.0 to -22.0 ft Model: Mohr-Coulomb Unit Weight: 109 pcf Cohesion': 0 psf Phi': 29 °
Name: -22.0 to -38.0 ft Model: Mohr-Coulomb Unit Weight: 109 pcf Cohesion': 1,000 psf Phi': 0 °
Name: -38.0 to -55.0 ft Model: Mohr-Coulomb Unit Weight: 109 pcf Cohesion': 0 psf Phi': 29 °

F of S: 5.481



Slope/W Stability – Critical Flood State – Waterside (Station 100+50)

North Shore Levee
Aberdeen and Hoquiam, Washington

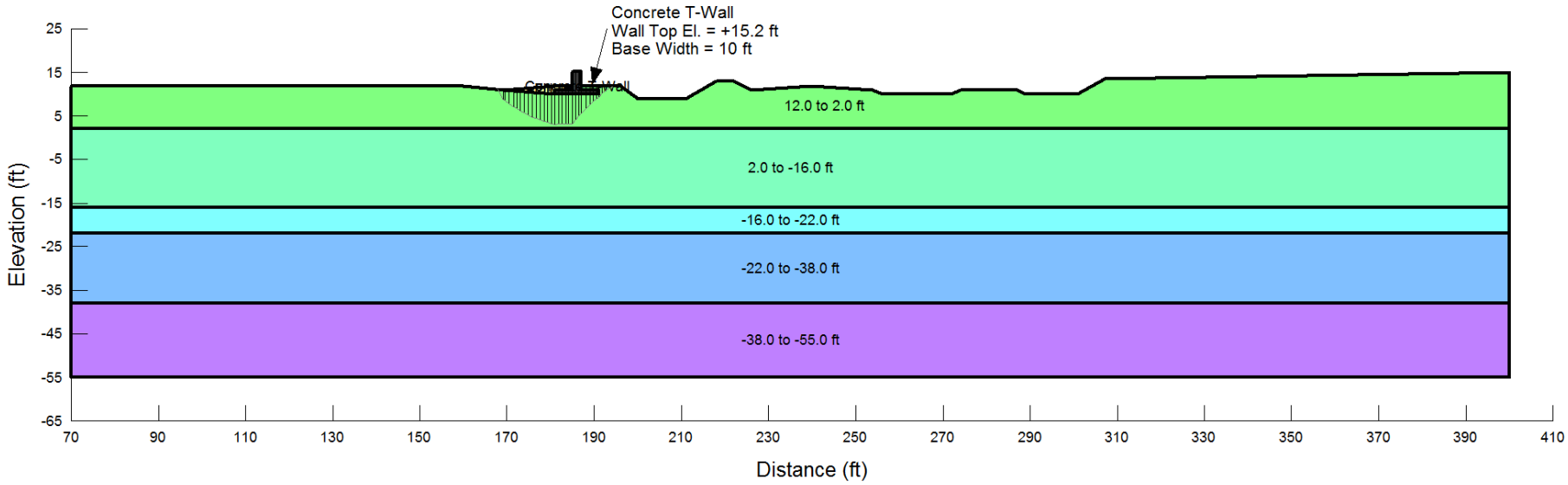
GeoEngineers

Figure 2B-3WS

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Concrete T-Wall Model: High Strength Unit Weight: 145 pcf
Name: Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: 12.0 to 2.0 ft Model: Mohr-Coulomb Unit Weight: 97 pcf Cohesion': 280 psf Phi': 0 °
Name: 2.0 to -16.0 ft Model: S=f(depth) Unit Weight: 109 pcf C-Top of Layer: 280 psf C-Rate of Change: 27.78 psf/ft C-Maximum: 780 psf
Name: -16.0 to -22.0 ft Model: Mohr-Coulomb Unit Weight: 109 pcf Cohesion': 0 psf Phi': 29 °
Name: -22.0 to -38.0 ft Model: Mohr-Coulomb Unit Weight: 109 pcf Cohesion': 1,000 psf Phi': 0 °
Name: -38.0 to -55.0 ft Model: Mohr-Coulomb Unit Weight: 109 pcf Cohesion': 0 psf Phi': 29 °

F of S: 4.358



Slope/W Stability – Critical Flood Stage – Landside (Station 100+50)

North Shore Levee
Aberdeen and Hoquiam, Washington

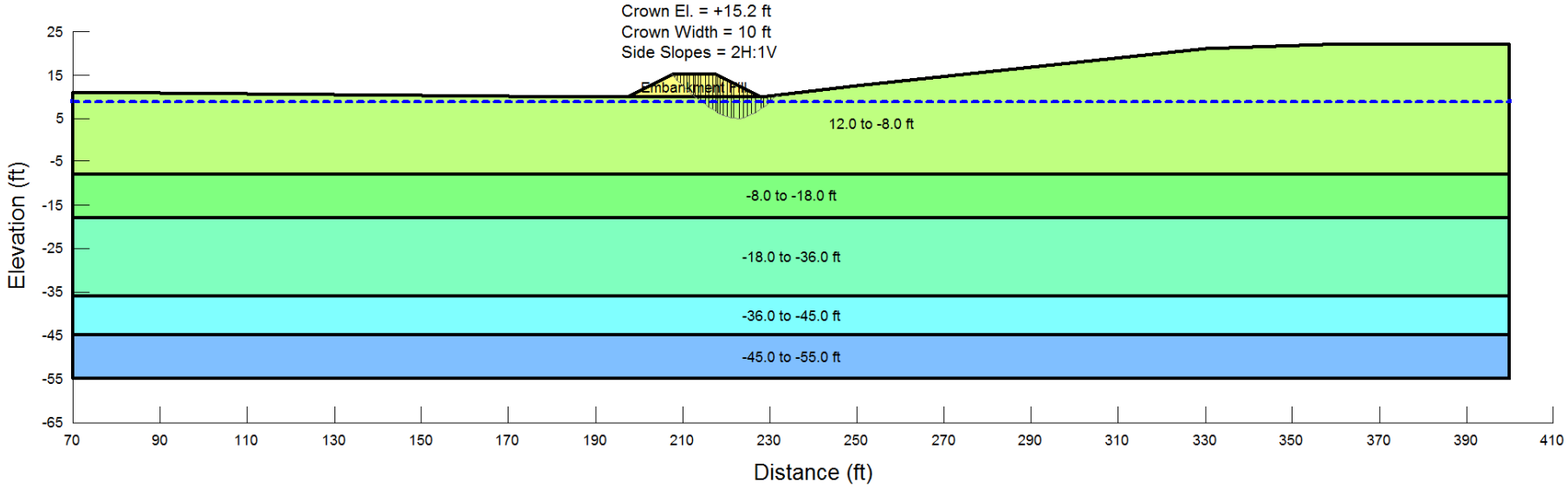
GeoEngineers

Figure 2B-3LS

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Embankment Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: 12.0 to -8.0 ft Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion': 430 psf Phi': 0 °
Name: -8.0 to -18.0 ft Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion': 350 psf Phi': 0 °
Name: -18.0 to -36.0 ft Model: Mohr-Coulomb Unit Weight: 107 pcf Cohesion': 700 psf Phi': 0 °
Name: -36.0 to -45.0 ft Model: Mohr-Coulomb Unit Weight: 107 pcf Cohesion': 0 psf Phi': 33 °
Name: -45.0 to -55.0 ft Model: Mohr-Coulomb Unit Weight: 107 pcf Cohesion': 970 psf Phi': 0 °

F of S: 3.538



Slope/W Stability – End of Construction (Station 155+00)

North Shore Levee
Aberdeen and Hoquiam, Washington

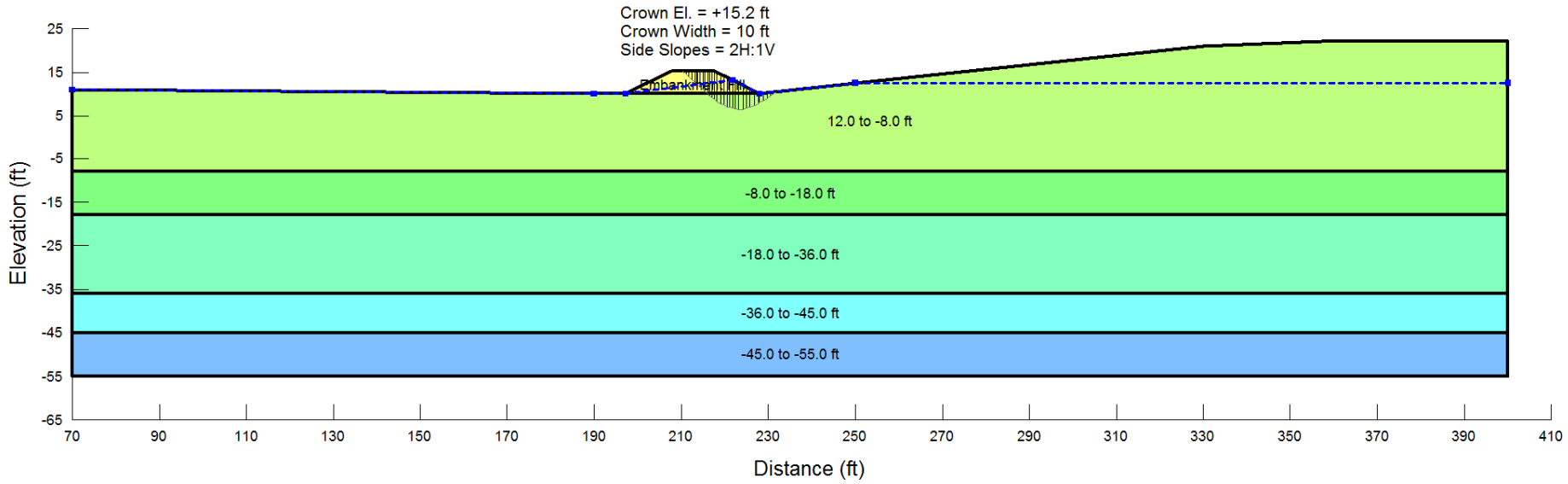
GeoEngineers

Figure 3A-1

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Embankment Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: 12.0 to -8.0 ft Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion': 430 psf Phi': 0 °
Name: -8.0 to -18.0 ft Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion': 350 psf Phi': 0 °
Name: -18.0 to -36.0 ft Model: Mohr-Coulomb Unit Weight: 107 pcf Cohesion': 700 psf Phi': 0 °
Name: -36.0 to -45.0 ft Model: Mohr-Coulomb Unit Weight: 107 pcf Cohesion': 0 psf Phi': 33 °
Name: -45.0 to -55.0 ft Model: Mohr-Coulomb Unit Weight: 107 pcf Cohesion': 970 psf Phi': 0 °

F of S: 3.574



Slope/W Stability – Sudden Drawdown (Station 155+00)

North Shore Levee
Aberdeen and Hoquiam, Washington

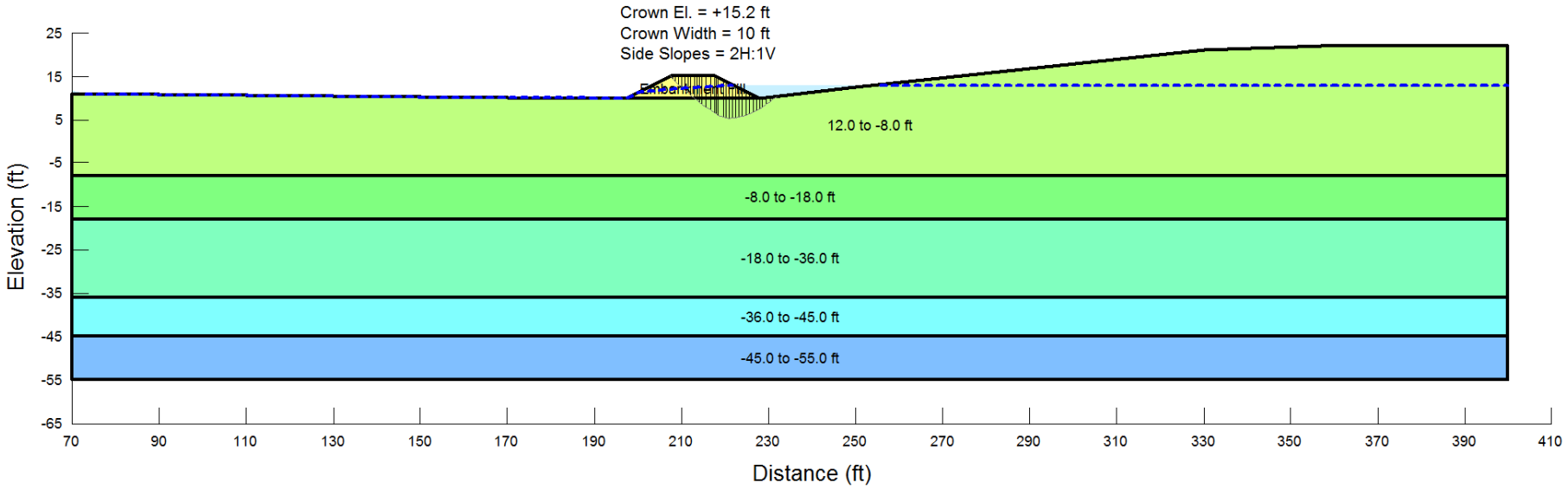
GeoEngineers

Figure 3A-2

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Embankment Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: 12.0 to -8.0 ft Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion': 430 psf Phi': 0 °
Name: -8.0 to -18.0 ft Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion': 350 psf Phi': 0 °
Name: -18.0 to -36.0 ft Model: Mohr-Coulomb Unit Weight: 107 pcf Cohesion': 700 psf Phi': 0 °
Name: -36.0 to -45.0 ft Model: Mohr-Coulomb Unit Weight: 107 pcf Cohesion': 0 psf Phi': 33 °
Name: -45.0 to -55.0 ft Model: Mohr-Coulomb Unit Weight: 107 pcf Cohesion': 970 psf Phi': 0 °

F of S: 4.801



Slope/W Stability – Critical Flood State – Waterside (Station 155+00)

North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

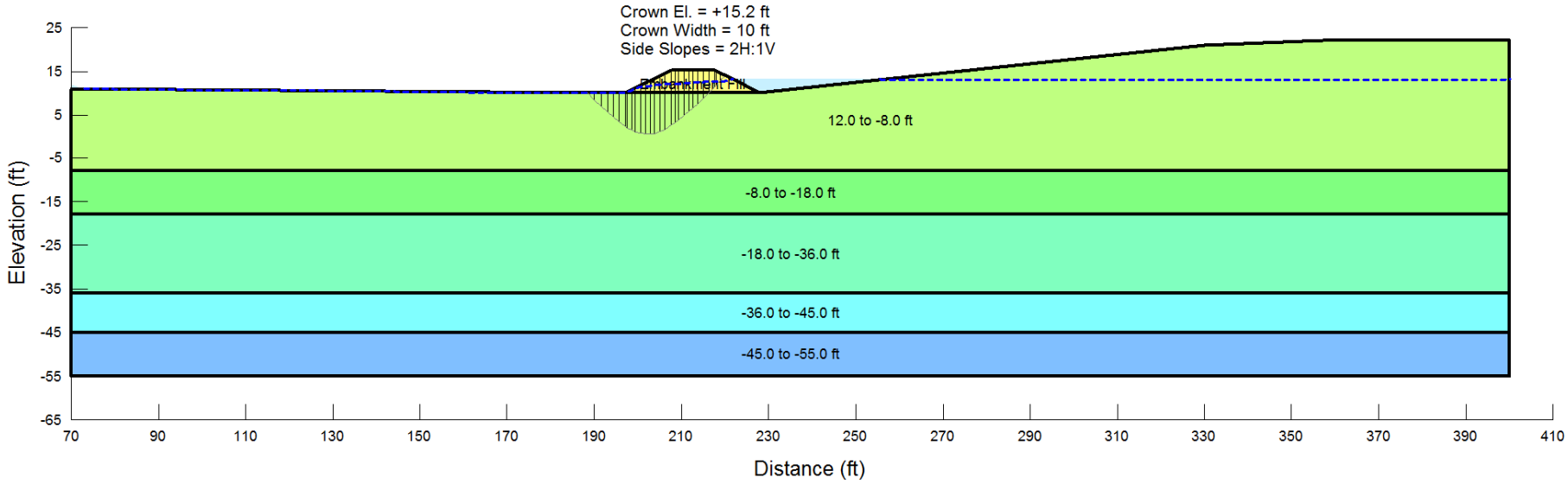
Figure 3A-3WS

0201-008-01 Date Exported: 02/10/17

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Embankment Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: 12.0 to -8.0 ft Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion': 430 psf Phi': 0 °
Name: -8.0 to -18.0 ft Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion': 350 psf Phi': 0 °
Name: -18.0 to -36.0 ft Model: Mohr-Coulomb Unit Weight: 107 pcf Cohesion': 700 psf Phi': 0 °
Name: -36.0 to -45.0 ft Model: Mohr-Coulomb Unit Weight: 107 pcf Cohesion': 0 psf Phi': 33 °
Name: -45.0 to -55.0 ft Model: Mohr-Coulomb Unit Weight: 107 pcf Cohesion': 970 psf Phi': 0 °

F of S: 3.319



Slope/W Stability – Critical Flood Stage – Landside (Station 155+00)

North Shore Levee
Aberdeen and Hoquiam, Washington

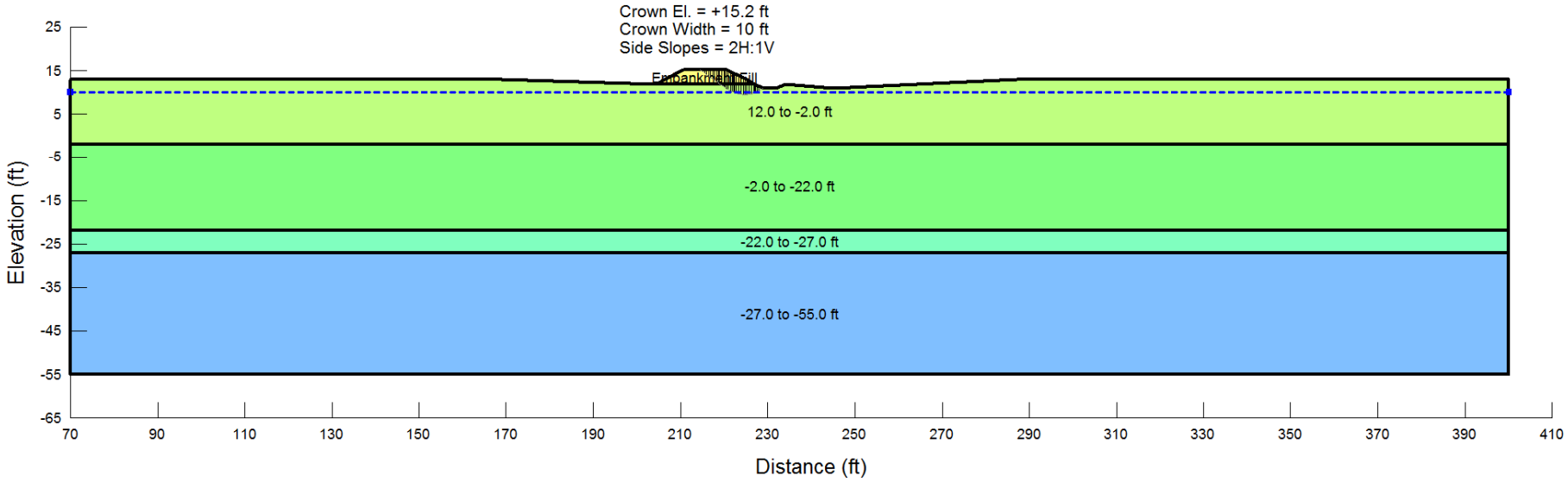
GeoEngineers

Figure 3A-3LS

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Embankment Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: 12.0 to -2.0 ft Model: Mohr-Coulomb Unit Weight: 83 pcf Cohesion': 420 psf Phi': 0 °
Name: -2.0 to -22.0 ft Model: Mohr-Coulomb Unit Weight: 99 pcf Cohesion': 500 psf Phi': 0 °
Name: -22.0 to -27.0 ft Model: Mohr-Coulomb Unit Weight: 99 pcf Cohesion': 0 psf Phi': 30 °
Name: -27.0 to -55.0 ft Model: Mohr-Coulomb Unit Weight: 99 pcf Cohesion': 800 psf Phi': 0 °

F of S: 4.370



Slope/W Stability – End of Construction (Station 192+50)

North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

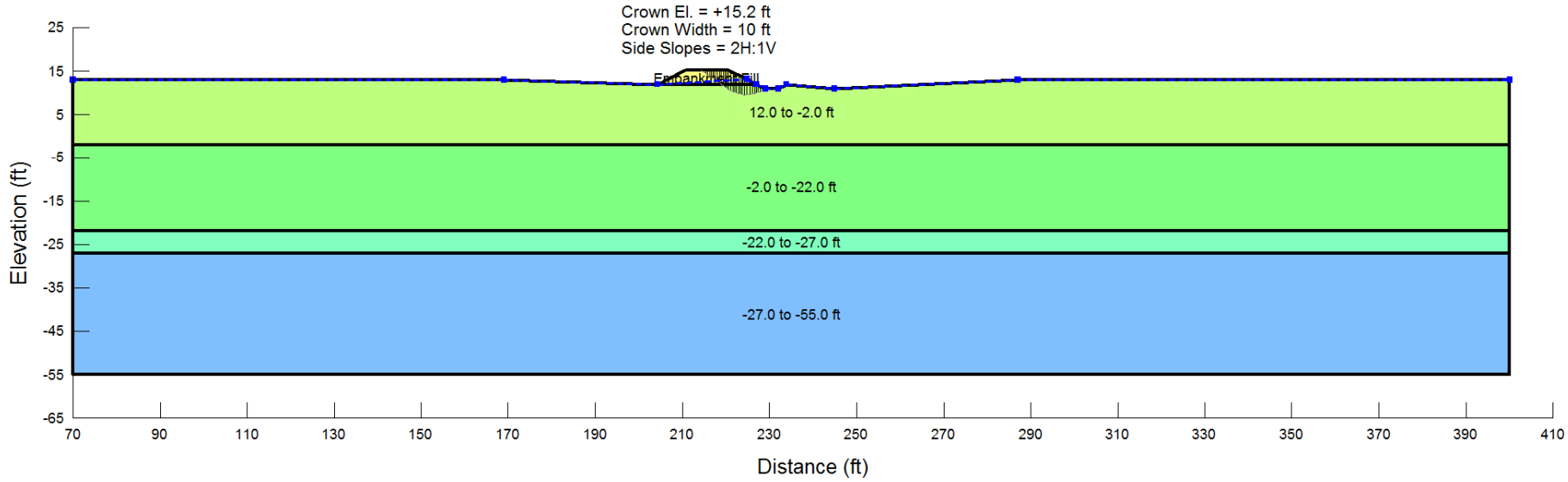
Figure 4A-1

0201-008-01 Date Exported: 02/10/17

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Embankment Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: 12.0 to -2.0 ft Model: Mohr-Coulomb Unit Weight: 83 pcf Cohesion': 420 psf Phi': 0 °
Name: -2.0 to -22.0 ft Model: Mohr-Coulomb Unit Weight: 99 pcf Cohesion': 500 psf Phi': 0 °
Name: -22.0 to -27.0 ft Model: Mohr-Coulomb Unit Weight: 99 pcf Cohesion': 0 psf Phi': 30 °
Name: -27.0 to -55.0 ft Model: Mohr-Coulomb Unit Weight: 99 pcf Cohesion': 800 psf Phi': 0 °

F of S: 4.361



Slope/W Stability – Sudden Drawdown (Station 192+50)

North Shore Levee
Aberdeen and Hoquiam, Washington

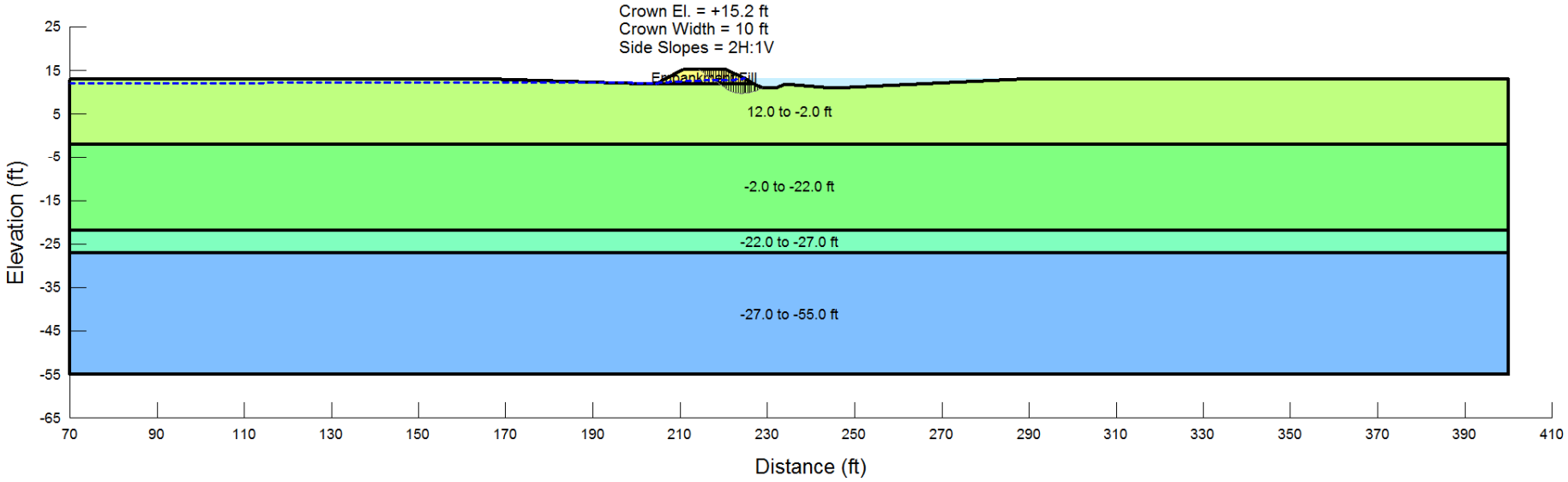
GeoEngineers

Figure 4A-2

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Embankment Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: 12.0 to -2.0 ft Model: Mohr-Coulomb Unit Weight: 83 pcf Cohesion': 420 psf Phi': 0 °
Name: -2.0 to -22.0 ft Model: Mohr-Coulomb Unit Weight: 99 pcf Cohesion': 500 psf Phi': 0 °
Name: -22.0 to -27.0 ft Model: Mohr-Coulomb Unit Weight: 99 pcf Cohesion': 0 psf Phi': 30 °
Name: -27.0 to -55.0 ft Model: Mohr-Coulomb Unit Weight: 99 pcf Cohesion': 800 psf Phi': 0 °

F of S: 5.357



Slope/W Stability – Critical Flood State – Waterside (Station 192+50)

North Shore Levee
Aberdeen and Hoquiam, Washington

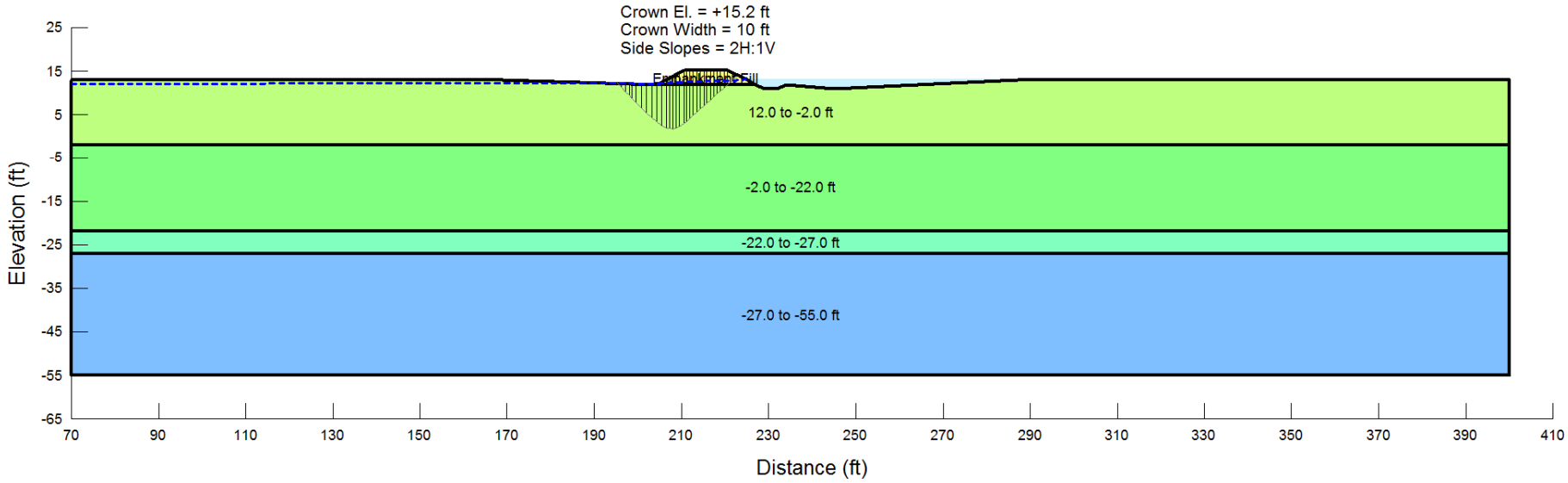
GeoEngineers

Figure 4A-3WS

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Embankment Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: 12.0 to -2.0 ft Model: Mohr-Coulomb Unit Weight: 83 pcf Cohesion': 420 psf Phi': 0 °
Name: -2.0 to -22.0 ft Model: Mohr-Coulomb Unit Weight: 99 pcf Cohesion': 500 psf Phi': 0 °
Name: -22.0 to -27.0 ft Model: Mohr-Coulomb Unit Weight: 99 pcf Cohesion': 0 psf Phi': 30 °
Name: -27.0 to -55.0 ft Model: Mohr-Coulomb Unit Weight: 99 pcf Cohesion': 800 psf Phi': 0 °

F of S: 5.164



Slope/W Stability – Critical Flood State – Waterside (Station 192+50)

North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

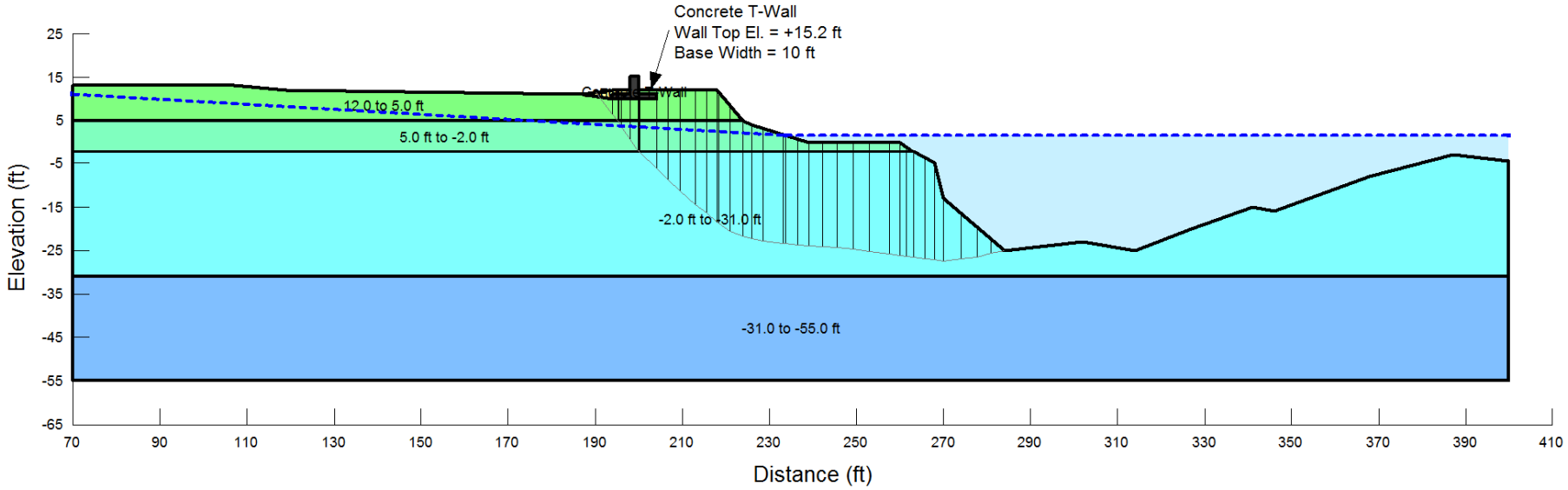
Figure 4A-3LS

0201-008-01 Date Exported: 02/10/17

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Concrete T-Wall Model: High Strength Unit Weight: 145 pcf
Name: Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: 12.0 to 5.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: 5.0 ft to -2.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: -2.0 ft to -31.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 250 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 458 psf
Name: -31.0 to -55.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 458 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 630 psf

F of S: 1.165



Slope/W Stability – End of Construction (Station 244+00)

North Shore Levee
Aberdeen and Hoquiam, Washington

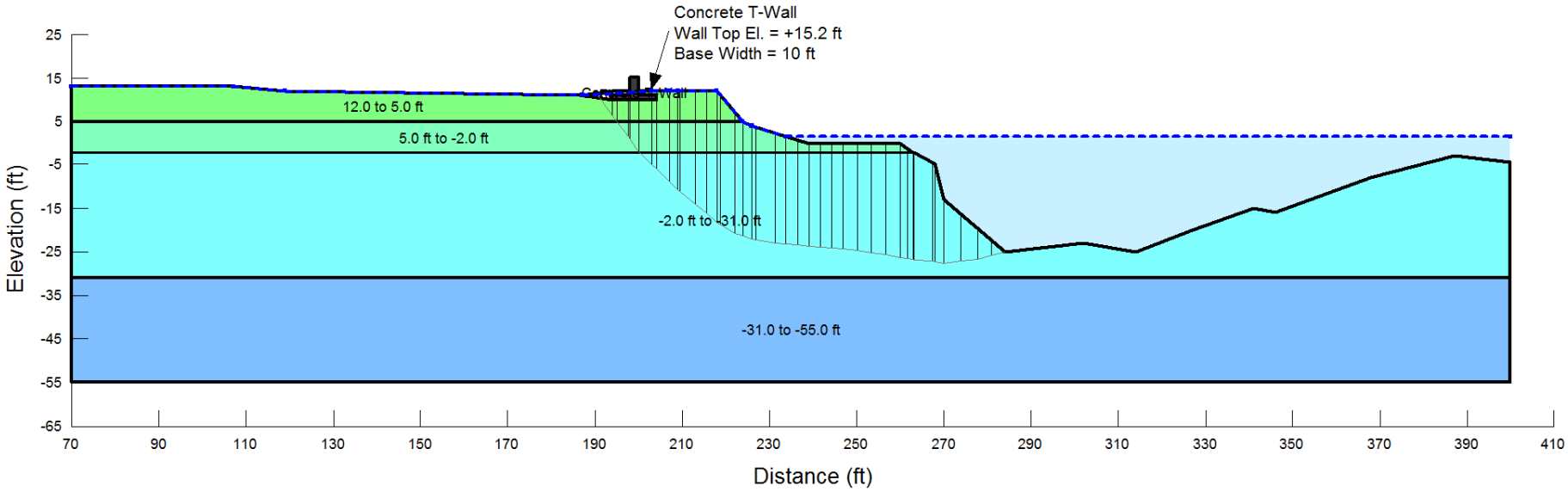
GeoEngineers

Figure 5A-1

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Concrete T-Wall Model: High Strength Unit Weight: 145 pcf
Name: Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: 12.0 to 5.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: 5.0 ft to -2.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: -2.0 ft to -31.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 250 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 458 psf
Name: -31.0 to -55.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 458 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 630 psf

F of S: 1.164



Slope/W Stability – Sudden Drawdown (Station 244+00)

North Shore Levee
Aberdeen and Hoquiam, Washington

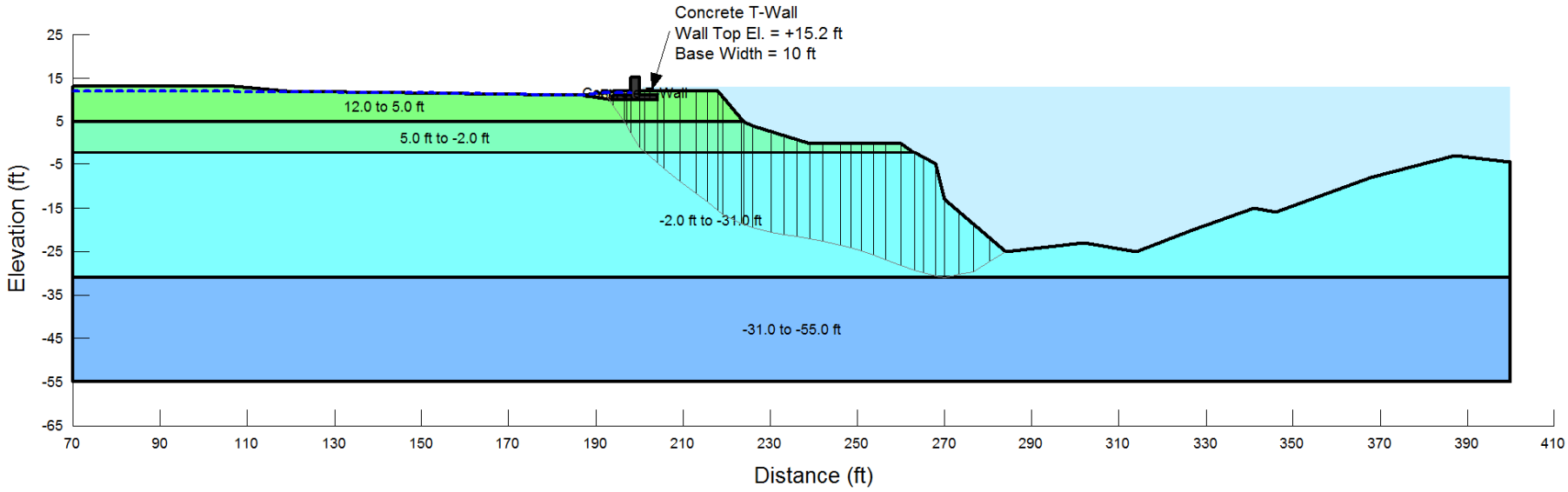
GeoEngineers

Figure 5A-2

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Concrete T-Wall Model: High Strength Unit Weight: 145 pcf
Name: Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: 12.0 to 5.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: 5.0 ft to -2.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: -2.0 ft to -31.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 250 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 458 psf
Name: -31.0 to -55.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 458 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 630 psf

F of S: 1.927



Slope/W Stability – Critical Flood State – Waterside (Station 244+00)

North Shore Levee
Aberdeen and Hoquiam, Washington

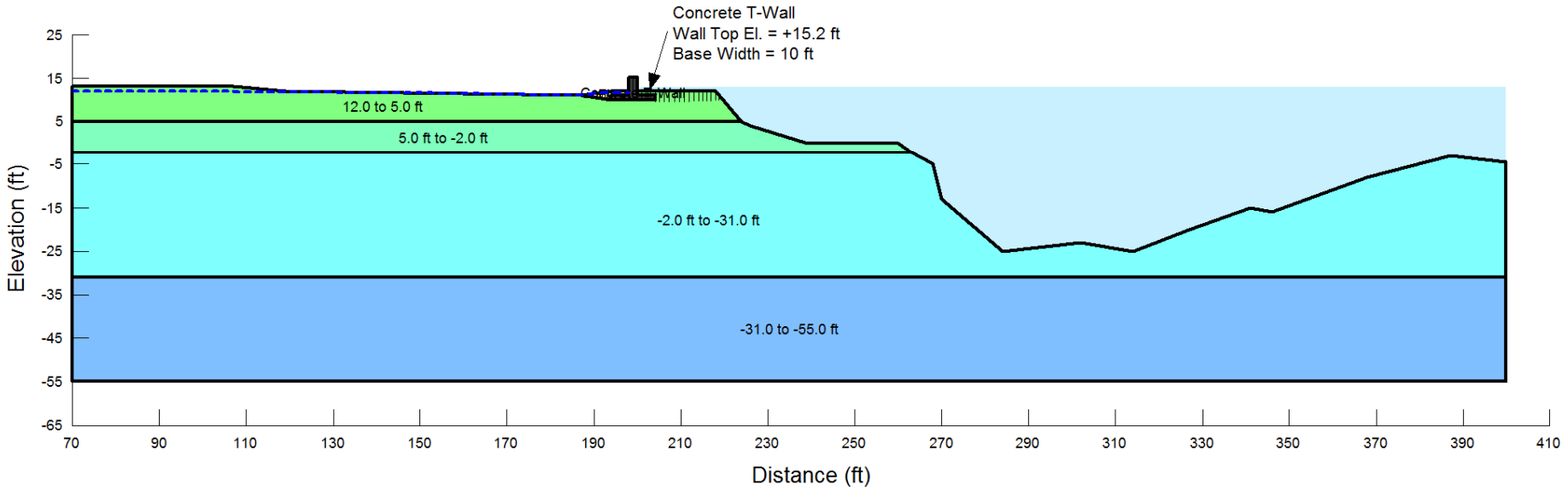
GeoEngineers

Figure 5A-3WS

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Concrete T-Wall Model: High Strength Unit Weight: 145 pcf
Name: Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: 12.0 to 5.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: 5.0 ft to -2.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: -2.0 ft to -31.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 250 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 458 psf
Name: -31.0 to -55.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 458 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 630 psf

F of S: E984



Slope/W Stability – Critical Flood Stage – Landside (Station 244+00)

North Shore Levee
Aberdeen and Hoquiam, Washington

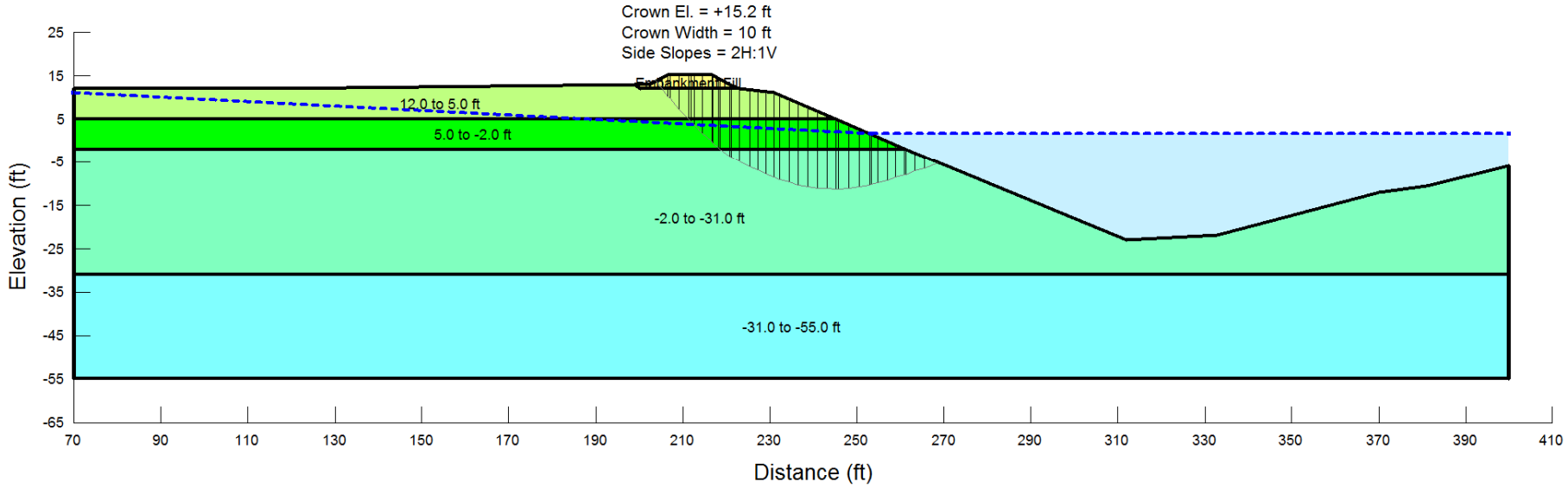
GeoEngineers

Figure 5A-3LS

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Embankment Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: 12.0 to 5.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: 5.0 to -2.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: -2.0 to -31.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 250 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 458 psf
Name: -31.0 to -55.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 458 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 630 psf

F of S: 1.129



Slope/W Stability – End of Construction (Station 248+00)

North Shore Levee
Aberdeen and Hoquiam, Washington

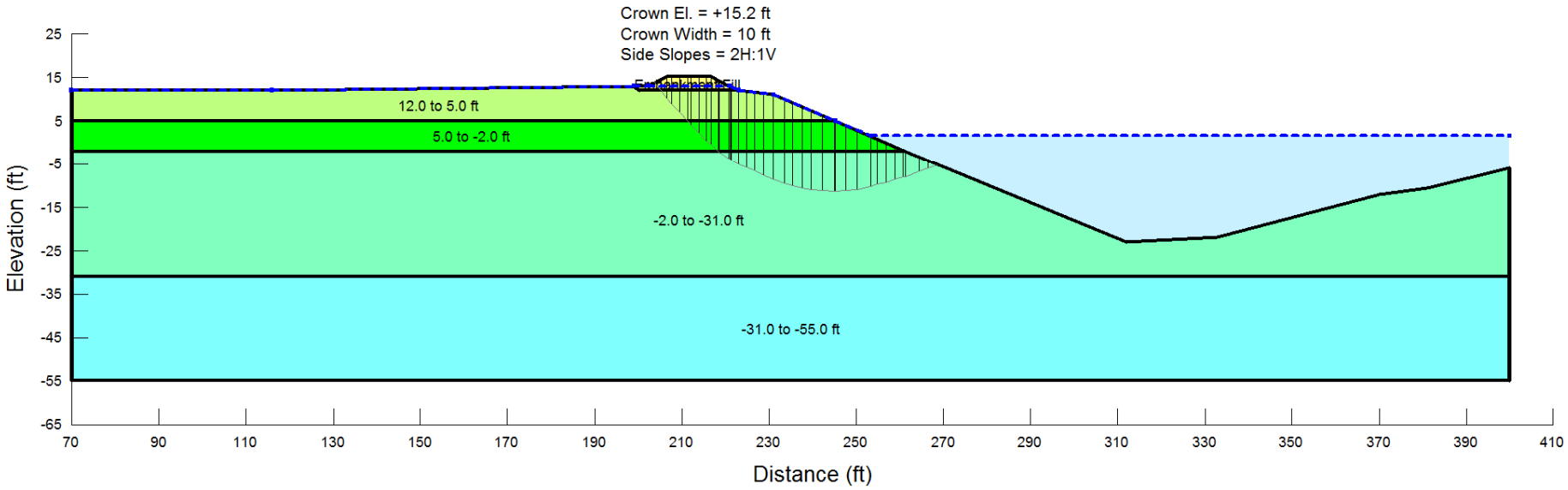
GeoEngineers

Figure 5B-1

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Embankment Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: 12.0 to 5.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: 5.0 to -2.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: -2.0 to -31.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 250 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 458 psf
Name: -31.0 to -55.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 458 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 630 psf

F of S: 1.130



Slope/W Stability – Sudden Drawdown (Station 248+00)

North Shore Levee
Aberdeen and Hoquiam, Washington

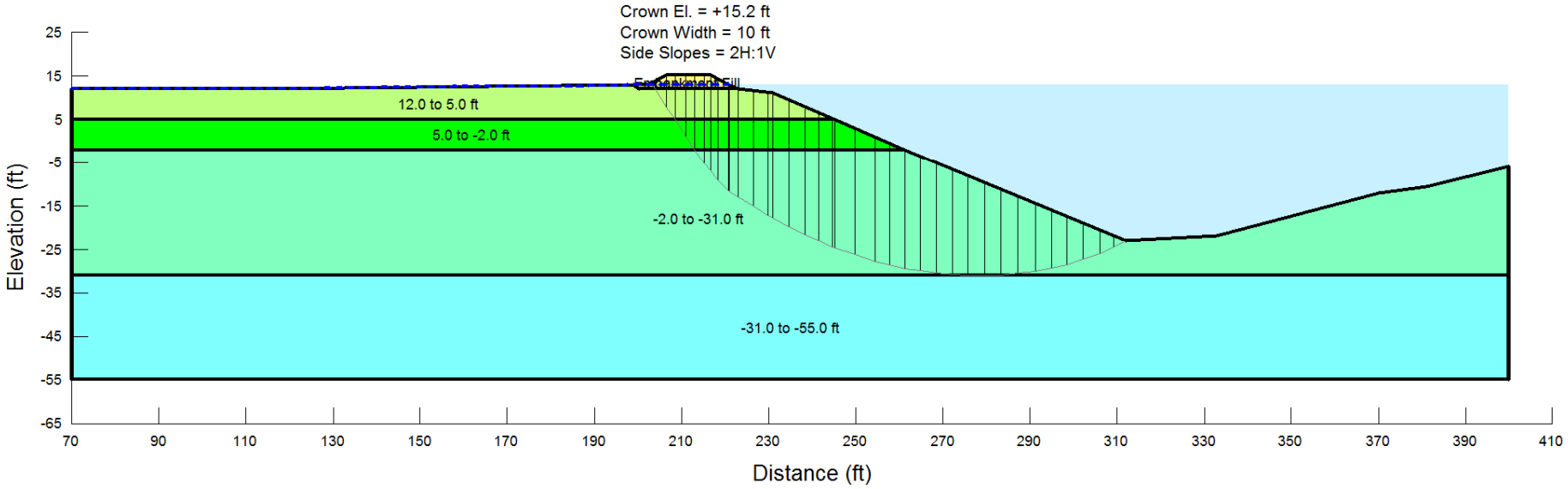
GeoEngineers

Figure 5B-2

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Embankment Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: 12.0 to 5.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: 5.0 to -2.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: -2.0 to -31.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 250 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 458 psf
Name: -31.0 to -55.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 458 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 630 psf

F of S: 1.949



Slope/W Stability – Critical Flood State – Waterside (Station 248+00)

North Shore Levee
Aberdeen and Hoquiam, Washington

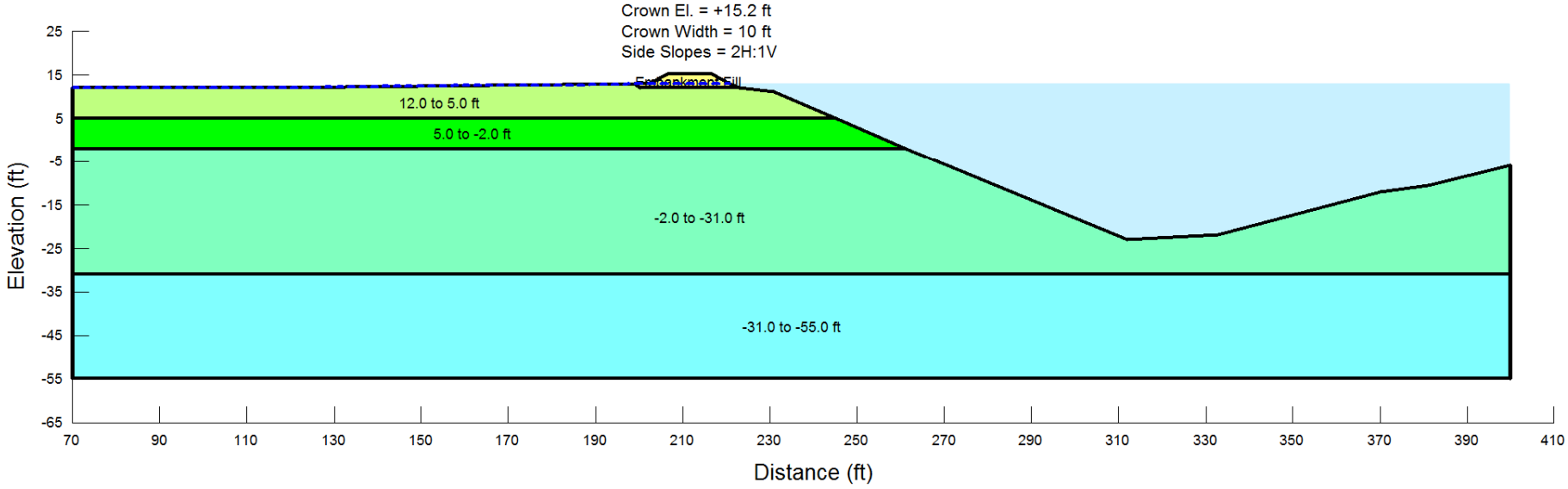
GeoEngineers

Figure 5B-3WS

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Embankment Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: 12.0 to 5.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: 5.0 to -2.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: -2.0 to -31.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 250 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 458 psf
Name: -31.0 to -55.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 458 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 630 psf

F of S: E993



Slope/W Stability – Critical Flood Stage – Landside (Station 248+00)

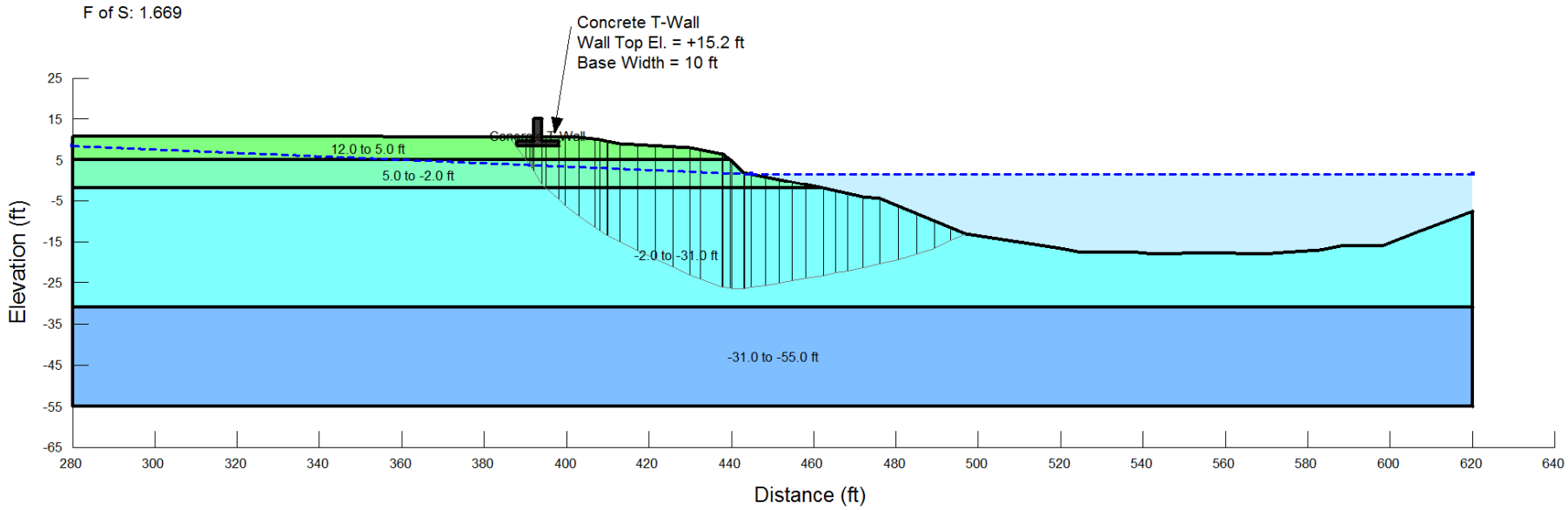
North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure 5B-3LS

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Concrete T-Wall Model: High Strength Unit Weight: 145 pcf
Name: 12.0 to 5.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: 5.0 to -2.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: -2.0 to -31.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 250 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 458 psf
Name: -31.0 to -55.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 458 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 630 psf



Slope/W Stability – End of Construction (Station 255+50)

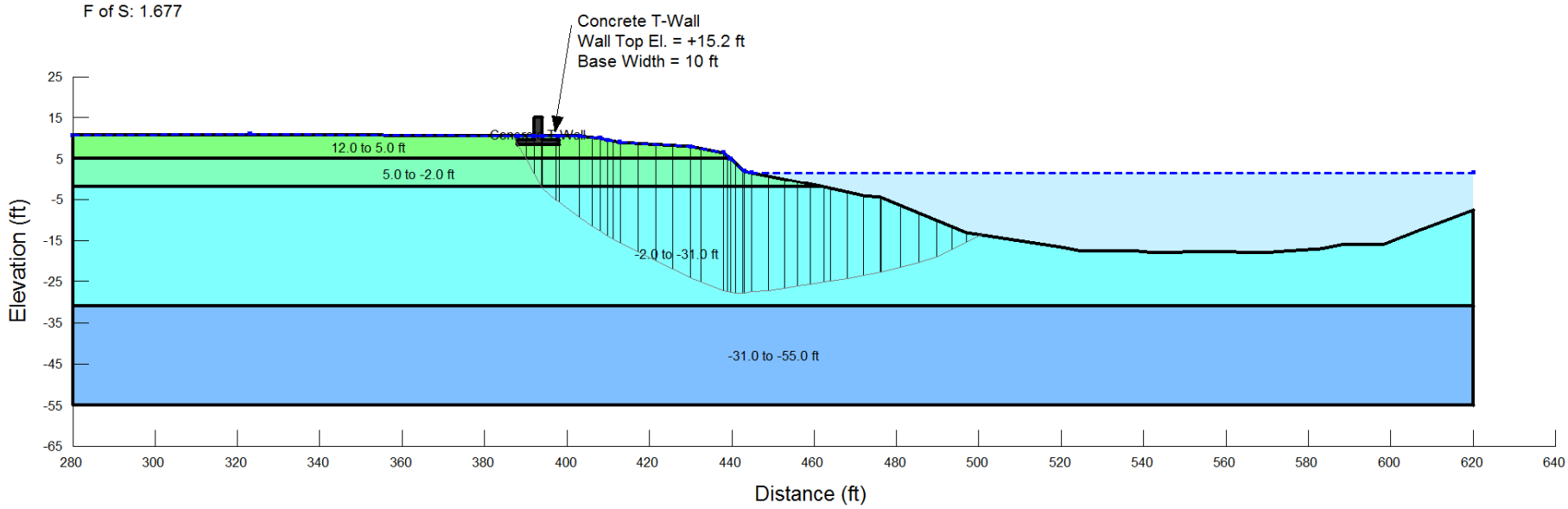
North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure 5C-1

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Concrete T-Wall Model: High Strength Unit Weight: 145 pcf
Name: 12.0 to 5.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: 5.0 to -2.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: -2.0 to -31.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 250 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 458 psf
Name: -31.0 to -55.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 458 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 630 psf



Slope/W Stability – Sudden Drawdown (Station 255+50)

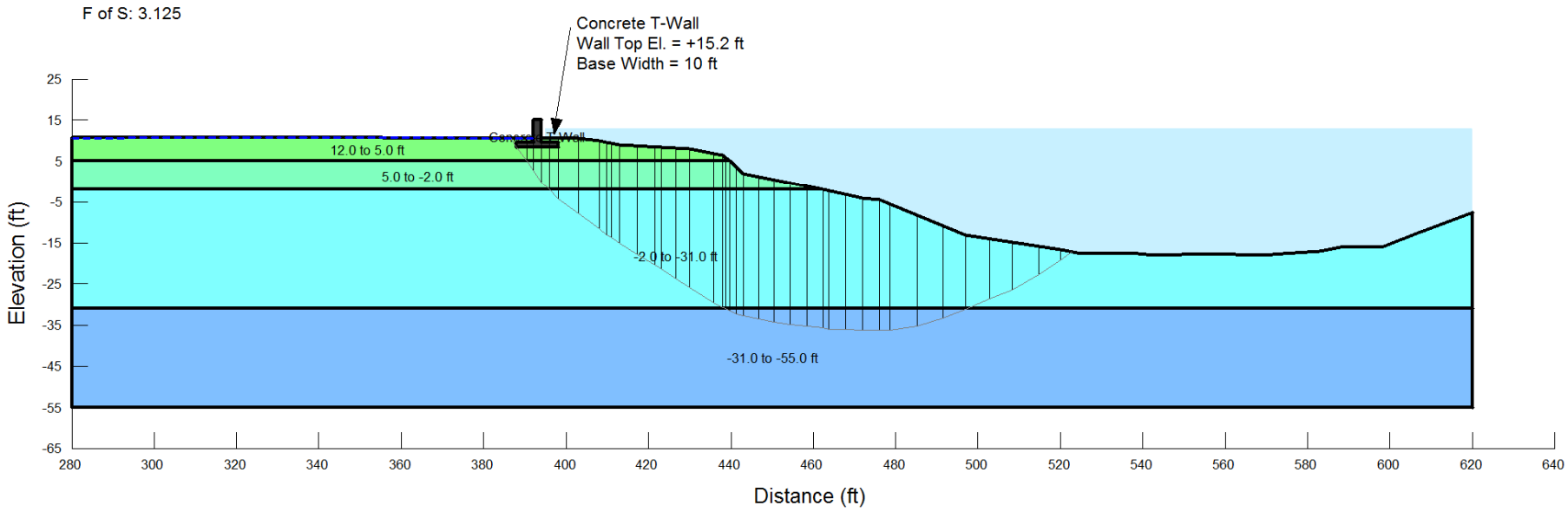
North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure 5C-2

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Concrete T-Wall Model: High Strength Unit Weight: 145 pcf
Name: 12.0 to 5.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: 5.0 to -2.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: -2.0 to -31.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 250 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 458 psf
Name: -31.0 to -55.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 458 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 630 psf



Slope/W Stability – Critical Flood State – Waterside (Station 255+50)

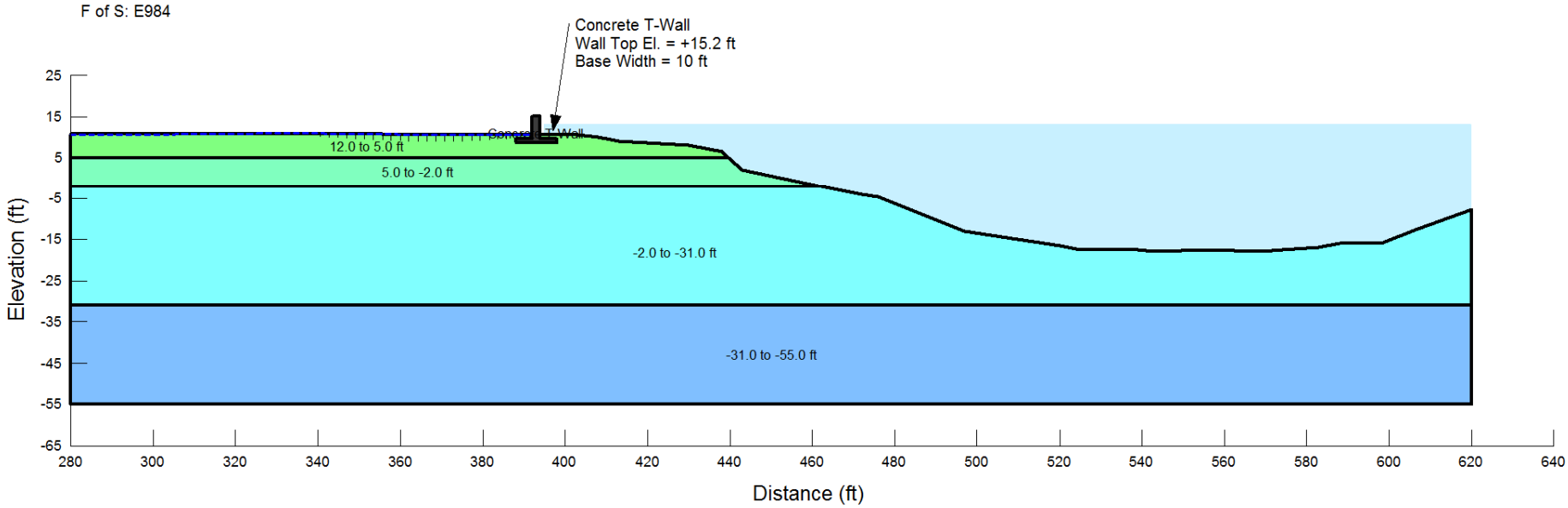
North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure 5C-3WS

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Concrete T-Wall Model: High Strength Unit Weight: 145 pcf
Name: 12.0 to 5.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: 5.0 to -2.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: -2.0 to -31.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 250 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 458 psf
Name: -31.0 to -55.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 458 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 630 psf



Slope/W Stability – Critical Flood Stage – Landside (Station 255+50)

North Shore Levee
Aberdeen and Hoquiam, Washington

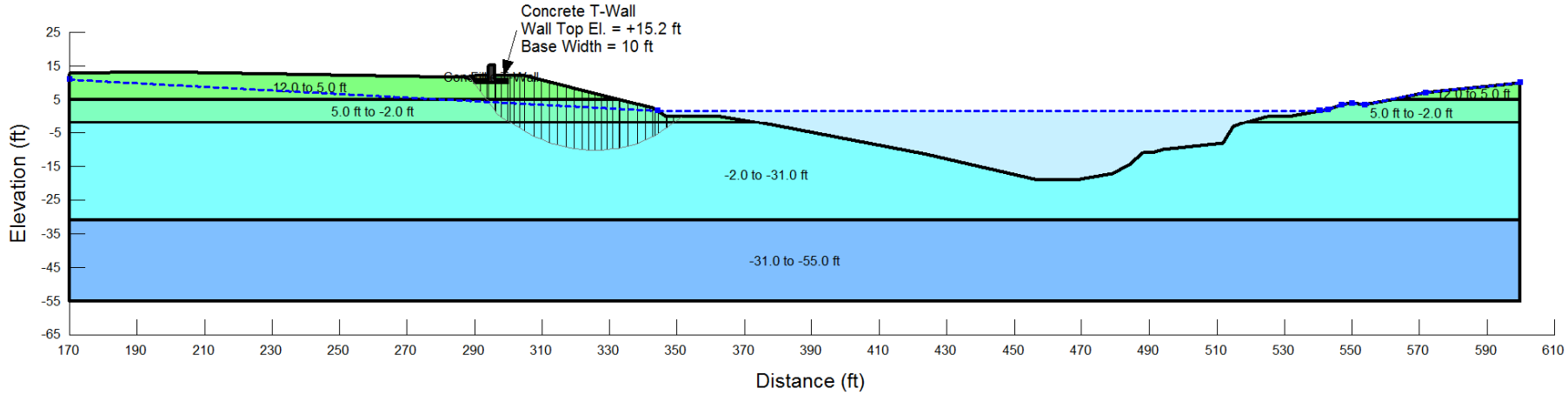
GeoEngineers

Figure 5C-3LS

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Concrete T-Wall Model: High Strength Unit Weight: 145 pcf
Name: Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: 12.0 to 5.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: 5.0 ft to -2.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: -2.0 to -31.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 250 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 458 psf
Name: -31.0 to -55.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 458 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 630 psf

F of S: 1.586



Slope/W Stability – End of Construction (Station 277+50)

North Shore Levee
Aberdeen and Hoquiam, Washington

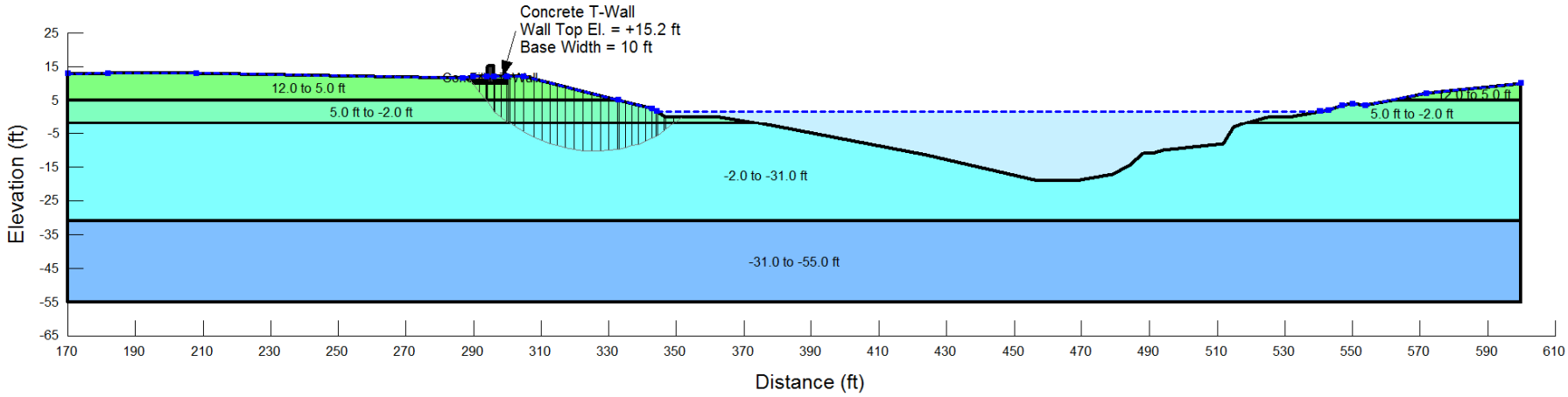
GeoEngineers

Figure 5D-1

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Concrete T-Wall Model: High Strength Unit Weight: 145 pcf
Name: Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: 12.0 to 5.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: 5.0 ft to -2.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: -2.0 to -31.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 250 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 458 psf
Name: -31.0 to -55.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 458 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 630 psf

F of S: 1.585



Slope/W Stability – Sudden Drawdown (Station 277+50)

North Shore Levee
Aberdeen and Hoquiam, Washington

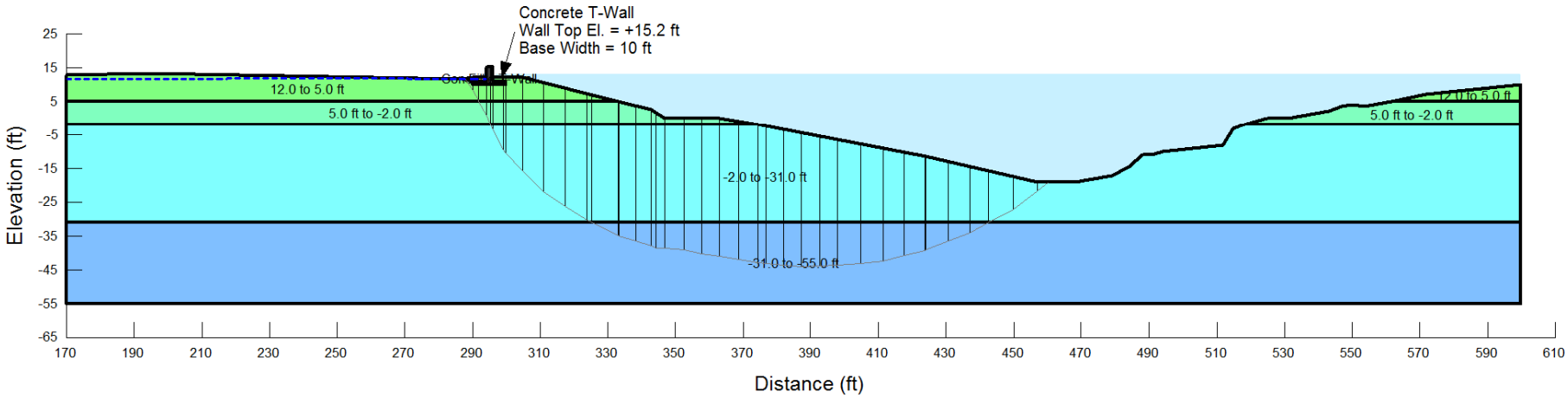
GeoEngineers

Figure 5D-2

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Concrete T-Wall Model: High Strength Unit Weight: 145 pcf
Name: Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: 12.0 to 5.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: 5.0 ft to -2.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: -2.0 to -31.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 250 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 458 psf
Name: -31.0 to -55.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 458 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 630 psf

F of S: 3.530



Slope/W Stability – Critical Flood State – Waterside (Station 277+50)

North Shore Levee
Aberdeen and Hoquiam, Washington

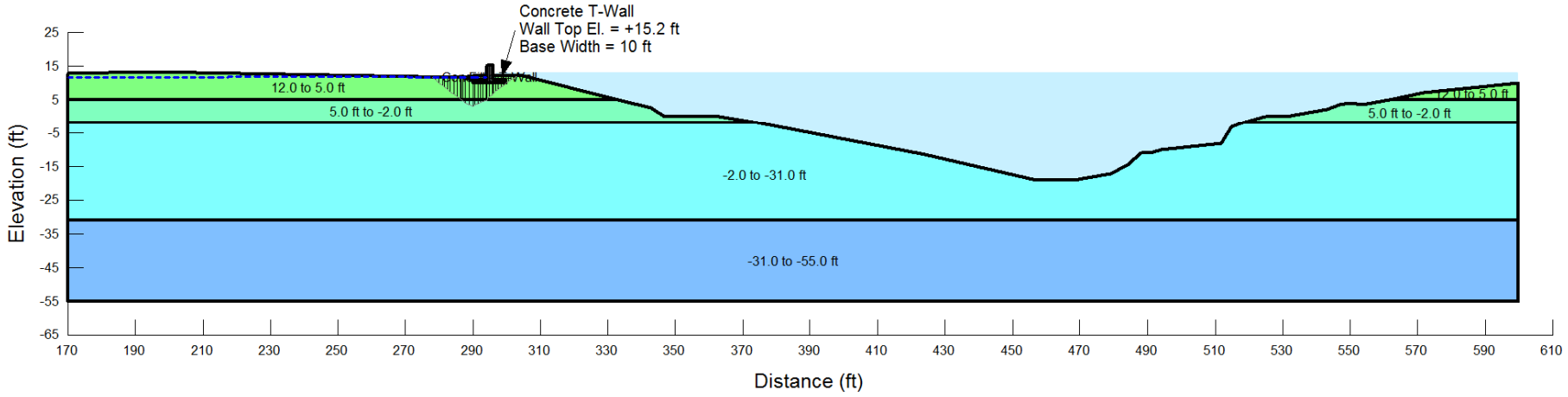
GeoEngineers

Figure 5D-3WS

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: Concrete T-Wall Model: High Strength Unit Weight: 145 pcf
Name: Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: 12.0 to 5.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: 5.0 ft to -2.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: -2.0 to -31.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 250 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 458 psf
Name: -31.0 to -55.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 458 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 630 psf

F of S: 4.161



Slope/W Stability – Critical Flood Stage – Landside (Station 277+50)

North Shore Levee
Aberdeen and Hoquiam, Washington

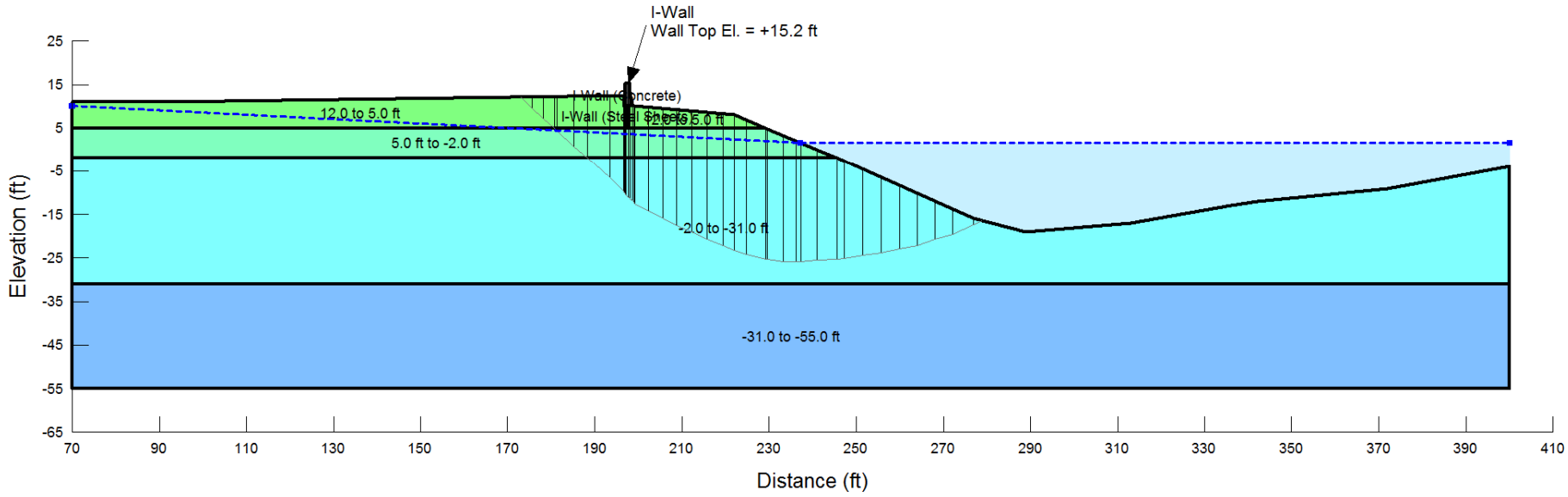
GeoEngineers

Figure 5D-3LS

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: I-Wall (Concrete) Model: High Strength Unit Weight: 145 pcf
Name: I-Wall (Steel Sheets) Model: High Strength Unit Weight: 484 pcf
Name: 12.0 to 5.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: 5.0 ft to -2.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: -2.0 to -31.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 250 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 458 psf
Name: -31.0 to -55.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 458 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 630 psf

F of S: 1.333



Slope/W Stability – End of Construction (Station 291+00)

North Shore Levee
Aberdeen and Hoquiam, Washington

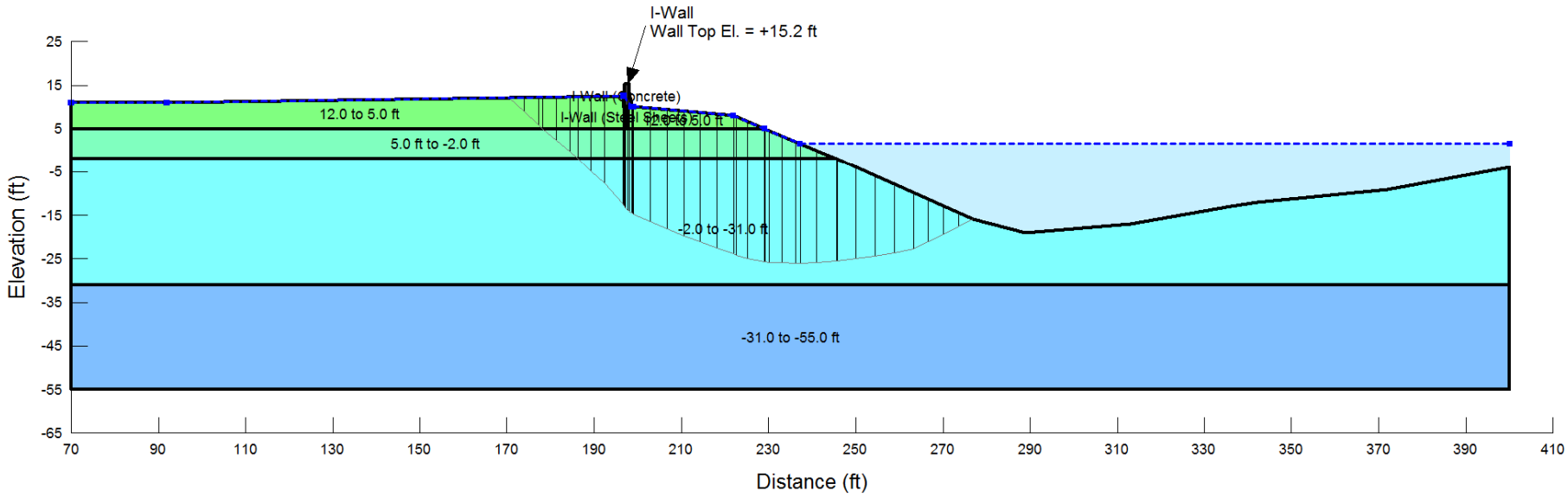
GeoEngineers

Figure 5E-1

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: I-Wall (Concrete) Model: High Strength Unit Weight: 145 pcf
Name: I-Wall (Steel Sheets) Model: High Strength Unit Weight: 484 pcf
Name: 12.0 to 5.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: 5.0 ft to -2.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: -2.0 to -31.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 250 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 458 psf
Name: -31.0 to -55.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 458 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 630 psf

F of S: 1.330



Slope/W Stability – Sudden Drawdown (Station 291+00)

North Shore Levee
Aberdeen and Hoquiam, Washington

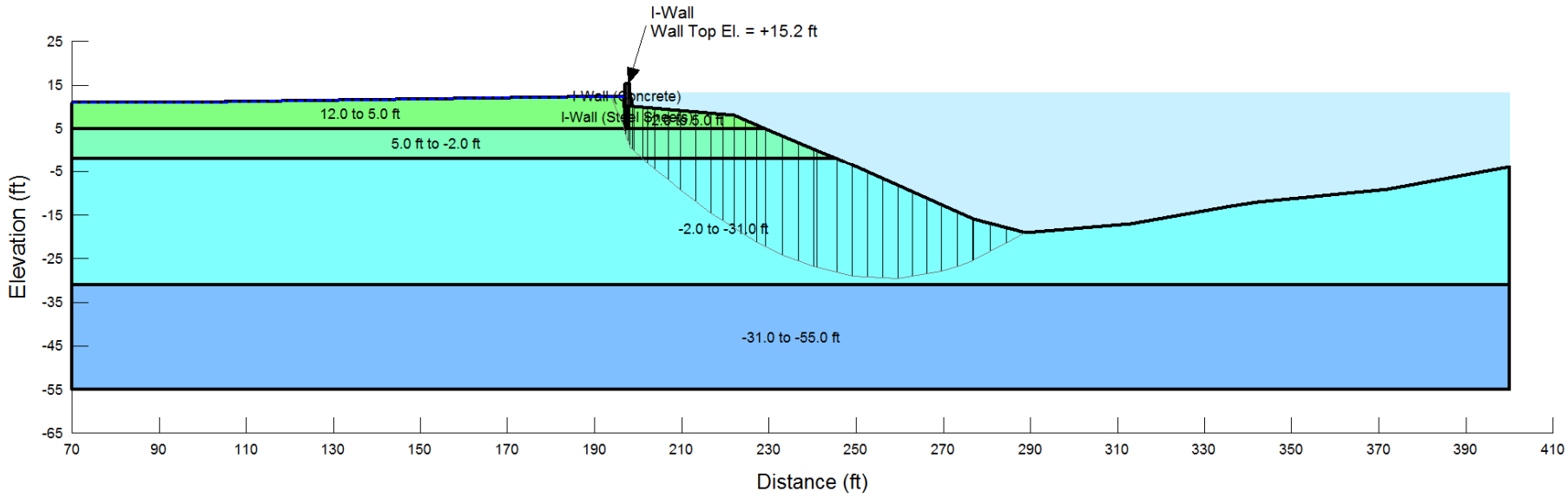
GeoEngineers

Figure 5E-2

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: I-Wall (Concrete) Model: High Strength Unit Weight: 145 pcf
Name: I-Wall (Steel Sheets) Model: High Strength Unit Weight: 484 pcf
Name: 12.0 to 5.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: 5.0 ft to -2.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: -2.0 to -31.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 250 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 458 psf
Name: -31.0 to -55.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 458 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 630 psf

F of S: 2.310



Slope/W Stability – Critical Flood State – Waterside (Station 291+00)

North Shore Levee
Aberdeen and Hoquiam, Washington

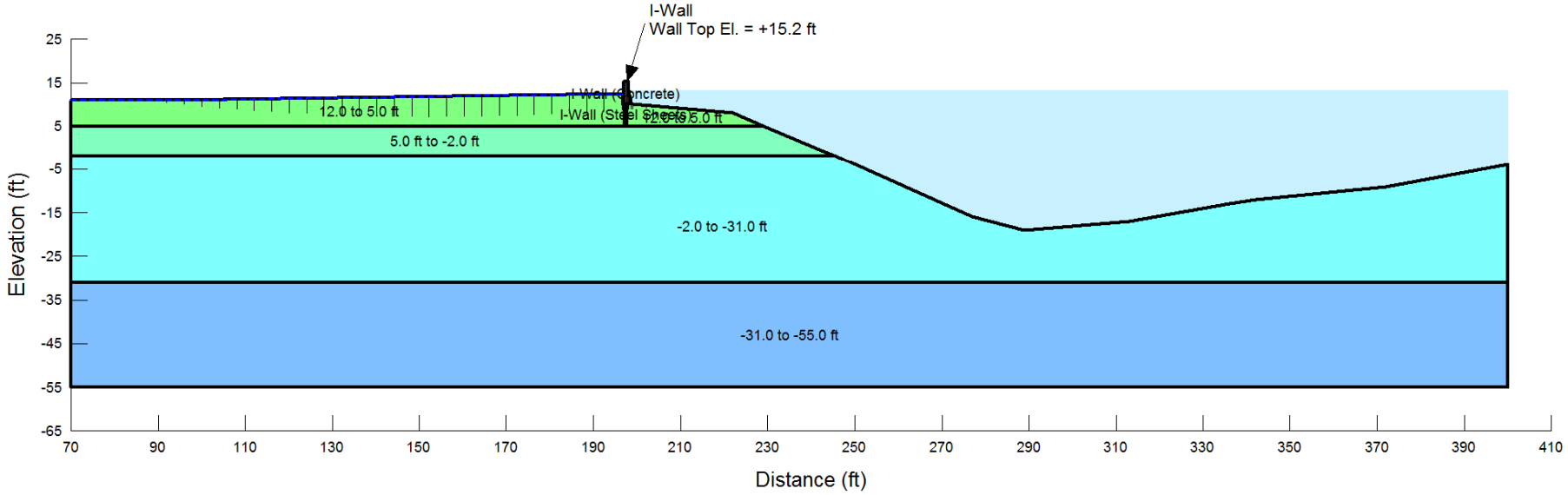
GeoEngineers

Figure 5E-3WS

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc.

Name: I-Wall (Concrete) Model: High Strength Unit Weight: 145 pcf
Name: I-Wall (Steel Sheets) Model: High Strength Unit Weight: 484 pcf
Name: 12.0 to 5.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: 5.0 ft to -2.0 ft Model: Mohr-Coulomb Unit Weight: 93 pcf Cohesion': 250 psf Phi': 0 °
Name: -2.0 to -31.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 250 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 458 psf
Name: -31.0 to -55.0 ft Model: S=f(depth) Unit Weight: 94 pcf C-Top of Layer: 458 psf C-Rate of Change: 7.17 psf/ft C-Maximum: 630 psf

F of S: E984



Slope/W Stability – Critical Flood Stage – Landside (Station 291+00)

North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure 5E-3LS

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APPENDIX A
Subsurface Explorations and Laboratory Testing

APPENDIX A
SUBSURFACE EXPLORATIONS AND LABORATORY TESTING

General

Subsurface conditions were explored by advancing 8 mud-rotary borings and 10 Cone Penetration Tests (CPTs). Subsurface exploratory services were completed by Holocene Drilling, Inc. and In-Situ Engineering under subcontract to GeoEngineers, Inc.

Borings

The first and second phases of borings were completed between July 25, 2016 and July 29, 2016. The locations of the borings were determined by measuring from existing site features such as roadways and structures. The elevations presented on the boring logs are based on the topographic survey data provided by KPFF Consulting Engineers, Inc. The location and elevation of the explorations should be considered approximate. The exploration location and other site features are included on the Site Plans, Figures 2 through 12.

Our field representative obtained samples, classified soils, maintained a detailed log of the exploration and observed groundwater conditions where applicable. The samples were taken with a standard split spoon sampler as well as a Shelby tube sampler in general accordance with ASTM International (ASTM) D 1586 and D 1587, respectively.

The samples collected with the split spoon sampler were retained in sealed plastic bags. The soils were classified visually in general accordance with the system described in Figure A-1, which includes a Key to Exploration Logs. Summary logs of the exploration are included as Figures A-2 through A-9.

Cone Penetration Tests

The CPTs were completed between July 25, 2016 and July 29, 2016. CPT soundings were completed using truck-mounted hydraulically driven cone penetrometers. Soil friction, tip resistance and dynamic pore pressure were recorded using electronic methods.

The CPT soundings were advanced to depths ranging from approximately 19 to 73 feet below ground surface (bgs). The CPTs data are presented as Figures A-10 through A-20. No soil samples are obtained during CPT soundings. Soil types are interpreted based on empirical relationships between measured CPTs data and the parameters described above.

Laboratory Testing

Soil samples obtained from the borings were returned to our laboratory for further examination and testing. Representative soil samples were selected for testing to assist in our evaluation of pertinent geotechnical engineering properties and to confirm our field classifications. Laboratory test descriptions are provided below.

Primary Testing

Moisture Content

The moisture content of selected samples was determined in general accordance with ASTM Test Method D 2216. The test results are used to aid in soil classification and correlation with other pertinent engineering soil properties. The results of these tests are presented on the exploration logs at the respective sample depths.

Sieve Analyses

Particle-size analyses were completed on selected samples in general accordance with ASTM Test Method D 422. This test method covers the quantitative determination of the distribution of particle sizes in soils. Typically, the distribution of particle sizes larger than 75 micrometers (µm) is determined by sieving. The results of the tests were used to verify field soil classifications and determine pertinent engineering characteristics. Figures A-21 and A-22 presents the results of our sieve analyses.

Atterberg Limits

Atterberg Limit tests were performed on selected samples in general accordance with ASTM Test Method D 4318. This test method determines the liquid limit, plastic limit and plasticity index of soil particles passing the No. 40 sieve. The results of the tests are used to assist in soil classification and determine pertinent engineering characteristics. Results for plastic soils are presented in Figures A-23 through A-27. Liquid limits and plasticity index are also presented on the exploration logs at the respective sample depths.

Percent Fines Determination

Selected samples were "washed" through the U.S. No. 200-mesh sieve to estimate the relative percentages of coarse and fine grained particles in the soil. The tests were conducted in general accordance with ASTM D 1140. The percent passing value represents the percentage by weight of the sample finer than the U.S. No. 200 sieve. These tests were conducted to verify field descriptions and to estimate the fines content for analysis purposes. The test results are shown on the exploration logs at the respective sample depths.

Secondary Testing

Unconsolidated-Undrained (UU) Triaxial Tests

UU triaxial tests were performed on relatively undisturbed samples obtained from the borings. The samples were collected during drilling using Thin-Walled Tube Samplers (Shelby Tubes) in general accordance with ASTM D 1587. The sample was prepared and tested in general accordance with ASTM D 2850.

The UU triaxial test is completed subjecting the sample to an axial load applied at a constant strain rate in an undrained state. A sample is considered undrained if pore water is prevented from draining from the sample during testing. The undrained state is achieved by closing the drainage lines, which allow consolidation prior to the application of axial load. Because the axial load is applied in the undrained state, volume change of the sample is not permitted during loading resulting in the development of pore pressure changes in compensation for the sample attempting to contract or dilate. Effective confining pressures were selected to generally match the effective stresses in the in-situ stress state to develop shear strength parameters that are applicable to the anticipated loading. Axial load, strain and pore pressure are recorded during the test.

The recorded data was used to estimate the undrained shear strength of the sample. The results of the UU tests are presented on the Figures A-28 through A-52.

One-Dimensional Consolidation

A one-dimensional consolidation testing was performed to determine the settlement potential of a selected sample in accordance with ASTM D 2435. The consolidation test determines the magnitude and rate of consolidation of soil restrained laterally and drained axially while subjected to incrementally applied controlled-stress loading. The results of our consolidation test are shown on Figure A-53.

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES
	MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
MORE THAN 50% RETAINED ON NO. 200 SIEVE	SAND AND SANDY SOILS	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS
				SP	POORLY-GRADED SANDS, GRAVELLY SAND
	MORE THAN 50% OF COARSE FRACTION PASSING NO. 4 SIEVE	SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS, ROCK FLOUR, CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
MORE THAN 50% PASSING NO. 200 SIEVE	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS AND SILTS OF MEDIUM TO HIGH PLASTICITY
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: Multiple symbols are used to indicate borderline or dual soil classifications

ADDITIONAL MATERIAL SYMBOLS

SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
	AC	Asphalt Concrete
	CC	Cement Concrete
	CR	Crushed Rock/ Quarry Spalls
	TS	Topsoil/ Forest Duff/Sod

Groundwater Contact

Measured groundwater level in exploration, well, or piezometer

Measured free product in well or piezometer

Graphic Log Contact

Distinct contact between soil strata

Approximate contact between soil strata

Material Description Contact

Contact between geologic units

Contact between soil of the same geologic unit

Sampler Symbol Descriptions

2.4-inch I.D. split barrel

Standard Penetration Test (SPT)

Shelby tube

Piston

Direct-Push

Bulk or grab

Continuous Coring

Blowcount is recorded for driven samplers as the number of blows required to advance sampler 12 inches (or distance noted). See exploration log for hammer weight and drop.

A "P" indicates sampler pushed using the weight of the drill rig.

A "WOH" indicates sampler pushed using the weight of the hammer.

Laboratory / Field Tests

%F	Percent fines
%G	Percent gravel
AL	Atterberg limits
CA	Chemical analysis
CP	Laboratory compaction test
CS	Consolidation test
DS	Direct shear
HA	Hydrometer analysis
MC	Moisture content
MD	Moisture content and dry density
OC	Organic content
PM	Permeability or hydraulic conductivity
PI	Plasticity index
PP	Pocket penetrometer
PPM	Parts per million
SA	Sieve analysis
TX	Triaxial compression
UC	Unconfined compression
VS	Vane shear

Sheen Classification

NS	No Visible Sheen
SS	Slight Sheen
MS	Moderate Sheen
HS	Heavy Sheen
NT	Not Tested

NOTE: The reader must refer to the discussion in the report text and the logs of explorations for a proper understanding of subsurface conditions. Descriptions on the logs apply only at the specific exploration locations and at the time the explorations were made; they are not warranted to be representative of subsurface conditions at other locations or times.

KEY TO EXPLORATION LOGS

GeoEngineers

FIGURE A-1

Rev. 02/16

Drilled Start 7/25/2016 End 7/25/2016	Total Depth (ft) 71.5	Logged By JLL Checked By LJS	Driller Holocene Drilling, Inc.	Drilling Method Mud Rotary	
Surface Elevation (ft) Vertical Datum 12		Hammer Data Autohammer (71% Efficient) 140 (lbs) / 30 (in) Drop		Drilling Equipment Brainard-Killman BK-81	
Easting (X) 438455.48 Northing (Y) 5203766.26		System Datum WA North		Groundwater not observed at time of exploration	

Notes:

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0	4	24		1 SA		SM	Light brown silty fine sand with gravel and organic matter (grass roots) (medium stiff, dry) (fill)	9	32	psf = pounds per square foot; pcf = pounds per cubic foot; DD = dry density
10			3		2		MH	Dark gray elastic silt with occasional organic matter (wood fragments and peat) (soft, wet) (alluvium)			
	5	3	Push		3						
5		8	2		4 AL				109		AL (LL=125; PI=63)
	10	6	Push		5			Grades to sandy with occasional organic matter (wood fragments)			
0		14	2		6 MC				81		
	15	18	1		7 AL			Grades to very soft with organic matter (wood, organic fragments and peat)	76		AL (LL=88; PI=46)
-5											
	20	24	Push		8			Grades to with sand			
-10		18	1		9 MC			Grades to trace organic matter (wood fragments) and shell fragments	74		
								Grades to without shell fragments			
	25	18	0		10 AL				103		AL (LL=112; PI=61)
-15											
	30	22	Push		11 TX			Grades to with organic matter (fine roots) and without sand	102		S_u=222 psf; DD=45.6 pcf
-20		12	2		12 MC				70		
	35	18	0		13 MC		OH	Brown organic silt with organic matter (peat) (very soft, wet)	122		
-25							MH	Gray green elastic silt with occasional organic matter (wood fibers and organic fragments) (very soft, wet)			
	40	2	0		14 MC				74		
-30											

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on , Vertical approximated based on

Tacoma: Date:4/26/17 Path:P:\0\0201008\GINT\020100801.GPJ DBTemplate/LibTemplate:GEOENGINEERS_DF_STD_US_2017.GDT/GEI8_GEOTECH_STANDARD_%F_NO_GW

Log of Boring B-1-16

GeoEngineers

Project: North Shore Levee
Project Location: Aberdeen and Hoquiam, Washington
Project Number: 0201-008-01

Figure A-2
Sheet 1 of 2

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	FIELD DATA: Blows/foot	FIELD DATA: Collected Sample / Sample Name Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
-35	45	16	0	15 AL			Grades to gray with trace organic matter and shell fragments	60		AL (LL=64; PI=29)
-40	50	18	0	16 MC				61		
-45	55	16	3	17 MC			Grades to soft with organic matter (black and brown wood organic fibers)	79		
-50	60	12	3	18 MC				86		
-55	65	16	0	19 MC			Grades to with occasional organic matter (wood and organic fragments)	65		
	70	4	3	20 MC				64		

Tacoma: Date:4/26/17 Path:P:\0\0201008\GINT\020100801.GPJ DBTemplate/LibTemplate:GEOENGINEERS_DF_STD_US_2017.GDT/GEI8_GEOTECH_STANDARD_%F_NO_GW

Log of Boring B-1-16 (continued)

GeoEngineers

Project: North Shore Levee
Project Location: Aberdeen and Hoquiam, Washington
Project Number: 0201-008-01

Drilled Start 7/26/2016 End 7/26/2016	Total Depth (ft) 71.5	Logged By JLL Checked By LJS	Driller Holocene Drilling, Inc.	Drilling Method Mud Rotary	
Surface Elevation (ft) Vertical Datum 13		Hammer Data Autohammer (71% Efficient) 140 (lbs) / 30 (in) Drop		Drilling Equipment Brainard-Killman BK-81	
Easting (X) 438580.95 Northing (Y) 5203386.01		System Datum WA North		Groundwater not observed at time of exploration	

Notes:

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0	2	24		1 SA		AC	2 inches asphalt concrete pavement	3	6	psf = pounds per square foot; pcf = pounds per cubic foot; DD = dry density
							GP-GM	Brown gravel with sand and silt (medium dense, moist) (aggregate base course)			
10		6	3		2 MC		ML	Brown-gray silt with sand and trace gravel (soft, moist) (fill)	33		
	5	18	Push		3 TX		MH	Dark gray elastic silt with sand and trace organic matter (organic fragments and wood) (soft, wet) (alluvium)	56 67		S_u=599 psf; 519 psf; DD=48.3 pcf; 61.7 pcf
5		9	2		4 AL				71		AL (LL=91; PI=47)
	10	22	Push		5 TX				174		S_u=417 psf; DD=33.4 pcf
									90		S_u=337 psf; DD=54.6 pcf
0		18	1		6 MC			Grades to very soft with occasional organic matter (peat)	65		
	15	18	0		7 AL		CH	Dark gray fat clay with trace organic matter (very soft, wet)	63		AL (LL=77; PI=43)
-5											
	20	22	Push		8 TX				68 58		S_u=344 psf; DD=58.7 pcf S_u=574 psf; DD=65.1 pcf
-10		18	2		9 MC			Grades to soft with sand	62		
	25	18	1		10 AL		MH	Gray elastic silt with organic matter (peat and wood fragments) and trace interbeds of silt with sand (very soft, moist)	60		AL (LL=62; PI=25)
-15											
	30		Push		11 TX			Grades to without interbeds	69 61		S_u=641 psf; 644 psf; DD=59.9 pcf; 65.2 pcf
-20		18	0		12 MC				70		
	35	18	0		13 MC			Grades to with occasional organic matter (wood fragments)	78		
-25											
	40	14	0		14 MC				84		

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on , Vertical approximated based on

Tacoma: Date:4/26/17 Path:P:\0\0201008\GINT\0201008O1.GPJ DBTemplate/LibTemplate:GEOENGINEERS_DF_STD_US_2017.GDT/GEI8_GEOTECH_STANDARD_%F_NO_GW

Log of Boring B-2-16

GeoEngineers

Project: North Shore Levee
Project Location: Aberdeen and Hoquiam, Washington
Project Number: 0201-008-01

Figure A-3
Sheet 1 of 2

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	FIELD DATA: Blows/foot	FIELD DATA: Collected Sample / Sample Name Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
-30										
	45	16	1	15 MC			Grades to with occasional organic matter (wood and organic fragments), trace sand and with interbeds of gray-brown sandy silt	85		
-35										
	50	16	0	16 AL				78		AL (LL=77; PI=39)
-40										
	55	16	2	17 MC			Grades to elastic silt with sand and trace organic matter (wood and organic fragments); soft	54		
-45										
	60	18	1	18 MC			Grades to occasional organic matter (wood and organic fragments); very soft	58		
-50										
	65	8	0	19 MC				61		
-55										
	70	9	0	20 MC				65		

Tacoma: Date:4/26/17 Path:P:\0\0201008\GINT\0201008O1.GPJ DBTemplate/LibTemplate:GEOENGINEERS_DF_STD_US_2017.GDT/GEI8_GEOTECH_STANDARD_%F_NO_GW

Log of Boring B-2-16 (continued)

GeoEngineers

Project: North Shore Levee
Project Location: Aberdeen and Hoquiam, Washington
Project Number: 0201-008-01

Figure A-3
Sheet 2 of 2

Drilled Start 7/25/2016 End 7/25/2016	Total Depth (ft) 41.5	Logged By JLL Checked By LJS	Driller Holocene Drilling, Inc.	Drilling Method Mud Rotary	
Surface Elevation (ft) Vertical Datum 13		Hammer Data Autohammer (71% Efficient) 140 (lbs) / 30 (in) Drop		Drilling Equipment Brainard-Killman BK-81	
Easting (X) 434878.58 Northing (Y) 5202360		System Datum WA North		Groundwater not observed at time of exploration	

Notes:

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0	3	18		1 SA		GM	Brown silty gravel with sand (medium dense, dry) (fill)	9	14	psf = pounds per square foot; pcf = pounds per cubic foot; DD = dry density
10		12	11		2A %F				10	11	
					2B MC		MH	Dark gray elastic silt (soft, moist) (alluvium)	55		
	5	18	Push		3 TX			Grades to with occasional organic matter (wood and organic fragments)	97		S_u=557 psf; DD=50.6 pcf
5		16	3		4 AL				90		AL (LL=100; PI=54)
	10	18	Push		5 TX				70		S_u=321 psf; DD=56.4 pcf
0		17	2		6 MC				65		
							ML	Dark gray silt with fine sand (soft, wet)			
	15	18	3		7 AL				41		AL (LL=45; PI=17)
-5							SM	Dark gray silty fine sand with trace gravel (very loose, wet)			Groundwater observed at approximately 18 feet below ground surface during drilling
	20	8	Push		8						
-10		18	0		9 MC				46		
	25	18	6		10 %F			Grades to loose	35	27	
-15											
	30	18	4		11 MC				43		
-20								Grades to very loose with interbeds of sandy silt			
	35	18	1		12 %F				45	34	
-25											
	40	18	3		13 MC				39		

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on , Vertical approximated based on

Log of Boring B-3-16

GeoEngineers

Project: North Shore Levee
Project Location: Aberdeen and Hoquiam, Washington
Project Number: 0201-008-01

Figure A-4
Sheet 1 of 1

Tacoma: Date:4/26/17 Path:P:\0\0201008\GINT\0201008O1.GPJ DBTemplate/LibTemplate:GEOENGINEERS_DF_STD_US_2017.GDT/GEI8_GEOTECH_STANDARD_%F_NO_GW

Drilled Start 7/28/2016 End 7/28/2016	Total Depth (ft) 41.5	Logged By JLL Checked By LJS	Driller Holocene Drilling, Inc.	Drilling Method Mud Rotary	
Surface Elevation (ft) Vertical Datum 11		Hammer Data Autohammer (71% Efficient) 140 (lbs) / 30 (in) Drop		Drilling Equipment Brainard-Killman BK-81	
Easting (X) 434540.41 Northing (Y) 5202385.99		System Datum WA North		Groundwater not observed at time of exploration	

Notes:

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
10	0		2	13		1 MC		AC	3 to 4 inches asphalt concrete pavement	14		psf = pounds per square foot; pcf = pounds per cubic foot; DD = dry density
								GM	Dark gray silty gravel with sand (8 to 10 inches aggregate base course) (medium dense, moist)			
			3	4		2 MC		GM ML	Yellow brown silty gravel with occasional sand (medium dense, moist) (fill)	39		
5	5		20	Push		3 TX			Dark gray silt with trace sand, gravel and occasional organic matter (soft, moist)	78		S_u=340 psf; DD=54.3 pcf
			7	1		4 AL		MH	Grades to very soft Dark gray elastic silt with interbeds of brown organic silt with organic matter (organic fibers and wood fragments) (very soft, moist)	81		AL (LL=101; PI=56)
0	10		22	Push		5 TX			Grades to with trace sand, organic matter and without interbeds	61		S_u=405 psf; DD=62.8 pcf
			8	1		6 MC				66		
-5	15		12	5		7 %F		SM	Dark gray silty fine sand with organic matter (loose, moist)	39	42	
									Grades to with trace organic matter and wet			
-10	20		24	Push		8 TX			Grades to with interbeds of silt with gravel, organic matter and trace shell fragments	31		S_u=1077 psf; DD=89.0 pcf
			18	0		9			Grades to with trace organic matter and very loose			
-15	25		18	6		10 %F			Grades to loose	30	13	
-20	30		6	Push		11			Grades to very loose			
			18	0		12						
-25	35			4		13 MC			Grades to loose with occasional organic matter (organic fragments and wood fragments) and occasional interbeds of sandy silt	36		
-30	40		18	4		14 MC				40		

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on , Vertical approximated based on

Log of Boring B-4A-16

GeoEngineers

Project: North Shore Levee
Project Location: Aberdeen and Hoquiam, Washington
Project Number: 0201-008-01

Figure A-5
Sheet 1 of 1

Tacoma: Date:4/26/17 Path:P:\0\0201008\GINT\0201008O1.GPJ DBTemplate/LibTemplate:GEOENGINEERS_DF_STD_US_2017.GDT/GEI8_GEOTECH_STANDARD_%F_NO_GW

Drilled Start 7/27/2016 End 7/27/2016	Total Depth (ft) 41.5	Logged By JLL Checked By LJS	Driller Holocene Drilling, Inc.	Drilling Method Mud Rotary	
Surface Elevation (ft) Vertical Datum 11		Hammer Data Autohammer (71% Efficient) 140 (lbs) / 30 (in) Drop		Drilling Equipment Brainard-Killman BK-81	
Easting (X) 433619.44 Northing (Y) 5202471.35		System Datum WA North		Groundwater not observed at time of exploration	

Notes:

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
10	0	9	6		1 MC		GM	Brown to gray-brown silty gravel with organic matter (roots up to 2 inches) (loose, moist) (fill)	33		psf = pounds per square foot; pcf = pounds per cubic foot; DD = dry density
			2		2 MC		ML	Brown silt with organic matter (roots) (soft, moist)	37		
5	5	18	Push		3		ML	Dark gray silt with trace sand and construction debris (geotextile fabric) (soft, moist)			
		18	2		4 MC			Grades to wet	59		Groundwater encountered at approximately 7 feet below ground surface during drilling
0	10	24	Push		5 TX				60		S_u=205 psf; 362 psf; DD=67.0 pcf; 62.6 pcf
							MH	Grades to very soft	66		
		18	1		6 AL			Dark gray elastic silt with trace sand and organic matter (roots and organic fragments) (very soft, wet)	65		AL (LL=70; PI=31)
-5	15	18	2		7 MC			Grades to with fine sand and occasional interbeds of sandy elastic silt (1 to 2 inches thick)	60		
							SM	Dark gray silty fine sand, trace organic matter (very loose, wet)			
-10	20	24	Push		8						
		9	0		9 %F				12	21	
-15	25	18	1		10 AL				41		AL (non-plastic)
							ML	Dark gray sandy non-plastic silt with trace organic matter (very soft, wet)			
-20	30	4	Push		11		SM	Dark gray silty fine to medium sand (very loose, wet)			
		18	4		12			Grades to loose			
-25	35	18	3		13 %F			Grades to very loose	46	33	
-30	40		6		14			Grades to loose			

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on , Vertical approximated based on

Log of Boring B-5-16

GeoEngineers

Project: North Shore Levee
Project Location: Aberdeen and Hoquiam, Washington
Project Number: 0201-008-01

Figure A-6
Sheet 1 of 1

Tacoma: Date:4/26/17 Path:P:\0\0201008\GINT\020100801.GPJ DBTemplate/LibTemplate:GEOENGINEERS_DF_STD_US_2017.GDT/GEI8_GEOTECH_STANDARD_%F_NO_GW

Drilled Start 7/26/2016 End 7/26/2016	Total Depth (ft) 71.5	Logged By JLL Checked By LJS	Driller Holocene Drilling, Inc.	Drilling Method Mud Rotary	
Surface Elevation (ft) Vertical Datum 12		Hammer Data Autohammer (71% Efficient) 140 (lbs) / 30 (in) Drop		Drilling Equipment Brainard-Killman BK-81	
Easting (X) 433283.49 Northing (Y) 5202947.58		System Datum WA North		Groundwater not observed at time of exploration	

Notes:

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0	4	24		1 SA		SM	Brown silty sand with gravel (medium dense, dry) (fill)	28	24	psf = pounds per square foot; pcf = pounds per cubic foot; DD = dry density
10		6	5		2 %F		SM	Gray-brown silty medium sand, trace road gravel (loose, moist)	22	20	
	5	4	1		3 AL		MH	Dark gray elastic silt with organic matter and trace fine sand (very soft, wet) (alluvium)	52		AL(LL=70; PI=32)
5	10	14	Push		4 TX				75		S_u=238 psf; DD=56.5 pcf
0		18	1		5 MC				71		
	15	9	1		6 AL			Grades to with trace organic matter (wood, organic fragments)	51		AL(LL=55; PI=21)
-5	20	24	Push		7 TX				64		S_u=515 psf; DD=62.8 pcf
-10		8	2		8 MC				69 61		S_u=543 psf; DD=60.8 pcf
	25	12	17		9 %F		SP-SM	Dark gray fine sand with silt, trace organic matter and gravel (medium dense, wet)	29	11	
-15	30	10	14		10 MC				30		
-20							SM	Dark gray silty fine to medium sand with occasional interbeds of sand with organic matter (wood debris) (loose, wet)			
	35	12	7		11 %F				62	19	
-25	40		2		12 MC			Grades to very loose	46		
-30											

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on , Vertical approximated based on

Tacoma: Date:4/26/17 Path:P:\0\0201008\GINT\020100801.GPJ DBTemplate/LibTemplate:GEOENGINEERS_DF_STD_US_2017.GDT/GEI8_GEOTECH_STANDARD_%F_NO_GW

Log of Boring B-6-16

GeoEngineers

Project: North Shore Levee
Project Location: Aberdeen and Hoquiam, Washington
Project Number: 0201-008-01

Figure A-7
Sheet 1 of 2

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	FIELD DATA: Blows/foot	FIELD DATA: Collected Sample / Sample Name Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	45	16	2	13 MC		ML	Dark gray silt with sand with interbeds of silty sand and occasional organic matter (wood fragments) (soft and very loose, wet)	70		
-35										
	50	8	1	14 MC			Grades to with occasional interbeds of black silty sand with shell fragments and organic matter (wood fragment to 2 inches) (very soft and very loose, wet)	80		
-40						MH	Dark gray elastic silt with trace sand (very soft, wet)			
	55	5	1	15 MC				62		
-45							Grades to with sand, interbeds of silty sand and occasional organic matter (organic and wood fragments)			
	60	16	1	16 MC				57		
-50						SM	Dark gray silty fine to medium sand, trace organic matter and white shell fragments (medium dense, wet)			
	65	12	11	17 %F				39	16	
-55						ML	Dark gray silt with sand and occasional organic matter (soft, wet)			
	70	16	2	18 MC				50		

Log of Boring B-6-16 (continued)

GeoEngineers

Project: North Shore Levee
Project Location: Aberdeen and Hoquiam, Washington
Project Number: 0201-008-01

Figure A-7
Sheet 2 of 2

Tacoma: Date:4/26/17 Path:P:\0\0201008\GINT\0201008O1.GPJ DBTemplate/LibTemplate:GEOENGINEERS_DF_STD_US_2017.GDT/GEI8_GEOTECH_STANDARD_%F_NO_GW

Drilled Start 7/27/2016 End 7/27/2016	Total Depth (ft) 63.5	Logged By JLL Checked By LJS	Driller Holocene Drilling, Inc.	Drilling Method Mud Rotary	
Surface Elevation (ft) Vertical Datum 13		Hammer Data Autohammer (71% Efficient) 140 (lbs) / 30 (in) Drop		Drilling Equipment Brainard-Killman BK-81	
Easting (X) 433074.46 Northing (Y) 5203095.42		System Datum WA North		Groundwater not observed at time of exploration	

Notes:

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0	6	14		1 SA		TS	Approximately 1 to 2 inches topsoil and sod	25	45	psf = pounds per square foot; pcf = pounds per cubic foot; DD = dry density
							SM	Brown silty sand with gravel and organic matter (grass roots to 2 inches) (medium dense, dry) (fill)			
10		2	3		2 MC		CL	Yellow lean clay with sand, angular siltstone fragments (chaotic appearance) (soft, moist)	46		
	5	14	Push		3 TX				64		S_u=881 psf; DD=61.3 pcf
5		5	0		4 MC			Grades to very soft	63		
								Grades to gray			
	10	6 18	46		5 AL 6		SM	Dark gray silty fine to medium sand (dense, wet) (alluvium)	38		AL (non-plastic)
0								10- to 12-inch spruce log			
	15	NR	1		7			Grades to very dense			
-5											
	20	2	15		8 MC			Grades to silty fine sand with occasional organic matter (wood fibers), medium dense	74		
-10											
	25	12	6		9 MC			Grades to loose	49		
-15											
	30	17	Push		10 TX		ML	Dark gray silt with sand and interbeds of sand (stiff, moist)	46		S_u=605 psf; DD=85.1 pcf
-20			12		11 %F		SM	Dark gray silty fine to medium sand (medium dense, wet)	41	19	
	35	18	24		12 MC				28		
-25											
	40		24		13 %F			Grades to gray	28	10	

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on , Vertical approximated based on

Tacoma: Date:4/26/17 Path:P:\0\0201008\GINT\0201008O1.GPJ DBTemplate/LibTemplate:GEOENGINEERS_DF_STD_US_2017.GDT/GEI8_GEOTECH_STANDARD_%F_NO_GW

Log of Boring B-7-16

GeoEngineers

Project: North Shore Levee
Project Location: Aberdeen and Hoquiam, Washington
Project Number: 0201-008-01

Figure A-8

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	FIELD DATA: Blows/foot	FIELD DATA: Collected Sample	FIELD DATA: Sample Name Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
-30							MH	Dark gray elastic silt with trace sand (very soft, moist)			
	45	12	0		14 AL				60		AL (LL=50; PI=17)
-35							ML	Dark gray sandy silt with interbeds of silty sand, trace organic matter and shell fragments			
	50	18	0		15 MC				51		
-40							ML	Light gray sandy silt weakly cemented (hard, moist) (siltstone)			
	55	6	50/6"		16 MC				24		Very slow, smooth drilling
-45											
	60	9	50/3"		17 %F				20	63	
-50			50/6"		18						Slow, smooth drilling

Tacoma: Date:4/26/17 Path:P:\0\0201008\GINT\020100801.GPJ DBTemplate/LibTemplate:GEOENGINEERS_DF_STD_US_2017.GDT/GEI8_GEOTECH_STANDARD_%F_NO_GW

Log of Boring B-7-16 (continued)

GeoEngineers

Project: North Shore Levee
Project Location: Aberdeen and Hoquiam, Washington
Project Number: 0201-008-01

Drilled Start 7/28/2016 End 7/28/2016	Total Depth (ft) 71.5	Logged By JLL Checked By LJS	Driller Holocene Drilling, Inc.	Drilling Method Mud Rotary	
Surface Elevation (ft) Vertical Datum 11		Hammer Data Autohammer (71% Efficient) 140 (lbs) / 30 (in) Drop		Drilling Equipment Brainard-Killman BK-81	
Easting (X) 432929.08 Northing (Y) 5203441.55		System Datum WA North		Groundwater not observed at time of exploration	

Notes:

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0	4	11		1 MC		AC	4 inches asphalt concrete pavement	4		psf = pounds per square foot; pcf = pounds per cubic foot; DD = dry density
							GM	8 to 12 inches thick aggregate base course			
		18	1		2 MC		ML	Gray silt with sand, interbeds of sandy silt and occasional organic matter (organic fragments and wood) (very soft, wet) (alluvium)	63		
	5	20	Push		3 TX; CS				85		S_u=445 psf; DD=53.7 pcf
		NR	1		4				86		DD=50.4
	10	22	Push		5 TX		MH	Dark gray elastic silt with trace sand and organic matter (wood and organic fragments) (very soft, wet)	63		S_u=439 psf; DD=62.7 pcf
		18	0		6 AL				72		AL (LL=72; PI=34)
	15	16	1		7 MC				70		
	20	24	Push		8 TX				70		S_u=503 psf; DD=60.6 pcf
		18	1		9 MC			Grades to with interbeds of sandy elastic silt and organic matter (wood and organic fragments)	79		
	25	16	1		10 %F		SM	Dark gray silty fine sand with interbeds of silt with sand and trace organic matter (very loose, wet)	61	42	
	30	22	Push		11 TX				48		S_u=1435 psf; DD=72.2 pcf
		8	3		12 MC			Grades to silty fine to medium sand with organic matter (wood fragments)	92		
	35	16	2		13 AL		ML	Dark gray-green silt with sand, interbeds of silty sand and trace organic matter (organic and wood fragments) (soft, wet)	44		AL (LL=57; PI=20)
	40	16	2		14 MC				45		

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on , Vertical approximated based on

Log of Boring B-8A-16

GeoEngineers

Project: North Shore Levee
Project Location: Aberdeen and Hoquiam, Washington
Project Number: 0201-008-01

Figure A-9
Sheet 1 of 2

Tacoma: Date:4/26/17 Path:P:\0\0201008\GINT\0201008O1.GPJ DBTemplate/LibTemplate:GEOENGINEERS_DF_STD_US_2017.GDT/GEI8_GEOTECH_STANDARD_%F_NO_GW

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	FIELD DATA: Blows/foot	FIELD DATA: Collected Sample / Sample Name Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
-35	45	6	2	15 AL		MH	Dark gray elastic silt with sand and trace organic matter (very soft, wet)	63		AL (LL=57; PI=20)
							Grades to with interbeds of sandy silt, occasional organic matter and trace white shell fragments			
-40	50	18	3	16 MC				64		
							Grades to with trace sand and organic matter			
-45	55	18	2	17 MC				52		
-50	60		2	18 MC				50		
						ML	Dark gray silt with sand, interbeds of silty sand and trace organic matter (very soft, wet)			
-55	65	18	1	19 MC				62		
-60	70	16	2	20 MC				53		

Tacoma: Date:4/26/17 Path:P:\0\0201008\GINT\020100801.GPJ DBTemplate/LibTemplate:GEOENGINEERS_DF_STD_US_2017.GDT/GEI8_GEOTECH_STANDARD_%F_NO_GW

Log of Boring B-8A-16 (continued)

GeoEngineers

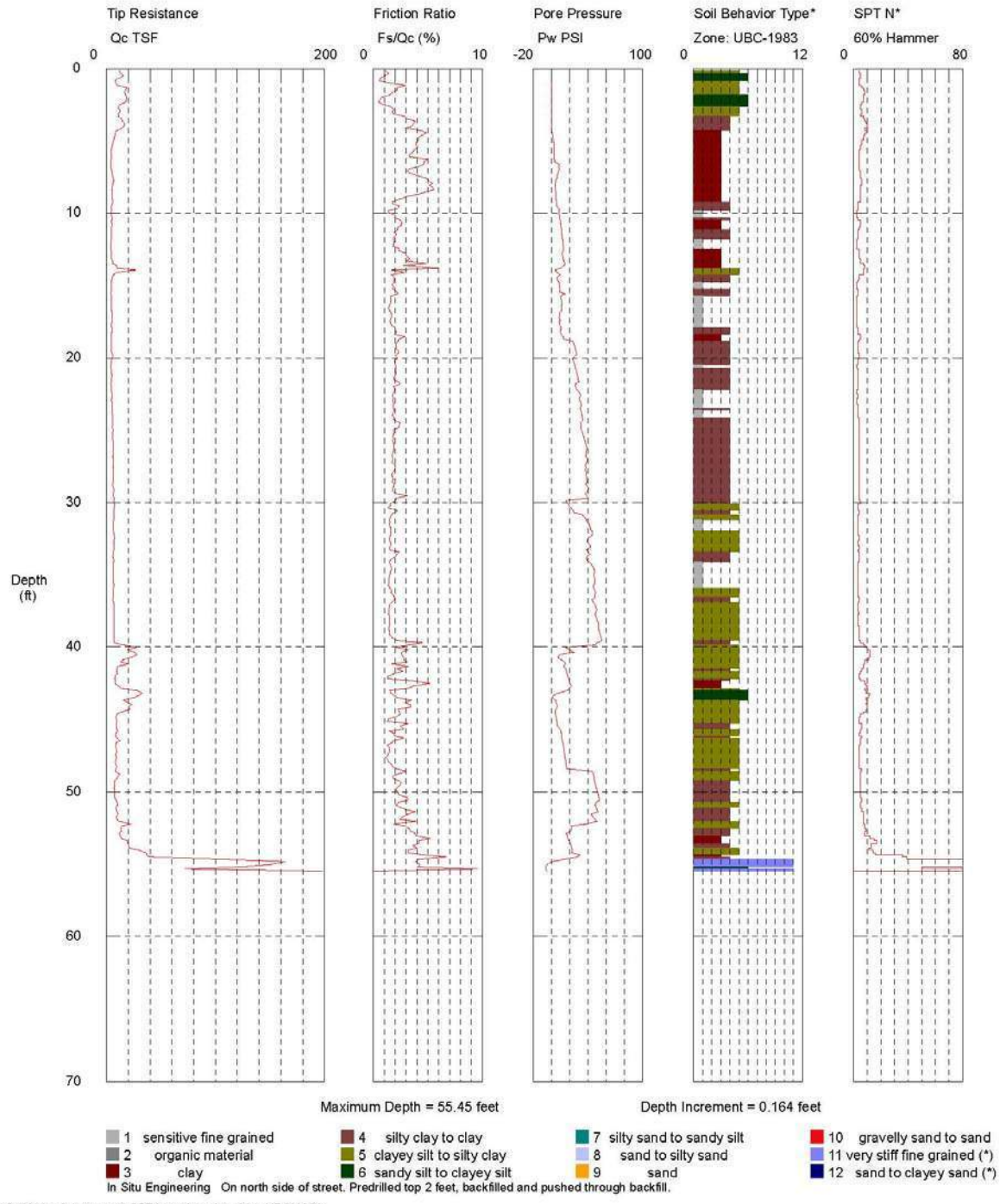
Project: North Shore Levee
Project Location: Aberdeen and Hoquiam, Washington
Project Number: 0201-008-01

Figure A-9
Sheet 2 of 2

GeoEngineers

Operator: Brown
Sounding: CPT-01
Cone Used: DDG1368
GPS Data: NO GPS

CPT Date/Time: 7/28/2016 12:34:40 PM
Location: Aberdeen Northside Levee
Job Number: 0201-008-01



In Situ Engineering On north side of street. Predrilled top 2 feet, backfilled and pushed through backfill.

*Soil behavior type and SPT based on data from UBC-1983

CPT-1 2016

North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

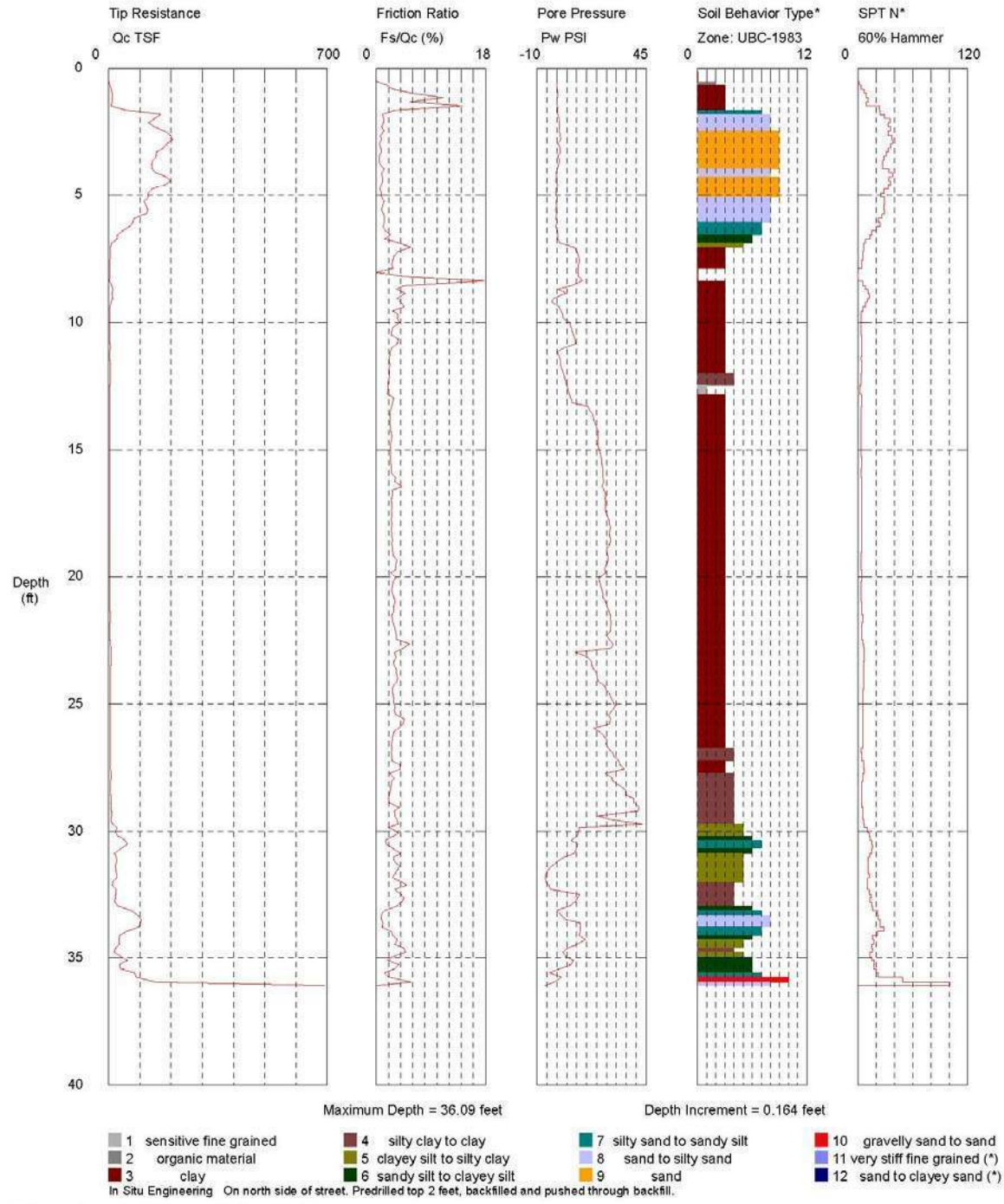
Figure A-10

0201-008-01 Date Exported: 2/17/17

GeoEngineers

Operator: Brown
Sounding: CPT-02
Cone Used: DDG1368
GPS Data: NO GPS

CPT Date/Time: 7/28/2016 1:46:40 PM
Location: Aberdeen Northside Levee
Job Number: 0201-008-01



In Situ Engineering On north side of street. Predrilled top 2 feet, backfilled and pushed through backfill.

*Soil behavior type and SPT based on data from UBC-1983

CPT-2 2016

North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

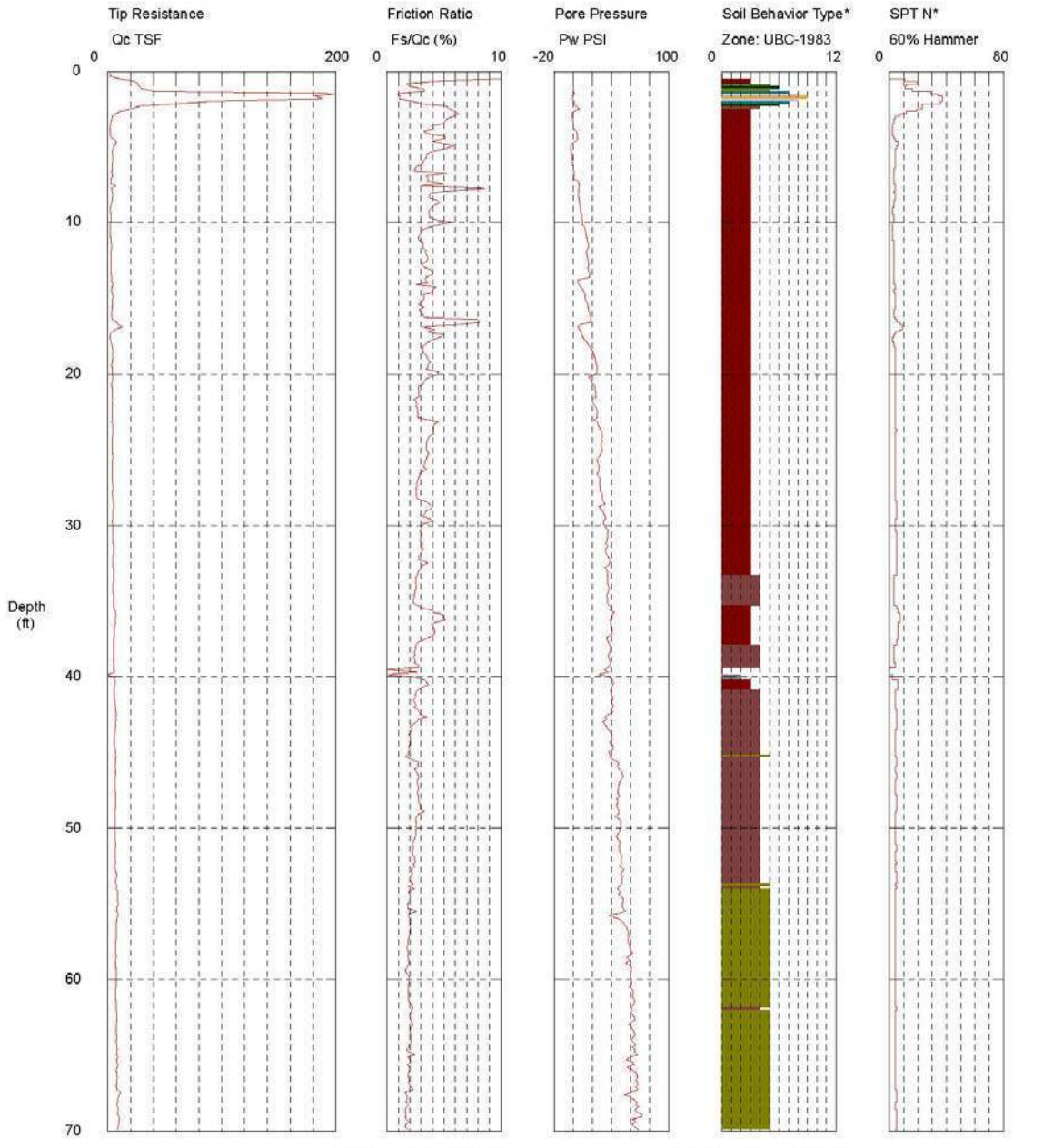
Figure A-11

0201-008-01 Date Exported: 2/17/17

GeoEngineers

Operator: Brown
Sounding: CPT-03
Cone Used: DDG1368
GPS Data: NO GPS

CPT Date/Time: 7/28/2016 2:45:59 PM
Location: Aberdeen Northside Levee
Job Number: 0201-008-01



In Situ Engineering On north side of street. Predrilled top 2 feet, backfilled and pushed through backfill.

*Soil behavior type and SPT based on data from UBC-1983

CPT-3 2016

North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

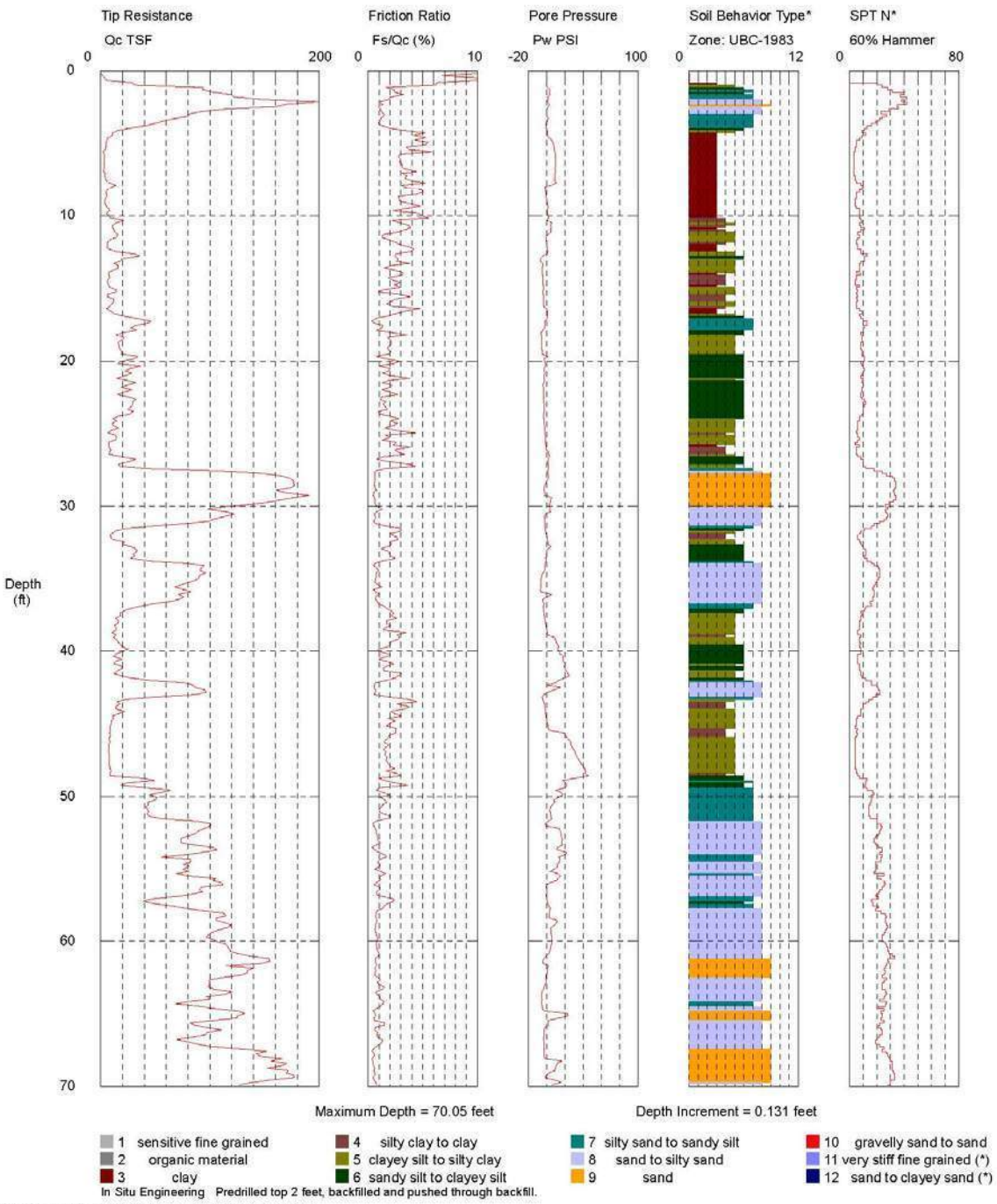
Figure A-12

0201-008-01 Date Exported: 2/17/17

GeoEngineers

Operator: Brown
Sounding: CPT-04
Cone Used: DDG1368
GPS Data: NO GPS

CPT Date/Time: 7/28/2016 4:20:04 PM
Location: Aberdeen Northside Levee
Job Number: 0201-008-01



*Soil behavior type and SPT based on data from UBC-1983

CPT-4 2016

North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

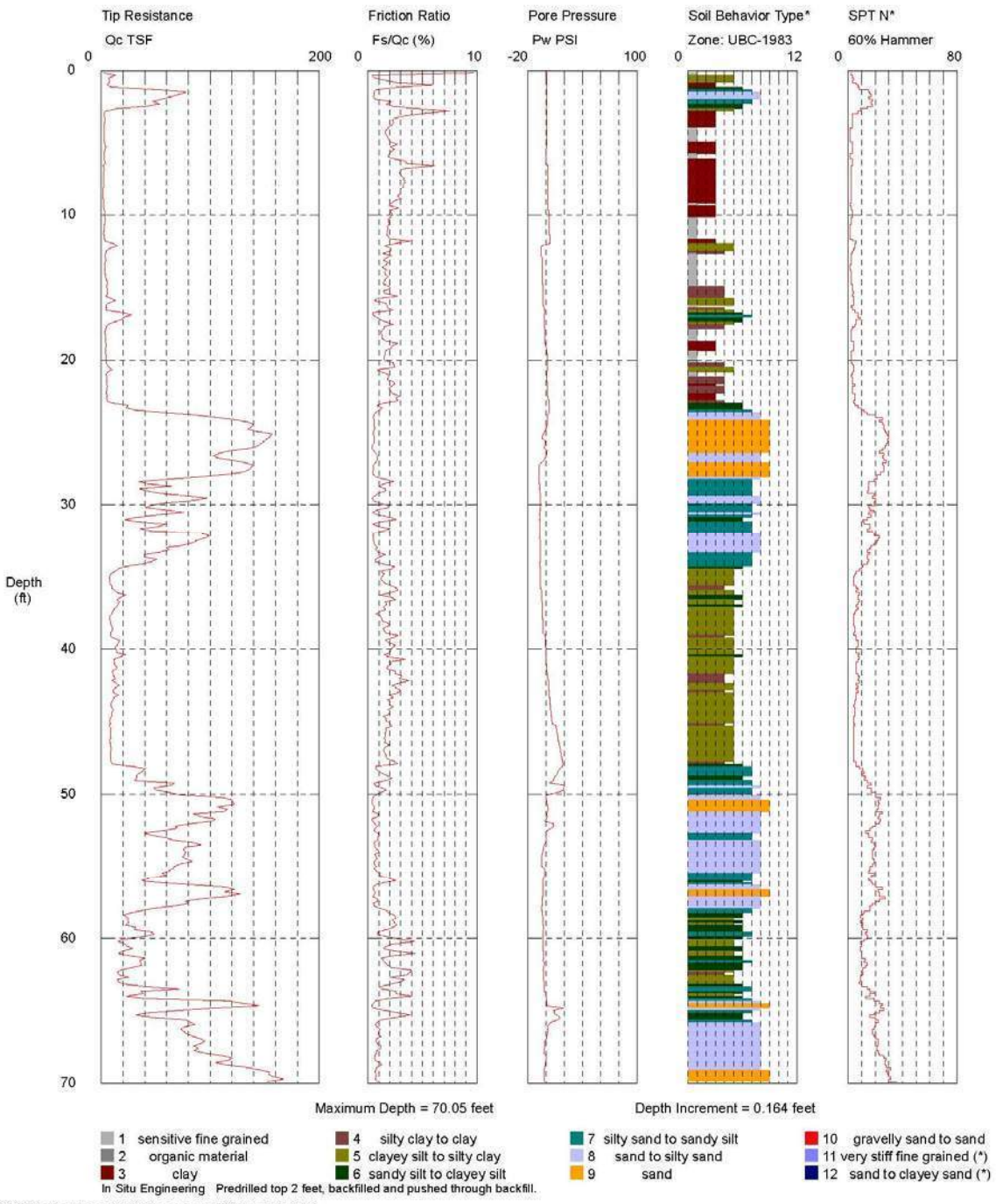
Figure A-13

0201-008-01 Date Exported: 2/17/17

GeoEngineers

Operator: Brown
Sounding: CPT-05
Cone Used: DDG1368
GPS Data: NO GPS

CPT Date/Time: 7/29/2016 3:22:35 PM
Location: Aberdeen Northside Levee
Job Number: 0201-008-01



*Soil behavior type and SPT based on data from UBC-1983

CPT-5 2016

North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

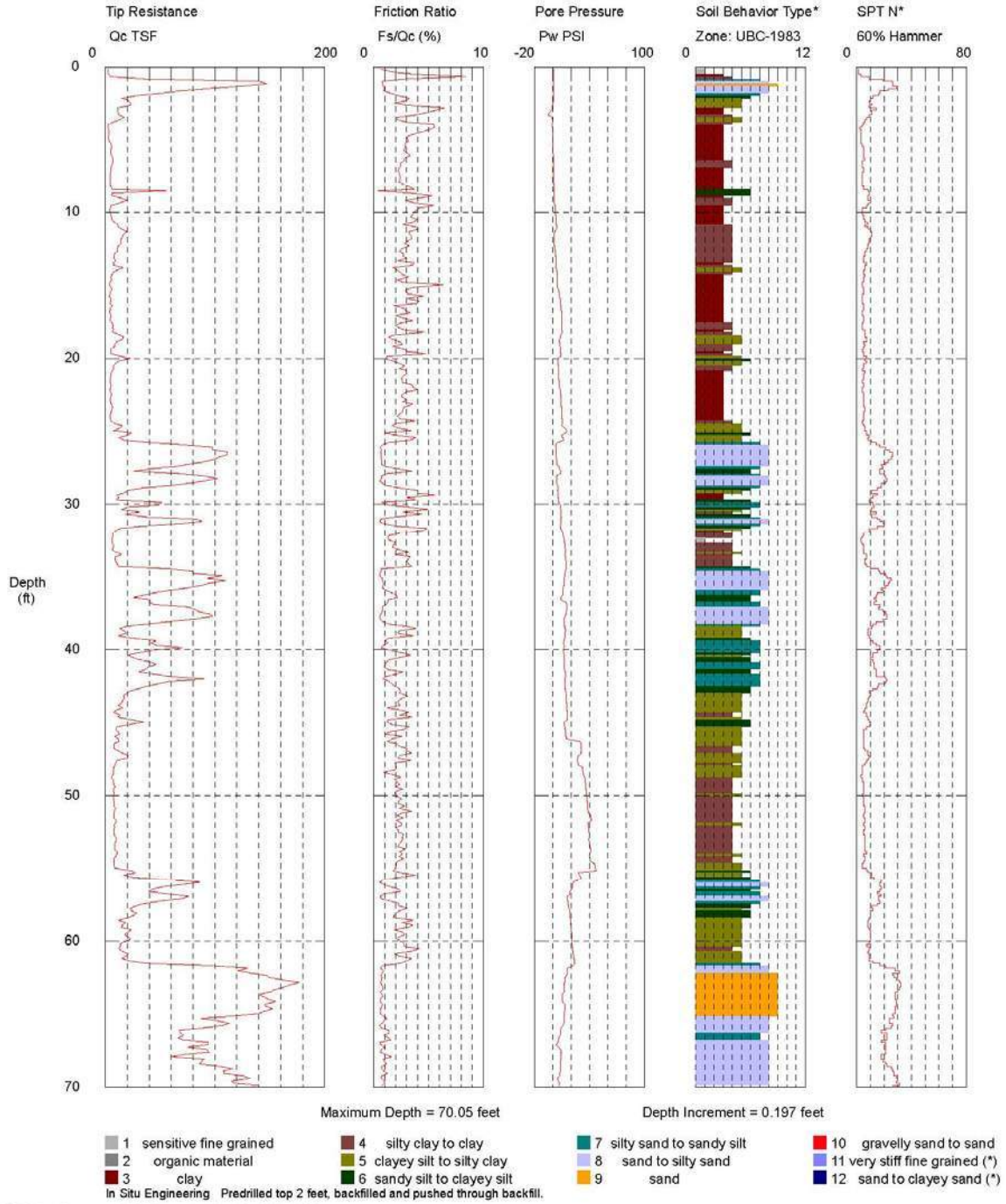
Figure A-14

0201-008-01 Date Exported: 2/17/17

GeoEngineers

Operator: Brown
Sounding: CPT-06
Cone Used: DDG1368
GPS Data: NO GPS

CPT Date/Time: 7/29/2016 4:48:26 PM
Location: Aberdeen Northside Levee
Job Number: 0201-008-01



In Situ Engineering Predrilled top 2 feet, backfilled and pushed through backfill.

*Soil behavior type and SPT based on data from UBC-1983

CPT-6 2016

North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

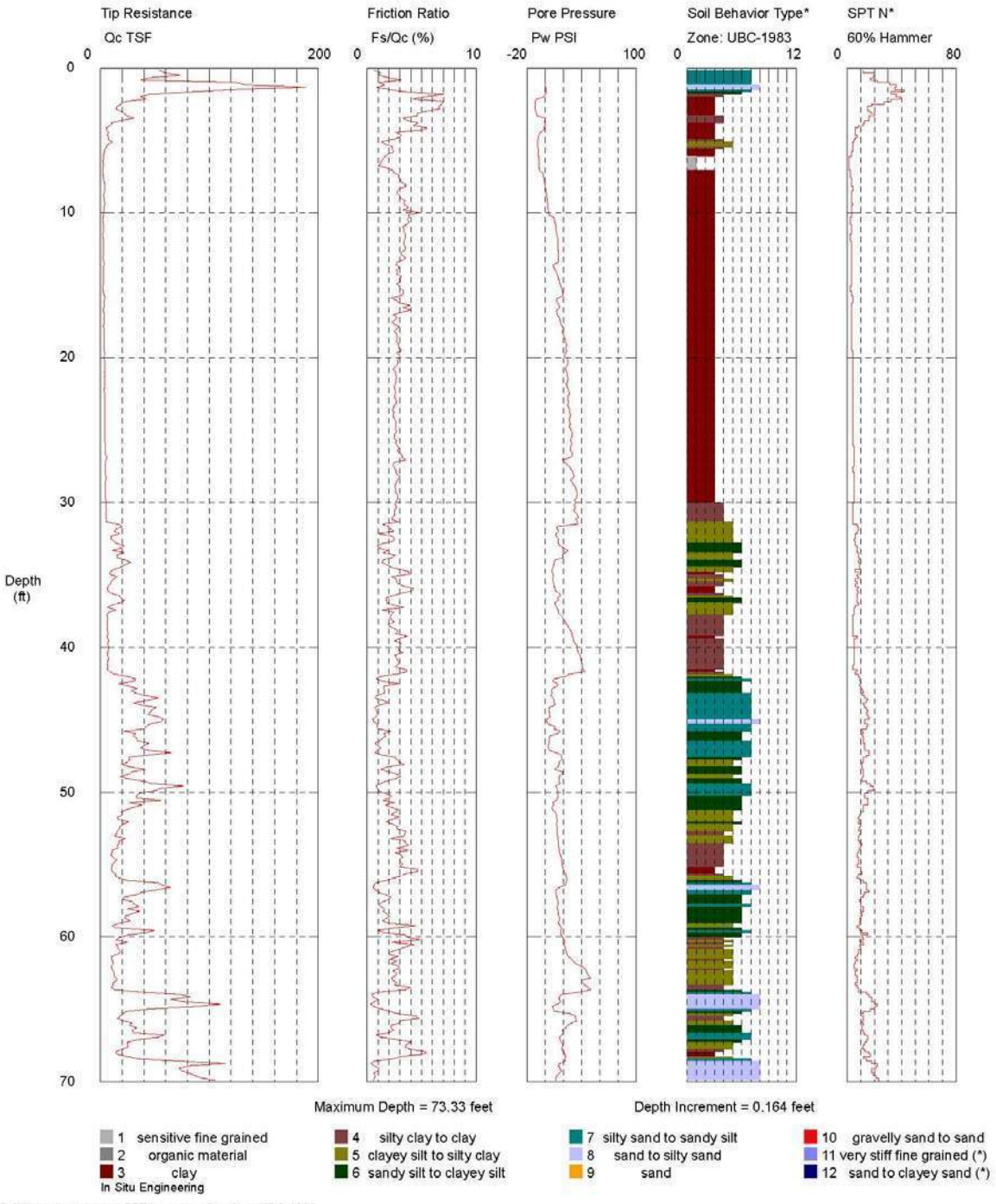
Figure A-15

0201-008-01 Date Exported: 2/17/17

GeoEngineers

Operator: Brown
Sounding: CPT-07
Cone Used: DDG1368
GPS Data: NO GPS

CPT Date/Time: 7/29/2016 1:23:52 PM
Location: Aberdeen Northside Levee
Job Number: 0201-008-01



*Soil behavior type and SPT based on data from UBC-1983

CPT-7 2016

North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

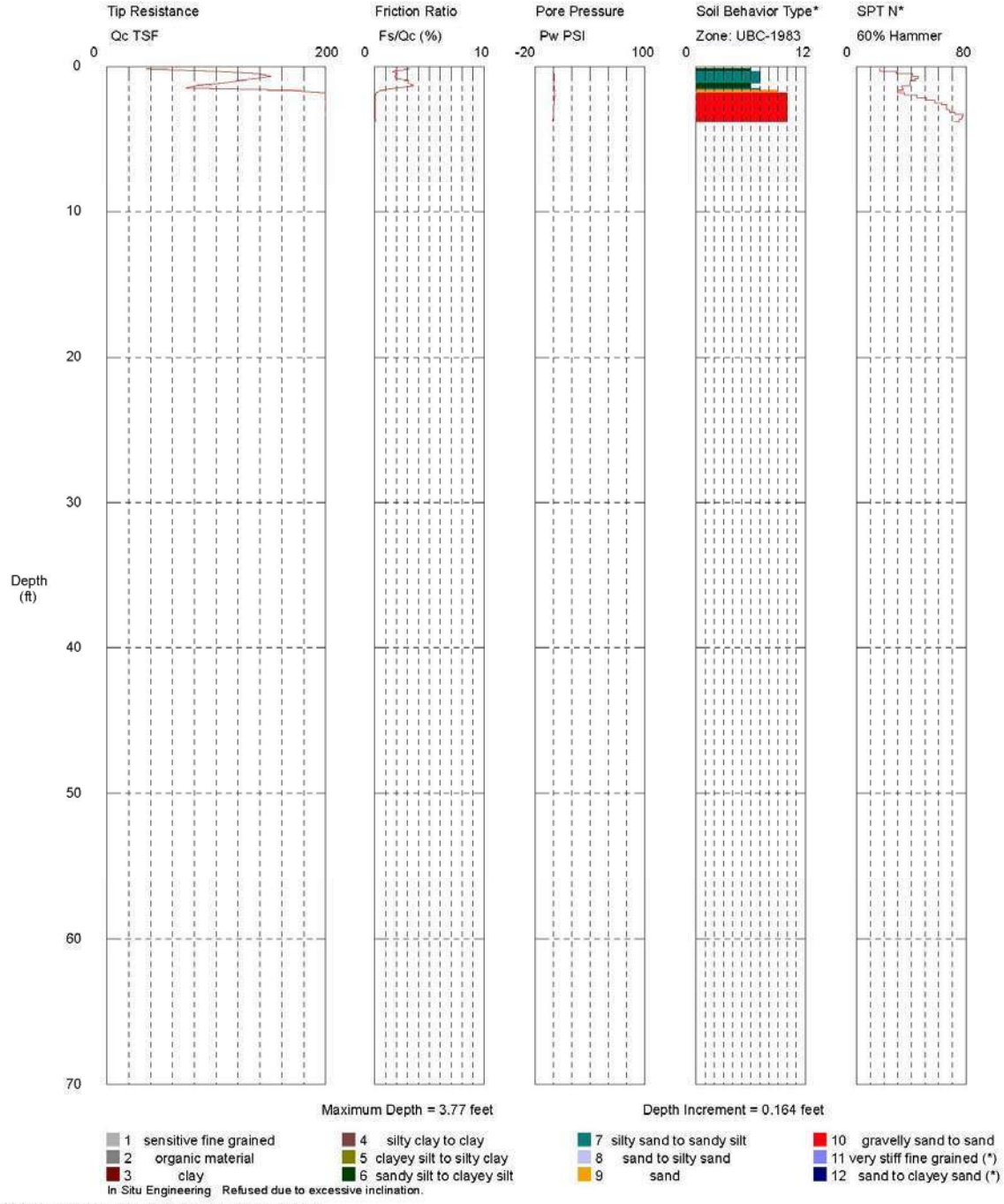
Figure A-16

0201-008-01 Date Exported: 2/17/17

GeoEngineers

Operator: Brown
Sounding: CPT-08
Cone Used: DDG1368
GPS Data: NO GPS

CPT Date/Time: 7/29/2016 9:34:01 AM
Location: Aberdeen Northside Levee
Job Number: 0201-008-01



*Soil behavior type and SPT based on data from UBC-1983

CPT-8 2016

North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

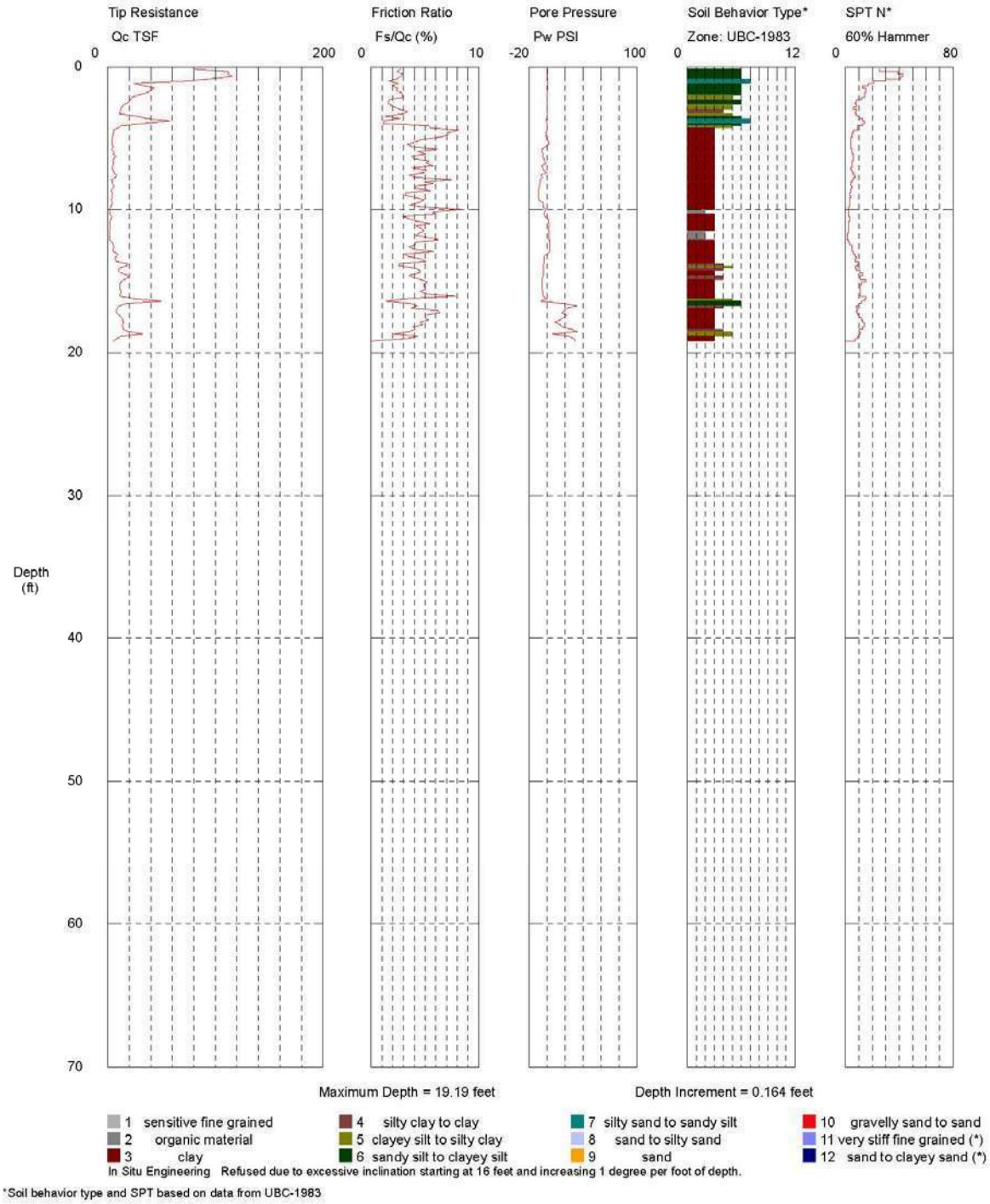
Figure A-17

0201-008-01 Date Exported: 2/17/17

GeoEngineers

Operator: Brown
Sounding: CPT-08A
Cone Used: DDG1368
GPS Data: NO GPS

CPT Date/Time: 7/29/2016 9:54:58 AM
Location: Aberdeen Northside Levee
Job Number: 0201-008-01



In Situ Engineering Refused due to excessive inclination starting at 16 feet and increasing 1 degree per foot of depth.

*Soil behavior type and SPT based on data from UBC-1983

CPT-8a 2016

North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

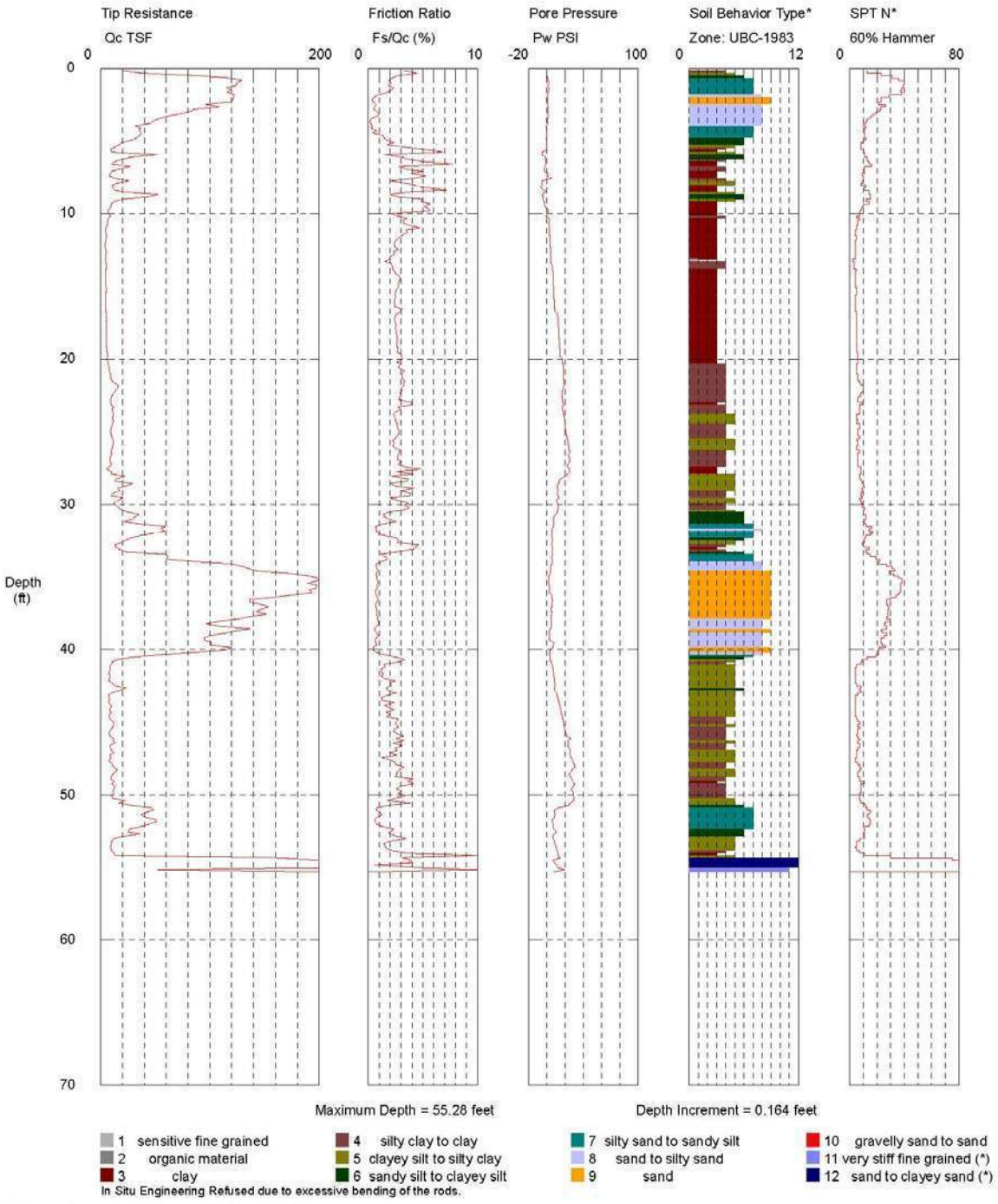
Figure A-18

0201-008-01 Date Exported: 2/17/17

GeoEngineers

Operator: Brown
Sounding: CPT-09
Cone Used: DDG1368
GPS Data: NO GPS

CPT Date/Time: 7/29/2016 10:30:20 AM
Location: Aberdeen Northside Levee
Job Number: 0201-008-01



In Situ Engineering Refused due to excessive bending of the rods.

*Soil behavior type and SPT based on data from UBC-1983

CPT-9 2016

North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

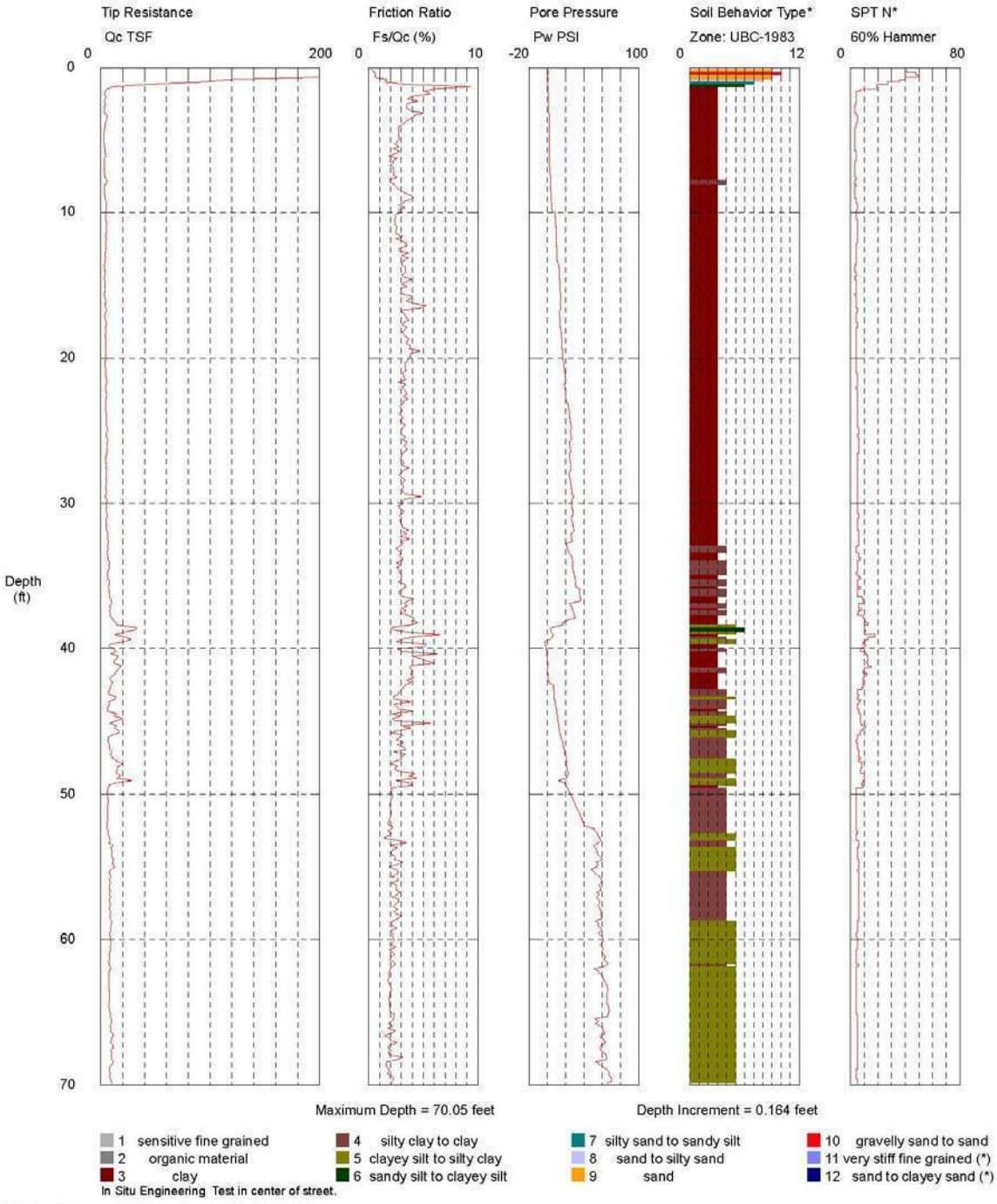
Figure A-19

0201-008-01 Date Exported: 2/17/17

GeoEngineers

Operator: Brown
Sounding: CPT-10
Cone Used: DDG1368
GPS Data: NO GPS

CPT Date/Time: 7/29/2016 11:31:29 AM
Location: Aberdeen Northside Levee
Job Number: 0201-008-01



*Soil behavior type and SPT based on data from UBC-1983

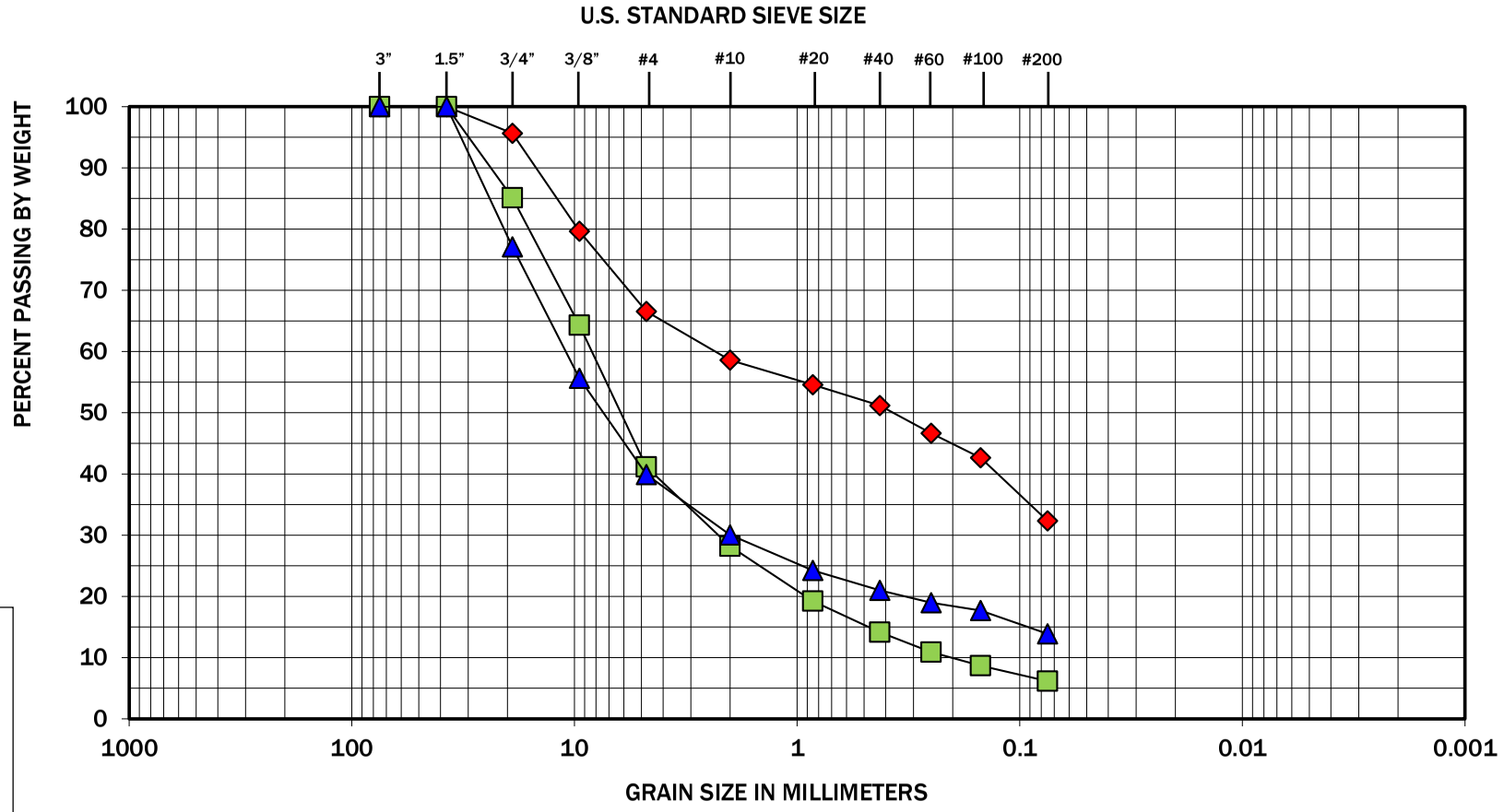
CPT-10 2016

North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure A-20

0201-008-01 Date Exported: 2/17/17



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Symbol	Boring Number	Depth (feet)	Moisture (%)	Soil Description
◆	B-1	0.5	9	Silty sand with gravel and organic matter (SM)
■	B-2	0.5	3	Poorly graded gravel with silt and sand (GP-GM)
▲	B-3	0.5	9	Silty gravel with sand (GM)

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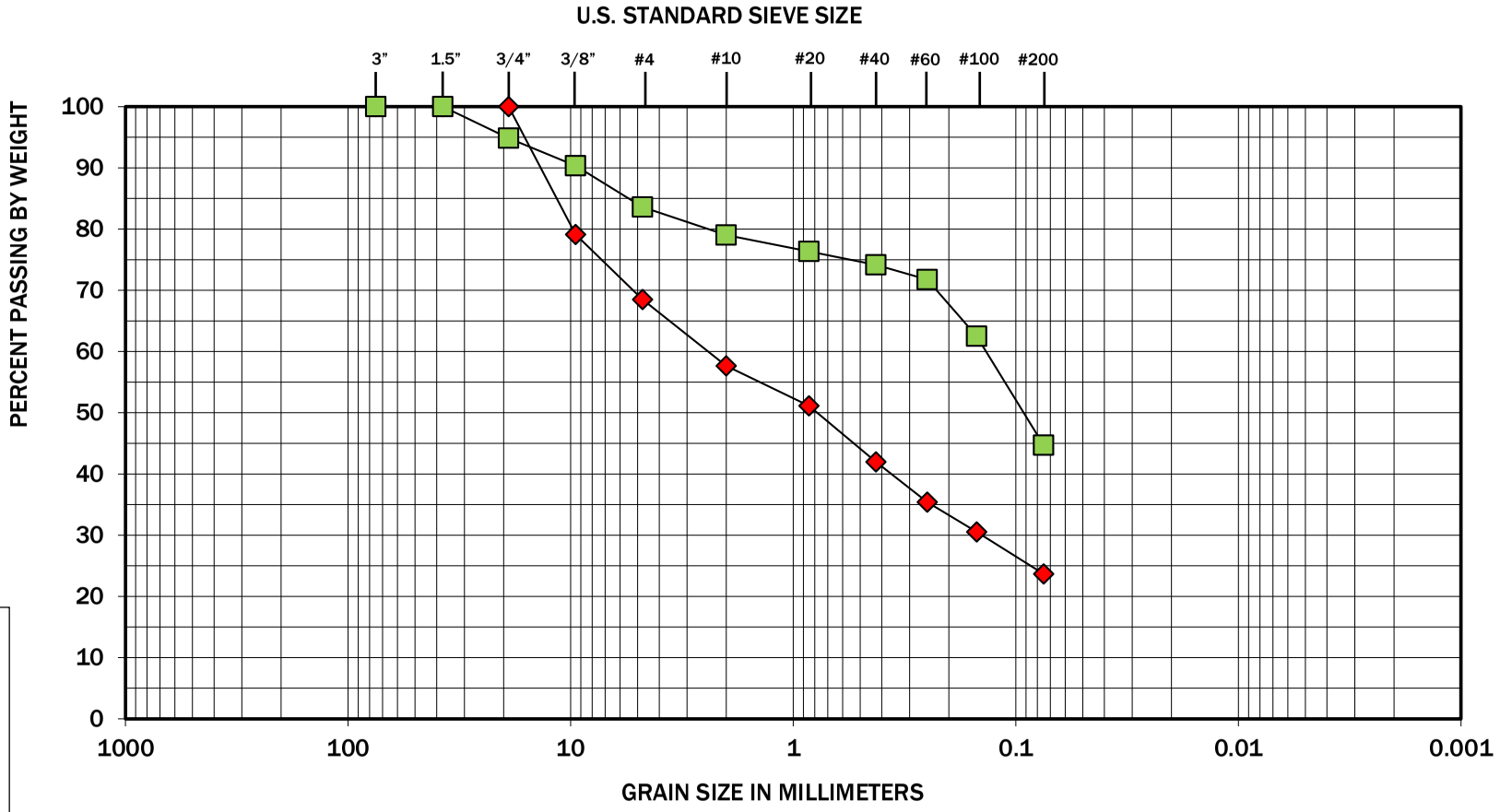
The grain size analysis results were obtained in general accordance with ASTM D 6913.

GeoEngineers

Figure A-21

North Shore Levee
Aberdeen and Hoquiam, Washington

Sieve Analysis Results



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Symbol	Boring Number	Depth (feet)	Moisture (%)	Soil Description
◆	B-6	0.5	28	Silty sand with gravel (SM)
■	B-7	0.5	25	Silty sand with gravel and organic matter (SM)

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The grain size analysis results were obtained in general accordance with ASTM D 6913.

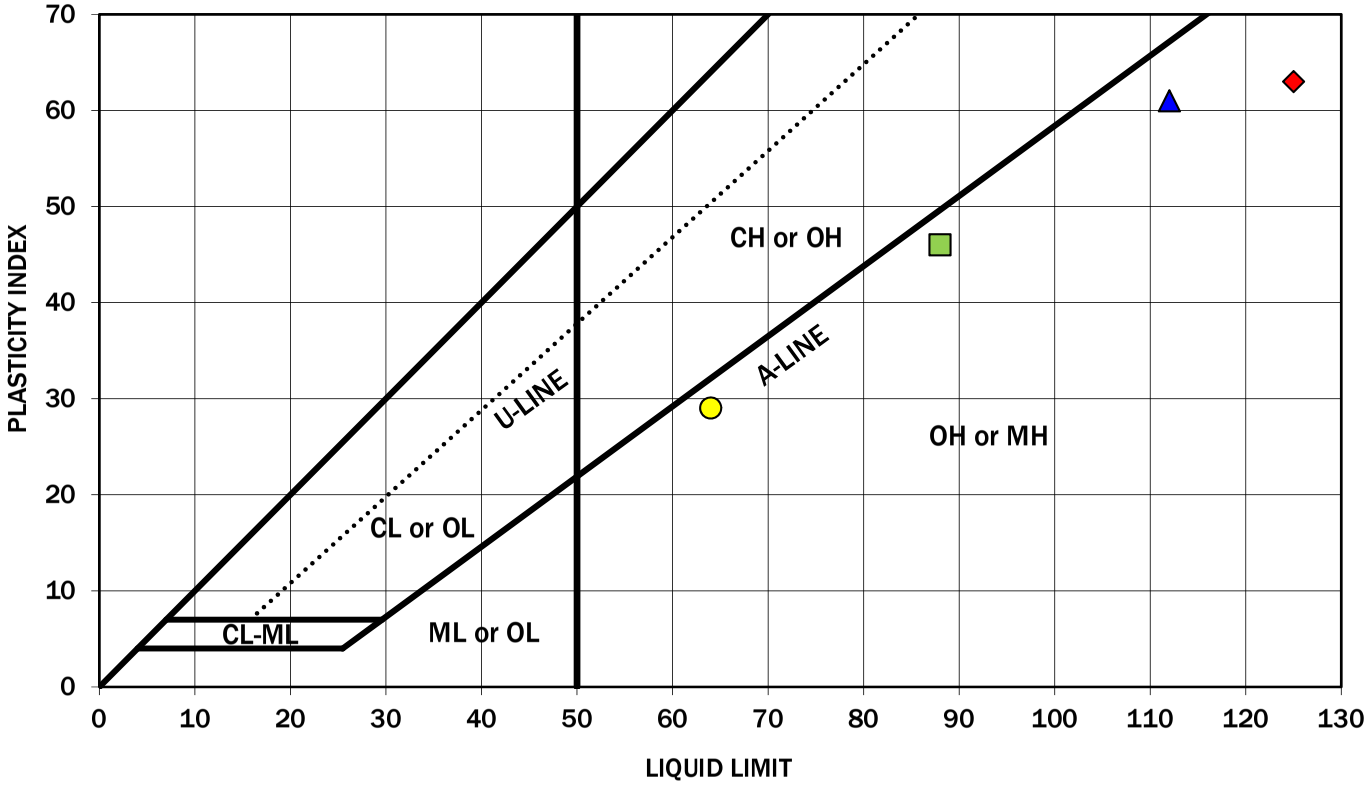
Sieve Analysis Results

North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure A-22

PLASTICITY CHART



Symbol	Boring Number	Depth (feet)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Soil Description
◆	B-1	7	109	125	63	Elastic silt with sand and organic matter (MH)
■	B-1	15	76	88	46	Elastic silt with sand (MH)
▲	B-1	25	103	112	61	Elastic silt (MH)
●	B-1	45	60	64	29	Elastic silt (MH)

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The liquid limit and plasticity index were obtained in general accordance with ASTM D 4318.

Atterberg Limits Test Results

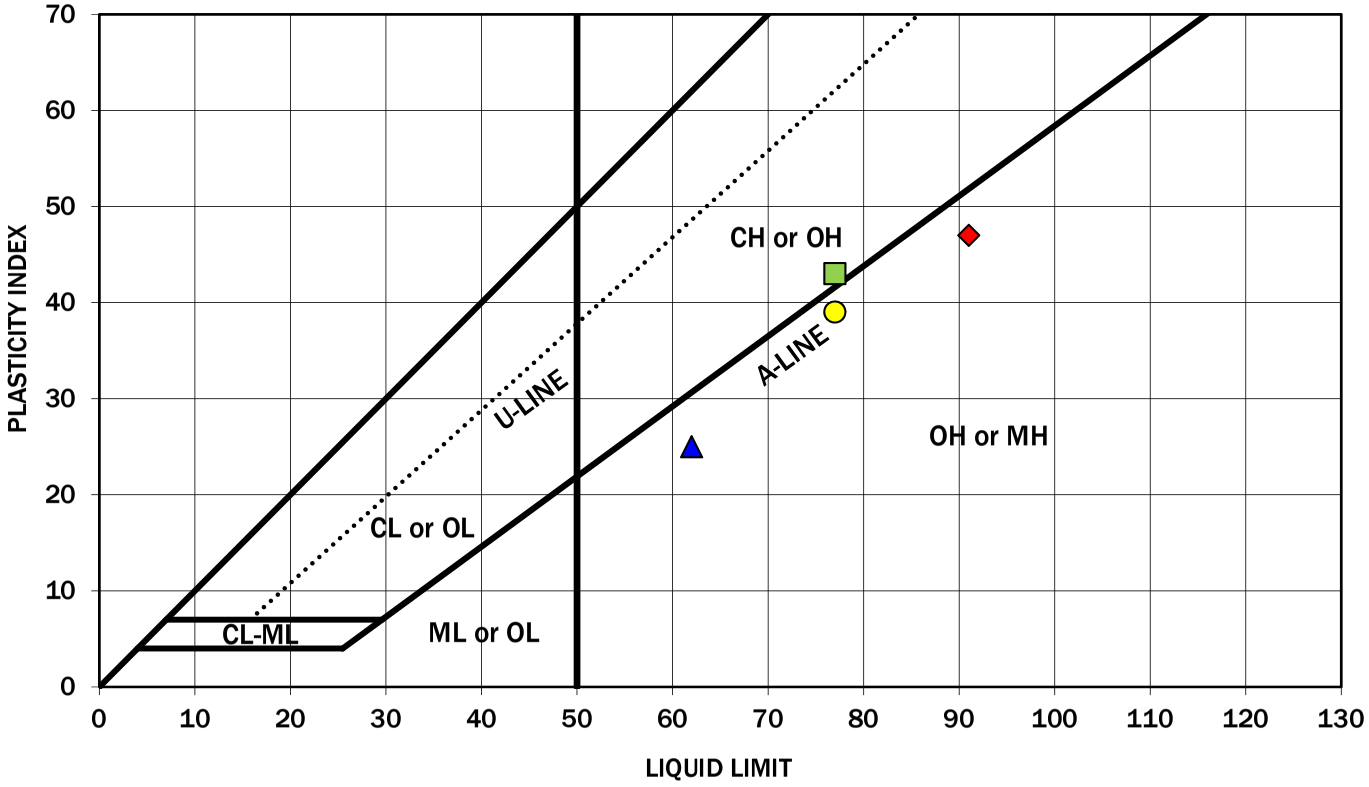
North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure A-23

0201-008-01 Date Exported: 02/17/17

PLASTICITY CHART



Symbol	Boring Number	Depth (feet)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Soil Description
◆	B-2	7	71	91	47	Elastic silt with sand and occasional gravel (MH)
■	B-2	15	63	77	43	Fat clay (CH)
▲	B-2	25	60	62	25	Elastic silt (MH)
●	B-2	50	78	77	39	Elastic silt (MH)

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The liquid limit and plasticity index were obtained in general accordance with ASTM D 4318.

Atterberg Limits Test Results

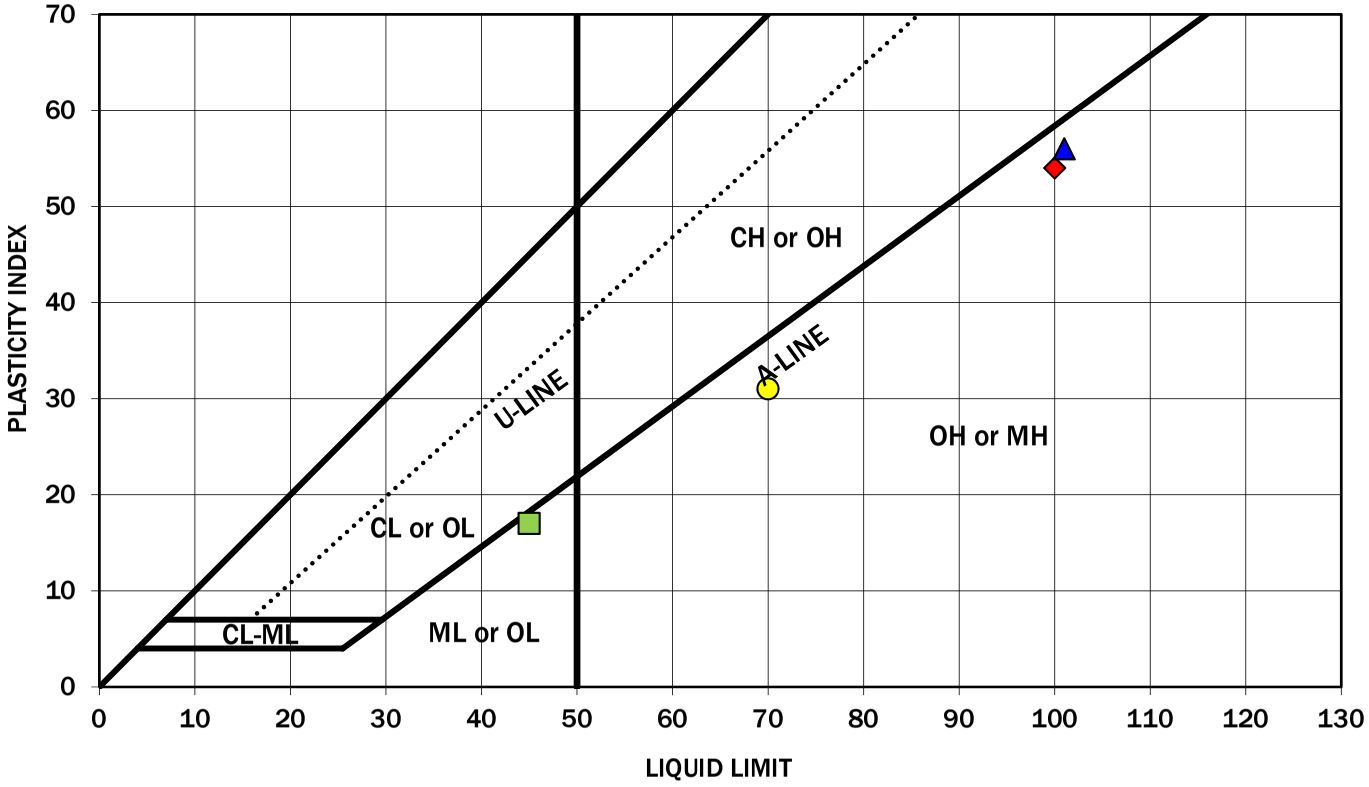
North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure A-24

0201-008-01 Date Exported: 02/17/17

PLASTICITY CHART



Symbol	Boring Number	Depth (feet)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Soil Description
◆	B-3	7	90	100	54	Elastic silt with organic matter (MH)
■	B-3	15	41	45	17	Silt with sand (ML)
▲	B-4A	7	81	101	56	Elastic silt with organic matter (MH)
●	B-5	12	65	70	31	Elastic silt (MH)

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The liquid limit and plasticity index were obtained in general accordance with ASTM D 4318.

Atterberg Limits Test Results

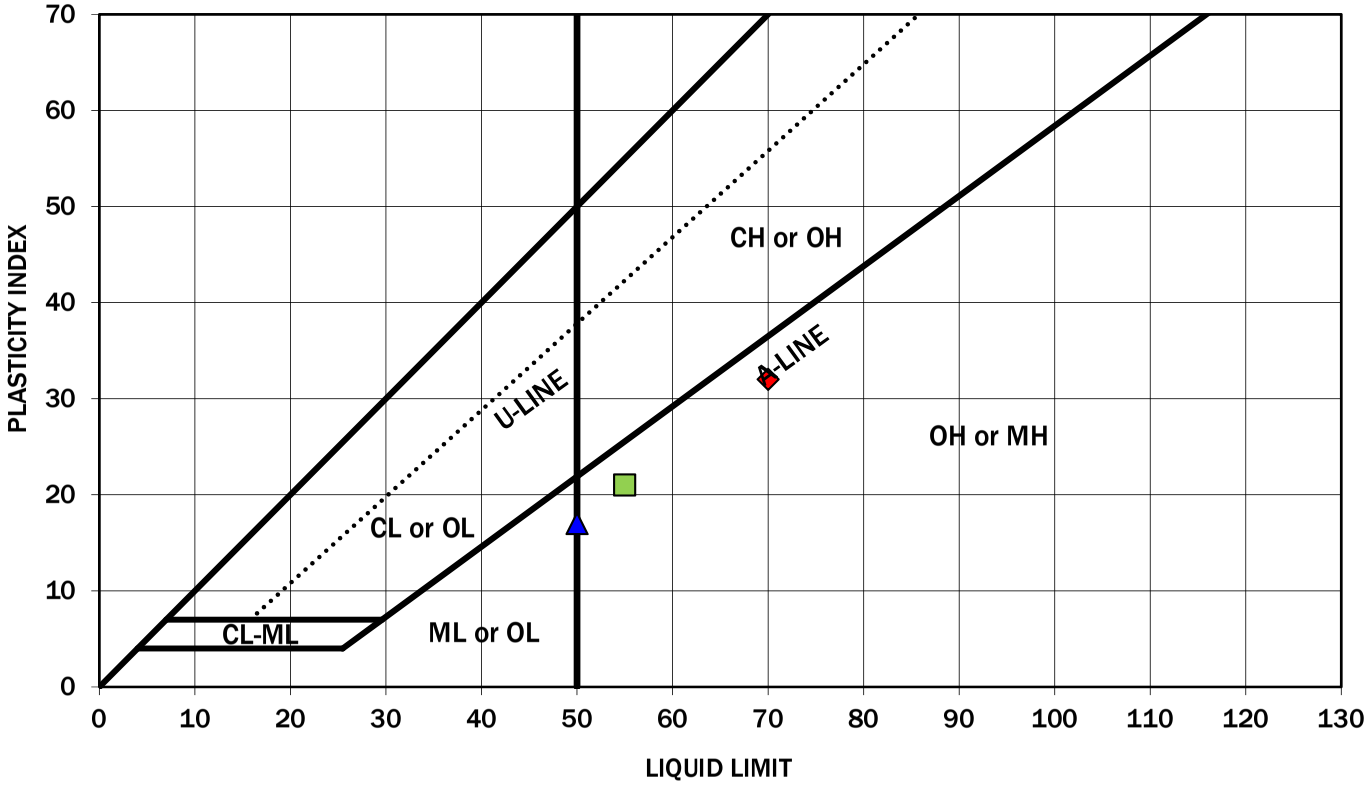
North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure A-25

0201-008-01 Date Exported: 02/17/17

PLASTICITY CHART



Symbol	Boring Number	Depth (feet)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Soil Description
◆	B-6	5	52	70	32	Elastic silt with occasional sand (MH)
■	B-6	15	51	55	21	Elastic silt (MH)
▲	B-7	45	60	50	17	Elastic silt (MH)

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The liquid limit and plasticity index were obtained in general accordance with ASTM D 4318.

Atterberg Limits Test Results

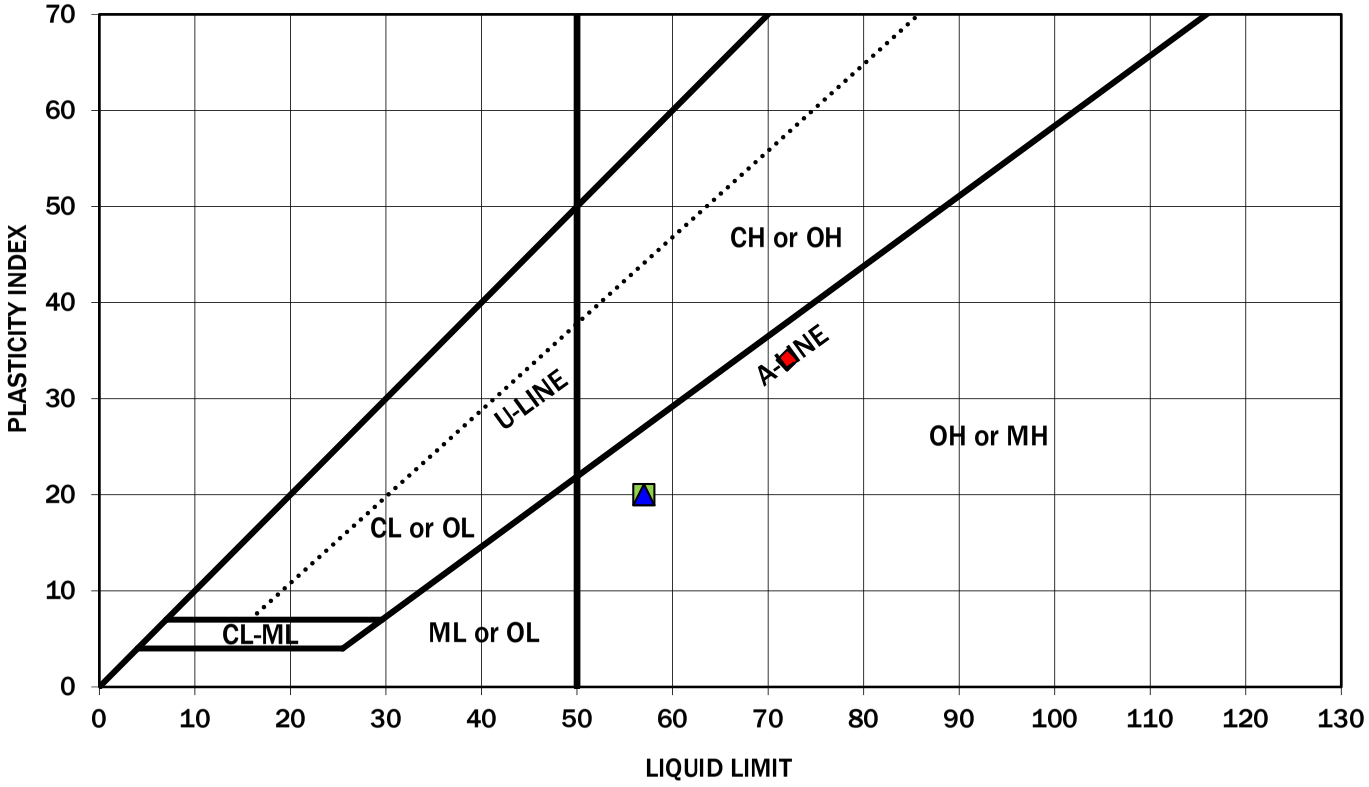
North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure A-26

0201-008-01 Date Exported: 02/17/17

PLASTICITY CHART



Symbol	Boring Number	Depth (feet)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Soil Description
◆	B-8A	12	72	72	34	Elastic silt (MH)
■	B-8A	35	44	57	20	Elastic silt with sand(MH)
▲	B-8A	45	63	57	20	Elastic silt with sand (MH)

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc. Test results are applicable only to the specific sample on which they were performed, and should not be interpreted as representative of any other samples obtained at other times, depths or locations, or generated by separate operations or processes.

The liquid limit and plasticity index were obtained in general accordance with ASTM D 4318.

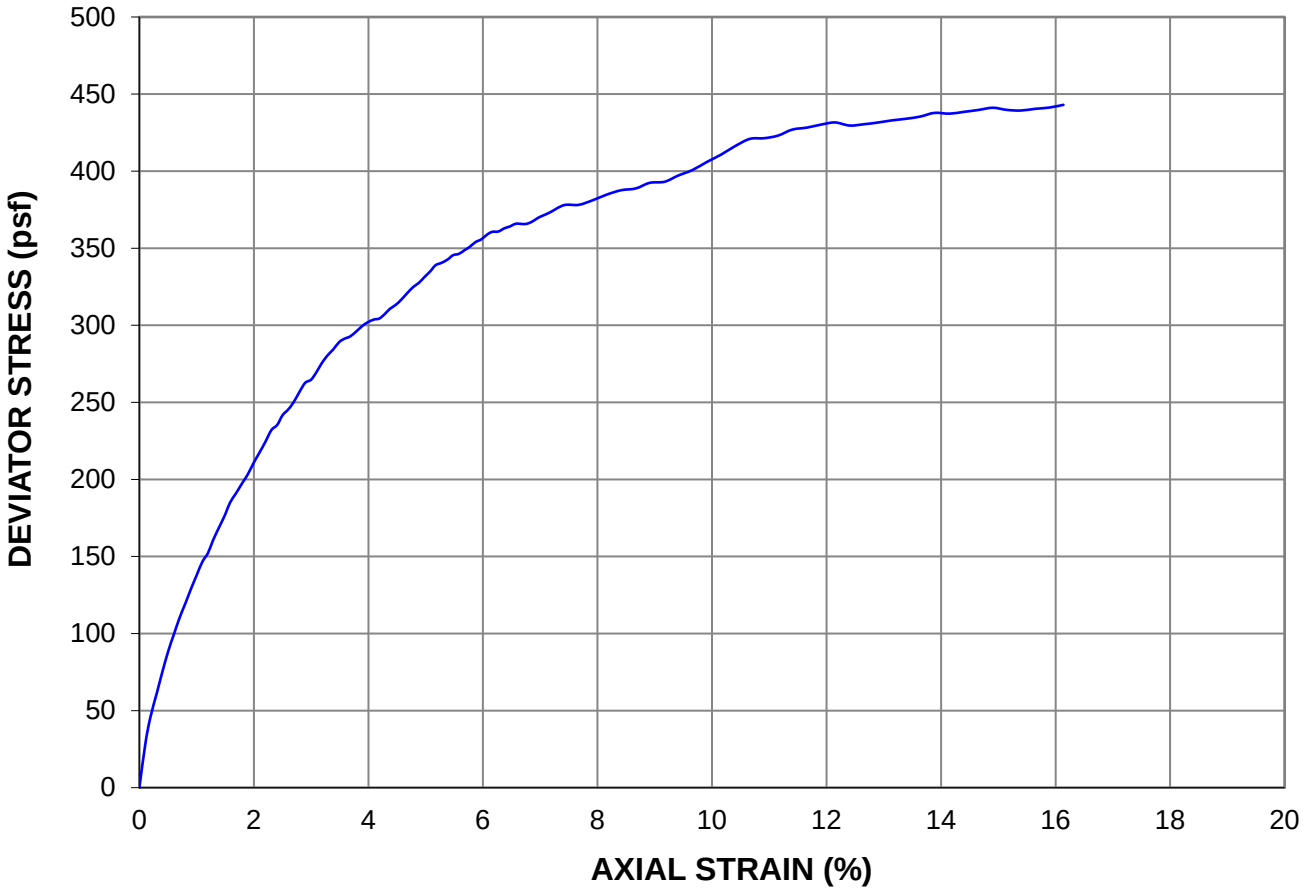
Atterberg Limits Test Results

North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure A-27

0201-008-01 Date Exported: 02/17/17



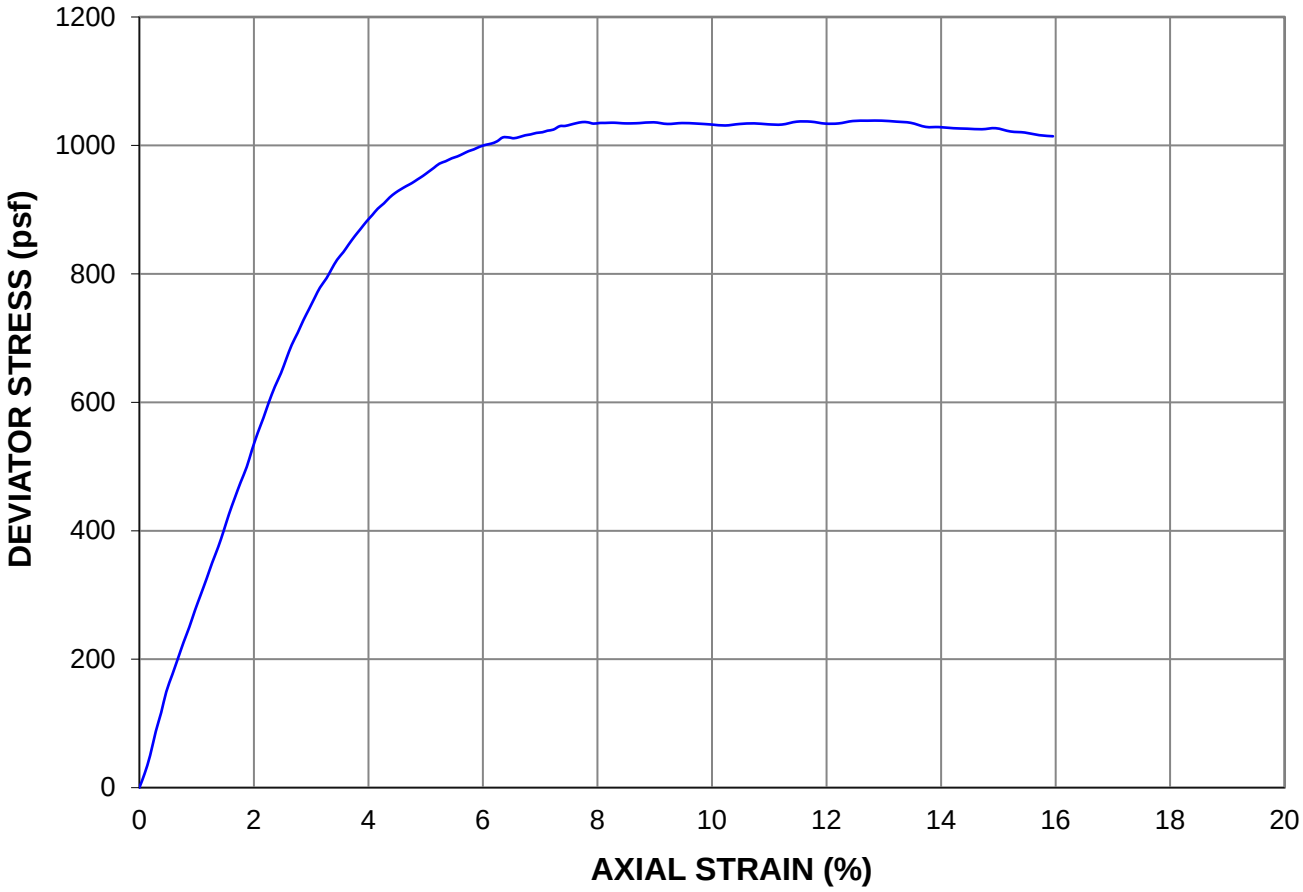
SPECIMEN AT FAILURE

DESCRIPTION :	Silt with o.m. (MH)
SPECIMEN TYPE:	Shelby tube
APPROXIMATE AXIAL STRAIN RATE:	1% / min
Su:	222 psf
AXIAL STRAIN AT FAILURE:	16.1%
CLASSIFICATION:	n/a
LL: n/a	PL: n/a / PI: n/a
INITIAL	HEIGHT : 5.705 in
	EFFECTIVE DIAMETER: 2.790 in
	HEIGHT/DIAMETER: 2
	WATER CONTENT: 102%
	DRY DENSITY: 45.6 pcf
	VOID RATIO: 2.63
	SATURATION: 100% (assumed)
BORING ID : B-1	SAMPLE NO.: 11
DEPTH/ELEV. : 30 ½ feet	DATE: 8/4/16
TECH: SAS	CHECKED:
REMARKS: Gs assumed 2.65; γ_{water} = 62.4pcf	
Cell Pressure=19.5 psi	

GeoEngineers

UU TRIAXIAL COMPRESSION TEST REPORT

Figure A-28

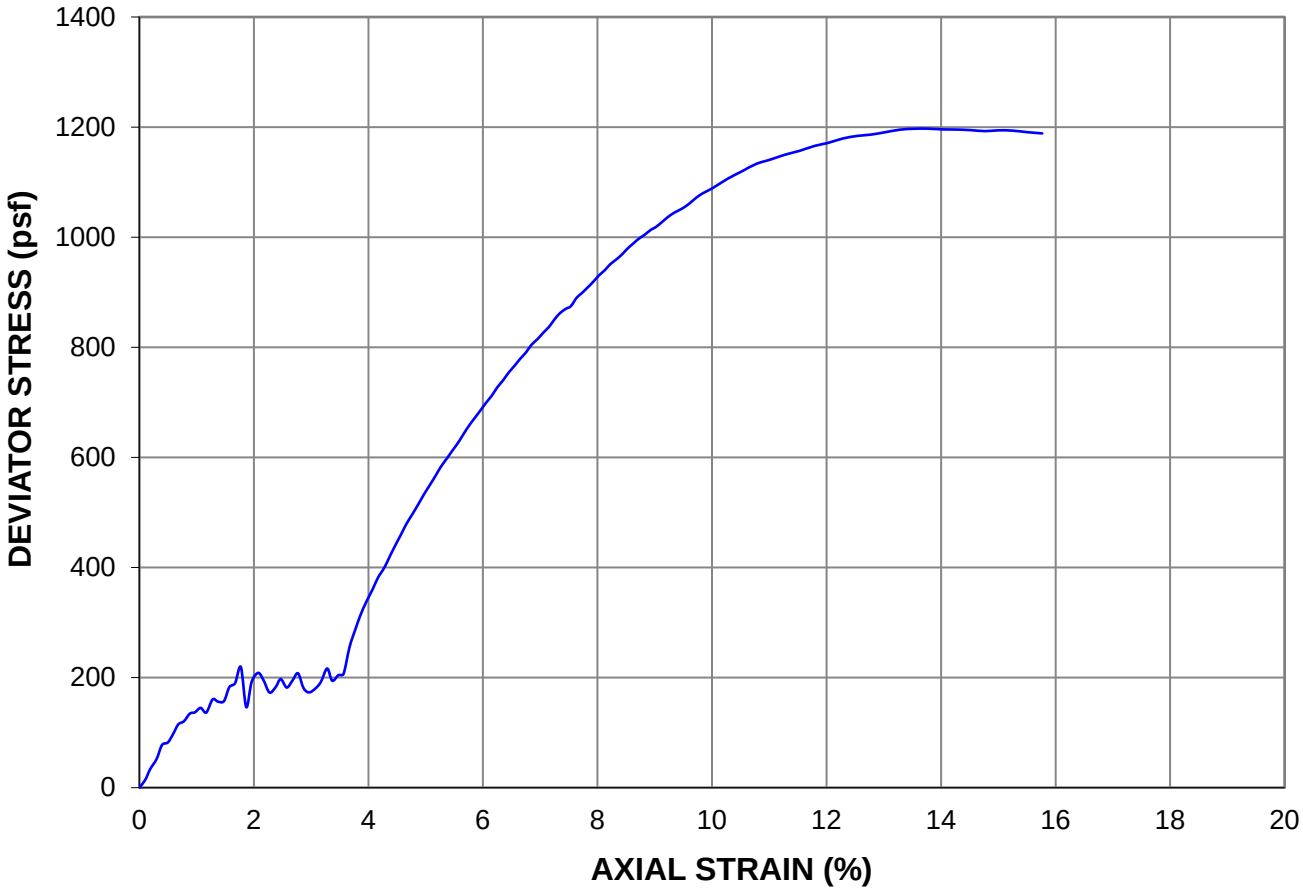


SPECIMEN AT FAILURE			
	DESCRIPTION : Silt with o.m. (MH)		
	SPECIMEN TYPE: Shelby tube		
	APPROXIMATE AXIAL STRAIN RATE: 1% / min		
	Su: 519 psf		
	AXIAL STRAIN AT FAILURE: 13.0%		
	CLASSIFICATION: n/a		
	LL: n/a	PL: n/a	PI: n/a
	INITIAL: HEIGHT : 5.745 in		
	INITIAL: EFFECTIVE DIAMETER: 2.817 in		
	INITIAL: HEIGHT/DIAMETER: 2		
	INITIAL: WATER CONTENT: 67%		
	INITIAL: DRY DENSITY: 61.7 pcf		
	INITIAL: VOID RATIO: 1.68		
	INITIAL: SATURATION: 100% (assumed)		
	BORING ID : B-2	SAMPLE NO.: 3	
	DEPTH/ELEV. : 5 ½ feet	DATE: 8/18/16	
	TECH: SAS	CHECKED:	
	REMARKS: Gs assumed 2.65; γ_{water} = 62.4pcf		
	Cell Pressure= 3.9 psi		

GeoEngineers

UU TRIAXIAL COMPRESSION TEST REPORT

Figure A-29



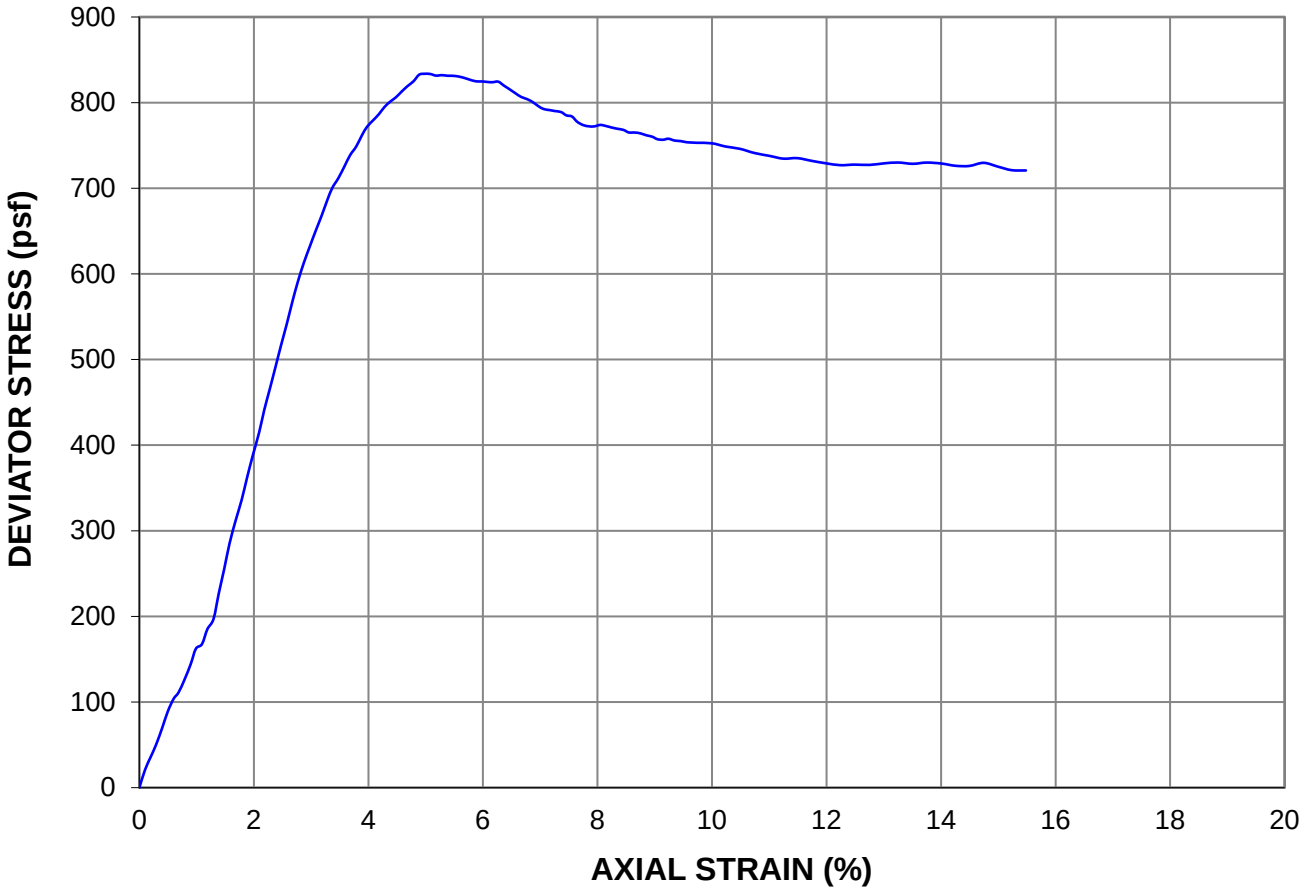
SPECIMEN AT FAILURE

DESCRIPTION :	Silt with o.m. (MH)
SPECIMEN TYPE:	Shelby tube
APPROXIMATE AXIAL STRAIN RATE:	1% / min
Su:	599 psf
AXIAL STRAIN AT FAILURE:	13.8%
CLASSIFICATION:	n/a
LL: n/a	PL: n/a / PI: n/a
INITIAL	HEIGHT : 5.342 in
	EFFECTIVE DIAMETER: 2.803 in
	HEIGHT/DIAMETER: 1.9
	WATER CONTENT: 56%
	DRY DENSITY: 48.3 pcf
	VOID RATIO: 2.42
	SATURATION: 100% (assumed)
BORING ID : B-2	SAMPLE NO.: 3
DEPTH/ELEV. : 5 feet	DATE: 8/12/16
TECH: SAS	CHECKED:
REMARKS: Gs assumed 2.65; γ_{water} = 62.4pcf	
Cell Pressure= 2.6 psi	

GeoEngineers

UU TRIAXIAL COMPRESSION TEST REPORT

Figure A-30



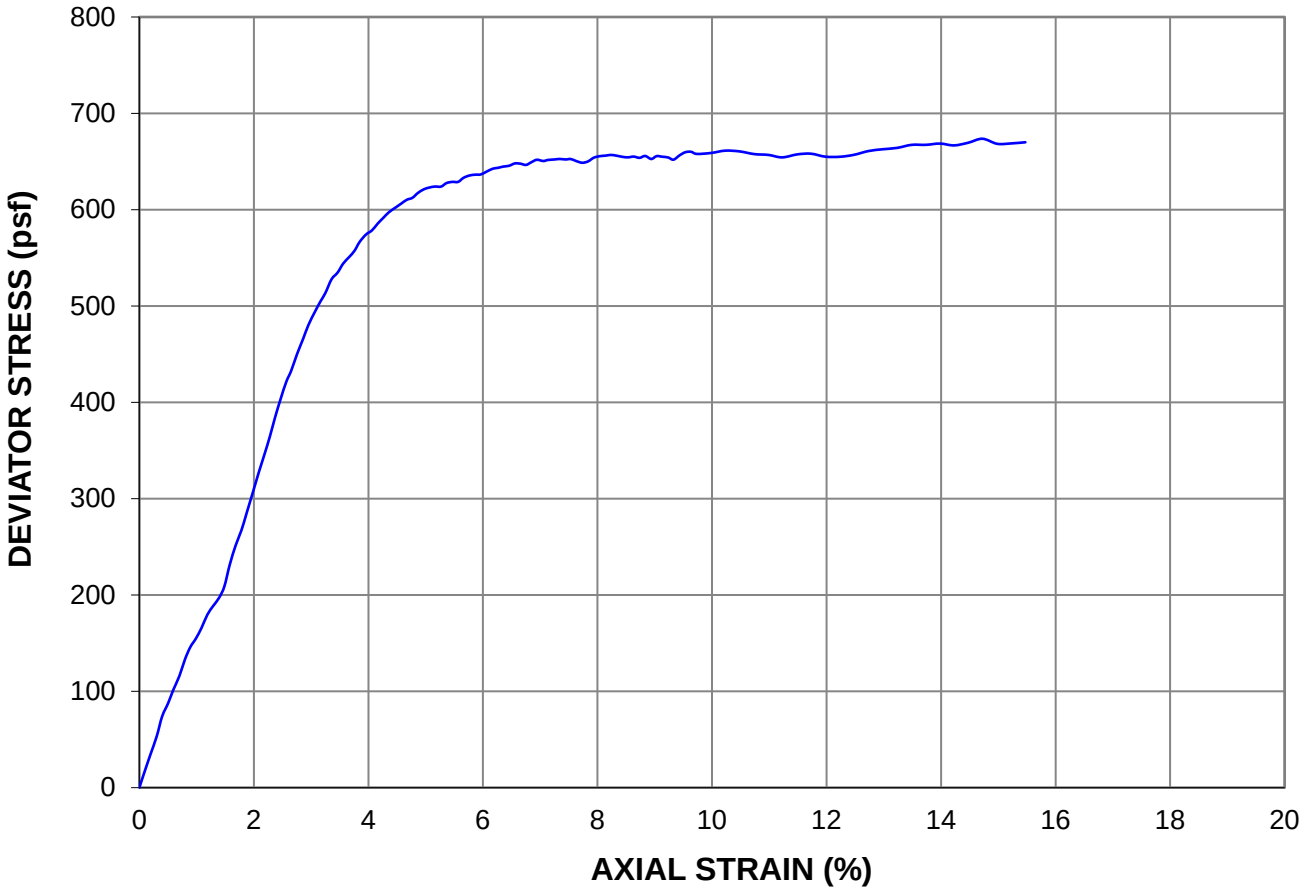
SPECIMEN AT FAILURE

DESCRIPTION : Silt with o.m. (MH)	
SPECIMEN TYPE: Shelby tube	
APPROXIMATE AXIAL STRAIN RATE: 1% / min	
Su: 417 psf	
AXIAL STRAIN AT FAILURE: 5.0%	
CLASSIFICATION: n/a	
LL: n/a	PL: n/a | PI: n/a
INITIAL	HEIGHT : 5.721 in
	EFFECTIVE DIAMETER: 2.820 in
	HEIGHT/DIAMETER: 2
	WATER CONTENT: 174%
	DRY DENSITY: 33.4 pcf
	VOID RATIO: 3.95
	SATURATION: 100% (assumed)
BORING ID : B-2	SAMPLE NO.: 5
DEPTH/ELEV. : 10 ½ feet	DATE: 8/1/16
TECH: SAS	CHECKED:
REMARKS: Gs assumed 2.65; γ_{water} = 62.4pcf	
Cell Pressure=6.4psi	

GeoEngineers

UU TRIAXIAL COMPRESSION TEST REPORT

Figure A-31



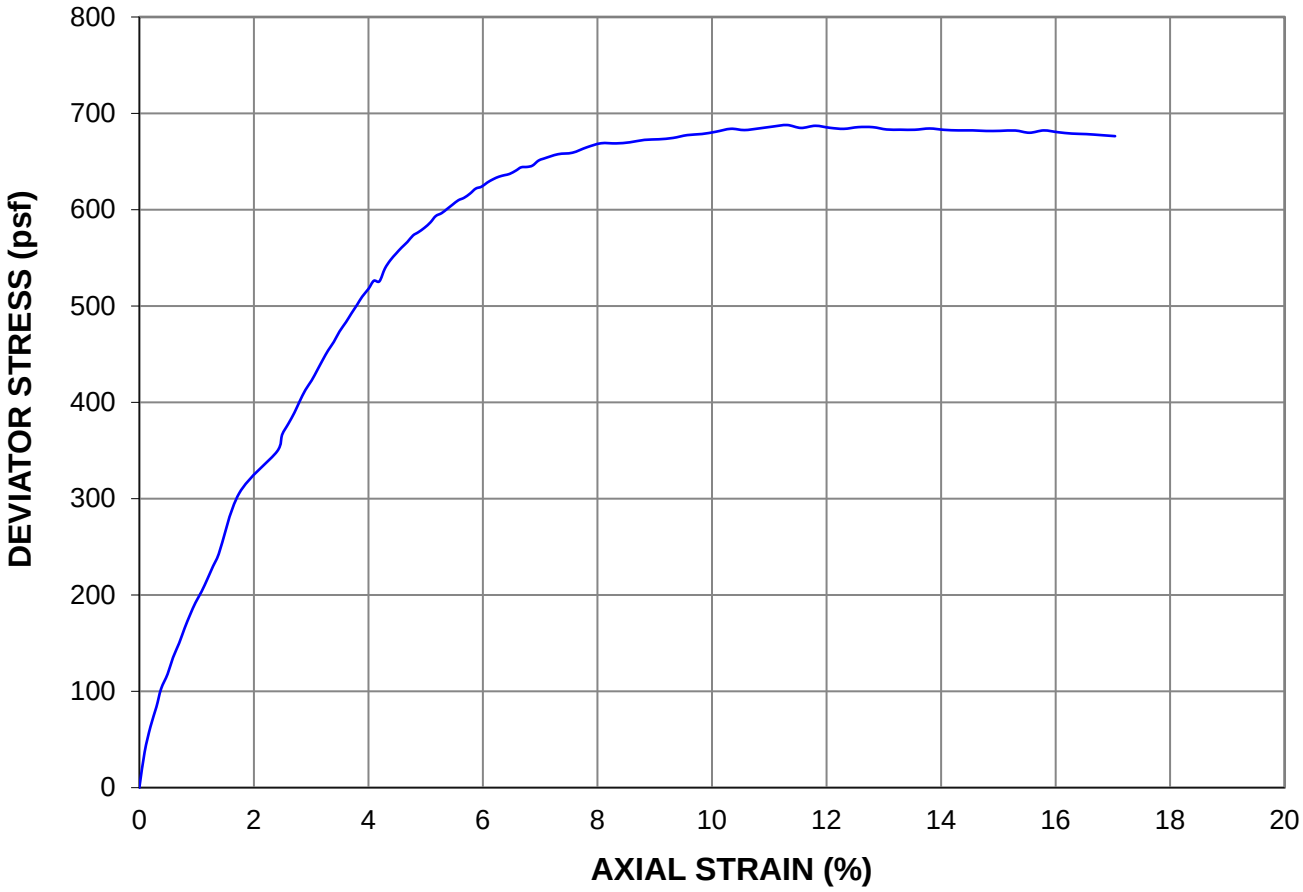
SPECIMEN AT FAILURE

DESCRIPTION : Silt with occasional om. (MH)		
SPECIMEN TYPE: Shelby tube		
APPROXIMATE AXIAL STRAIN RATE: 1% / min		
Su: 337 psf		
AXIAL STRAIN AT FAILURE: 14.7%		
CLASSIFICATION: n/a		
LL: n/a	PL: n/a	PI: n/a
INITIAL	HEIGHT : 5.727 in	
	EFFECTIVE DIAMETER: 2.806 in	
	HEIGHT/DIAMETER: 2	
	WATER CONTENT: 90%	
	DRY DENSITY: 54.6 pcf	
	VOID RATIO: 2.03	
	SATURATION: 100% (assumed)	
BORING ID : B-2	SAMPLE NO.: 5	
DEPTH/ELEV. : 11 feet	DATE: 8/1/16	
TECH: SAS	CHECKED:	
REMARKS: Gs assumed 2.65; γ_{water} = 62.4pcf		
Cell Pressure=7.9psi		

GeoEngineers

UU TRIAXIAL COMPRESSION TEST REPORT

Figure A-32



SPECIMEN AT FAILURE

DESCRIPTION Clay (CH)

SPECIMEN TYPE: Shelby tube

APPROXIMATE AXIAL STRAIN RATE: 1% / min

Su: 344 psf

AXIAL STRAIN AT FAILURE: 11.3%

CLASSIFICATION: n/a

LL: n/a	PL: n/a	PI: n/a

INITIAL

- HEIGHT : 5.732 in
- EFFECTIVE DIAMETER: 2.817 in
- HEIGHT/DIAMETER: 2
- WATER CONTENT: 68%
- DRY DENSITY: 58.7 pcf
- VOID RATIO: 1.82
- SATURATION: 100% (assumed)

BORING ID : B-2	SAMPLE NO.: 8
DEPTH/ELEV. : 20 feet	DATE: 7/19/16
TECH: SAS	CHECKED:

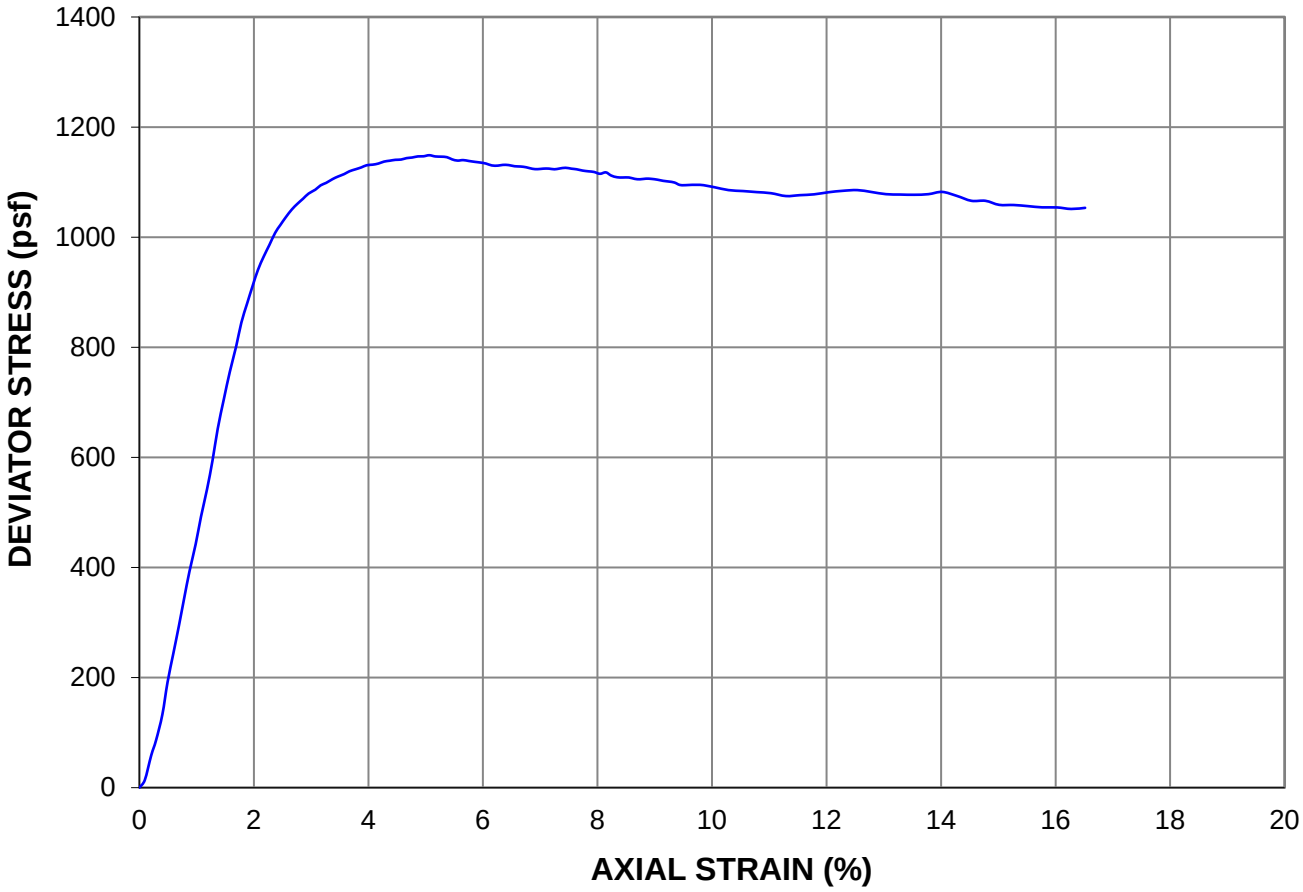
REMARKS: Gs assumed 2.65; γ_{water} = 62.4pcf

Cell Pressure=13.7psi

GeoEngineers

UU TRIAXIAL COMPRESSION TEST REPORT

Figure A-33



SPECIMEN AT FAILURE

DESCRIPTION : Clay (CH)	
SPECIMEN TYPE: Shelby tube	
APPROXIMATE AXIAL STRAIN RATE: 1% / min	
Su: 574 psf	
AXIAL STRAIN AT FAILURE: 5.0%	
CLASSIFICATION: n/a	
LL: n/a	PL: n/a | PI: n/a
INITIAL	HEIGHT : 5.765 in
	EFFECTIVE DIAMETER: 2.812 in
	HEIGHT/DIAMETER: 2
	WATER CONTENT: 58%
	DRY DENSITY: 65.1 pcf
	VOID RATIO: 1.54
	SATURATION: 100% (assumed)
BORING ID : B-2	SAMPLE NO.: 8
DEPTH/ELEV. : 21 ½ feet	DATE: 7/29/16
TECH: SAS	CHECKED:
REMARKS: Gs assumed 2.65; γ_{water} = 62.4pcf	
Cell Pressure=15.3psi	

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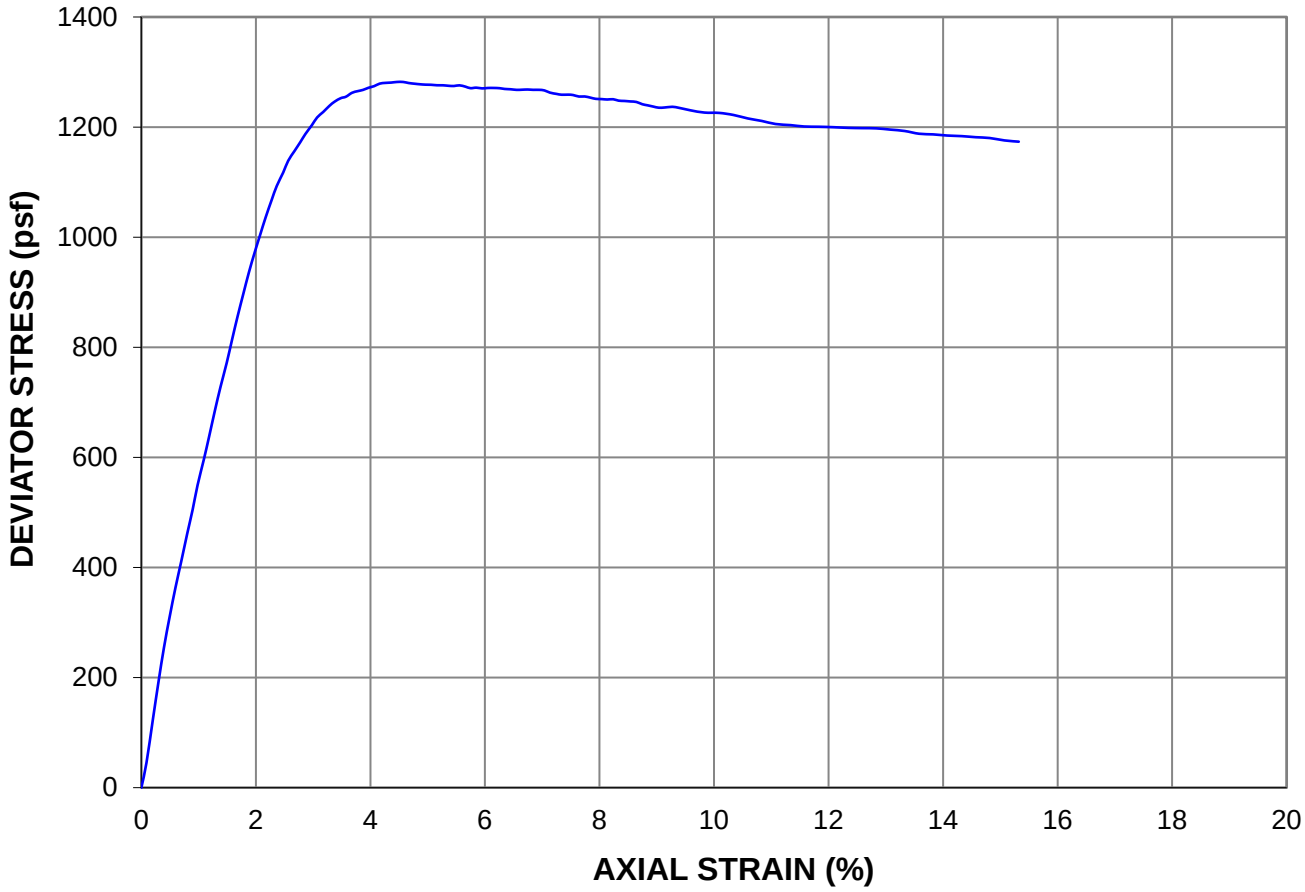
UU TRIAXIAL COMPRESSION TEST REPORT

Figure A-34



SPECIMEN AT FAILURE

DESCRIPTION : Silt with o.m. (MH)

SPECIMEN TYPE: Shelby tube

APPROXIMATE AXIAL STRAIN RATE: 1% / min

Su: 641 psf

AXIAL STRAIN AT FAILURE: 4.6%

CLASSIFICATION: n/a

LL: n/a	PL: n/a	PI: n/a

INITIAL

HEIGHT : 5.725 in

EFFECTIVE DIAMETER: 2.810 in

HEIGHT/DIAMETER: 2

WATER CONTENT: 69%

DRY DENSITY: 59.9 pcf

VOID RATIO: 1.76

SATURATION: 100% (assumed)

BORING ID : B-2	SAMPLE NO.: 11
DEPTH/ELEV. : 30 ½ feet	DATE: 8/181/6
TECH: SAS	CHECKED:

REMARKS: Gs assumed 2.65; γ_{water} = 62.4pcf

Cell Pressure= 21.5 psi

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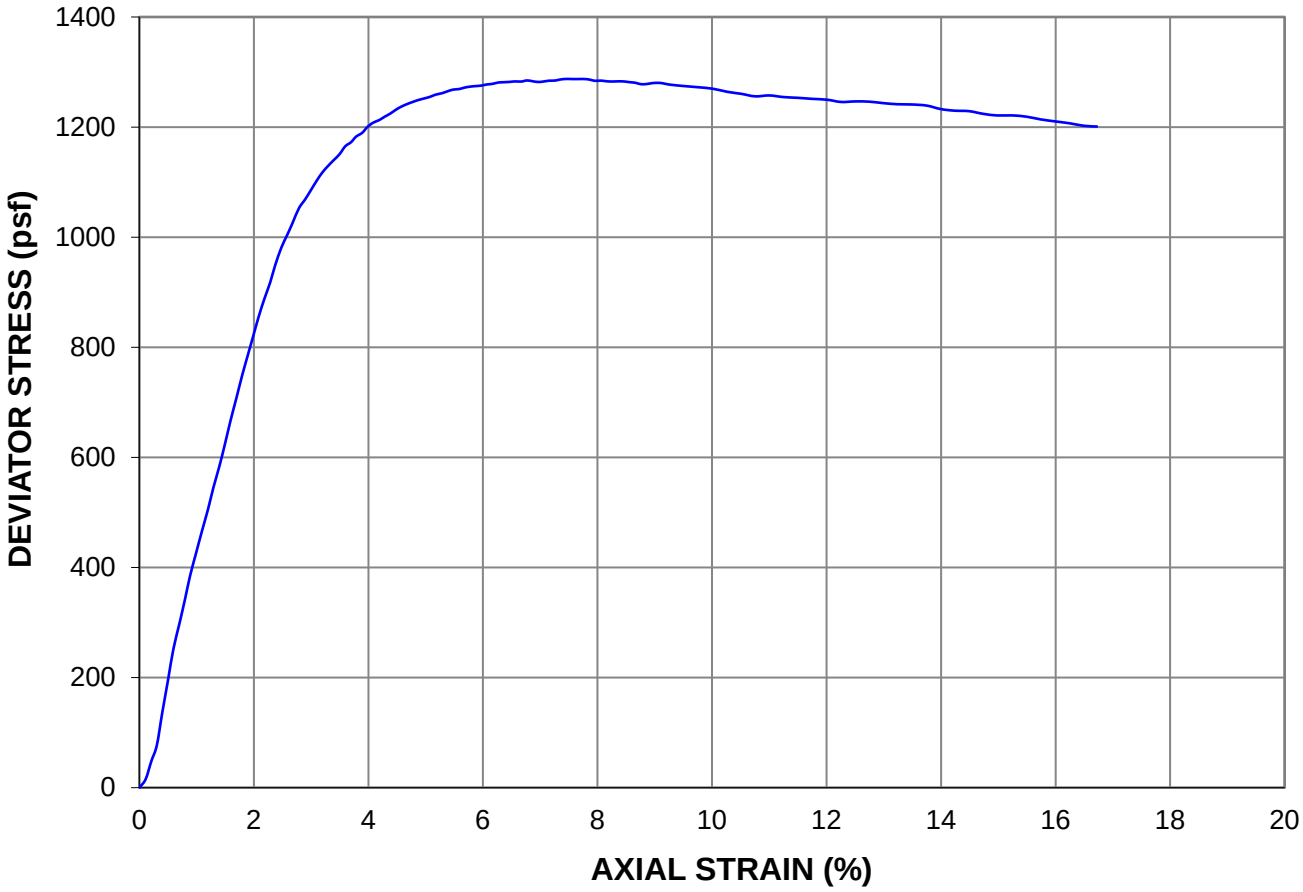
UU TRIAXIAL COMPRESSION TEST REPORT

Figure A-35



SPECIMEN AT FAILURE

DESCRIPTION : Silt with o.m. (MH)

SPECIMEN TYPE: Shelby tube

APPROXIMATE AXIAL STRAIN RATE: 1% / min

Su: 644 psf

AXIAL STRAIN AT FAILURE: 7.5%

CLASSIFICATION: n/a

LL: n/a	PL: n/a	PI: n/a

INITIAL

- HEIGHT : 5.717 in
- EFFECTIVE DIAMETER: 2.803 in
- HEIGHT/DIAMETER: 2
- WATER CONTENT: 61%
- DRY DENSITY: 65.2 pcf
- VOID RATIO: 1.53
- SATURATION: 100% (assumed)

BORING ID : B-2	SAMPLE NO.: 11
DEPTH/ELEV. : 31 feet	DATE: 8/18/16
TECH: RBM	CHECKED:

REMARKS: Gs assumed 2.65; γ_{water} = 62.4pcf

Cell Pressure= 22.5 psi

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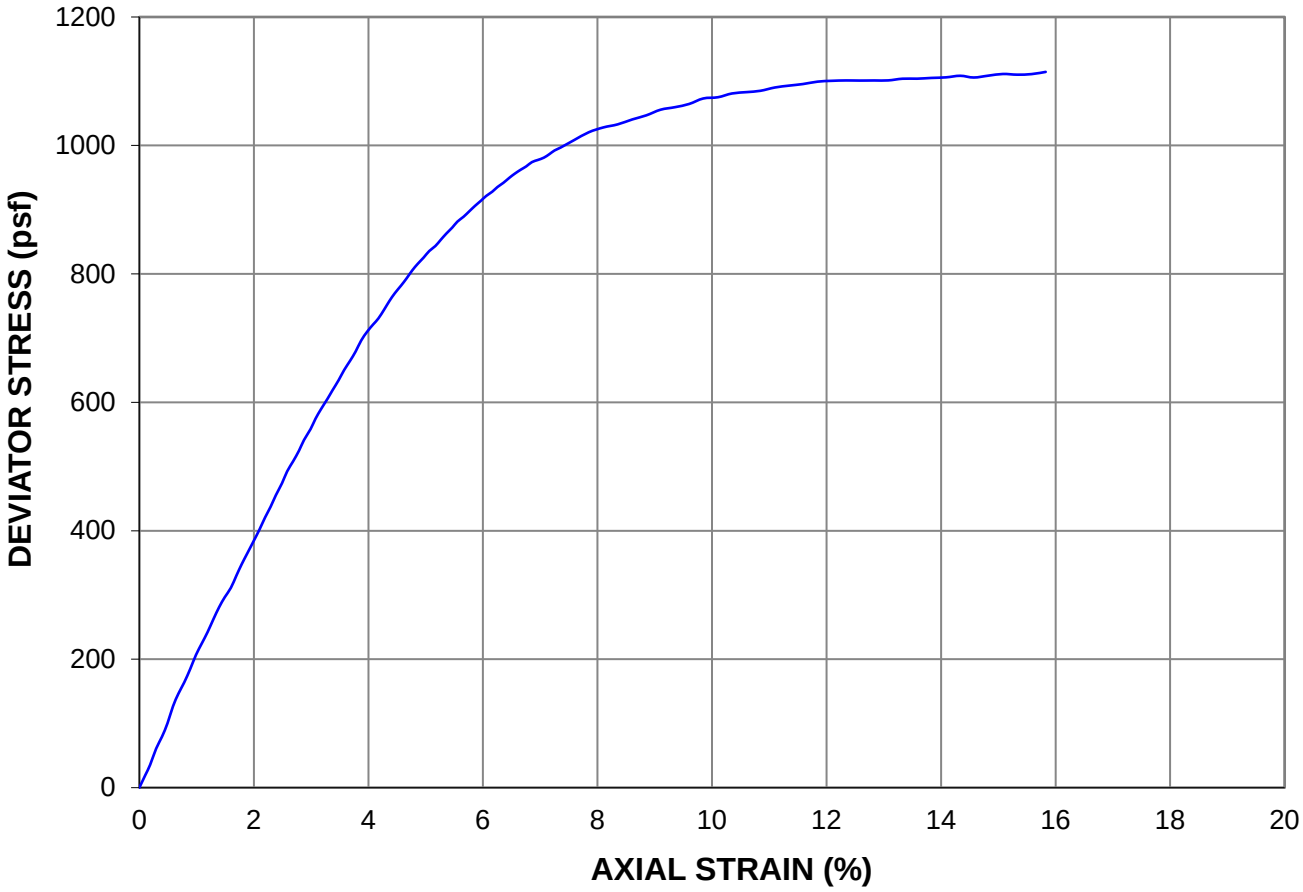
UU TRIAXIAL COMPRESSION TEST REPORT

Figure A-36



SPECIMEN AT FAILURE

DESCRIPTION :	Silt with occasional o.m. (MH)
SPECIMEN TYPE:	Shelby tube
APPROXIMATE AXIAL STRAIN RATE:	1% / min
Su:	557 psf
AXIAL STRAIN AT FAILURE:	15.8%
CLASSIFICATION:	n/a
LL: n/a	PL: n/a / PI: n/a
INITIAL	HEIGHT : 5.721 in
	EFFECTIVE DIAMETER: 2.808 in
	HEIGHT/DIAMETER: 2
	WATER CONTENT: 97%
	DRY DENSITY: 50.6 pcf
	VOID RATIO: 2.27
	SATURATION: 100% (assumed)
BORING ID : B-3	SAMPLE NO.: 3
DEPTH/ELEV. : 6 feet	DATE: 8/12/16
TECH: SAS	CHECKED:
REMARKS: Gs assumed 2.65; γ_{water} = 62.4pcf	
Cell Pressure= 4.1 psi	

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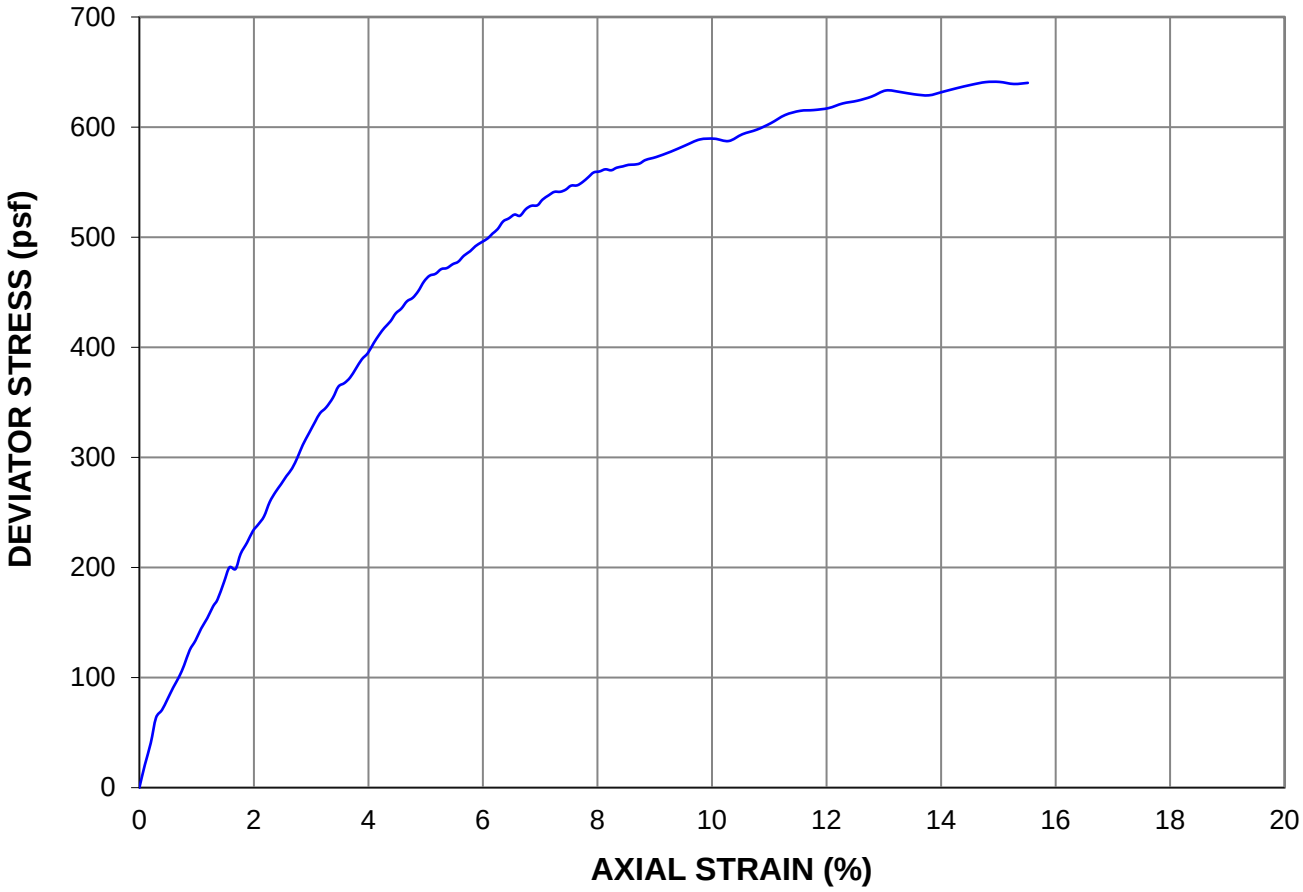
UU TRIAXIAL COMPRESSION TEST REPORT

Figure A-37



SPECIMEN AT FAILURE

DESCRIPTION : Silt with o.m. (MH)	
SPECIMEN TYPE: Shelby tube	
APPROXIMATE AXIAL STRAIN RATE: 1% / min	
Su: 321 psf	
AXIAL STRAIN AT FAILURE: 15%	
CLASSIFICATION: n/a	
LL: n/a	PL: n/a | PI: n/a
INITIAL	HEIGHT : 5.717 in
	EFFECTIVE DIAMETER: 2.805 in
	HEIGHT/DIAMETER: 2
	WATER CONTENT: 70%
	DRY DENSITY: 56.4 pcf
	VOID RATIO: 1.93
	SATURATION: 100% (assumed)
BORING ID : B-3	SAMPLE NO.: 5
DEPTH/ELEV. : 10 ½ feet	DATE: 8/4/16
TECH: SAS	CHECKED:
REMARKS: Gs assumed 2.65; γ_{water} = 62.4pcf	
Cell Pressure=7.0 psi	

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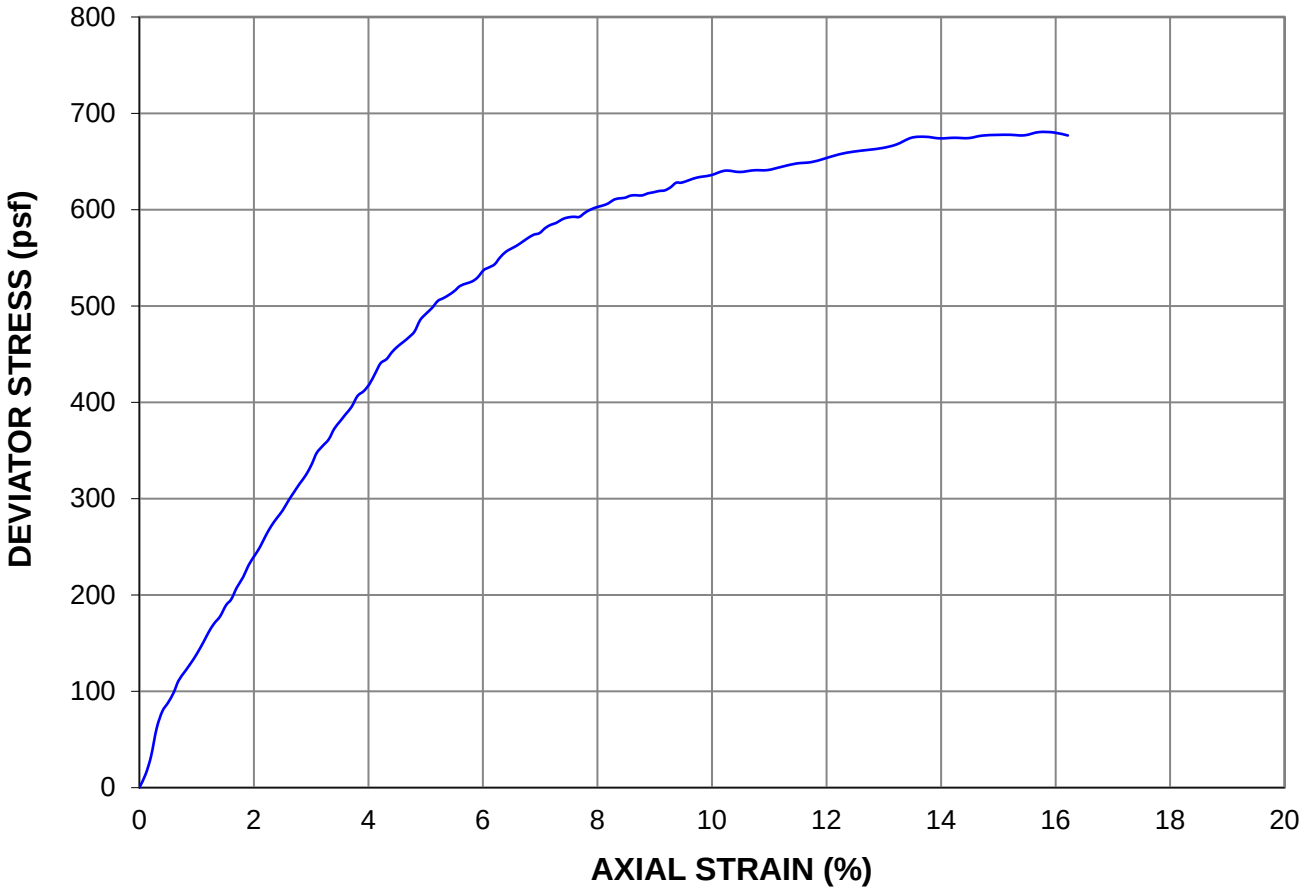
UU TRIAXIAL COMPRESSION TEST REPORT

Figure A-38



SPECIMEN AT FAILURE

DESCRIPTION : Silt (ML)

SPECIMEN TYPE: Shelby tube

APPROXIMATE AXIAL STRAIN RATE: 1% / min

Su: 340 psf

AXIAL STRAIN AT FAILURE: 15.7%

CLASSIFICATION: n/a

LL: n/a	PL: n/a	PI: n/a

INITIAL

- HEIGHT : 5.754 in
- EFFECTIVE DIAMETER: 2.787 in
- HEIGHT/DIAMETER: 2
- WATER CONTENT: 78%
- DRY DENSITY: 54.3pcf
- VOID RATIO: 2.05
- SATURATION: 100% (assumed)

BORING ID : B-4A	SAMPLE NO.: 3
DEPTH/ELEV. : 5 1/2 feet	DATE: 8/18/16
TECH: SAS	CHECKED:

REMARKS: Gs assumed 2.65; γ_{water} = 62.4pcf

Cell Pressure= 3.7 psi

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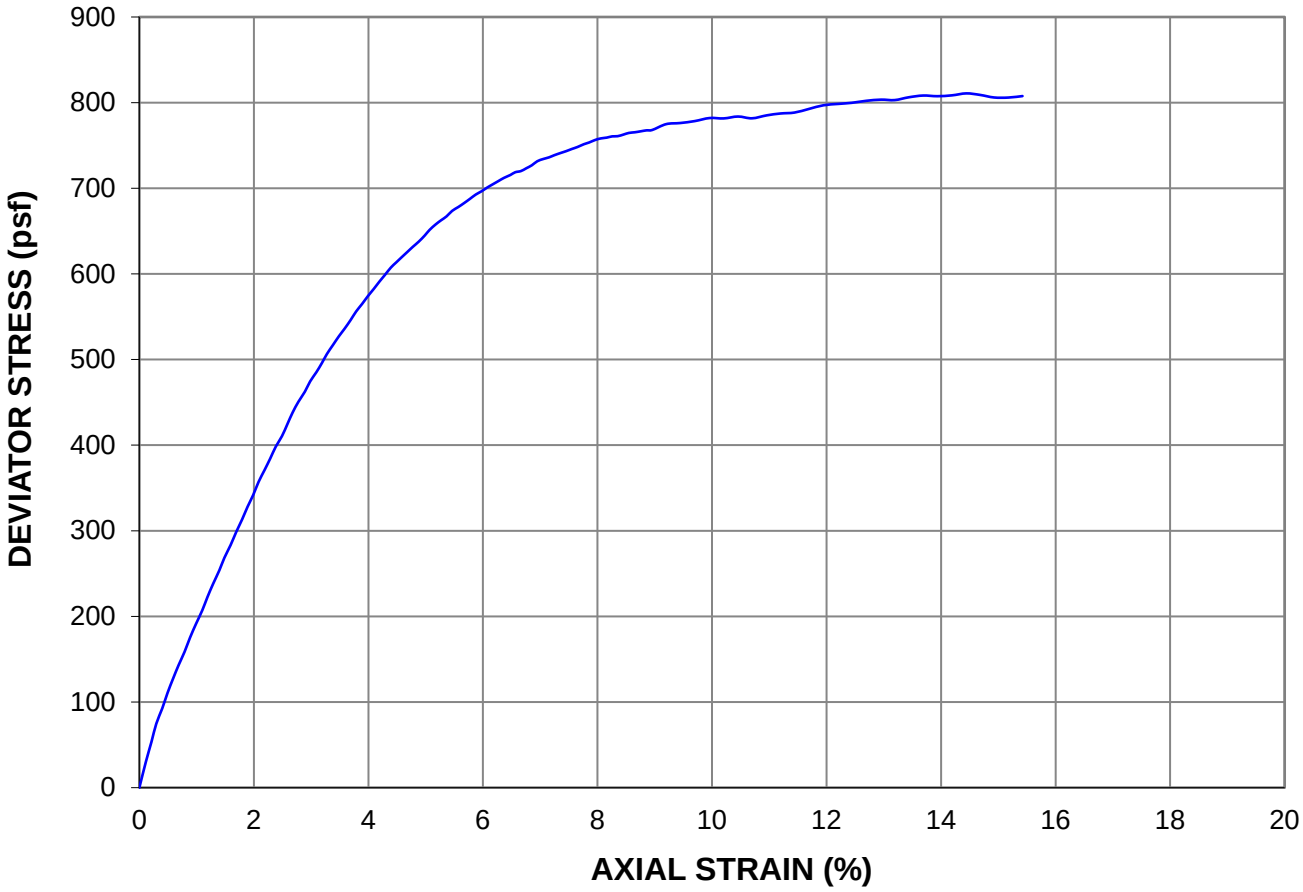
UU TRIAXIAL COMPRESSION TEST REPORT

Figure A-39



SPECIMEN AT FAILURE

DESCRIPTION : Silt (MH)

SPECIMEN TYPE: Shelby tube

APPROXIMATE AXIAL STRAIN RATE: 1% / min

Su: 405 psf

AXIAL STRAIN AT FAILURE: 14.4%

CLASSIFICATION: n/a

LL: n/a	PL: n/a	PI: n/a

INITIAL

HEIGHT : 5.727 in

EFFECTIVE DIAMETER: 2.803 in

HEIGHT/DIAMETER: 2

WATER CONTENT: 61%

DRY DENSITY: 62.8 pcf

VOID RATIO: 1.63

SATURATION: 100% (assumed)

BORING ID : B-4A	SAMPLE NO.: 5
DEPTH/ELEV. : 10 ½ feet	DATE: 8/18/16
TECH: SAS	CHECKED:

REMARKS: Gs assumed 2.65; γ_{water} = 62.4pcf

Cell Pressure= 7.4 psi

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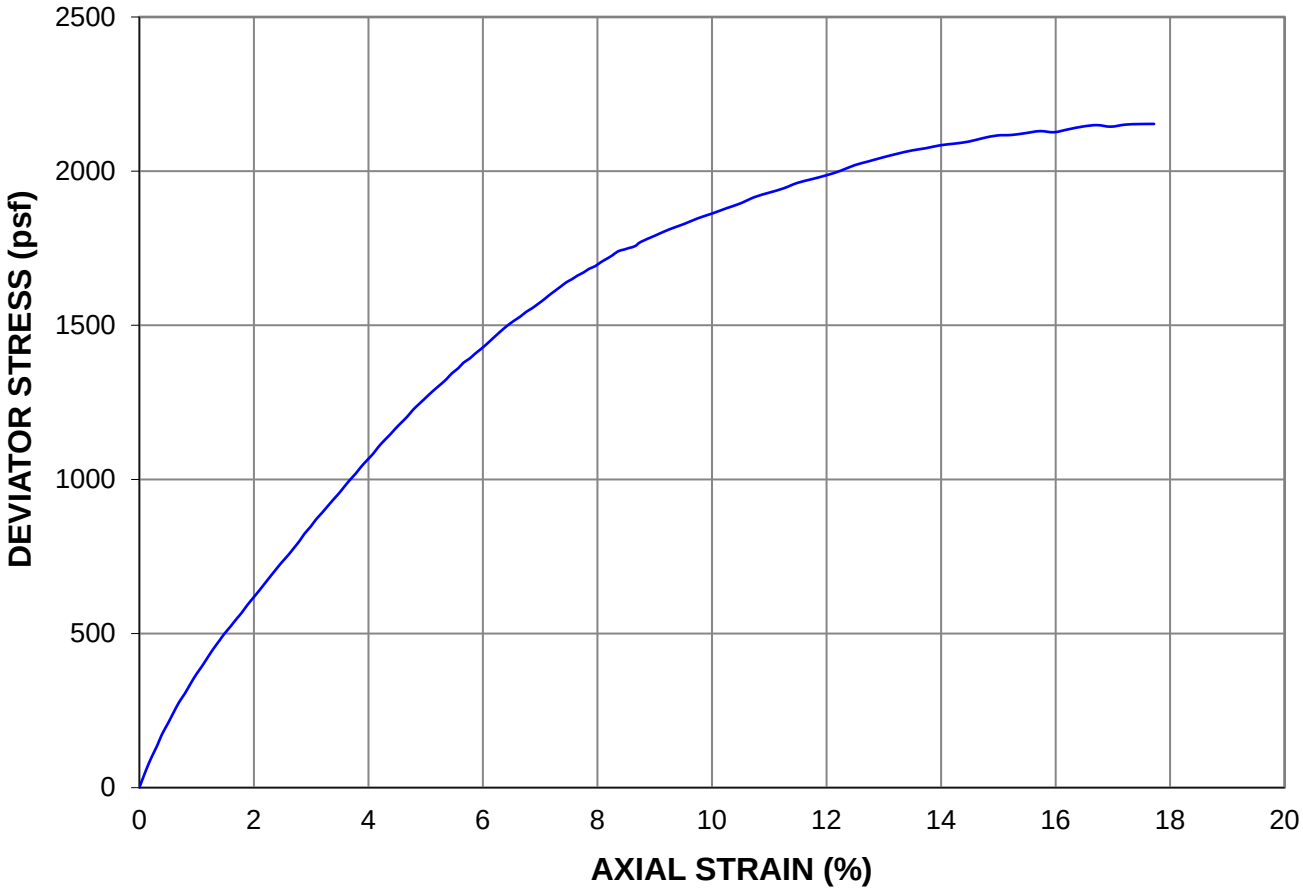
UU TRIAXIAL COMPRESSION TEST REPORT

Figure A-40



SPECIMEN AT FAILURE

DESCRIPTION : Silt/silty fine sand transition (ML/SM)

SPECIMEN TYPE: Shelby tube

APPROXIMATE AXIAL STRAIN RATE: 1% / min

Su: 1077 psf

AXIAL STRAIN AT FAILURE: 17.7%

CLASSIFICATION: n/a

LL: n/a	PL: n/a	PI: n/a

INITIAL

HEIGHT : 5.720 in

EFFECTIVE DIAMETER: 2.824 in

HEIGHT/DIAMETER: 2

WATER CONTENT: 31%

DRY DENSITY: 89.0 pcf

VOID RATIO: 0.86

SATURATION: 100% (assumed)

BORING ID : B-4A	SAMPLE NO.: 8
DEPTH/ELEV. : 20 feet	DATE: 8/18/16
TECH: SAS	CHECKED:

REMARKS: Gs assumed 2.65; γ_{water} = 62.4pcf

Cell Pressure= 16.1 psi

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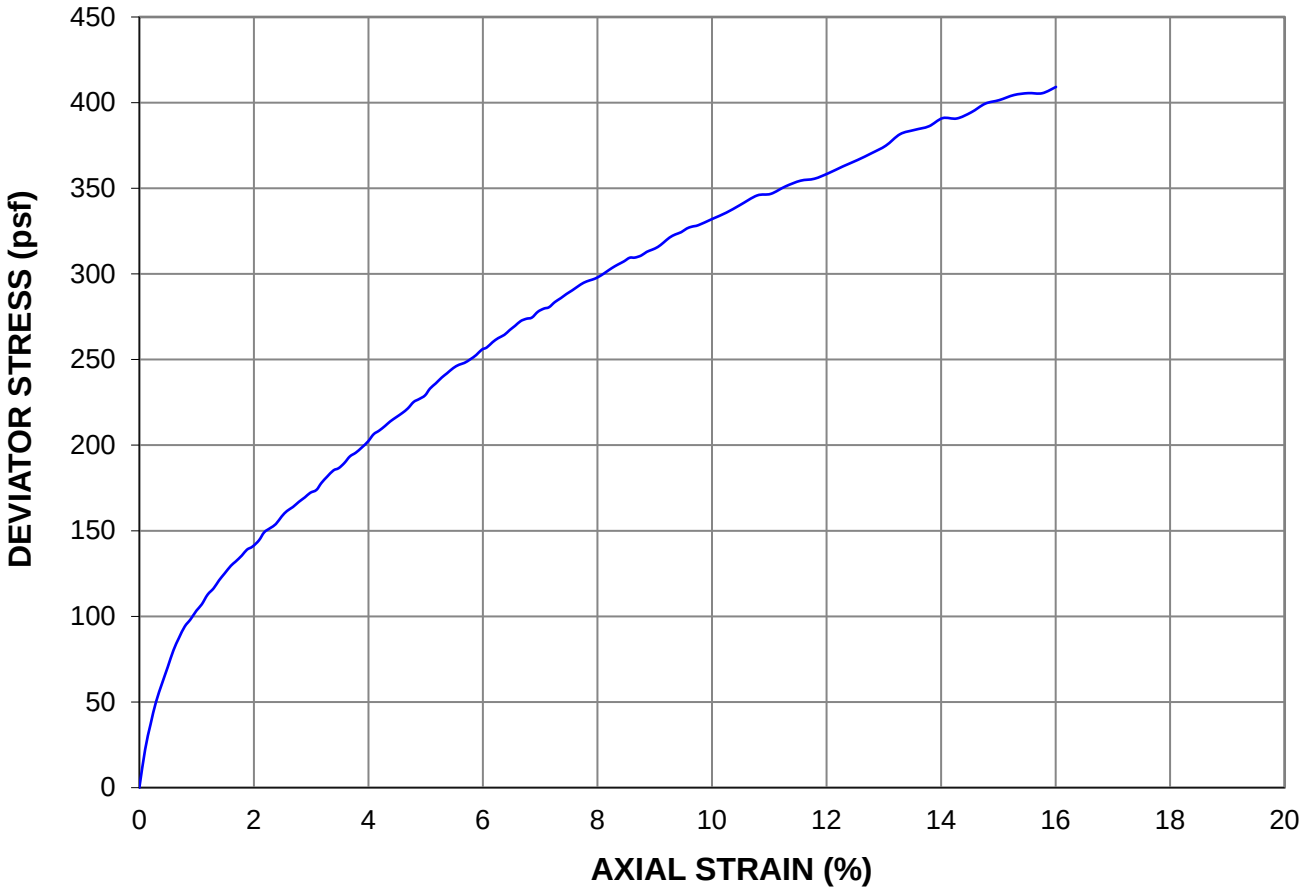
UU TRIAXIAL COMPRESSION TEST REPORT

Figure A-41



SPECIMEN AT FAILURE

DESCRIPTION : Silt (ML)

SPECIMEN TYPE: Shelby tube

APPROXIMATE AXIAL STRAIN RATE: 1% / min

Su: 204.6 psf

AXIAL STRAIN AT FAILURE: 16.0%

CLASSIFICATION: n/a

LL: n/a	PL: n/a	PI: n/a

INITIAL

HEIGHT : 5.694 in
EFFECTIVE DIAMETER: 2.781 in
HEIGHT/DIAMETER: 2
WATER CONTENT: 60%
DRY DENSITY: 67.0 pcf
VOID RATIO: 1.47
SATURATION: 100% (assumed)

BORING ID : B-5	SAMPLE NO.: 5
DEPTH/ELEV. : 10 ½ feet	DATE: 8/18/16
TECH: SAS	CHECKED:

REMARKS: Gs assumed 2.65; γ_{water} = 62.4pcf

Cell Pressure= 7.8 psi

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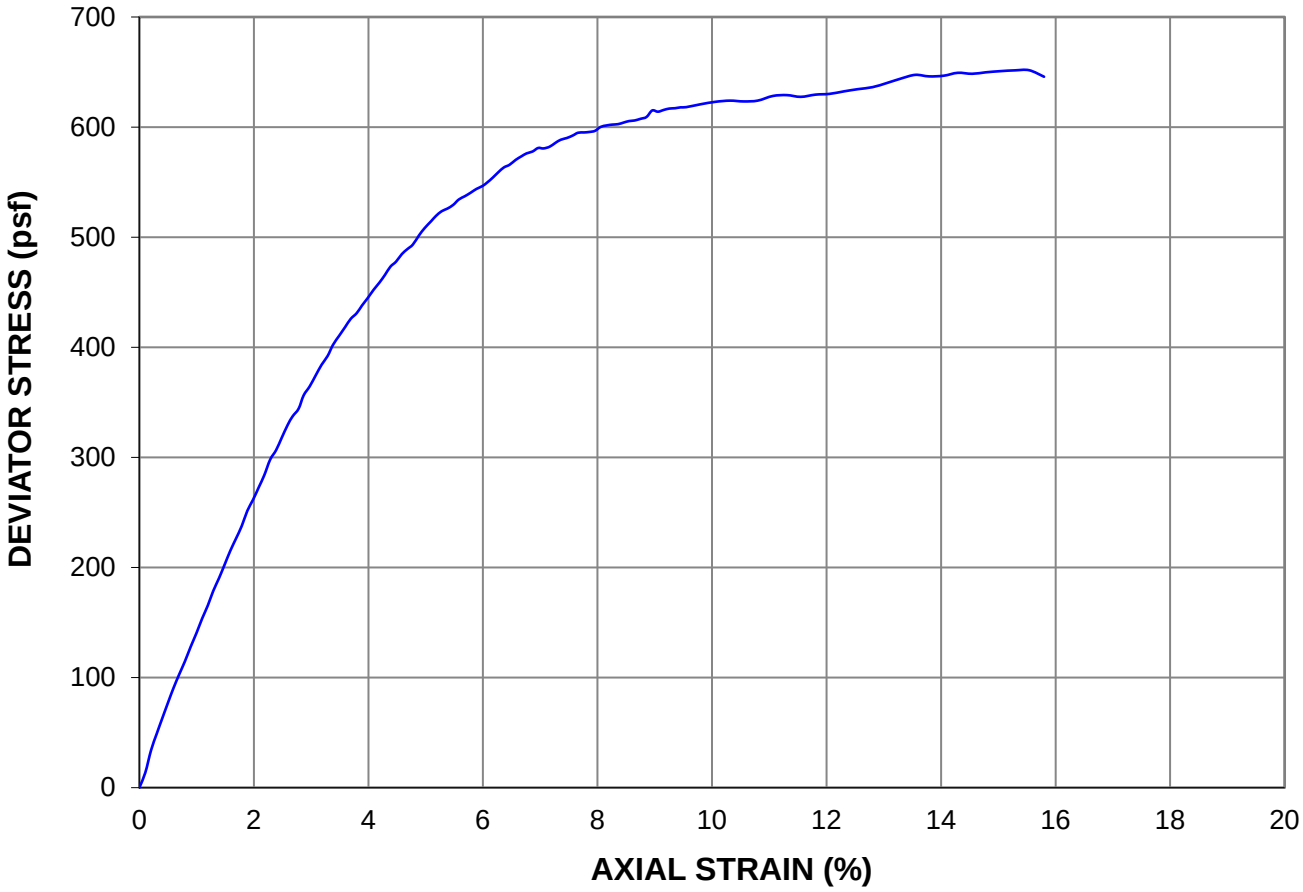
UU TRIAXIAL COMPRESSION TEST REPORT

Figure A-42



SPECIMEN AT FAILURE

DESCRIPTION : Silt (ML)		
SPECIMEN TYPE: Shelby tube		
APPROXIMATE AXIAL STRAIN RATE: 1% / min		
Su: 362 psf		
AXIAL STRAIN AT FAILURE: 15.5%		
CLASSIFICATION: n/a		
LL: n/a	PL: n/a	PI: n/a
INITIAL	HEIGHT : 5.724 in	
	EFFECTIVE DIAMETER: 2.798 in	
	HEIGHT/DIAMETER: 2	
	WATER CONTENT: 66%	
	DRY DENSITY: 62.6 pcf	
	VOID RATIO: 1.64	
	SATURATION: 100% (assumed)	
BORING ID : B-5	SAMPLE NO.: 5	
DEPTH/ELEV. : 11 feet	DATE: 8/18/16	
TECH: SAS	CHECKED:	
REMARKS: Gs assumed 2.65; γ_{water} = 62.4pcf		
Cell Pressure= 7.9 psi		

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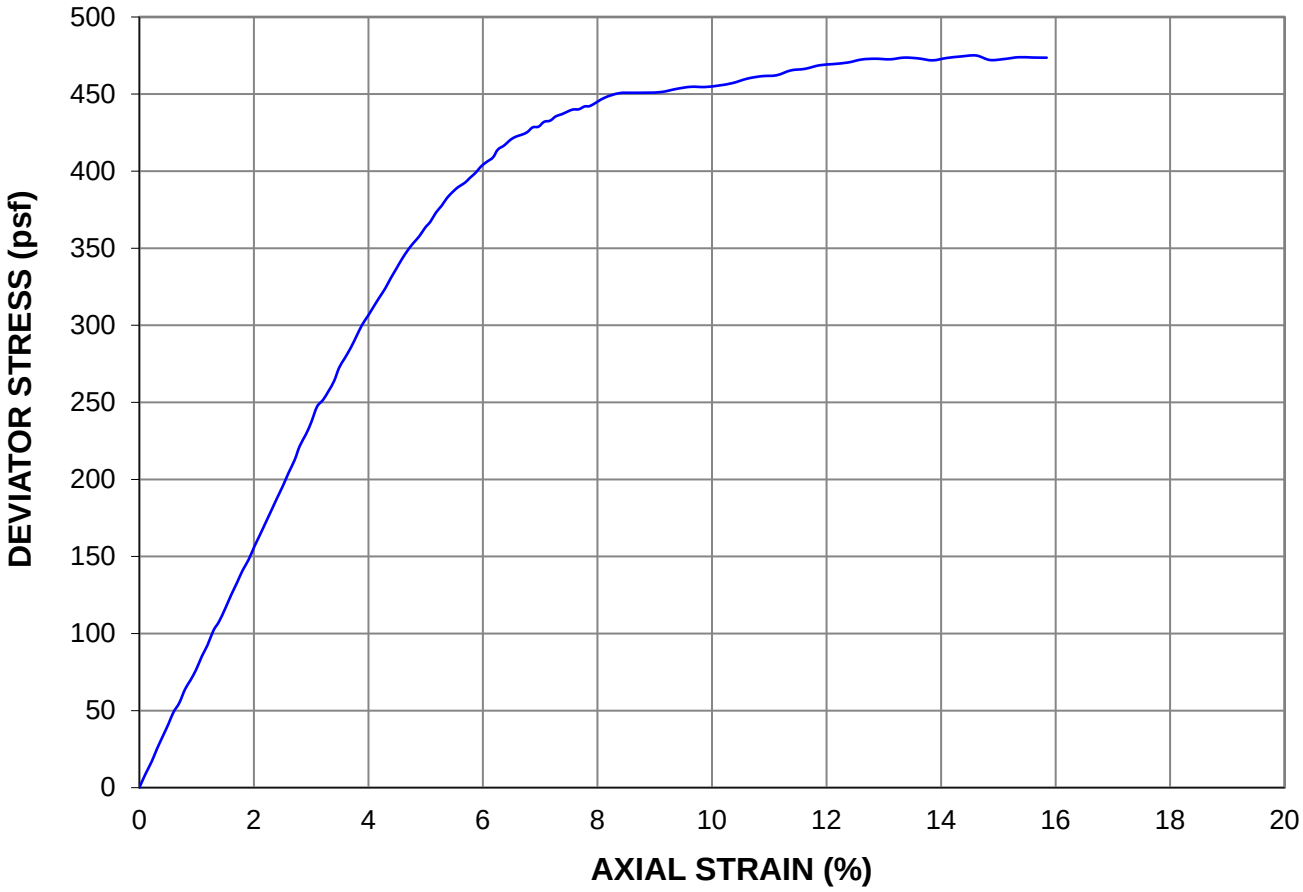
UU TRIAXIAL COMPRESSION TEST REPORT

Figure A-43



SPECIMEN AT FAILURE

DESCRIPTION : Silt with o.m. (MH)		
SPECIMEN TYPE: Shelby tube		
APPROXIMATE AXIAL STRAIN RATE: 1% / min		
Su: 238 psf		
AXIAL STRAIN AT FAILURE: 14.6%		
CLASSIFICATION: n/a		
LL: n/a	PL: n/a	PI: n/a
INITIAL	HEIGHT : 5.676 in	
	EFFECTIVE DIAMETER: 2.753 in	
	HEIGHT/DIAMETER: 2	
	WATER CONTENT: 75%	
	DRY DENSITY: 56.5 pcf	
	VOID RATIO: 1.93	
	SATURATION: 100% (assumed)	
BORING ID : B-6	SAMPLE NO.: 4	
DEPTH/ELEV. : 10 1/2 feet	DATE: 8/12/16	
TECH: SAS	CHECKED:	
REMARKS: Gs assumed 2.65; γ_{water} = 62.4pcf		
Cell Pressure= 8.2 psi		

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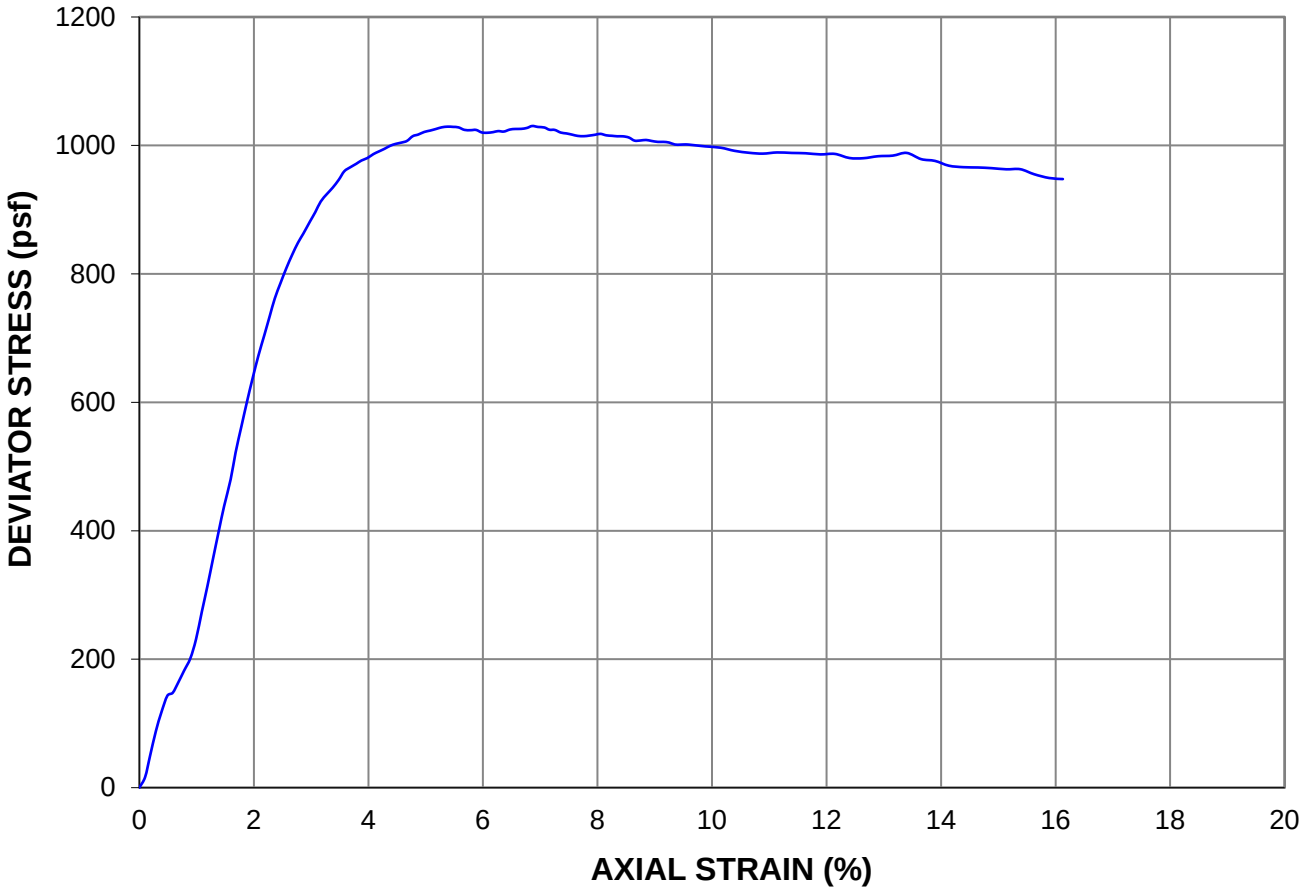
UU TRIAXIAL COMPRESSION TEST REPORT

Figure A-44



SPECIMEN AT FAILURE

DESCRIPTION : Silt with sand (ML)		
SPECIMEN TYPE: Shelby tube		
APPROXIMATE AXIAL STRAIN RATE: 1% / min		
Su: 515 psf		
AXIAL STRAIN AT FAILURE: 6.9%		
CLASSIFICATION: n/a		
LL: n/a	PL: n/a	PI: n/a
INITIAL	HEIGHT : 5.721 in	
	EFFECTIVE DIAMETER: 2.834 in	
	HEIGHT/DIAMETER: 2	
	WATER CONTENT: 64%	
	DRY DENSITY: 62.8 pcf	
	VOID RATIO: 1.63	
	SATURATION: 100% (assumed)	
BORING ID : B-6	SAMPLE NO.: 7	
DEPTH/ELEV. : 20 feet	DATE: 8/12/16	
TECH: SAS	CHECKED:	
REMARKS: Gs assumed 2.65; γ_{water} = 62.4pcf		
Cell Pressure= 14.3 psi		

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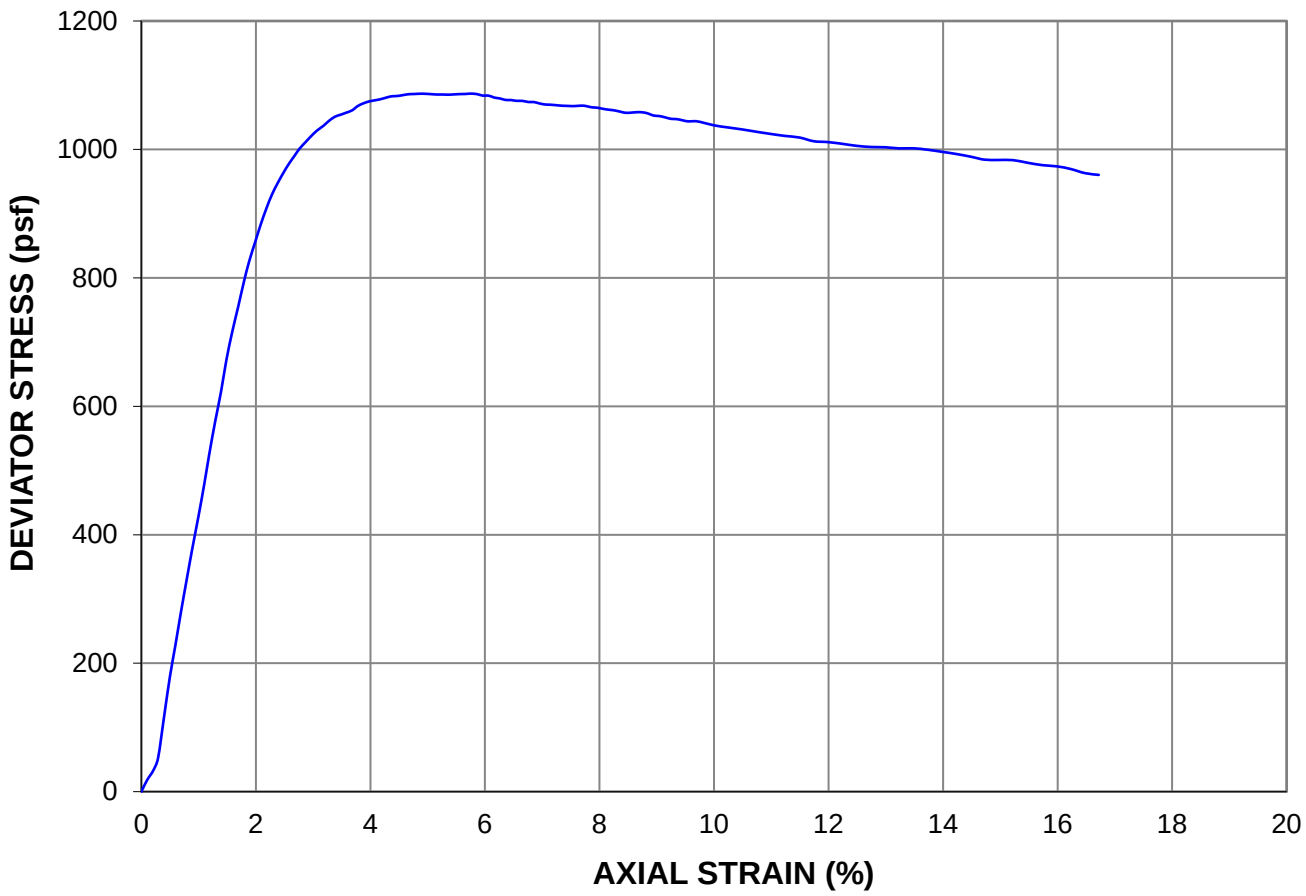
UU TRIAXIAL COMPRESSION TEST REPORT

Figure A-45



SPECIMEN AT FAILURE

DESCRIPTION : Silt with sand (MH)

SPECIMEN TYPE: Shelby tube

APPROXIMATE AXIAL STRAIN RATE: 1% / min

Su: 543 psf

AXIAL STRAIN AT FAILURE: 5.8%

CLASSIFICATION: n/a

LL: n/a	PL: n/a	PI: n/a

INITIAL

HEIGHT : 5.708 in

EFFECTIVE DIAMETER: 2.823 in

HEIGHT/DIAMETER: 2

WATER CONTENT: 69%

DRY DENSITY: 60.8 pcf

VOID RATIO: 1.72

SATURATION: 100% (assumed)

BORING ID : B-6	SAMPLE NO.: 7
DEPTH/ELEV. : 20 ½ feet	DATE: 8/12/16
TECH: SAS	CHECKED:

REMARKS: Gs assumed 2.65; γ_{water} = 62.4pcf

Cell Pressure= 14.7 psi

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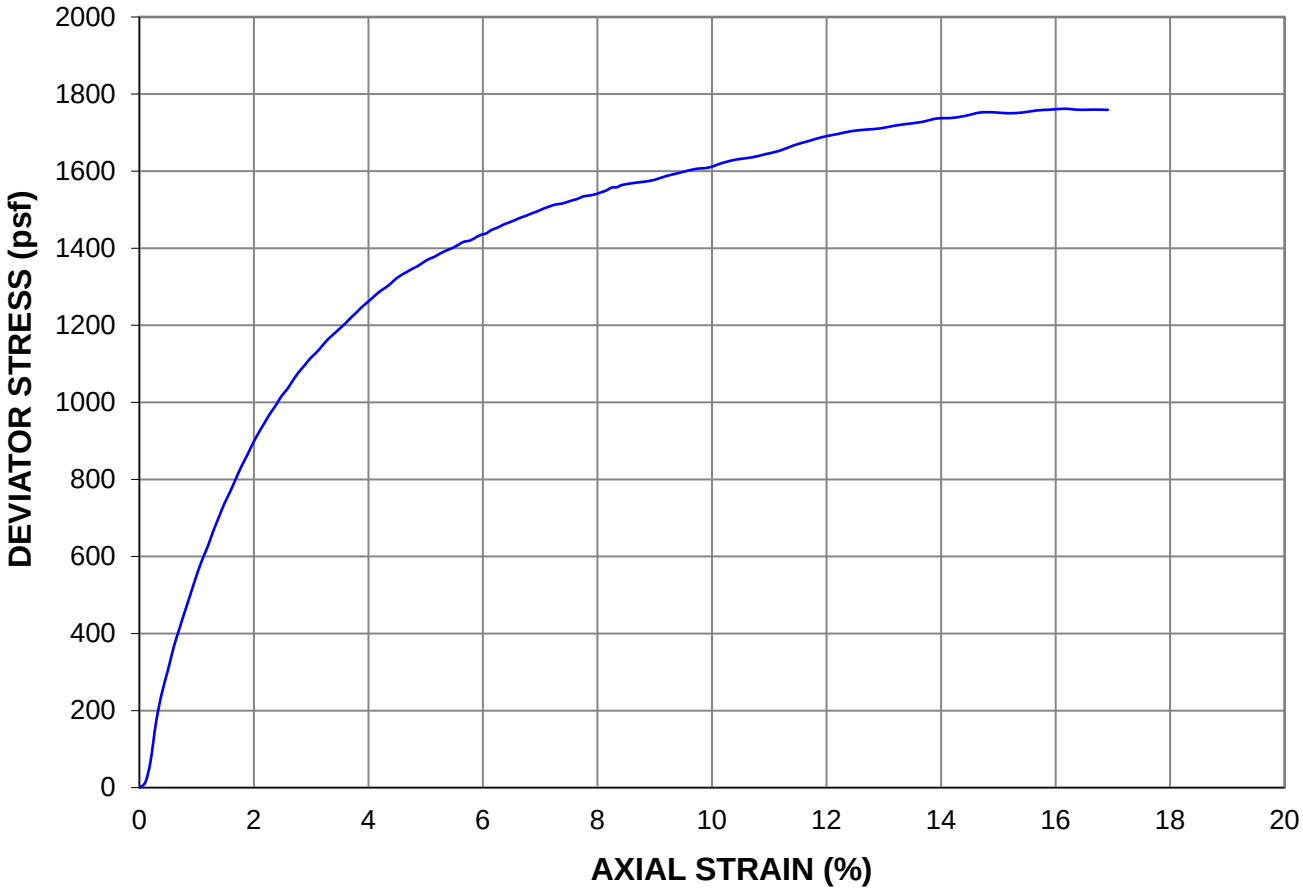
UU TRIAXIAL COMPRESSION TEST REPORT

Figure A-46



SPECIMEN AT FAILURE

DESCRIPTION : Sandy clay with occasional o.m. (CL)	
SPECIMEN TYPE: Shelby tube	
APPROXIMATE AXIAL STRAIN RATE: 1% / min	
Su: 881 psf	
AXIAL STRAIN AT FAILURE: 16.2%	
CLASSIFICATION: n/a	
LL: n/a	PL: n/a | PI: n/a
INITIAL	HEIGHT : 5.746 in
	EFFECTIVE DIAMETER: 2.838 in
	HEIGHT/DIAMETER: 2
	WATER CONTENT: 64%
	DRY DENSITY: 61.3 pcf
	VOID RATIO: 1.70
	SATURATION: 100% (assumed)
BORING ID : B-7	SAMPLE NO.: 3
DEPTH/ELEV. : 5 feet	DATE: 8/12/16
TECH: SAS	CHECKED:
REMARKS: Gs assumed 2.65; γ_{water} = 62.4pcf	
Cell Pressure= 4.9 psi	

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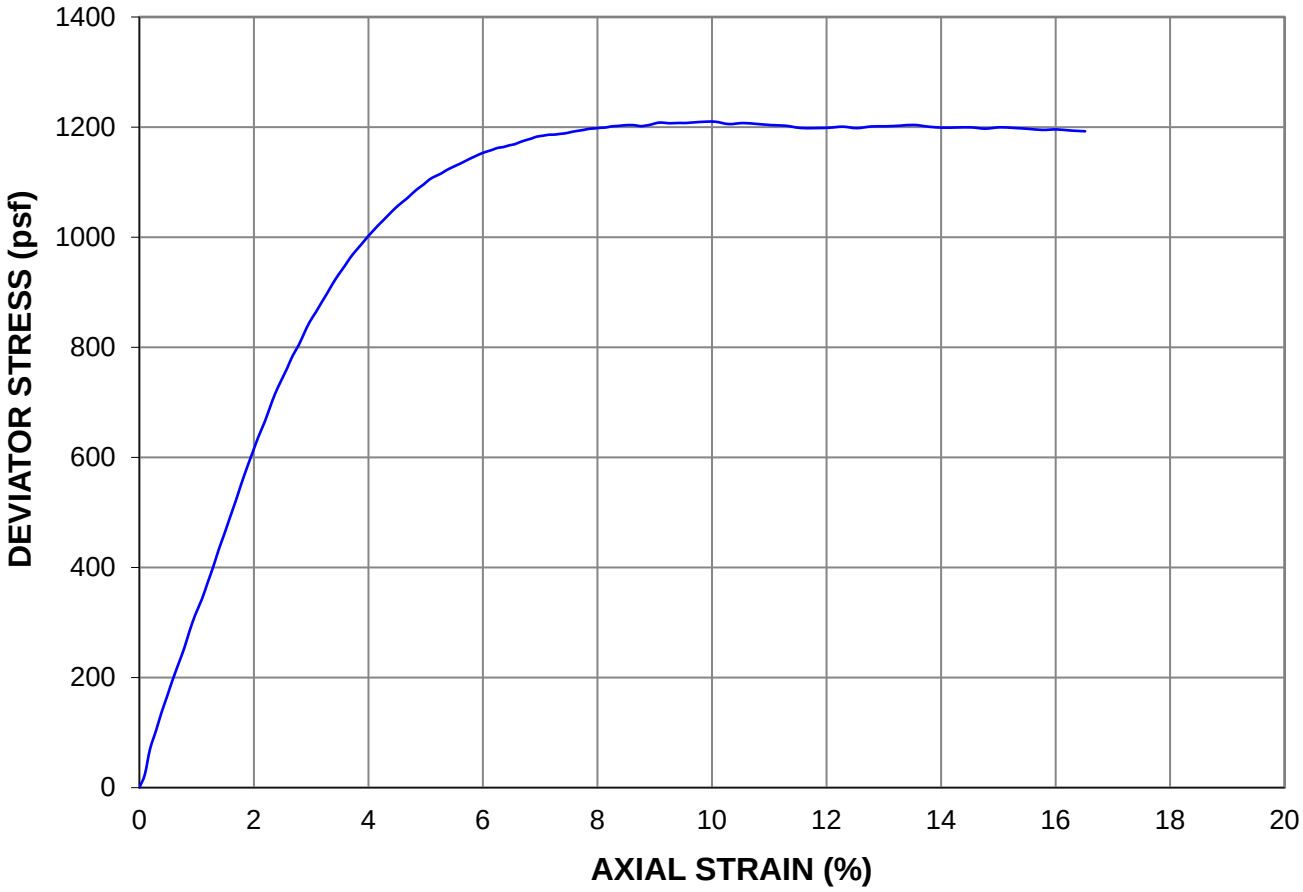
UU TRIAXIAL COMPRESSION TEST REPORT

Figure A-47



SPECIMEN AT FAILURE

DESCRIPTION : Silt with interbedded sand (ML)

SPECIMEN TYPE: Shelby tube

APPROXIMATE AXIAL STRAIN RATE: 1% / min

Su: 605 psf

AXIAL STRAIN AT FAILURE: 9.8%

CLASSIFICATION: n/a

LL: n/a	PL: n/a	PI: n/a

INITIAL

HEIGHT : 5.714 in
EFFECTIVE DIAMETER: 2.830 in
HEIGHT/DIAMETER: 2
WATER CONTENT: 46%
DRY DENSITY: 85.1 pcf
VOID RATIO: 0.94
SATURATION: 100% (assumed)

BORING ID : B-7	SAMPLE NO.: 10
DEPTH/ELEV. : 30 ½ feet	DATE: 8/4/16
TECH: SAS	CHECKED:

REMARKS: Gs assumed 2.65; γ_{water} = 62.4pcf

Cell Pressure=26.4 psi

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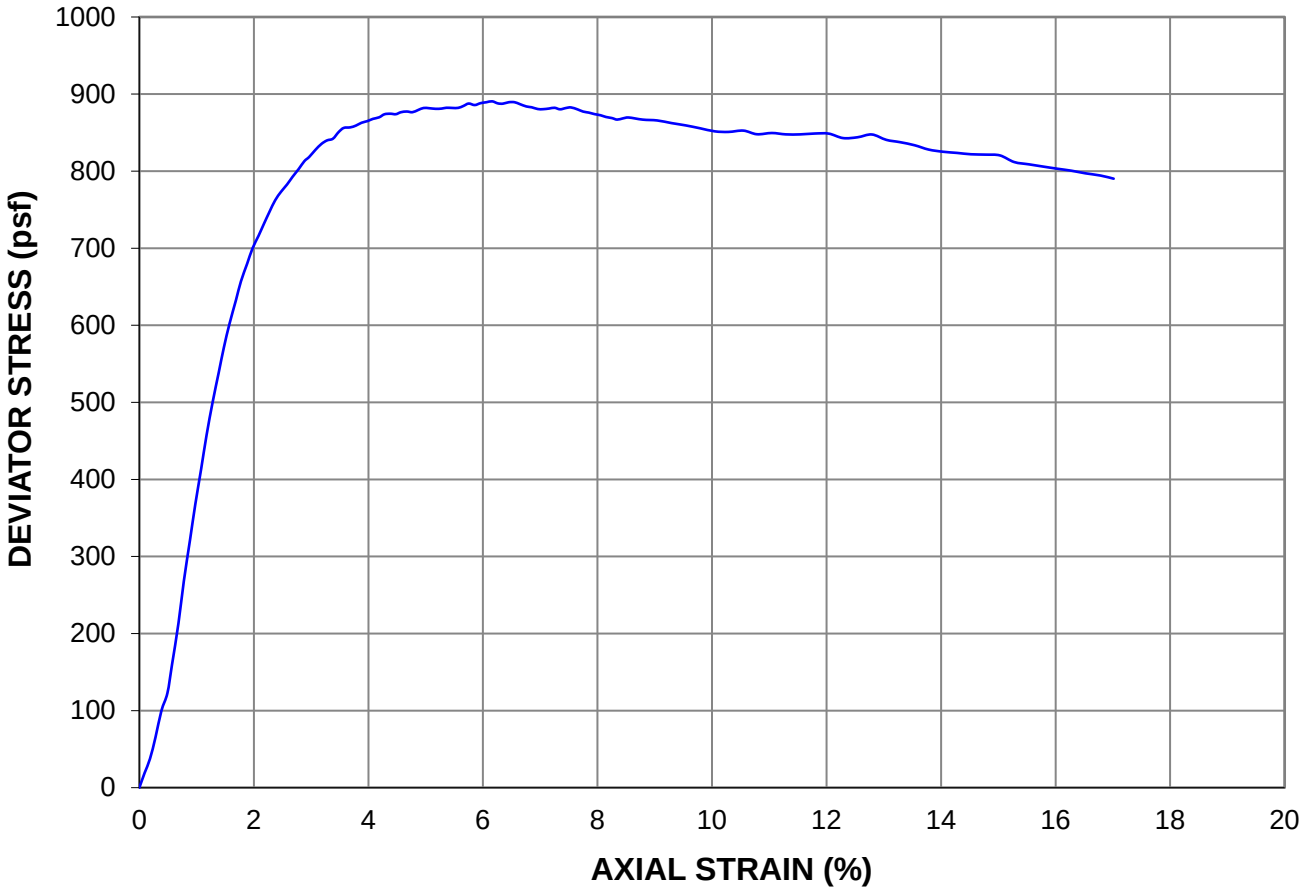
UU TRIAXIAL COMPRESSION TEST REPORT

Figure A-48



SPECIMEN AT FAILURE

DESCRIPTION : Silt (ML)	
SPECIMEN TYPE: Shelby tube	
APPROXIMATE AXIAL STRAIN RATE: 1% / min	
Su: 445 psf	
AXIAL STRAIN AT FAILURE: 6.2%	
CLASSIFICATION: n/a	
LL: n/a	PL: n/a | PI: n/a
INITIAL: HEIGHT : 5.727 in	
INITIAL: EFFECTIVE DIAMETER: 2.820 in	
INITIAL: HEIGHT/DIAMETER: 2	
INITIAL: WATER CONTENT: 85%	
INITIAL: DRY DENSITY: 53.7 pcf	
INITIAL: VOID RATIO: 2.08	
INITIAL: SATURATION: 100% (assumed)	
BORING ID : B-8A	SAMPLE NO.: 3
DEPTH/ELEV. : 5 feet	DATE: 8/18/16
TECH: SAS	CHECKED:
REMARKS: Gs assumed 2.65; γ_{water} = 62.4pcf	
Cell Pressure= 3.4 psi	

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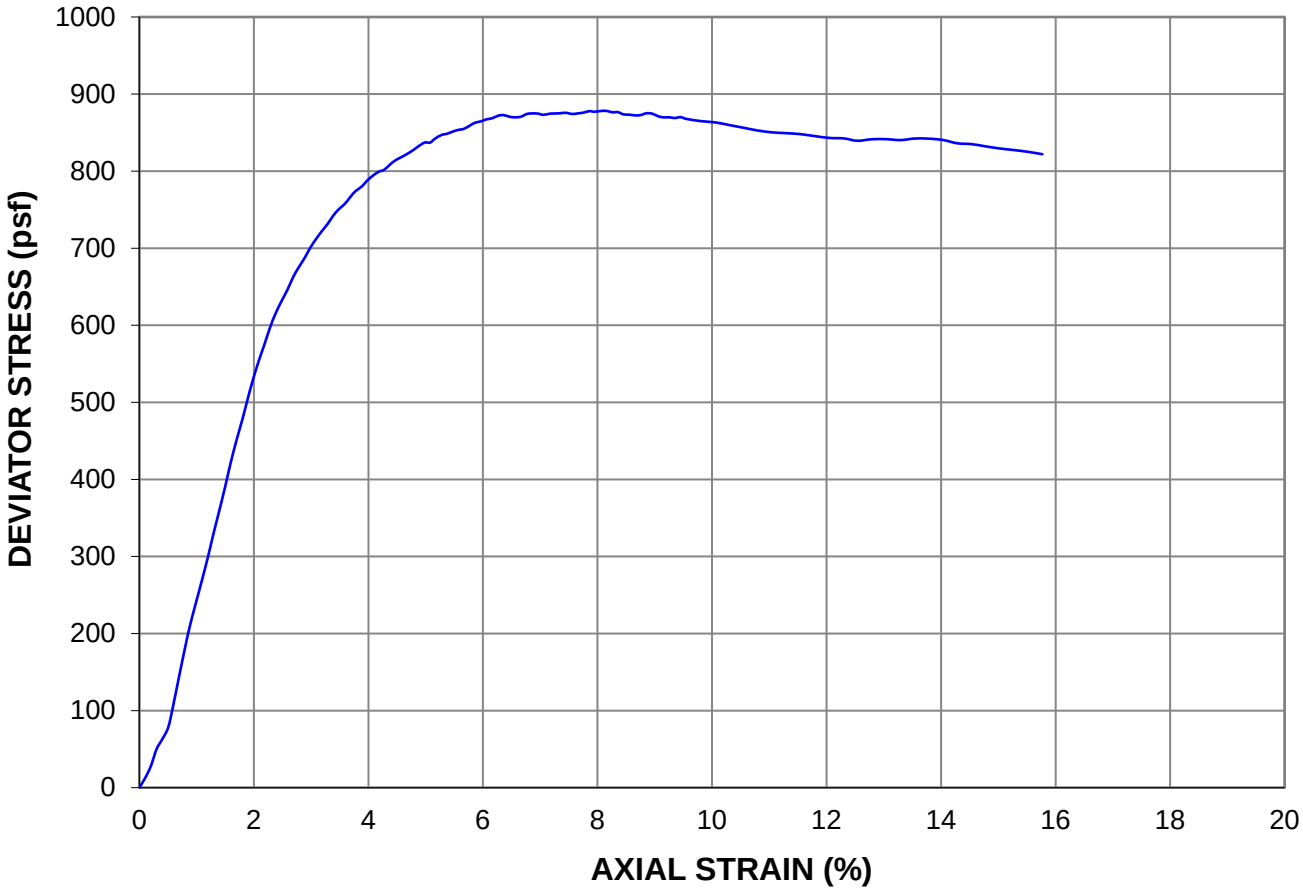
UU TRIAXIAL COMPRESSION TEST REPORT

Figure A-49



SPECIMEN AT FAILURE

DESCRIPTION : Silt (MH)	
SPECIMEN TYPE: Shelby tube	
APPROXIMATE AXIAL STRAIN RATE: 1% / min	
Su: 439 psf	
AXIAL STRAIN AT FAILURE: 8.2%	
CLASSIFICATION: n/a	
LL: n/a	PL: n/a | PI: n/a
INITIAL	HEIGHT : 5.720 in
	EFFECTIVE DIAMETER: 2.817 in
	HEIGHT/DIAMETER: 2
	WATER CONTENT: 62.7%
	DRY DENSITY: 62.7 pcf
	VOID RATIO: 1.64
	SATURATION: 100% (assumed)
BORING ID : B-8A	SAMPLE NO.: 5
DEPTH/ELEV. : 11 ½ feet	DATE: 8/18/16
TECH: SAS	CHECKED:
REMARKS: Gs assumed 2.65; γ_{water} = 62.4pcf	
Cell Pressure= 8.4 psi	

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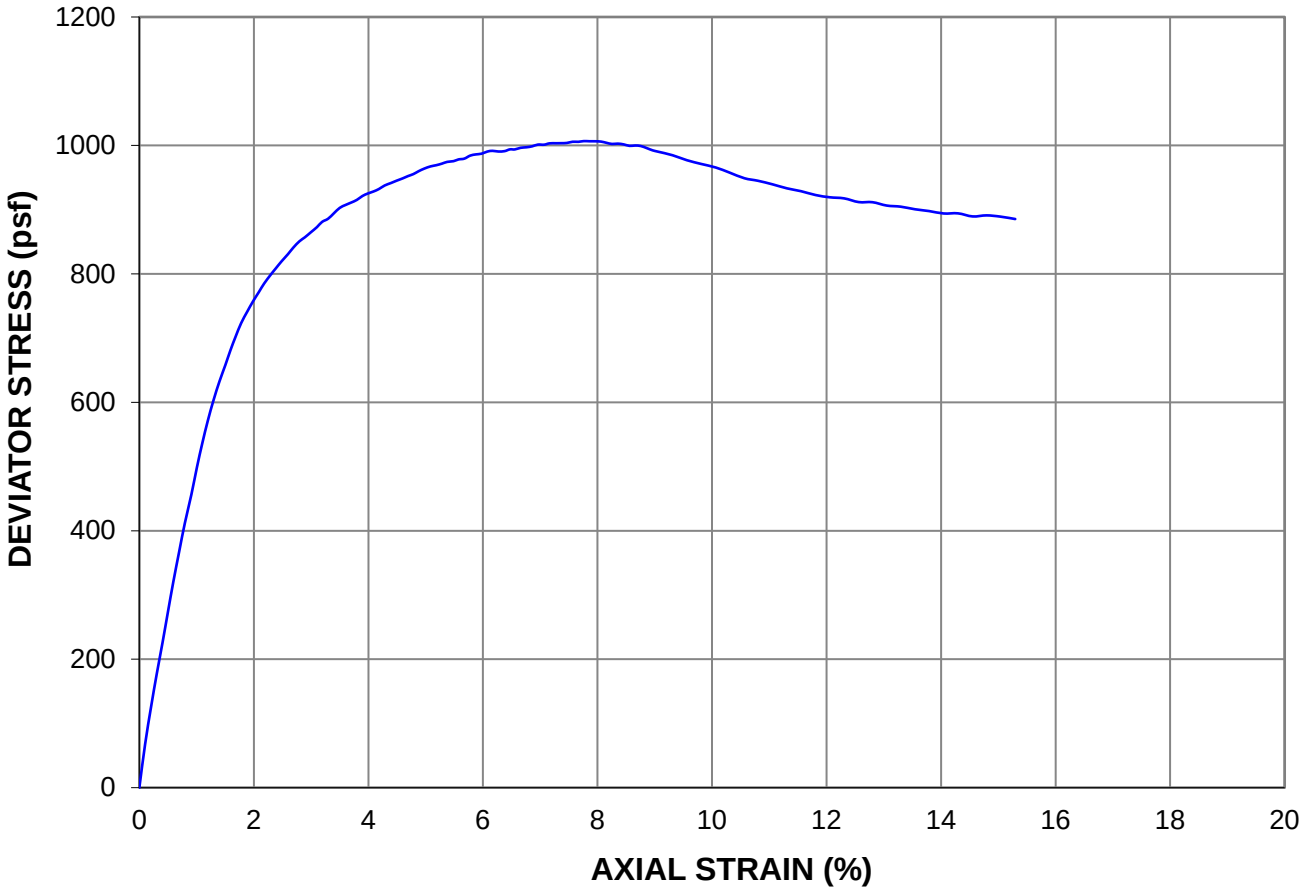
UU TRIAXIAL COMPRESSION TEST REPORT

Figure A-50



SPECIMEN AT FAILURE

DESCRIPTION : Silt (MH)

SPECIMEN TYPE: Shelby tube

APPROXIMATE AXIAL STRAIN RATE: 1% / min

Su: 503 psf

AXIAL STRAIN AT FAILURE: 7.8%

CLASSIFICATION: n/a

LL: n/a	PL: n/a	PI: n/a

INITIAL

- HEIGHT : 5.726 in
- EFFECTIVE DIAMETER: 2.788 in
- HEIGHT/DIAMETER: 2
- WATER CONTENT: 70%
- DRY DENSITY: 60.6 pcf
- VOID RATIO: 1.78
- SATURATION: 100% (assumed)

BORING ID : B-8A	SAMPLE NO.: 8
DEPTH/ELEV. : 20 ½ feet	DATE: 8/18/16
TECH: SAS	CHECKED:

REMARKS: Gs assumed 2.65; γ_{water} = 62.4pcf

Cell Pressure= 14.7 psi

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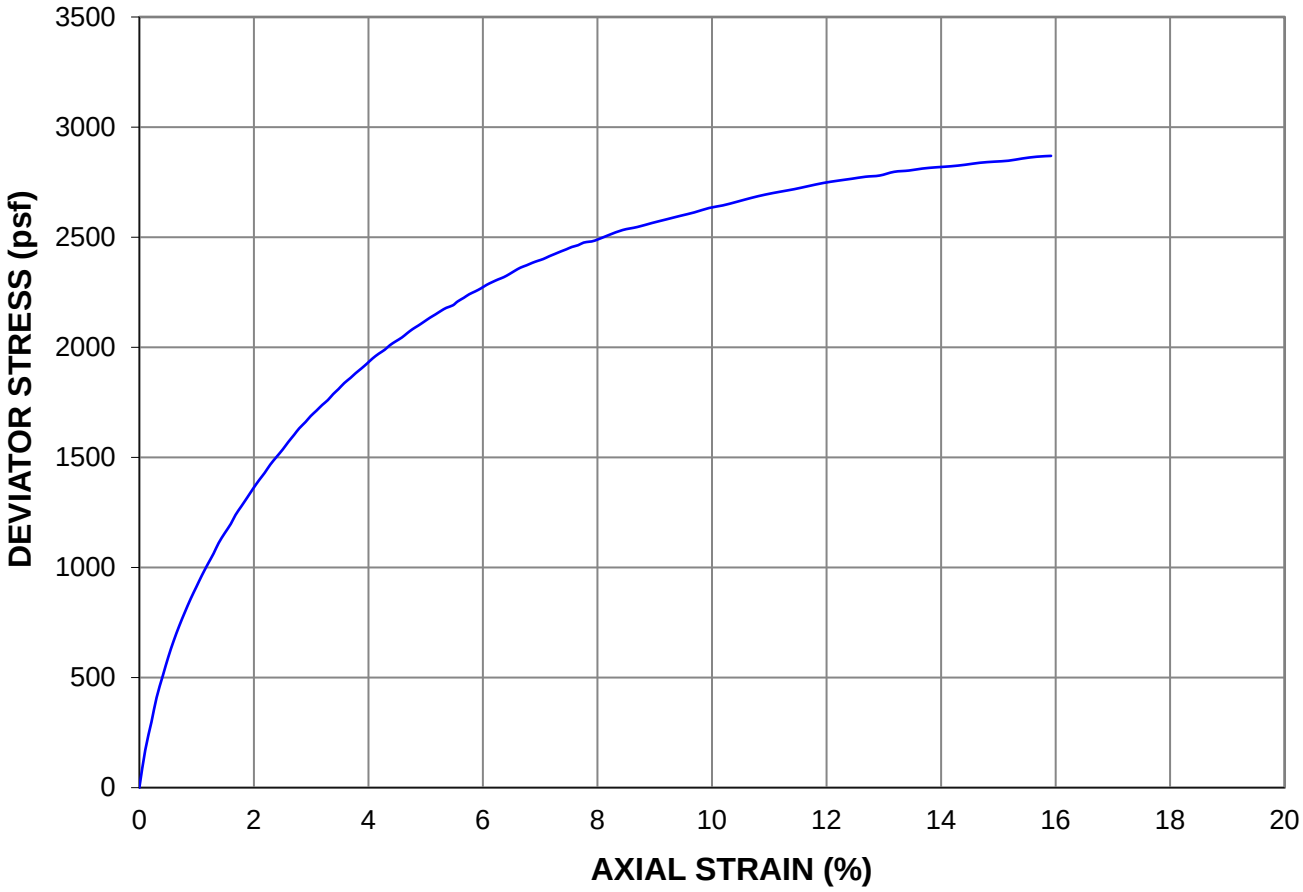
UU TRIAXIAL COMPRESSION TEST REPORT

Figure A-51



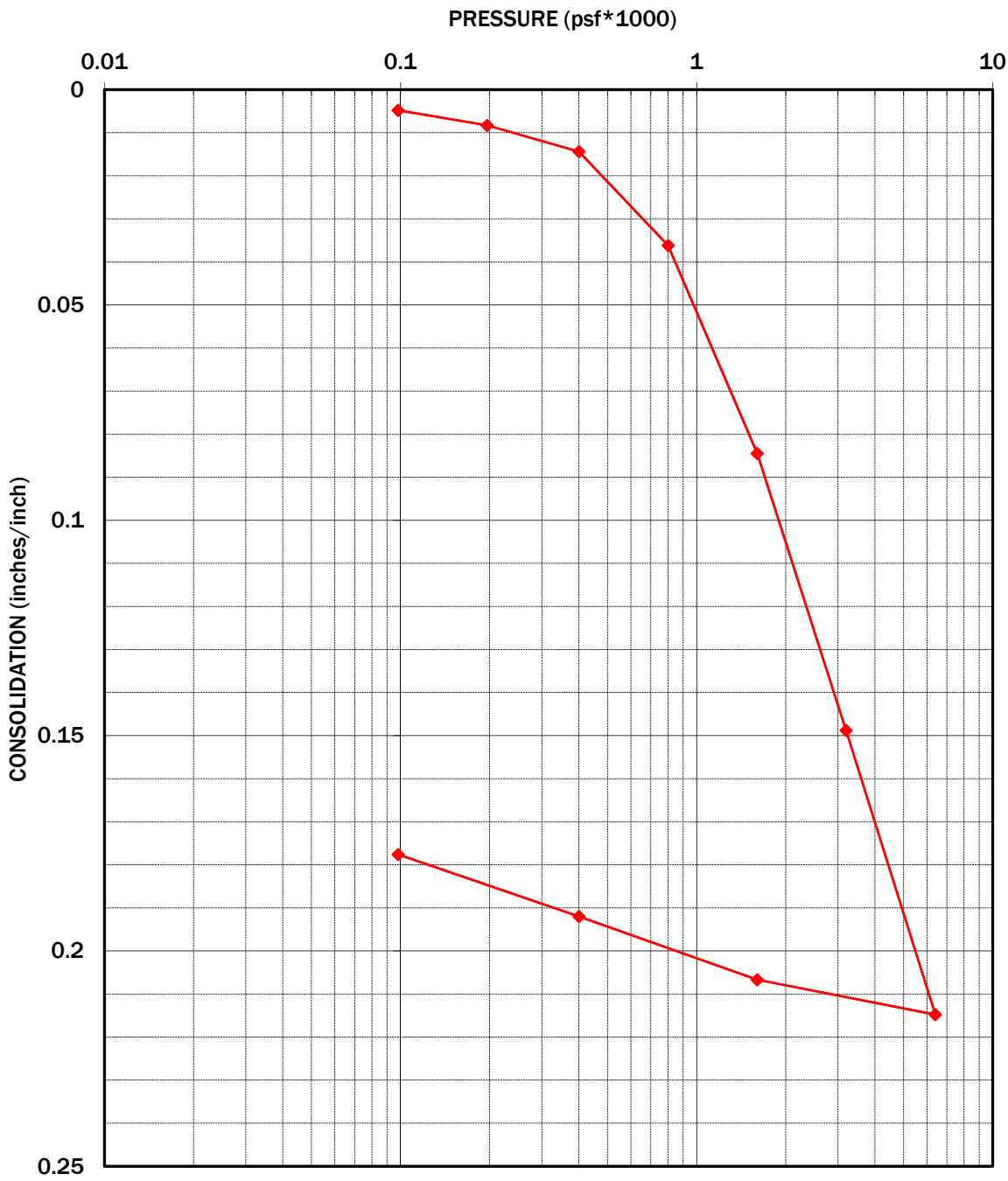
SPECIMEN AT FAILURE

DESCRIPTION :	Sandy silt with occasional gravel (ML)
SPECIMEN TYPE:	Shelby tube
APPROXIMATE AXIAL STRAIN RATE:	1% / min
Su:	1434.6 psf
AXIAL STRAIN AT FAILURE:	15.9%
CLASSIFICATION:	n/a
LL: n/a	PL: n/a
PI: n/a	
INITIAL	HEIGHT : 5.722 in
	EFFECTIVE DIAMETER: 2.837 in
	HEIGHT/DIAMETER: 2
	WATER CONTENT: 48%
	DRY DENSITY: 72.2 pcf
	VOID RATIO: 1.29
	SATURATION: 100% (assumed)
BORING ID : B-8A	SAMPLE NO.: 11
DEPTH/ELEV. : 30 feet	DATE: 8/18/16
TECH: SAS	CHECKED:
REMARKS: Gs assumed 2.65; γ_{water} = 62.4pcf	
Cell Pressure= 22.2 psi	

GeoEngineers

UU TRIAXIAL COMPRESSION TEST REPORT

Figure A-52



Boring Number	Depth (feet)	Soil Description	Initial Moisture (%)	Initial Dry Density (lbs/ft^3)
B-8A	7	Silt (ML)	86	50.4

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The consolidation test results were obtained in general accordance with ASTM D 2435.

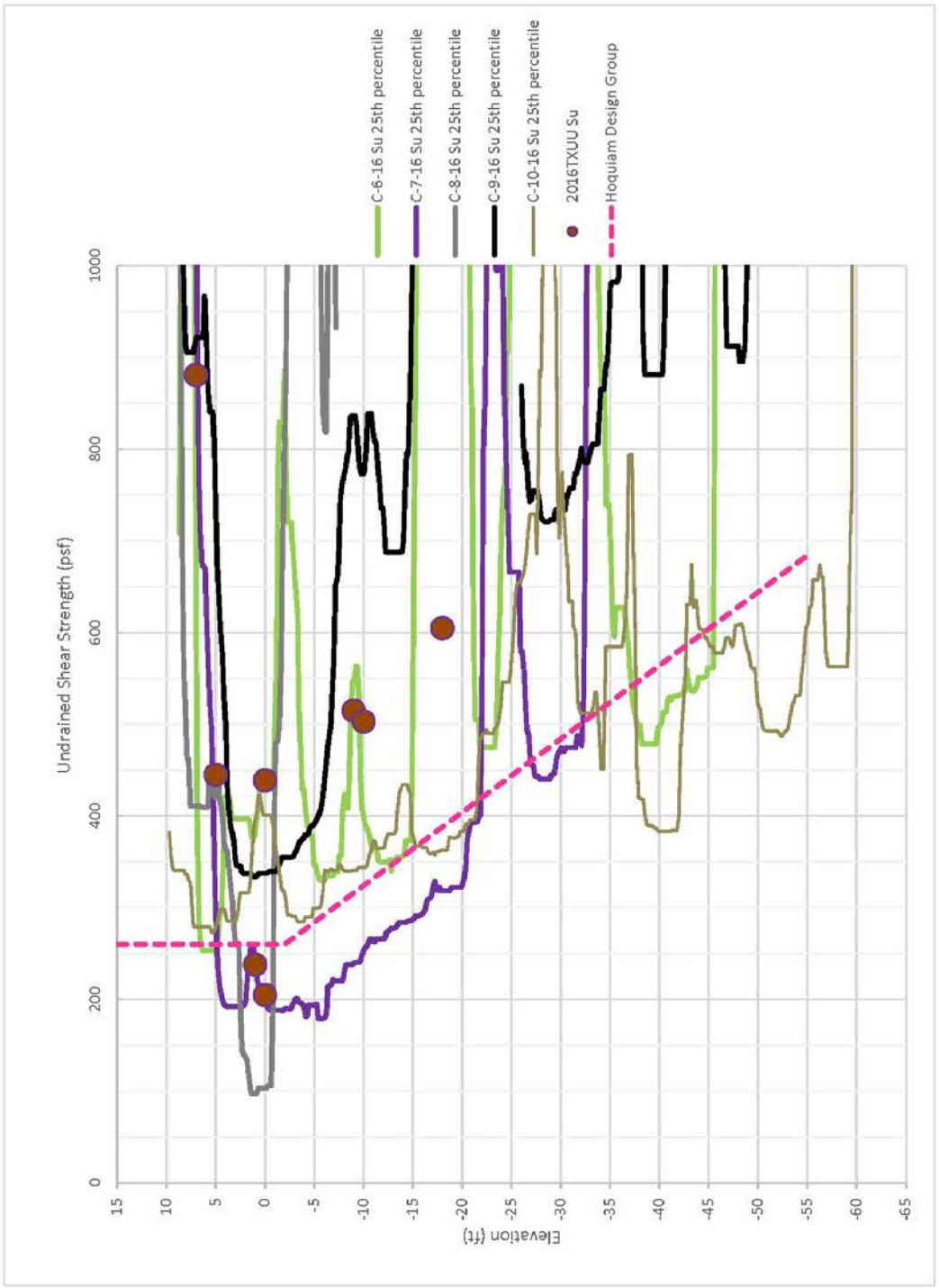
Consolidation Test Results

North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure A-53

0201-008-01 Date Exported: 02/17/17



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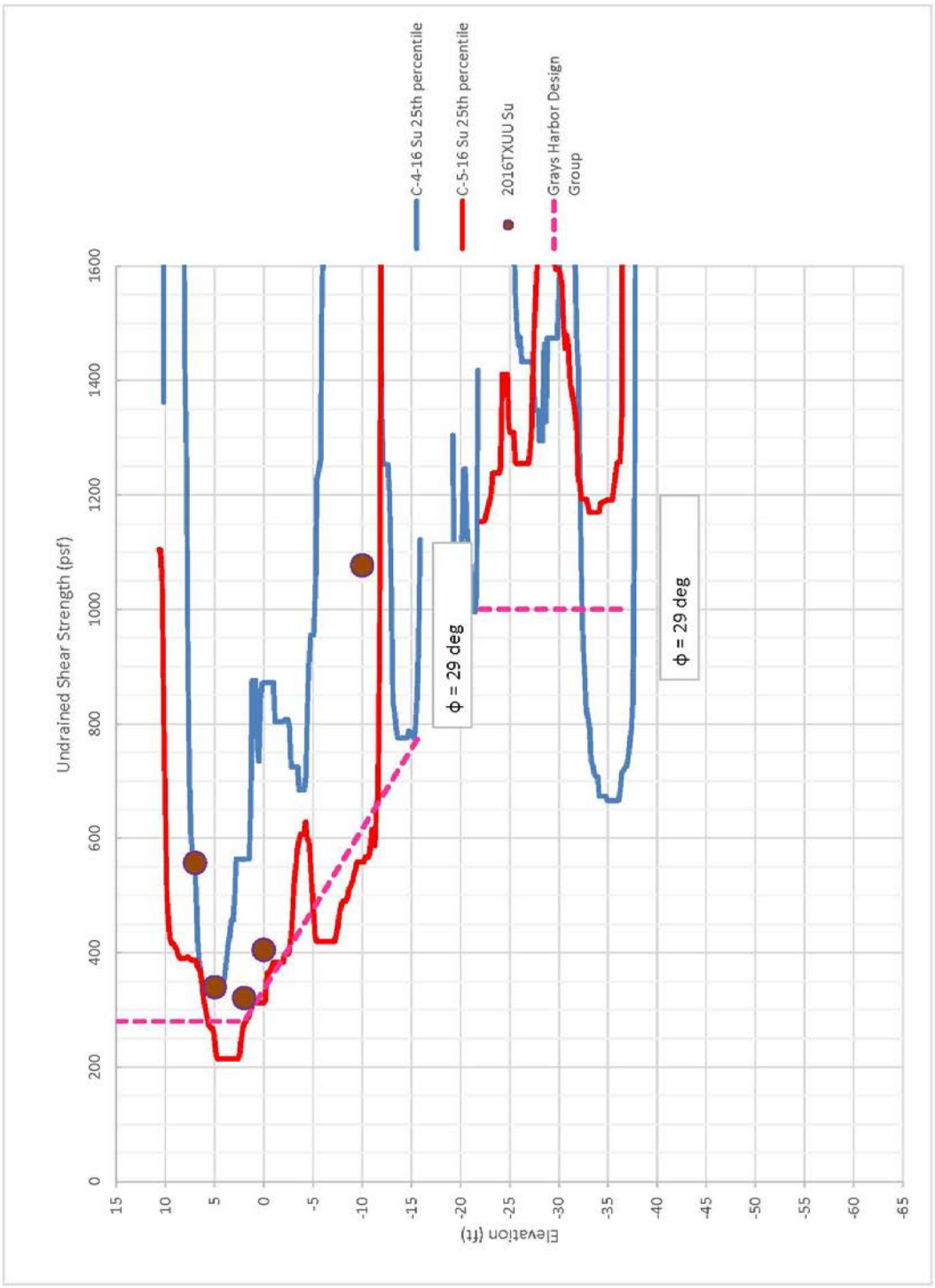
Reach 1 - Hoquiam Design Strength Analysis Results

North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure A-54

0201-008-01 Date Exported: 02/17/17



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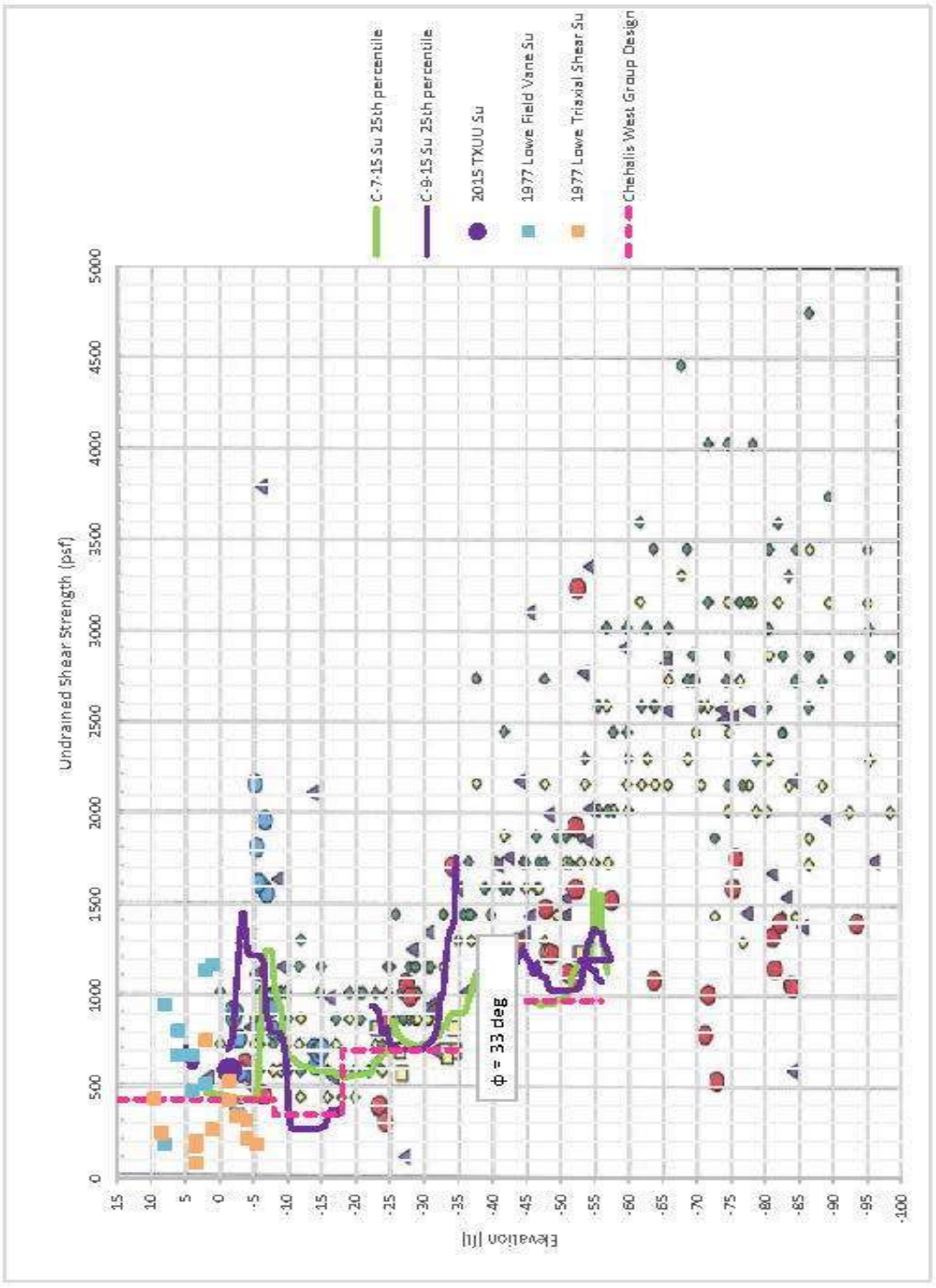
Reach 2 – Grays Harbor Design Strength Analysis Results

North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure A-55



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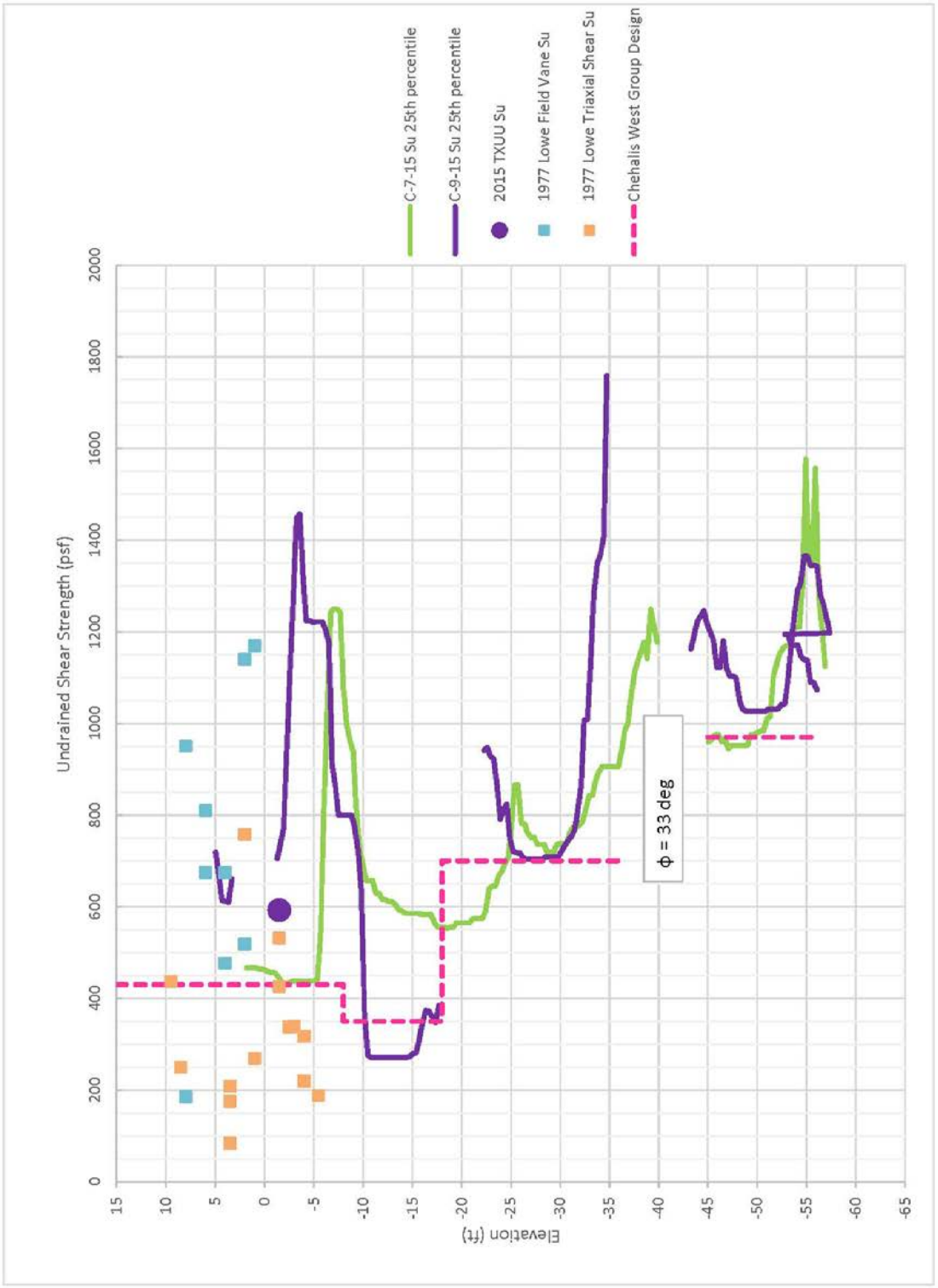
Reach 3 – Chehalis West with S&W Strength Analysis Results

North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure A-56



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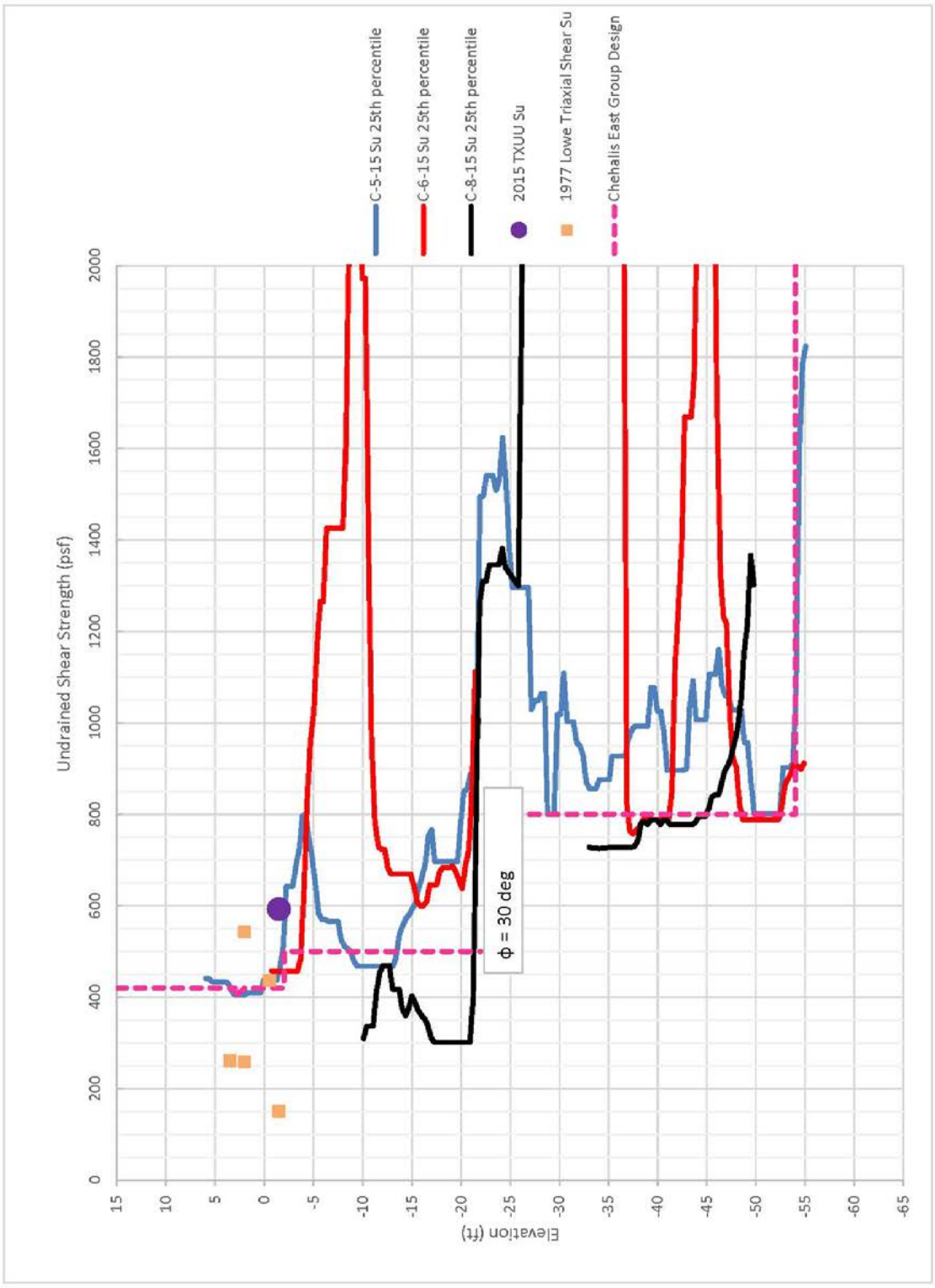
Reach 3 – Chehalis West Design Strength Analysis Results

North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure A-57

0201-008-01 Date Exported: 02/17/17



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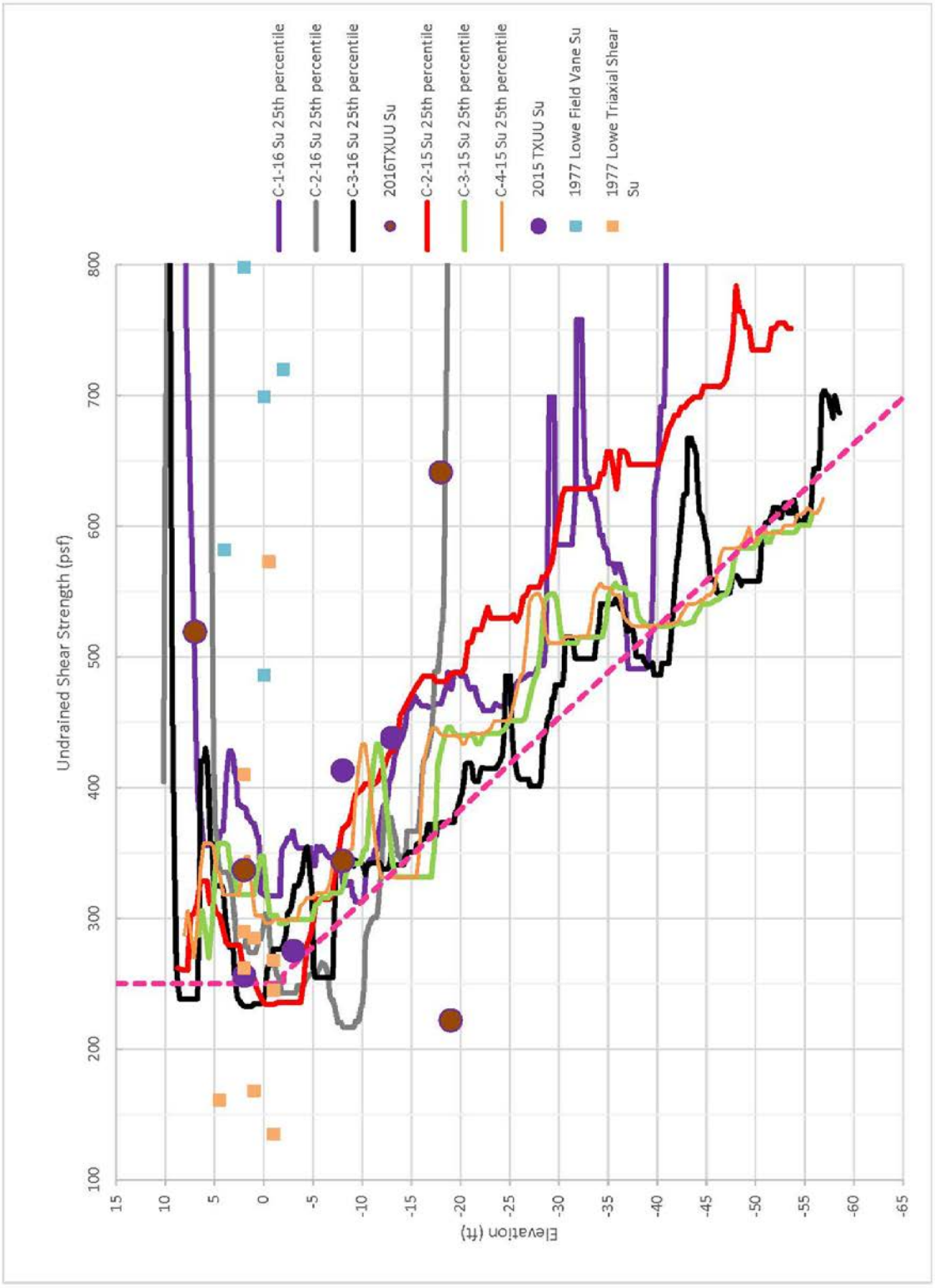
Reach 4 – Chealis East Design
Strength Analysis Results

North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure A-58



Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc. Test results are applicable only to the specific sample on which they were performed, and should not be interpreted as representative of any other samples obtained at other times, depths or locations, or generated by separate operations or processes.

Reach 5 – Wishkah Design Strength Analysis Results

North Shore Levee
Aberdeen and Hoquiam, Washington

GeoEngineers

Figure A-59

0201-008-01 Date Exported: 02/17/17

APPENDIX B
Prior Exploration Logs

GeoEngineers 2015 Report

Geotechnical Analysis and Levee Certification Report

Northside Levee
Aberdeen, Washington

for
KPFF Consulting Engineers, Inc.

August 5, 2015

GeoEngineers
Earth Science + Technology

APPENDIX A
Subsurface Explorations and Laboratory Testing

APPENDIX A
SUBSURFACE EXPLORATIONS AND LABORATORY TESTING

General

Subsurface conditions were explored by advancing 6 mud-rotary borings and 10 Cone Penetration Tests (CPTs). Subsurface exploratory services were completed by Subsurface Technologies, Inc. under subcontract to GeoEngineers, Inc.

Borings

The borings were completed between April 27 and May 28, 2015. The locations of the borings were determined by measuring from existing site features such as roadways and structures. The elevations presented on the boring logs are based on the topographic survey data provided by KPFF Consulting Engineers, Inc. The location and elevation of the explorations should be considered approximate. The exploration location and other site features are included on the Site Plans, Figures 3 through 6.

Our field representative obtained samples, classified soils, maintained a detailed log of the exploration and observed groundwater conditions where applicable. The samples were taken with a standard split spoon sampler as well as a Shelby tube sampler in general accordance with ASTM International (ASTM) D 1586 and D 1587, respectively.

The samples collected with the split spoon sampler were retained in sealed plastic bags. The soils were classified visually in general accordance with the system described in Figure A-1, which includes a Key to Exploration Logs. Summary logs of the exploration are included as Figures A-2 through A-9.

Cone Penetration Tests

CPTs soundings were completed using truck-mounted hydraulically driven cone penetrometers. Soil friction, tip resistance and dynamic pore pressure were recorded using electronic methods.

The CPTs soundings were advanced to depths ranging from approximately 35 to 70 feet below ground surface. The CPTs data are presented as Figures A-10 through A-19. No soil samples are obtained during CPT soundings. Soil types are interpreted based on empirical relationships between measured CPTs data and the parameters described above.

Laboratory Testing

Soil samples obtained from the boring were returned to our laboratory for further examination and testing. Representative soil samples were selected for testing to assist in our evaluation of pertinent geotechnical engineering properties and to confirm our field classifications. Laboratory test descriptions are provided below.

Primary Testing

Moisture Content

The moisture content of selected samples was determined in general accordance with ASTM Test Method D 2216. The test results are used to aid in soil classification and correlation with other pertinent

engineering soil properties. The results of these tests are presented on the exploration logs at the respective sample depths.

Sieve Analyses

Particle-size analyses were completed on selected samples in general accordance with ASTM Test Method D 422. This test method covers the quantitative determination of the distribution of particle sizes in soils. Typically, the distribution of particle sizes larger than 75 micrometers (µm) is determined by sieving. The results of the tests were used to verify field soil classifications and determine pertinent engineering characteristics. Figures A-20 and A-21 presents the results of our sieve analyses.

Atterberg Limits

Atterberg Limit tests were performed on selected samples in general accordance with ASTM Test Method D 4318. This test method determines the liquid limit, plastic limit and plasticity index of soil particles passing the No. 40 sieve. The results of the tests are used to assist in soil classification and determine pertinent engineering characteristics. Results for plastic soils are presented in Figures A-22 through A-27. Liquid limits and plasticity index are also presented on the exploration logs at the respective sample depths.

Percent Fines Determination

Selected samples were "washed" through the U.S. No. 200-mesh sieve to estimate the relative percentages of coarse and fine grained particles in the soil. The tests were conducted in general accordance with ASTM D 1140. The percent passing value represents the percentage by weight of the sample finer than the U.S. No. 200 sieve. These tests were conducted to verify field descriptions and to estimate the fines content for analysis purposes. The test results are shown on the exploration logs at the respective sample depths.

Secondary Testing

Unconsolidated-Undrained (UU) Triaxial Tests

UU triaxial tests were performed on a relatively undisturbed samples obtained from the borings. The samples were collected during drilling using Thin-Walled Tube Samplers (Shelby Tubes) in general accordance with ASTM D 1587. The sample was prepared and tested in general accordance with ASTM D 2850.

The UU triaxial test is completed subjecting the sample to an axial load applied at a constant strain rate in an undrained state. A sample is considered undrained if pore water is prevented from draining from the sample during testing. The undrained state is achieved by closing the drainage lines, which allow consolidation prior to the application of axial load. Because the axial load is applied in the undrained state, volume change of the sample is not permitted during loading resulting in the development of pore pressure changes in compensation for the sample attempting to contract or dilate. Effective confining pressures were selected to generally match the effective stresses in the in-situ stress state to develop shear strength parameters that are applicable to the anticipated loading. Axial load, strain and pore pressure are recorded during the test.

The recorded data was used to estimate the undrained shear strength of the sample. The results of the UU tests are presented on the Figures A-28 through A-32.

One-Dimensional Consolidation

One-dimensional consolidation testing was performed to determine the settlement potential of selected samples in accordance with ASTM D 2435. The consolidation test determines the magnitude and rate of consolidation of soil restrained laterally and drained axially while subjected to incrementally applied controlled-stress loading. The results of our consolidation tests are shown on Figures A-33 through A-41.

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES
	MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
MORE THAN 50% RETAINED ON NO. 200 SIEVE	SAND AND SANDY SOILS	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS
				SP	POORLY-GRADED SANDS, GRAVELLY SAND
	MORE THAN 50% OF COARSE FRACTION PASSING NO. 4 SIEVE	SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS, ROCK FLOUR, CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
MORE THAN 50% PASSING NO. 200 SIEVE	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS AND SILTS OF MEDIUM TO HIGH PLASTICITY
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: Multiple symbols are used to indicate borderline or dual soil classifications

Sampler Symbol Descriptions

- **2.4-inch I.D. split barrel**
- **Standard Penetration Test (SPT)**
- **Shelby tube**
- **Piston**
- **Direct-Push**
- **Bulk or grab**
- **Continuous Coring**

Blowcount is recorded for driven samplers as the number of blows required to advance sampler 12 inches (or distance noted). See exploration log for hammer weight and drop.

A "P" indicates sampler pushed using the weight of the drill rig.

ADDITIONAL MATERIAL SYMBOLS

SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
	AC	Asphalt Concrete
	CC	Cement Concrete
	CR	Crushed Rock/ Quarry Spalls
	TS	Topsoil/ Forest Duff/Sod

Groundwater Contact

Measured groundwater level in exploration, well, or piezometer

Measured free product in well or piezometer

Graphic Log Contact

Distinct contact between soil strata or geologic units

Approximate location of soil strata change within a geologic soil unit

Material Description Contact

Distinct contact between soil strata or geologic units

Approximate location of soil strata change within a geologic soil unit

Laboratory / Field Tests

%F	Percent fines
AL	Atterberg limits
CA	Chemical analysis
CP	Laboratory compaction test
CS	Consolidation test
DS	Direct shear
HA	Hydrometer analysis
MC	Moisture content
MD	Moisture content and dry density
OC	Organic content
PM	Permeability or hydraulic conductivity
PI	Plasticity index
PP	Pocket penetrometer
PPM	Parts per million
SA	Sieve analysis
TX	Triaxial compression
UC	Unconfined compression
VS	Vane shear

Sheen Classification

NS	No Visible Sheen
SS	Slight Sheen
MS	Moderate Sheen
HS	Heavy Sheen
NT	Not Tested

NOTE: The reader must refer to the discussion in the report text and the logs of explorations for a proper understanding of subsurface conditions. Descriptions on the logs apply only at the specific exploration locations and at the time the explorations were made; they are not warranted to be representative of subsurface conditions at other locations or times.

KEY TO EXPLORATION LOGS

GeoEngineers

FIGURE A-1

Drilled	Start 4/28/2015	End 4/28/2015	Total Depth (ft)	31.5	Logged By / Checked By	BTK / LJS	Driller	Subsurface Technologies	Drilling Method	Mud Rotary
Surface Elevation (ft) / Vertical Datum	11 / NAVD88				Hammer Data	Autohammer 140 (lbs) / 30 (in) Drop			Drilling Equipment	Diedrich D90
Easting (X) / Northing (Y)	813768.017972 / 617454.77686				System Datum	NAD83 (feet)			Groundwater	Date Measured / Depth to Water (ft) / Elevation (ft)
Notes:										

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Blows/foot	Collected Sample: Sample Name / Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content, %	Dry Density, (pcf)	REMARKS
10	0						AC	2 to 3 inches asphalt concrete			
							SM	Brown silty sand with gravel (moist to wet)			
		22		1 Consol					114	40	PP=0.02 tsf; TV=0.08 tsf
							OH	Black organic silt (very soft, moist)			
5	5	12	2	2 AL					92		AL (LL=103; PI=48)
				3 AL			OH	Gray organic clay with occasional organic matter (grass) and trace sand (very soft, moist)	67		AL (LL=107; PI=64)
		24		4 Consol TXUU			PT	Brown peat with trace silt (very soft, wet to moist)	190 162	25 28	Su=256 psf; PP=0.13 tsf; TV=0.2 tsf
0	10	16	WOH	5 MC 6 MC			PT	Brown peat (very soft, moist to wet)	356 101		
							MH	Gray elastic silt with organic matter (grass) and layers of organic silt (very soft, moist to wet)			
		24		7 Consol TXUU					36 30	73 75	Su=275 psf; PP=0.2 tsp; TV=0.3 tsf
-5	15	18	WOH	8 AL					95		AL (LL=91; PI=44)
		9		9 MC					72		PP=0.15 tsf; TV=0.15 tsf; MC from organic silt (OL) layer
-10	20	18	1	10 MC					88		
		24		11 TXUU					93	46	Su=438 psf
-15	25	18	1	12 MC				Grades with increased organic matter (grass)	84		
		16		13 MC					72		PP=0.0 tsf; TV=0.1 tsf
-20	30	18	2	14 MC 15 MC			PT	Brown peat (grass) (very soft, wet)	68 157		

Note: See Figure A-1 for explanation of symbols.

Log of Boring B-2

GeoEngineers

Project: Northside Levee
Project Location: Aberdeen, Washington
Project Number: 0201-008-00

Figure A-3
Sheet 1 of 1

Tacoma: Date:7/30/15 Path:P:\0\0201008\GINT\0201008800.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_STANDARD

Drilled	Start 4/29/2015	End 4/29/2015	Total Depth (ft)	71.5	Logged By / Checked By	BTK / LJS	Driller	Subsurface Technologies	Drilling Method	Mud Rotary
Surface Elevation (ft) / Vertical Datum	12 / NAVD88		Hammer Data	Autohammer 140 (lbs) / 30 (in) Drop			Drilling Equipment	Diedrich D90		
Easting (X) / Northing (Y)	814258.930845 / 615639.924973		System Datum	NAD83 (feet)			Groundwater	Date Measured	Depth to Water (ft)	Elevation (ft)
Notes:										

Depth (feet)	Elevation (feet)	Interval Recovered (in)	Blows/foot	Collected Sample / Sample Name / Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content, %	Dry Density, (pcf)	REMARKS
0	10						SP-SM	Gray-black fine sand with silt (loose, moist to wet)			
		8	1	1 MC			OH	Brown organic clay with organic matter (grass) (very soft, moist to wet)	22		
				2 MC					98		
5	5	18	4	3 AL				With wood chunks	116		AL (LL=134; PI=85)
				4 MC				Becomes dark gray	91		PP=0.05 tsf; TV=0.03 tsf
		23	P	5							Sample SS highly disturbed and contained drill fluids
							PT	Brown peat			
10	0	18	9	6 MC			MH	Dark gray elastic silt with organic matter (grass) (very soft, moist to wet)	84		Wood chunk in bottom 2 to 3 inches of sampler shoe
15	-5	18	1	7 AL				With peat layers approximately 2 inches thick	85		AL (LL=72: PI=31)
		23	P	8 Consul TXUU					55	61	Su=413 psf PP=0.1 tsf; TV=0.13 tsf
							MH	Gray elastic sandy silt and occasional organic matter (grass) (very soft, moist to wet)	55	62	
20	-10	18	11	9 %F					66		%F=65
25	-15	18	11	10 AL				With trace organic matter and laminated with fine sand	73		AL (LL=68; PI=31)
		12	P	11 MC					63		PP=0.33 tsf; TV=0.22 tsf
30	-20	18	8	12 MC			SM	Gray silty fine sand with silt lenses (loose to medium dense, moist to wet)	75		%F=30
				13 %F					40		
35							SM				

Note: See Figure A-1 for explanation of symbols.

Log of Boring B-3 Alt

GeoEngineers

Project: Northside Levee
Project Location: Aberdeen, Washington
Project Number: 0201-008-00

Figure A-4
Sheet 1 of 2

Tacoma: Date:7/30/15 Path:P:\0\0201008\GINT\020100800.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_STANDARD

Elevation (feet)	Depth (feet)	Interval Recovered (in)	Blows/foot	Collected Sample / Sample Name Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content, %	Dry Density, (pcf)	REMARKS
-25	35	14	4	14 %F			SM	Gray silty fine sand with silt layers up to ½ inch thick and trace organic matter (grass) (loose, wet)	52		%F=35
		24	P	15 MC					51		Hard pushing
-30	40	17	6	16 %F				Becomes loose to medium dense	41		%F=26
-35	45	17	14	17 %F			SM	Gray silty fine to medium sand, occasional organic matter (grass) and occasional silt layers ¼ inch thick (medium dense, wet)	31		%F=19
											No Shelby sample at 48 feet due to sandy material in SPT
-40	50	12	13	18 %F			SP-SM	Gray fine to coarse sand with silt (medium dense, wet)	16		%F=6.8
-45	55	16	51	19 MC				With gravel layer approximately 1½ inches thick, becomes very dense	15		
-50	60	15	38	20 MC				Becomes fine to medium sand and dense with silt layers up to 1 inch	20		
							ML	Gray silt with sand and organic matter (grass and wood) (medium stiff to stiff, wet)			
-55	65	18	6	21 MC			SP-SM	Gray fine sand with silt and organic matter (grass) (loose, wet)	59		
				22 MC			ML	Gray silt with sand and occasional organic matter (grass and wood) (medium stiff to stiff, wet)	68		
		24	P	23 MC			SP-SM	Gray fine sand with silt (medium dense to dense, wet)	27		
	70	16	21	24 MC					30		

Note: See Figure A-1 for explanation of symbols.

Log of Boring B-3 Alt (continued)

GeoEngineers

Project: Northside Levee
Project Location: Aberdeen, Washington
Project Number: 0201-008-00

Figure A-4
Sheet 2 of 2

Tacoma: Date:7/30/15 Path:P:\0\0201008\GINT\020100800.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_STANDARD

Drilled	Start 5/28/2015	End 5/28/2015	Total Depth (ft)	71.5	Logged By / Checked By	BTK / LJS	Driller	Subsurface Technologies	Drilling Method	Mud Rotary
Surface Elevation (ft) / Vertical Datum	12.5 / NAVD88		Hammer Data	Autohammer 140 (lbs) / 30 (in) Drop			Drilling Equipment	Diedrich D90		
Easting (X) / Northing (Y)	810978.718647 / 613458.444309		System Datum	NAD83 (feet)			Groundwater: Date Measured	Depth to Water (ft)	Elevation (ft)	

Notes:

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Blows/foot	Collected Sample: Sample Name / Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content, %	Dry Density, (pcf)	REMARKS
10	0	4	11	1 SA			GM	Dark gray silty fine gravel with sand (medium dense, moist)	18		Drill chatter; driller notes of apparent cuttings appear to be ground up gravel (medium to coarse) %F=16
5	5	3	5	2 MC				Grades to loose, moist	23		
		7	5	3 MC			OH	Gray organic silt with occasional organic matter (wood debris) (medium stiff, moist)	66		Driller notes significant wood content in cuttings from 6 to 7.5 feet
0	10	8	1	4 AL				Grades to with organic matter (wood debris and grass) (very soft, moist)	82		AL (LL=110; PI=51)
		18		5 TXUU					113	39	Su=593 psf
-5	15	12	5	6 MC			PT/WD	Peat with silt and organic matter (wood debris) (very soft, moist to wet)	140		
				7 MC			MH	Gray elastic silt with occasional organic matter (medium stiff, moist)	46		
-10	20	12	5	8 AL				With interbedded silty fine sand approximately 1-inch-thick	59		AL (LL=68; PI=22)
		15		9 MC			SM	Gray silty fine sand with occasional organic matter (grass) and lenses of brown silt 0.5-inch-thick (loose to medium dense, moist)	39		
-15	25	8	8	10 %F					47		%F=23
							SM	Gray silty fine to medium sand with occasional organic matter (grass) (medium dense, moist)			
-20	30	15	12	11 %F					36		%F=14
	35						SM	Gray silty fine sand with occasional organic matter and stratified layers of silt and silty			

Note: See Figure A-1 for explanation of symbols.

Log of Boring B-5

GeoEngineers

Project: Northside Levee
Project Location: Aberdeen, Washington
Project Number: 0201-008-00

Figure A-5
Sheet 1 of 2

Tacoma: Date:7/30/15 Path:P:\0\0201008\GINT\0201008GPJ DBTemplate\LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_STANDARD

Elevation (feet)	Depth (feet)	Interval Recovered (in)	Blows/foot	Collected Sample / Sample Name Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content, %	Dry Density, (pcf)	REMARKS
	35	18	11	12 %F 13 MC				fine sand (medium dense, wet)	47 26		%F=27
-25							SP-SM	Gray fine sand with silt (medium dense, wet)			
							MH	Gray elastic silt with occasional organic matter (wood debris and grass) (very soft, wet)			
	40	18	0	14 AL					62		AL (LL=56; PI=18)
-30		21		15 MC					40		
							ML	Gray silt with sand and occasional organic matter (grass) (medium stiff, wet)			
	45	18	4	16 AL					44		AL (LL=41; PI=6)
-35											
	50	9	3	17 MC					46		
-40											
		17		18 MC			SM	Gray silty fine to medium sand (loose, wet)	23		
	55	11	5	19 MC 20 MC			ML	Gray silt with sand and occasional organic matter (wood debris and grass) (medium stiff, moist to wet)	35 49		
-45							ML	Gray sandy silt with trace organic matter (grass) (very soft, wet)			
	60	14	WOH	21 AL					50		AL (LL=39; PI=1)
-50											
	65	18	0	22 MC					47		
-55							ML	Gray silt with sand (wet)			
		24		23 MC					43		
	70	18	6	24 MC			SM	Gray silty fine sand (loose to medium dense, wet)	42		

Note: See Figure A-1 for explanation of symbols.

Log of Boring B-5 (continued)

GeoEngineers

Project: Northside Levee
Project Location: Aberdeen, Washington
Project Number: 0201-008-00

Figure A-5
Sheet 2 of 2

Tacoma: Date:7/30/15 Path:P:\0\0201008\GINT\020100800.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_STANDARD

Drilled: Start 4/30/2015 End 4/30/2015	Total Depth (ft): 71.5	Logged By: BTK Checked By: LJS	Driller: Subsurface Technologies	Drilling Method: Mud Rotary	
Surface Elevation (ft): 11.5 Vertical Datum: NAVD88		Hammer Data: Autohammer 140 (lbs) / 30 (in) Drop		Drilling Equipment: Diedrich D90	
Easting (X): 809490.017384 Northing (Y): 612898.112703		System Datum: NAD83 (feet)		Groundwater: Date Measured / Depth to Water (ft) / Elevation (ft)	
Notes:					

Elevation (feet)	Depth (feet)	Interval Recovered (in)	Blows/foot	Collected Sample: Sample Name / Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content, %	Dry Density, (pcf)	REMARKS
10	0						AC	4 inches asphalt concrete			
							SM	Gray silty fine to coarse sand with gravel (dense, wet)			
		7	31	1 SA					18		%F=16
5	5	9	7	2 MC			ML	Gray silt with occasional gravel and organic matter (wood chunks and log) (medium stiff to stiff, wet)	54		Significant wood shards in cuttings from approximately 6 to 18 feet
											No Shelby sample at 8 feet due to wood chunks
0	10	6	2	3 MC				Becomes soft and moist to wet	52		
	15	9	2	4 MC					67		
-5											No Shelby sample at 18 feet due to wood chunks in cuttings
	20	18	2	5 AL			MH	Gray elastic silt with occasional sand and organic matter (grass) (soft, moist to wet)	56		AL (LL=66; PI=20)
-10											
	25	18	2	6 MC				Laminated to stratified with layers of fine sand	57		
-15		6	P	7 MC			SP-SM	Gray fine to medium sand with silt	39		
	30	12	20	8 MC 9 MC			WD	Logs and wood debris	26 173		
-20							ML	Gray silt with layers of fine to coarse sand 0.5 to 4 inches thick (medium stiff to stiff, moist to wet)			
	35										

Note: See Figure A-1 for explanation of symbols.

Log of Boring B-7

GeoEngineers

Project: Northside Levee
Project Location: Aberdeen, Washington
Project Number: 0201-008-00

Figure A-6
Sheet 1 of 2

Tacoma: Date:7/30/15 Path:P:\0\0201008\GINT\020100800.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_STANDARD

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Blows/foot	Collected Sample: Sample Name Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content, %	Dry Density, (pcf)	REMARKS
-25	35	16	7	10 MC					32		
							MH	Gray elastic silt with occasional organic matter (grass) (soft to medium soft, moist to wet)			
-30	40	18	3	11 AL					60		AL (LL=61; PI=20)
		24	P	12 MC					39		
							SP-SM	Gray fine to medium sand with silt (medium dense to dense, wet)			
-35	45	17	20	13 MC					29		
							ML	Gray silt (medium stiff, moist)			
-40	50	18	5	14 AL					47		AL (LL=46; PI=10)
		1	P	15 MC					42		
-45	55										
		18	8	16 AL			ML	Gray silt with sand, organic matter (grass) and occasional seashells (stiff, moist to wet)	48		AL (LL=45; PI=13)
-50	60	18	9	17 AL 18 %F			ML	Gray sandy silt with occasional seashells and organic matter (stiff, moist to wet)	48 44		Top half of sample very soft to touch AL (LL=48; PI=8) %F=57
-55	65	18	8	19 MC					53		
		0	P	20							
-60	70	18	4	21 MC				Grades to medium stiff	37		

Note: See Figure A-1 for explanation of symbols.

Log of Boring B-7 (continued)

GeoEngineers

Project: Northside Levee
Project Location: Aberdeen, Washington
Project Number: 0201-008-00

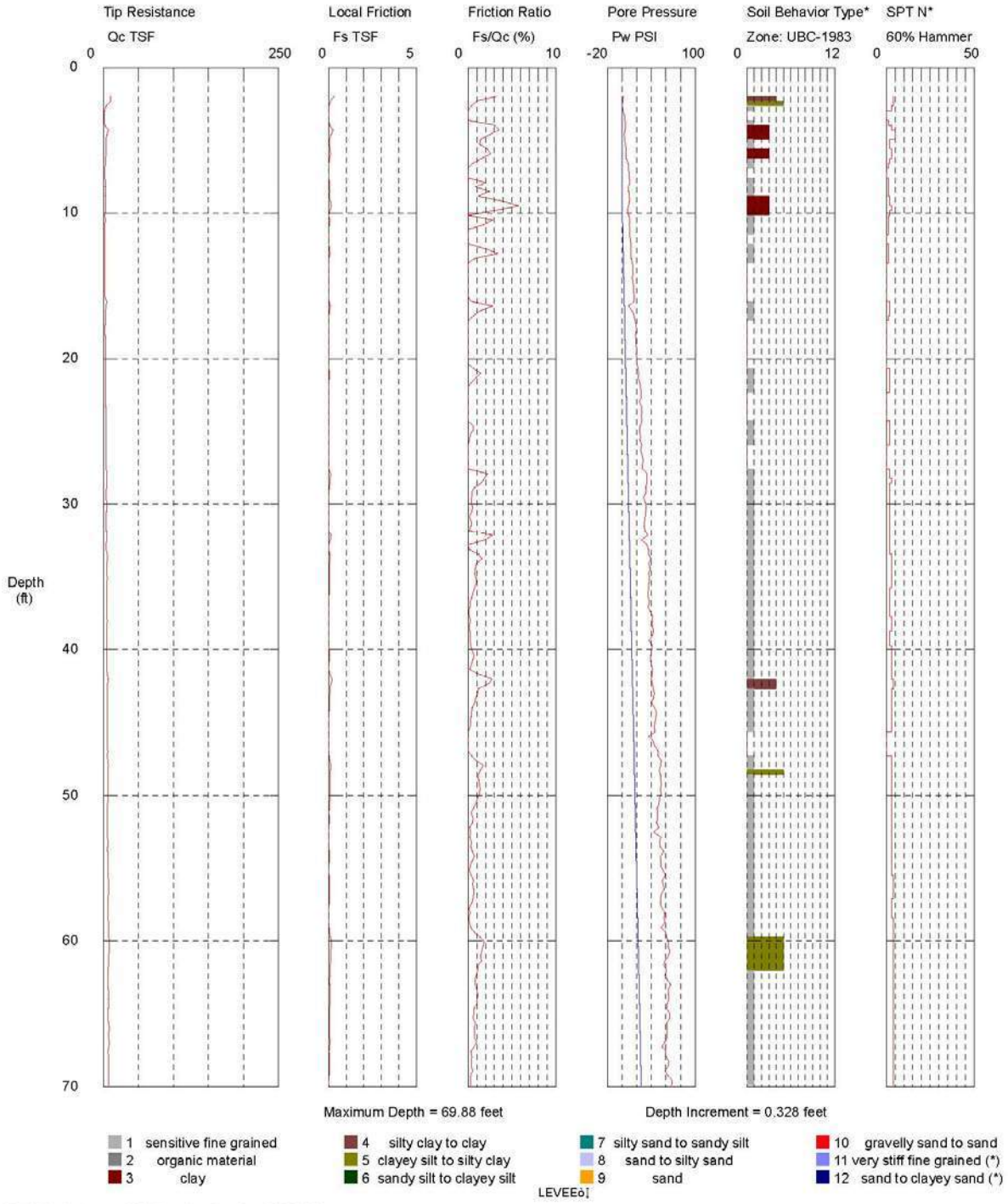
Figure A-6
Sheet 2 of 2

Tacoma: Date:7/30/15 Path:P:\0\0201008\GINT\020100800.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_STANDARD

Subsurface Technologies

Operator: SAM
Sounding: CPT-2
Cone Used: DDG1296

CPT Date/Time: 4/27/2015 3:01:44 PM
Location: ABERDEEN N. LEVEE
Job Number: 201-008-00



*Soil behavior type and SPT based on data from UBC-1983

CPT-2

Northside Levee
Aberdeen, Washington

GeoEngineers

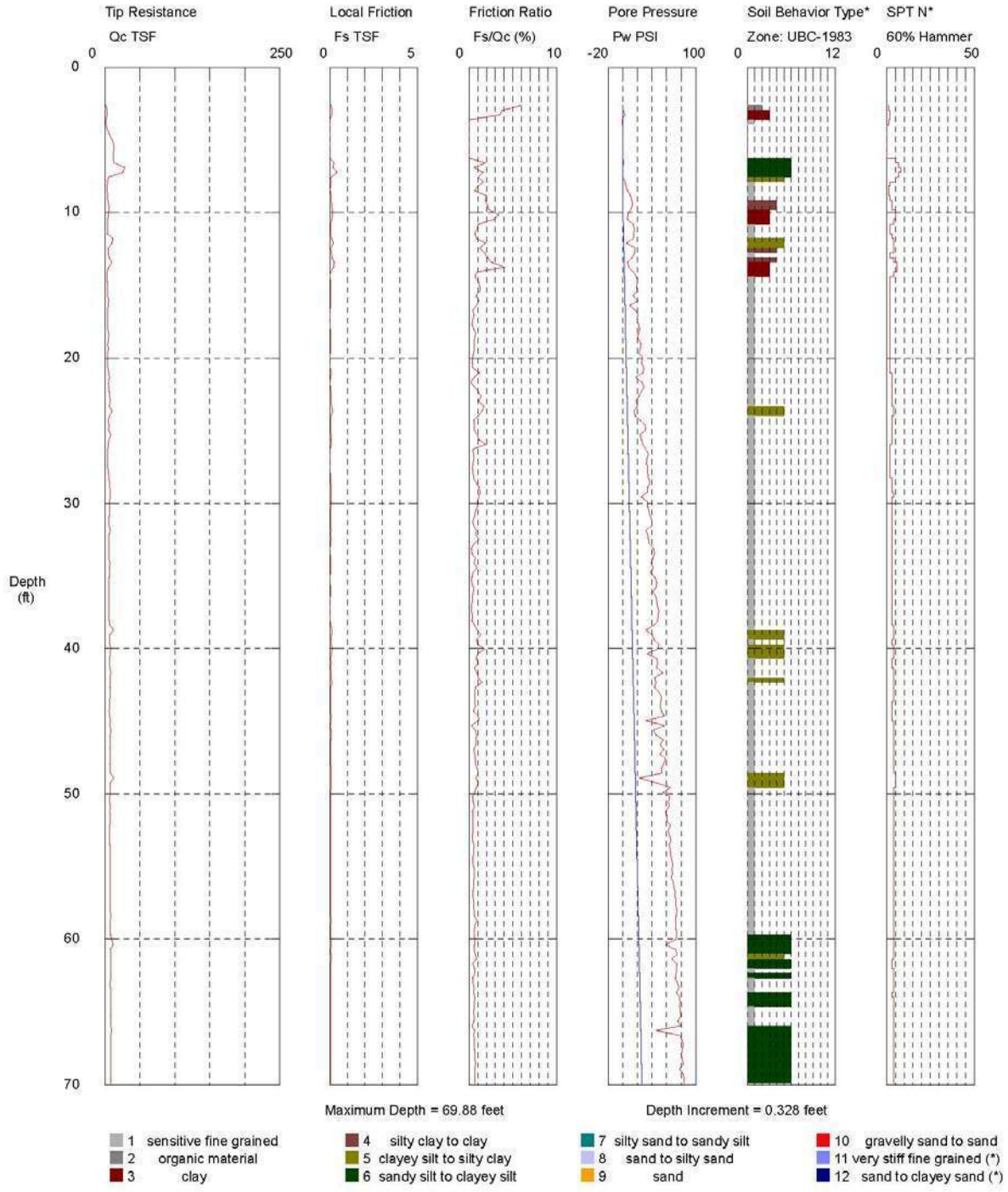
Figure A-11

0201-008-00 Date Exported: 06/10/15

Subsurface Technologies

Operator: SAM
Sounding: CPT-3
Cone Used: DDG1296

CPT Date/Time: 4/27/2015 4:55:35 PM
Location: ABERDEEN N. LEVEE
Job Number: 201-008-00



*Soil behavior type and SPT based on data from UBC-1983

CPT-3

Northside Levee
Aberdeen, Washington

GeoEngineers

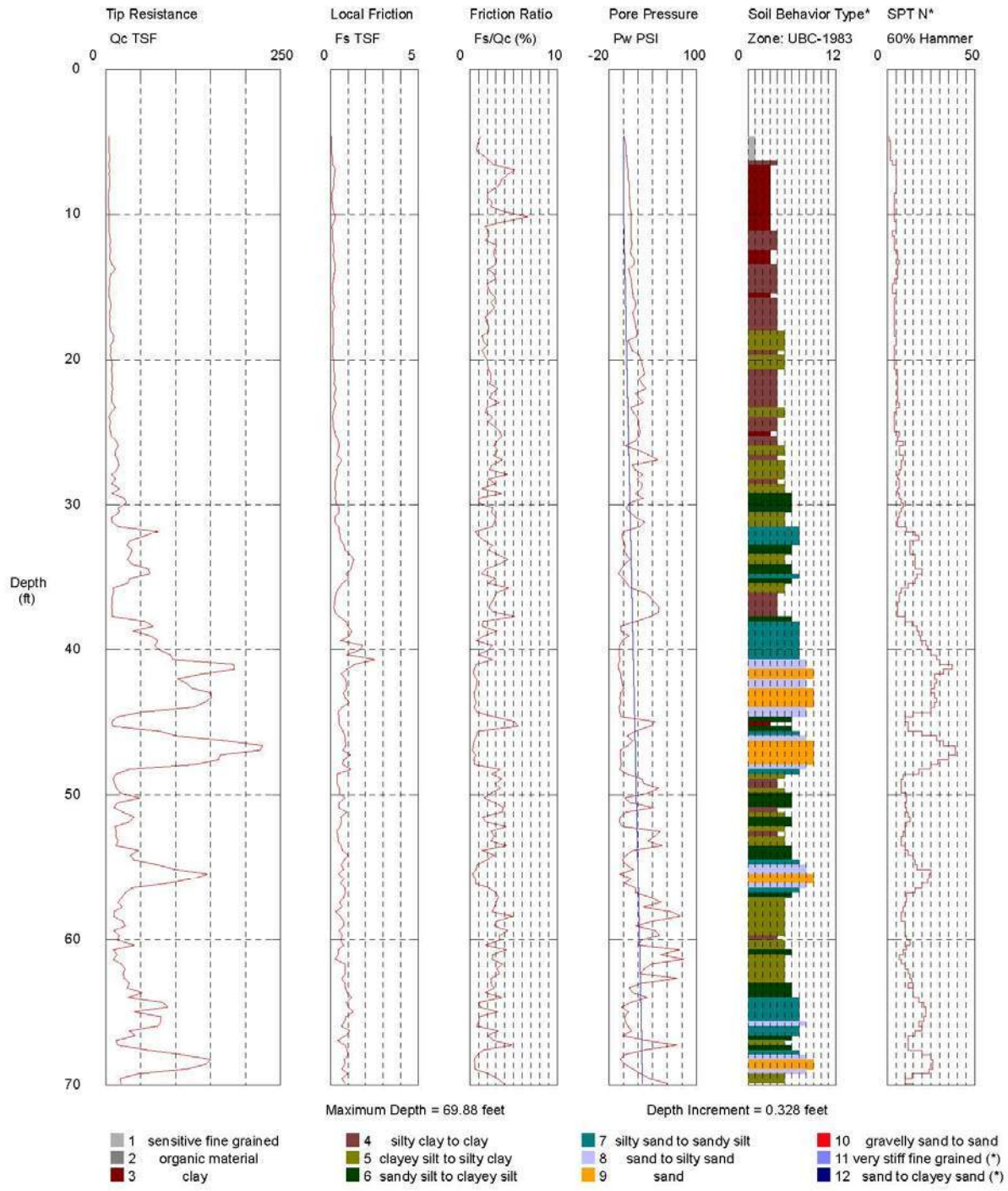
Figure A-12

0201-008-00 Date Exported: 06/10/15

Subsurface Technologies

Operator: SAM
Sounding: CPT-4
Cone Used: DDG1296

CPT Date/Time: 4/29/2015 12:45:52 PM
Location: ABERDEEN N. LEVEE
Job Number: 201-008-00



*Soil behavior type and SPT based on data from UBC-1983

CPT-4

Northside Levee
Aberdeen, Washington

GeoEngineers

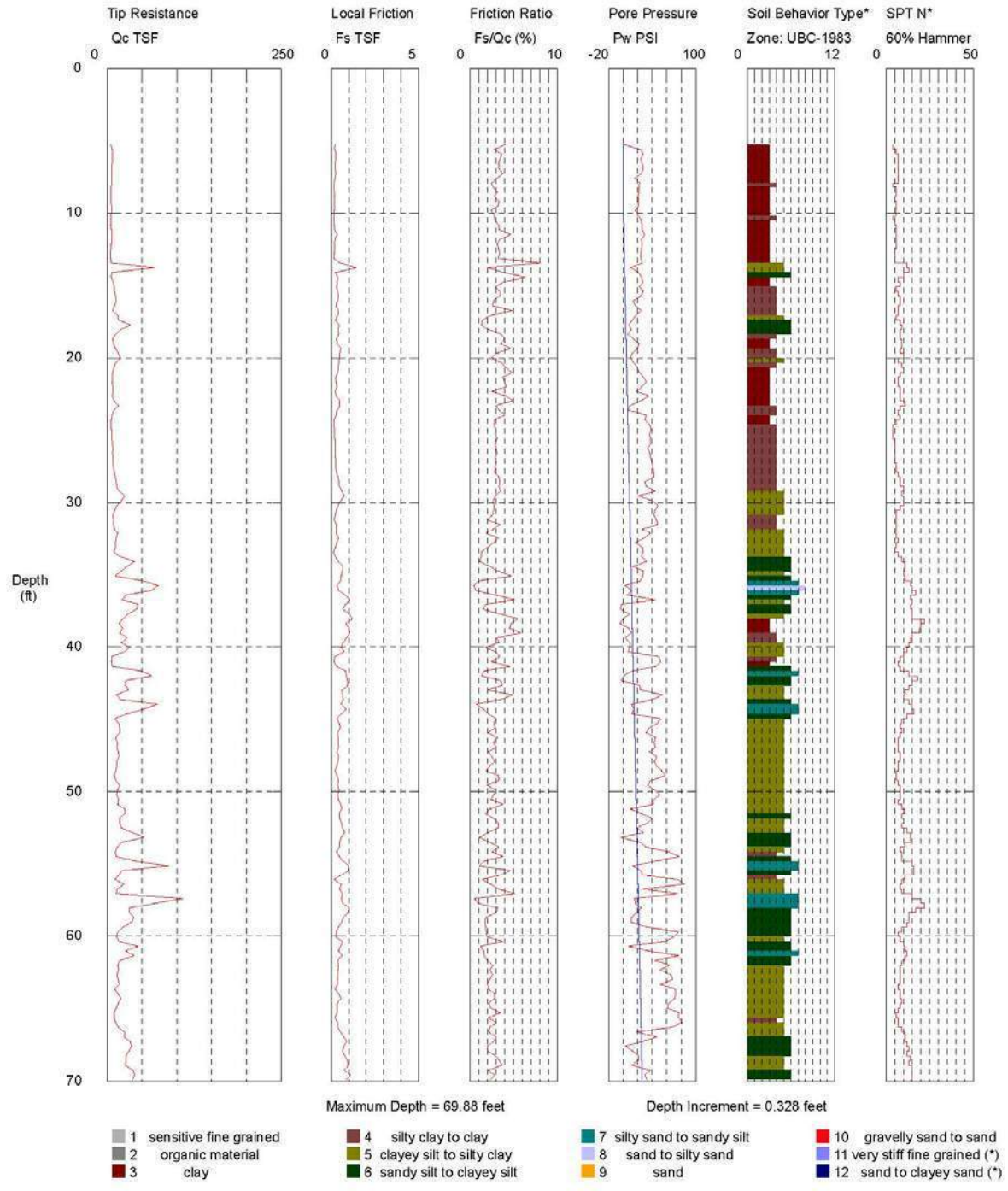
Figure A-13

0201-008-00 Date Exported: 06/10/15

Subsurface Technologies

Operator: SAM
Sounding: CPT-5
Cone Used: DDG1296

CPT Date/Time: 4/29/2015 11:22:25 AM
Location: ABERDEEN N. LEVEE
Job Number: 201-008-00



*Soil behavior type and SPT based on data from UBC-1983

CPT-5

Northside Levee
Aberdeen, Washington

GeoEngineers

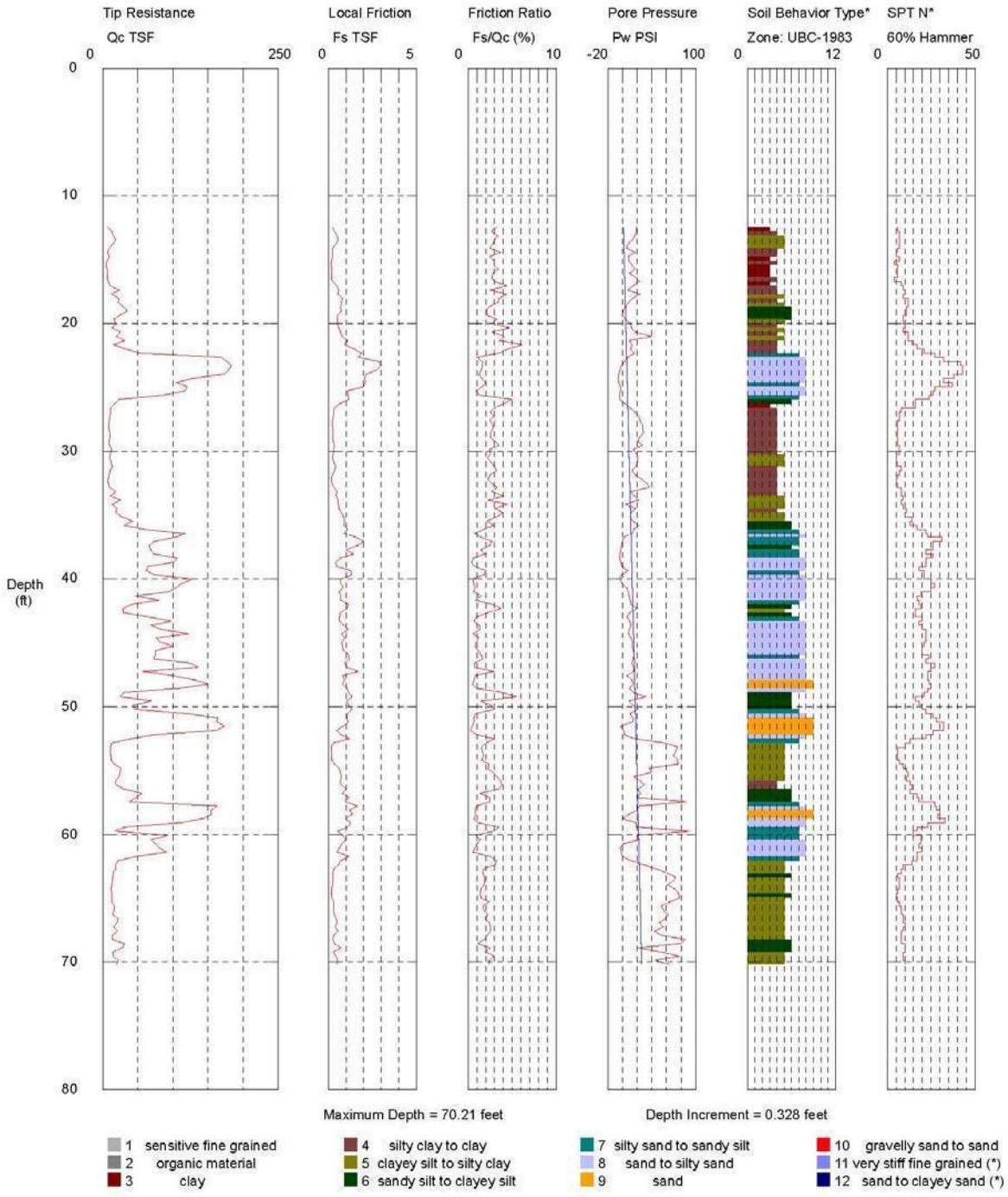
Figure A-14

0201-008-00 Date Exported: 06/10/15

Subsurface Technologies

Operator: SAM
Sounding: CPT-6A
Cone Used: DDG1296

CPT Date/Time: 5/29/2015 10:14:29 AM
Location: ABERDEEN N. LEVEE
Job Number: 0201-008-00



*Soil behavior type and SPT based on data from UBC-1983

CPT-6

Northside Levee
Aberdeen, Washington

GeoEngineers

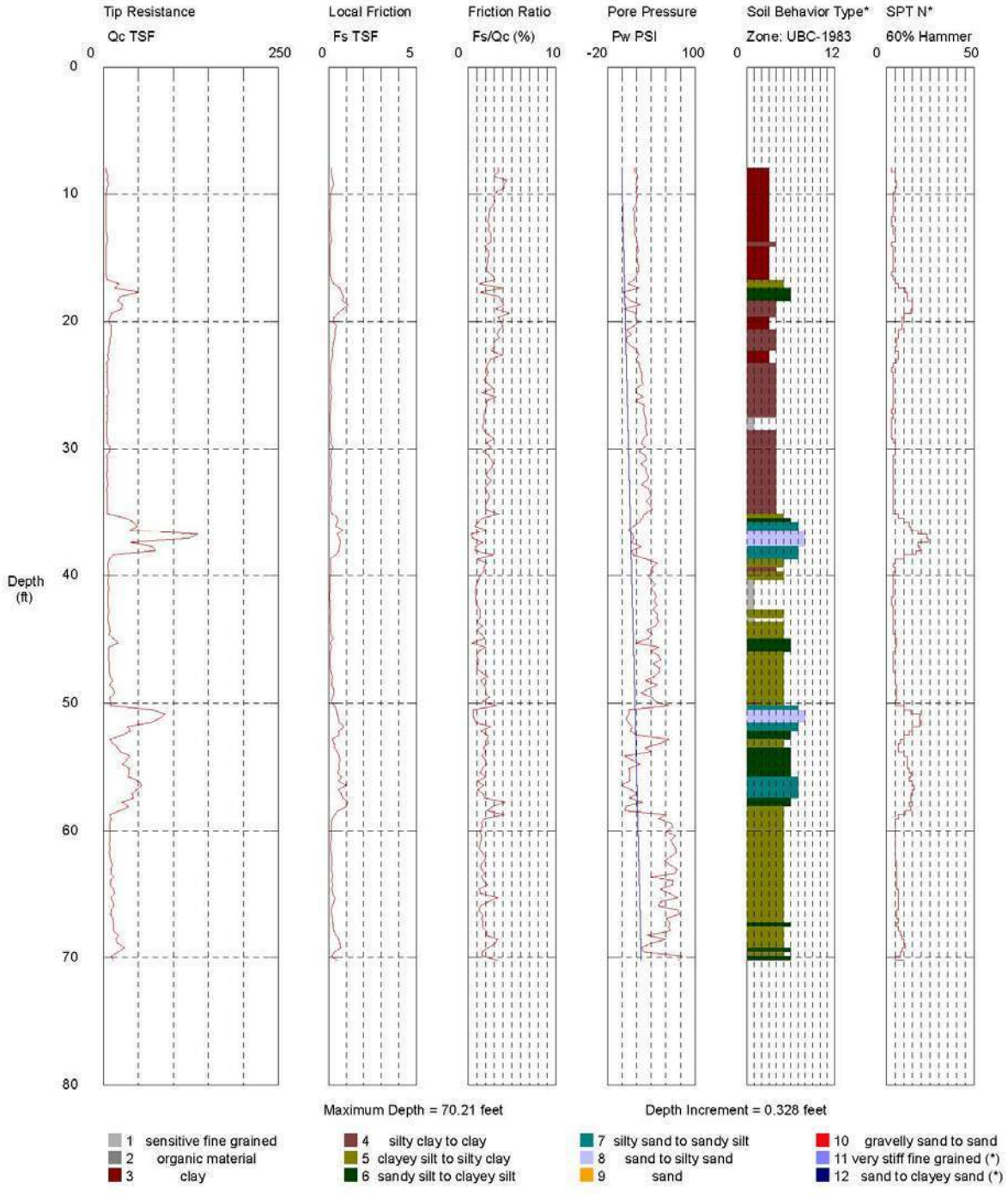
Figure A-15

0201-008-00 Date Exported: 06/10/15

Subsurface Technologies

Operator: SAM
Sounding: CPT-7
Cone Used: DDG1296

CPT Date/Time: 5/28/2015 1:18:42 PM
Location: ABERDEEN N. LEVEE
Job Number: 0201-008-00



*Soil behavior type and SPT based on data from UBC-1983

CPT-7

Northside Levee
Aberdeen, Washington

GeoEngineers

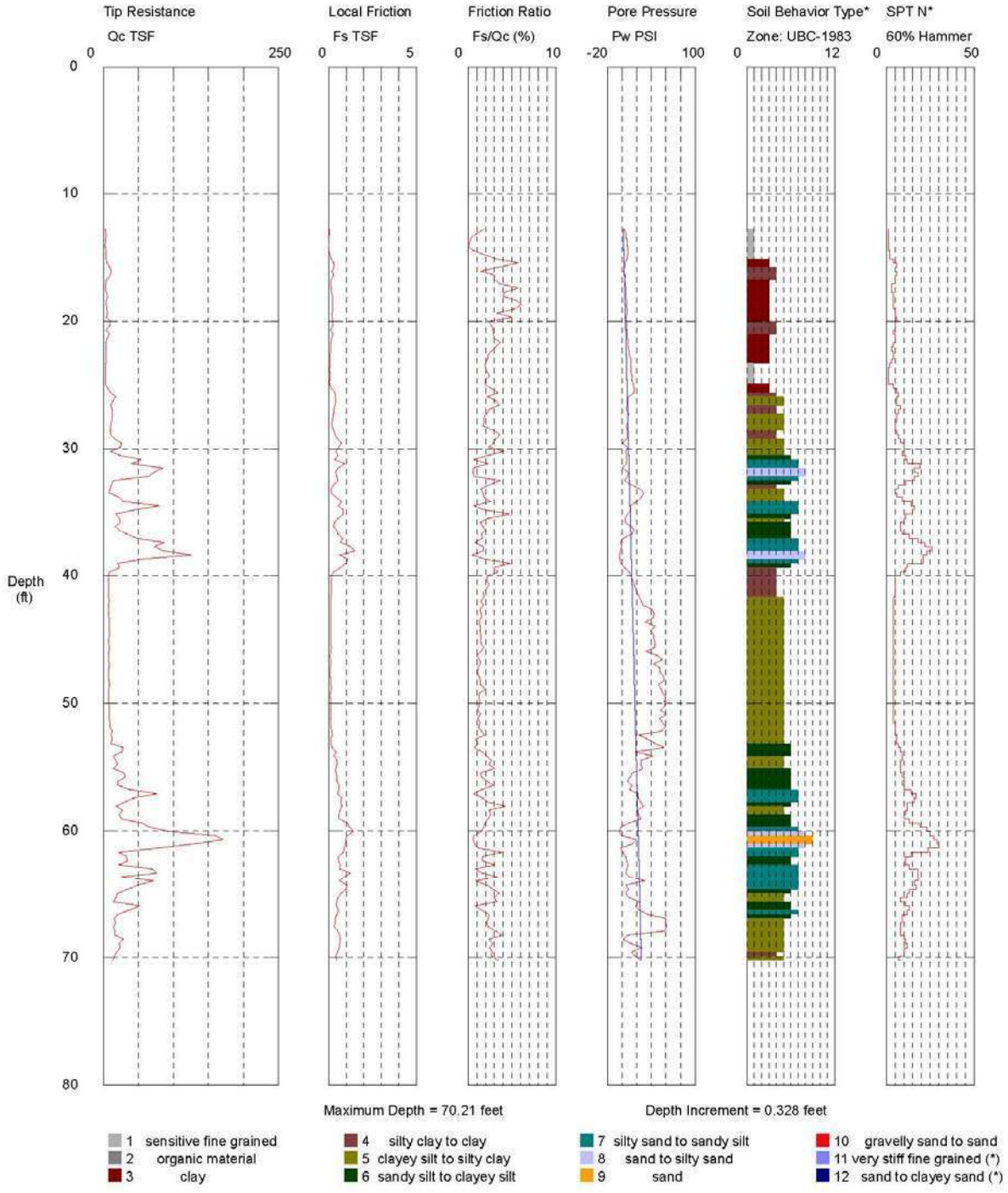
Figure A-16

0201-008-00 Date Exported: 06/10/15

Subsurface Technologies

Operator: SAM
Sounding: CPT-B4
Cone Used: DDG1296

CPT Date/Time: 4/29/2015 3:27:07 PM
Location: ABERDEEN N. LEVEE
Job Number: 201-008-00



*Soil behavior type and SPT based on data from UBC-1983

CPT-8

Northside Levee
Aberdeen, Washington

GeoEngineers

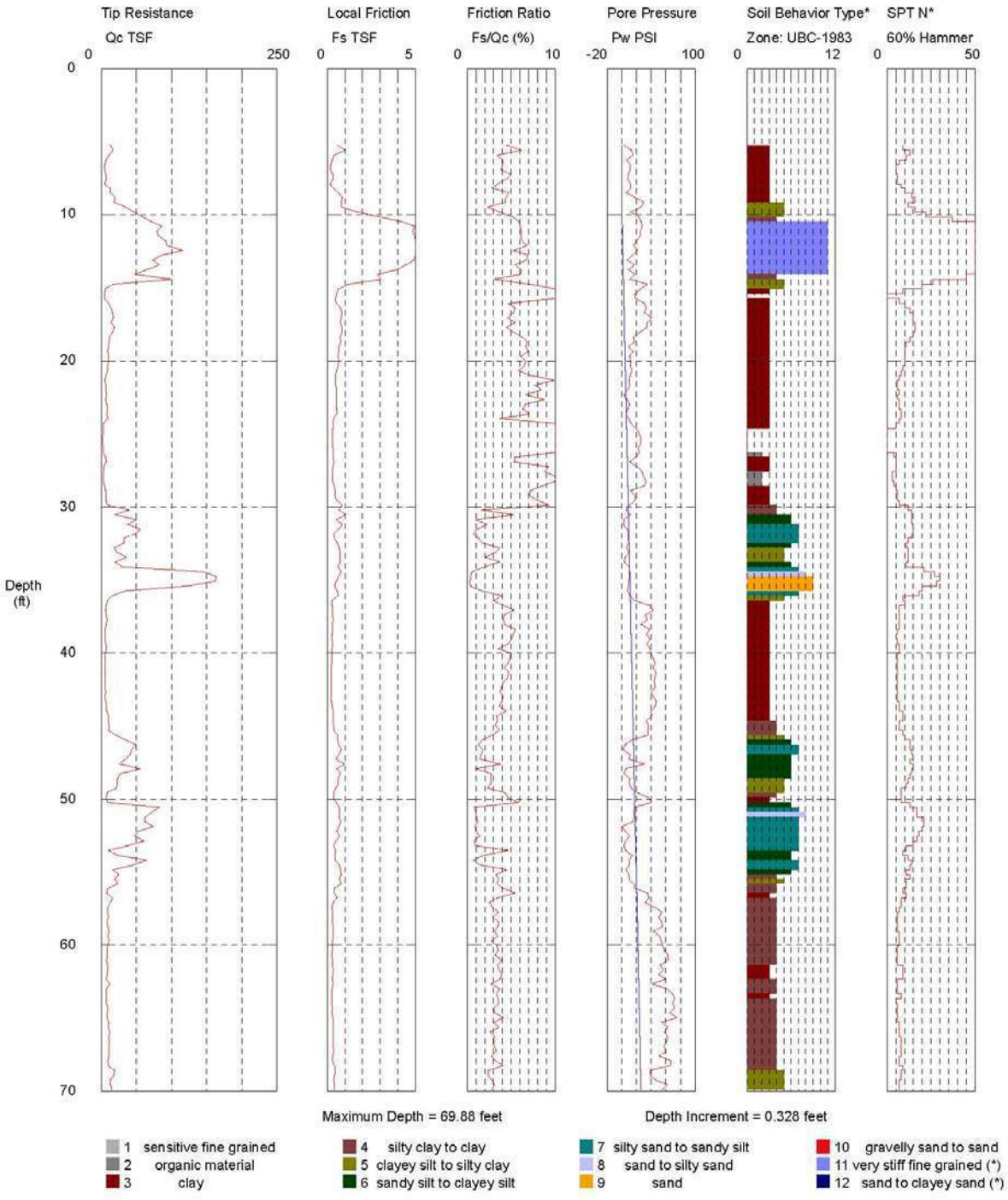
Figure A-17

0201-008-00 Date Exported: 06/10/15

Subsurface Technologies

Operator: SAM
Sounding: CPT-9
Cone Used: DDG1296

CPT Date/Time: 4/28/2015 2:29:40 PM
Location: ABERDEEN N. LEVEE
Job Number: 201-008-00



*Soil behavior type and SPT based on data from UBC-1983

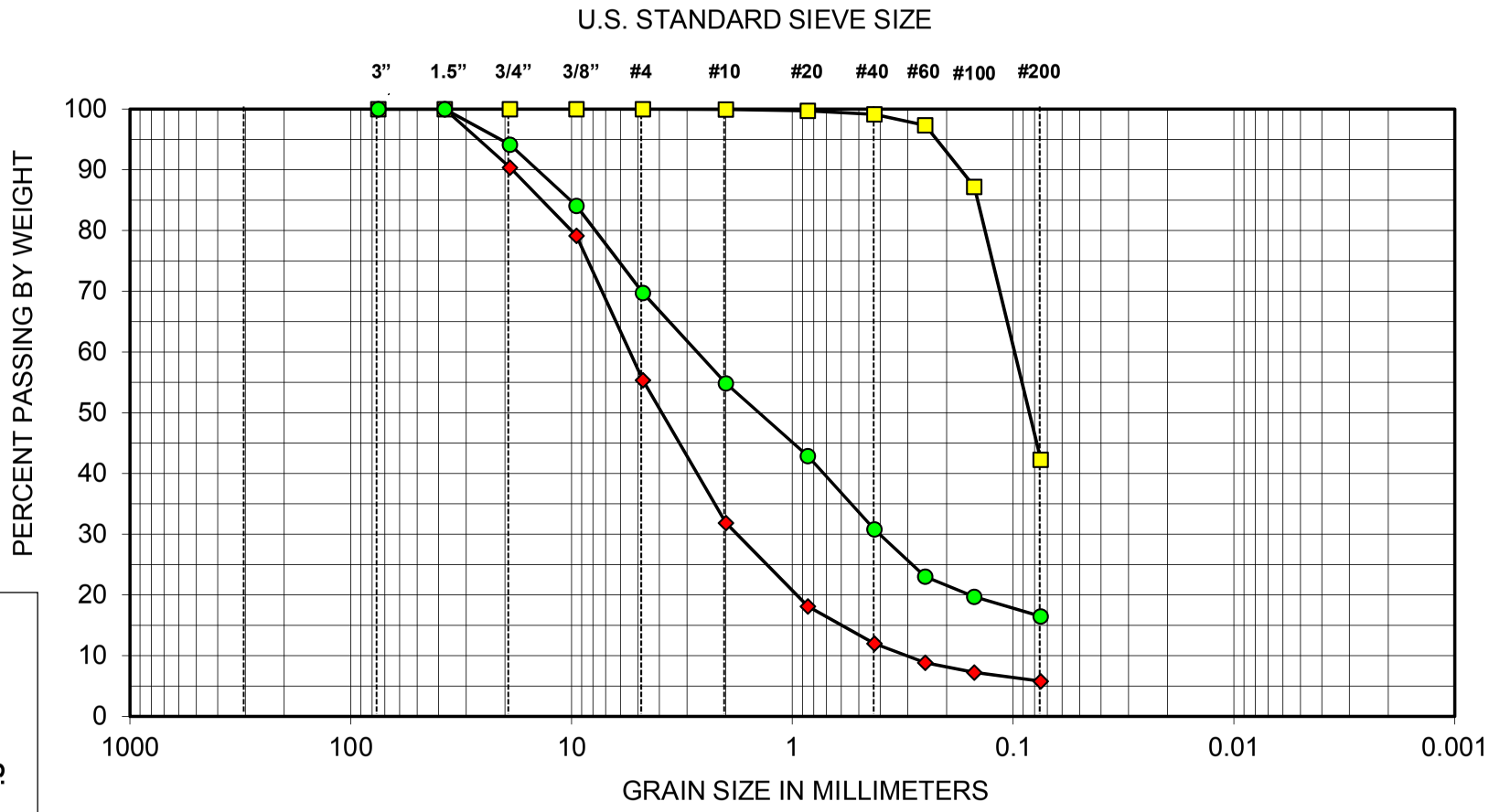
CPT-9

Northside Levee
Aberdeen, Washington

GeoEngineers

Figure A-18

0201-008-00 Date Exported: 06/10/15



BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	EXPLORATION NUMBER	DEPTH (ft)	SOIL CLASSIFICATION
◆	B-1	2.5	Well-graded sand with silt and gravel (SW-SM)
□	B-8	20	Silty sand (SM)
○	B-7	2.5	Silty sand with gravel (SM)

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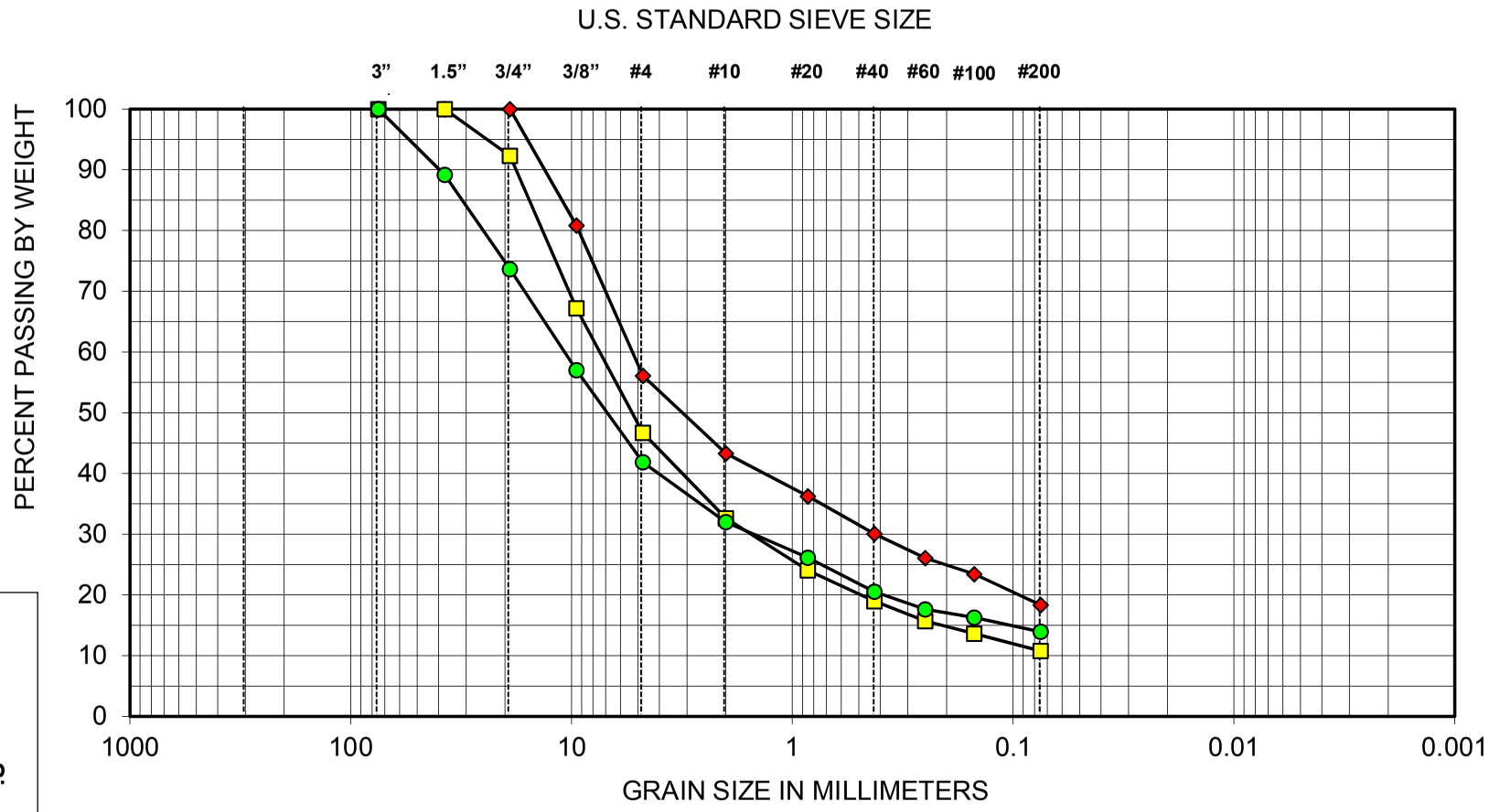
The grain size analysis results were obtained in general accordance with ASTM D 6913.

GeoEngineers

Northside Levee
Aberdeen, Washington

Sieve Analysis Results

Figure A-20



BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	EXPLORATION NUMBER	DEPTH (ft)	SOIL CLASSIFICATION
◆	B-5	2.5	Silty gravel with sand (GM)
□	CPT-6	1.5	Poorly graded gravel with silt and sand (GP-GM)
○	CPT-7	2.5	Silty gravel with sand (GM)

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The grain size analysis results were obtained in general accordance with ASTM D 6913.

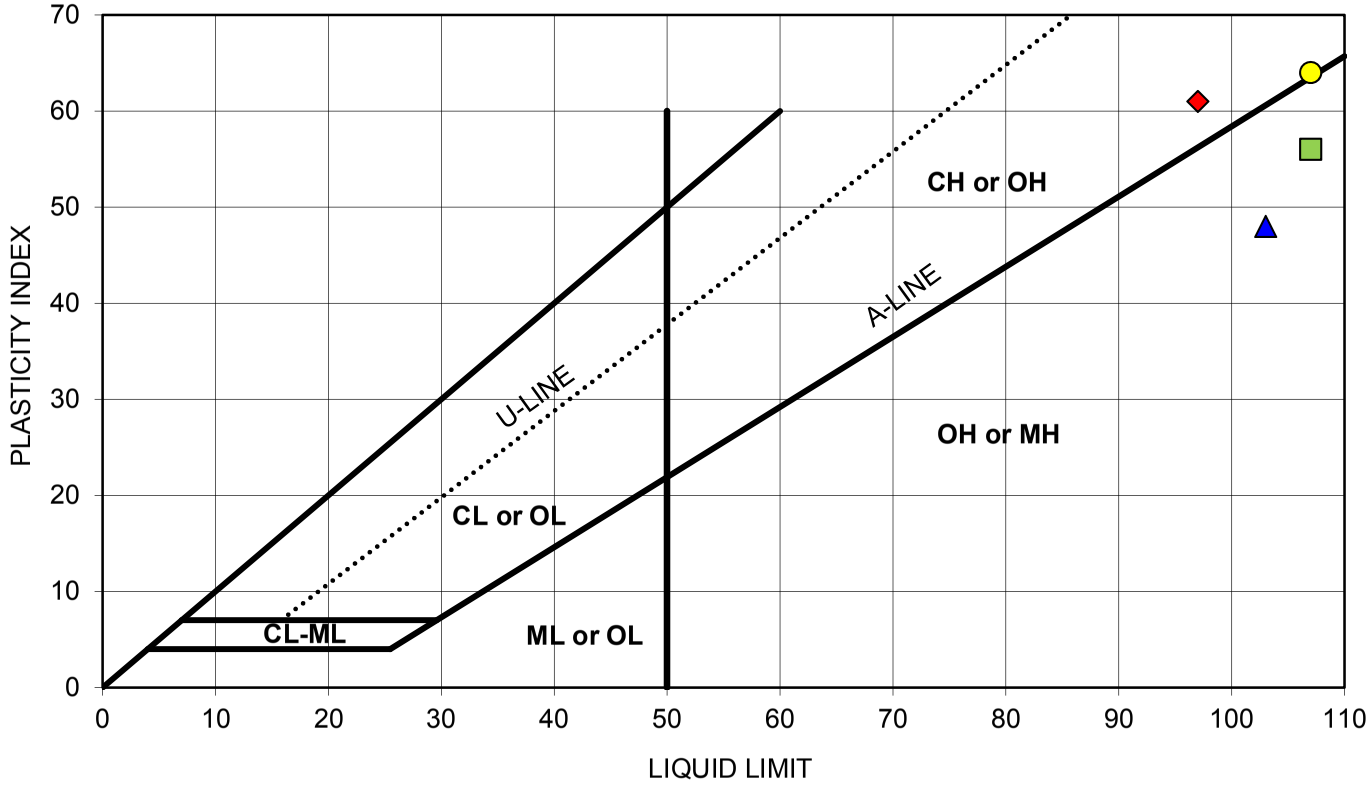
GeoEngineers

Northside Levee
Aberdeen, Washington

Sieve Analysis Results

Figure A-21

PLASTICITY CHART



SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH (ft)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	SOIL DESCRIPTION
◆	B-1	20	87	97	61	Fat Clay (CH)
■	B-1	35	112	107	56	Organic Silt (OH)
▲	B-2	5	92	103	48	Organic Silt (OH)
●	B-2	5.4	67	107	64	Organic Clay (OH)

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The liquid limit and plasticity index were obtained in general accordance with ASTM D 4318.

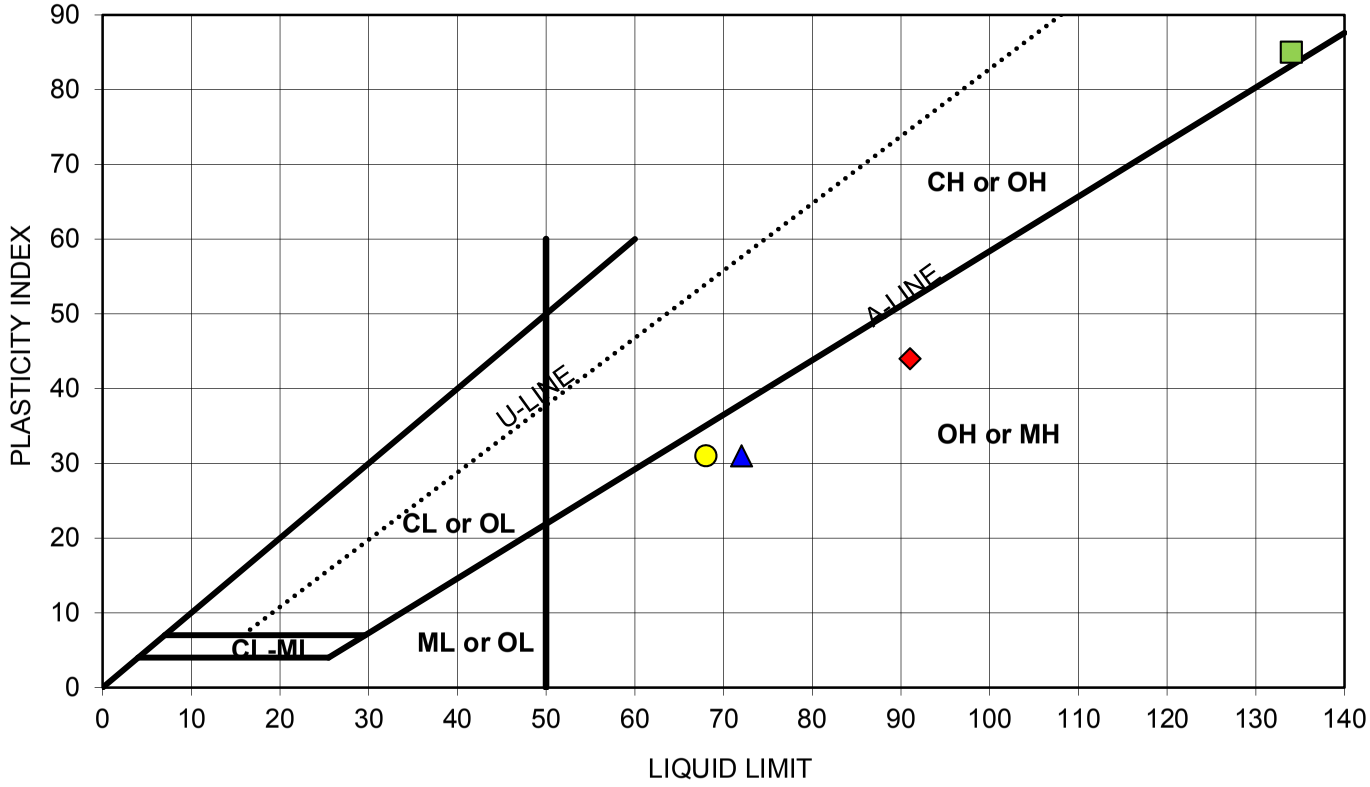
Atterberg Limits Test Results

Northside Levee
Aberdeen, Washington

GeoEngineers

Figure A-22

PLASTICITY CHART



SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH (ft)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	SOIL DESCRIPTION
◆	B-2	15	95	91	44	Elastic Silt (MH)
■	B-3alt	5	116	134	85	Organic Clay (OH)
▲	B-3alt	15	85	72	31	Elastic Silt with Organic Matter (MH)
●	B-3alt	25	73	68	31	Elastic Silt (MH)

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The liquid limit and plasticity index were obtained in general accordance with ASTM D 4318.

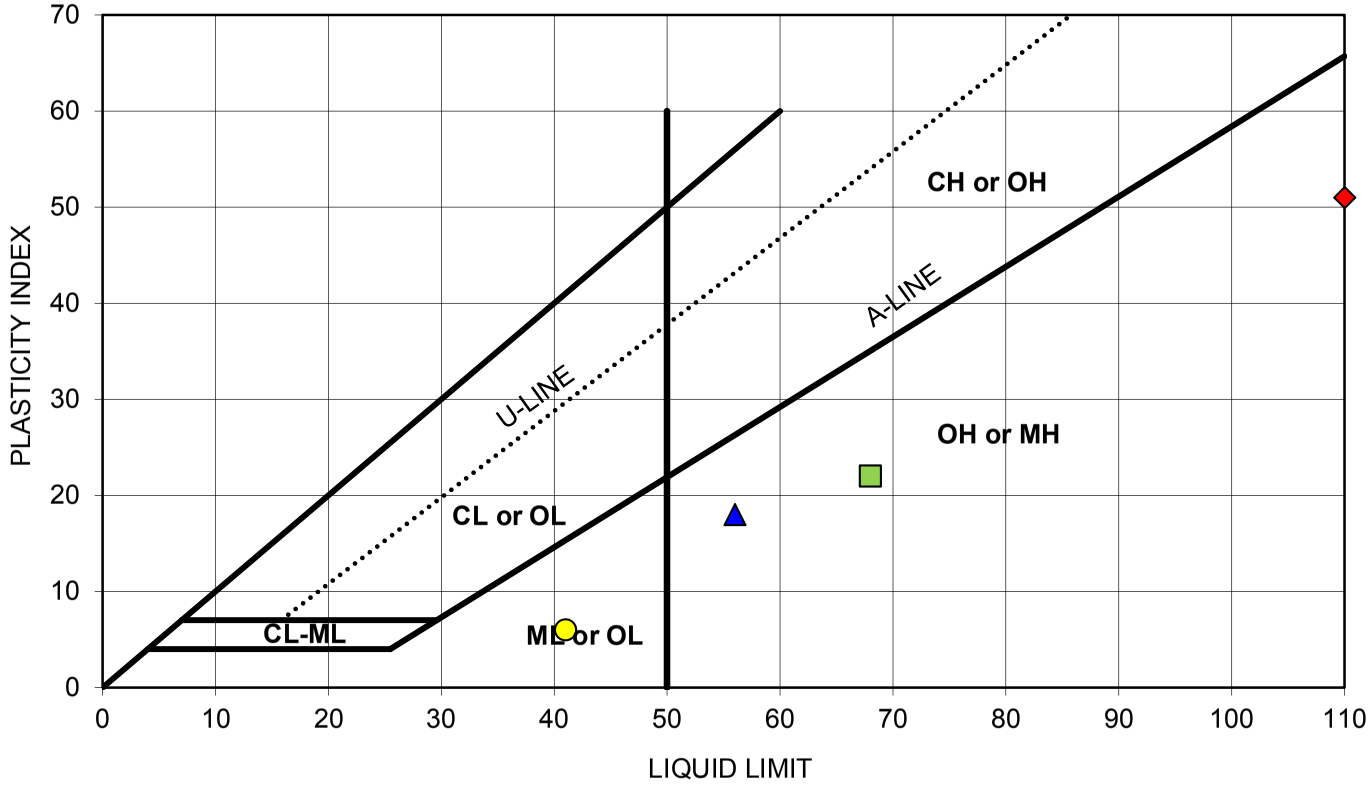
Atterberg Limits Test Results

Northside Levee
Aberdeen, Washington

GeoEngineers

Figure A-23

PLASTICITY CHART



SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH (ft)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	SOIL DESCRIPTION
◆	B-5	10	82	110	51	Organic Silt (OH)
■	B-5	20	59	68	22	Elastic Silt (MH)
▲	B-5	40	62	56	18	Elastic Silt (MH)
●	B-5	45	44	41	6	Silt (ML)

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The liquid limit and plasticity index were obtained in general accordance with ASTM D 4318.

Atterberg Limits Test Results

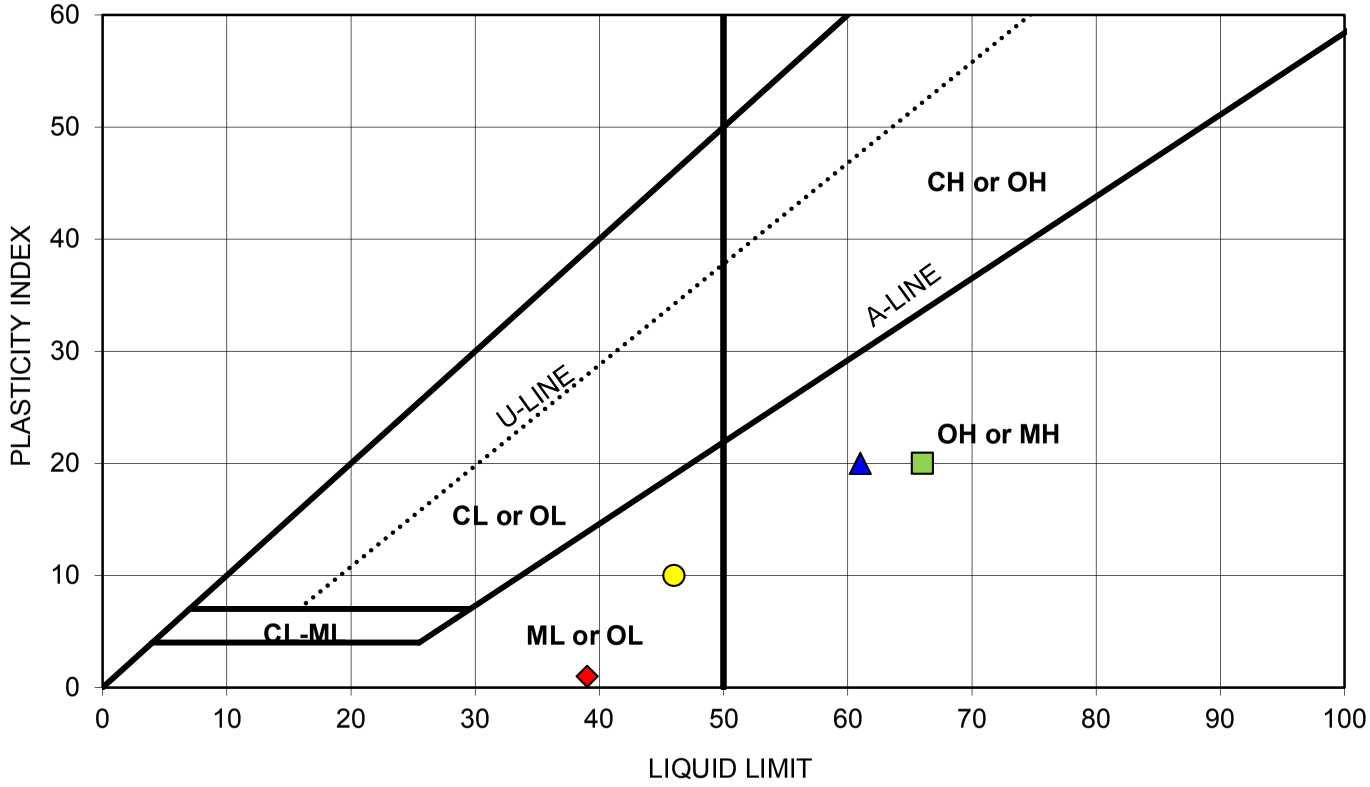
Northside Levee
Aberdeen, Washington

GeoEngineers

Figure A-24

0201-008-00 Date Exported: 6/11/2015

PLASTICITY CHART



SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH (ft)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	SOIL DESCRIPTION
◆	B-5	60	50	39	1	Silt (ML)
■	B-7	20	56	66	20	Elastic Silt (MH)
▲	B-7	40	60	61	20	Elastic Silt (MH)
●	B-7	50	47	46	10	Silt (ML)

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The liquid limit and plasticity index were obtained in general accordance with ASTM D 4318.

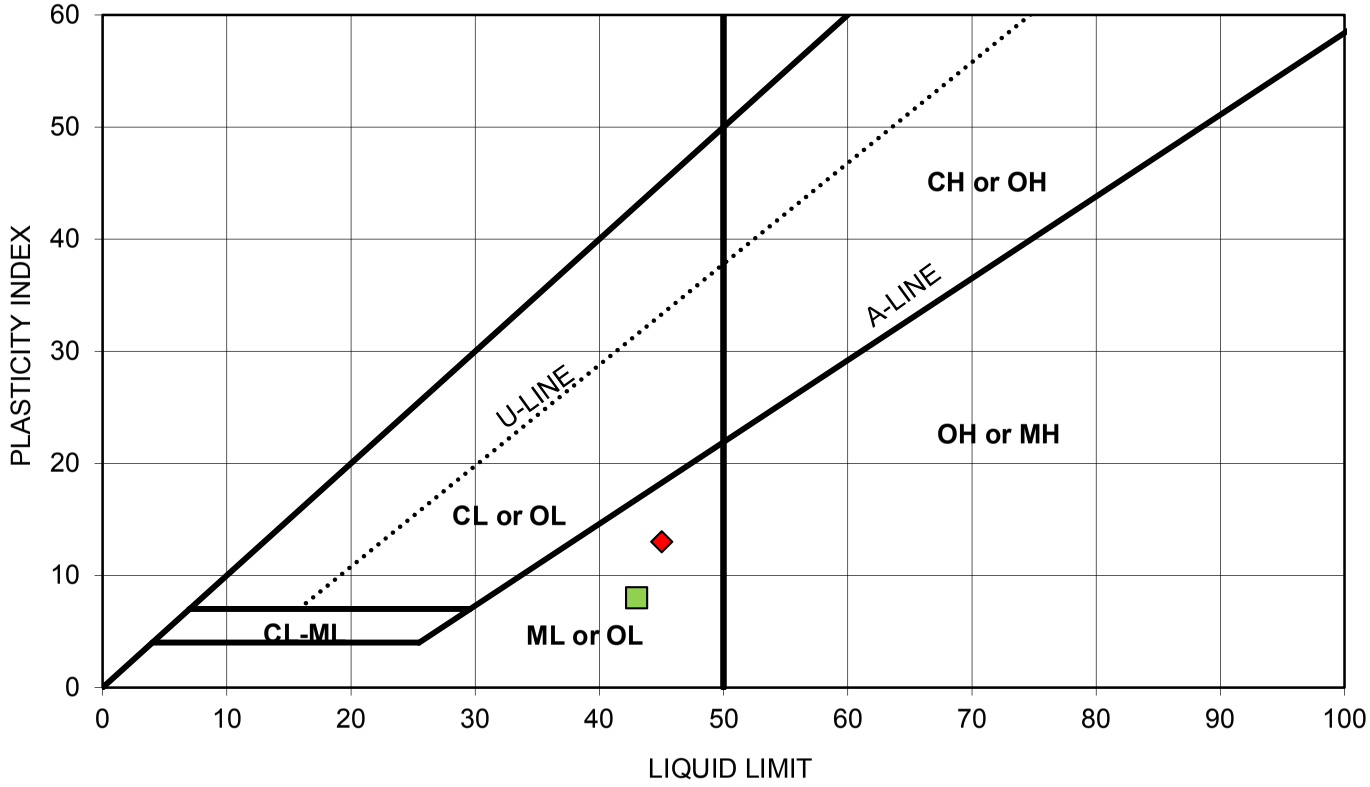
Atterberg Limits Test Results

Northside Levee
Aberdeen, Washington

GeoEngineers

Figure A-25

PLASTICITY CHART



SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH (ft)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	SOIL DESCRIPTION
◆	B-7	57	48	45	13	Silt with Sand (ML)
■	B-7	60	48	43	8	Silt with Sand (ML)

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The liquid limit and plasticity index were obtained in general accordance with ASTM D 4318.

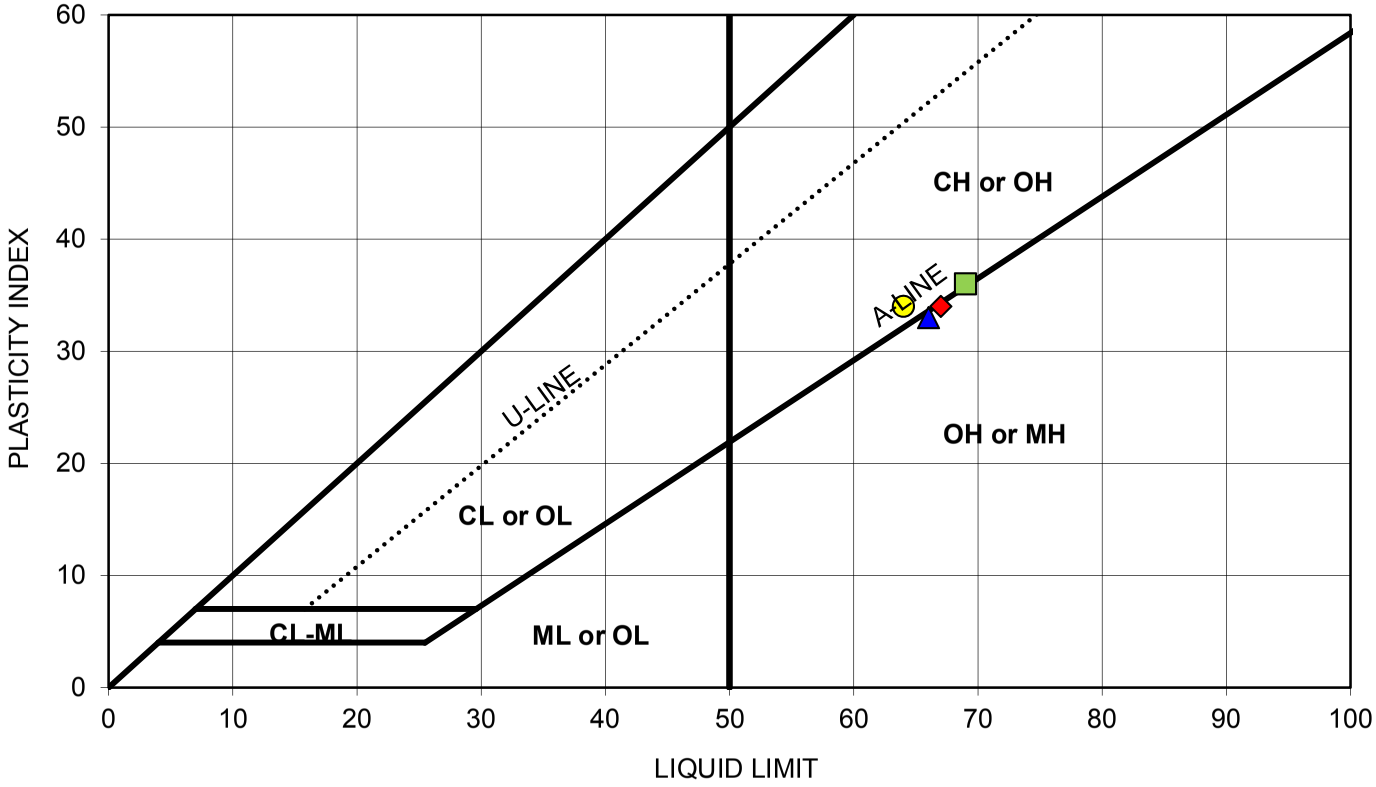
Atterberg Limits Test Results

Northside Levee
Aberdeen, Washington

GeoEngineers

Figure A-26

PLASTICITY CHART



SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH (ft)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	SOIL DESCRIPTION
◆	B-8	5	65	67	34	Elastic Silt with Sand and Organic Matter (MH)
■	B-8	10	74	69	36	Fat Clay with Sand and Organic Matter (CH)
▲	B-8	15	66	66	33	Elastic Silt with Sand (MH)
●	B-8	25	62	64	34	Fat Clay (CH)

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The liquid limit and plasticity index were obtained in general accordance with ASTM D 4318.

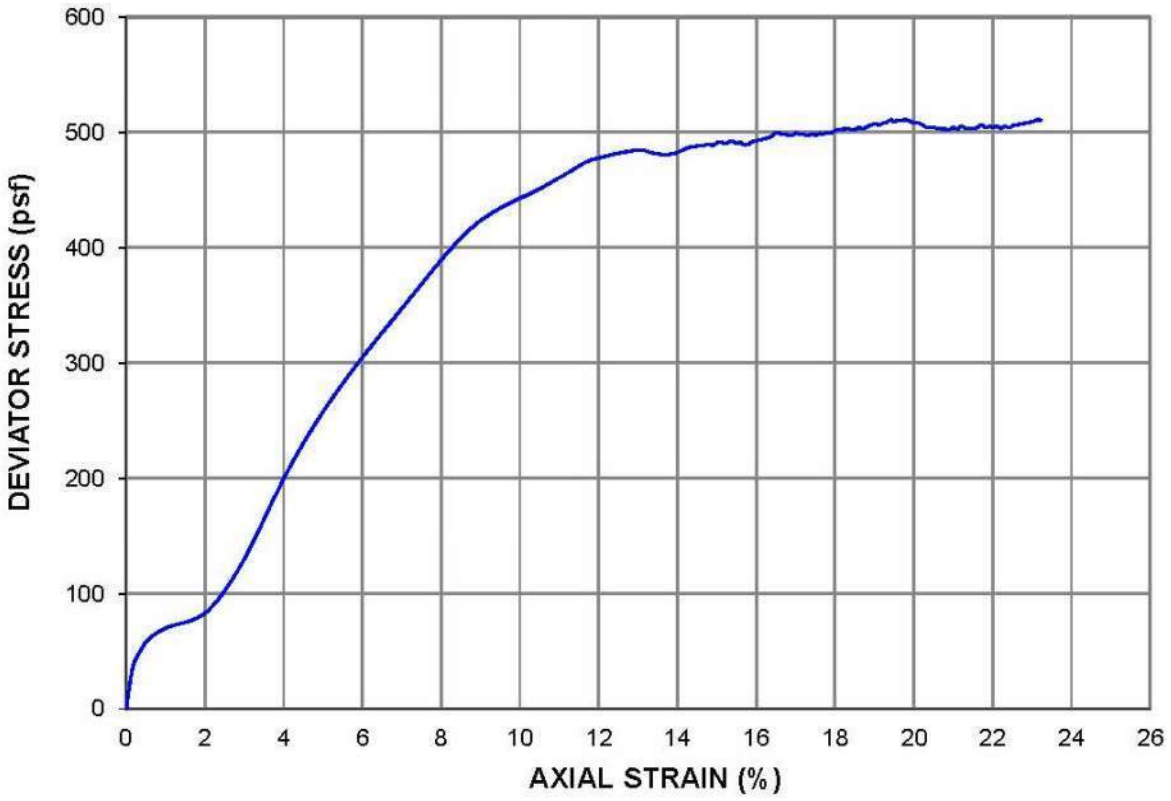
Atterberg Limits Test Results

Northside Levee
Aberdeen, Washington

GeoEngineers

Figure A-27

0201-008-00 Date Exported: 6/11/2015



SPECIMEN AT FAILURE	
	DESCRIPTION : Peat with tace silt (Pt)
	SPECIMEN TYPE: Shelby tube
	APPROXIMATE AXIAL STRAIN RATE: 1% / min
	Su: 256 psf
	AXIAL STRAIN AT FAILURE: 19.8%
	CLASSIFICATION: n/a
	LL: n/a | PL: n/a | PI: n/a
	INITIAL: HEIGHT : 5.47 in
	INITIAL: EFFECTIVE DIAMETER: 2.87 in
	INITIAL: HEIGHT/DIAMETER: 1.9
	INITIAL: WATER CONTENT: 162.1 %
	INITIAL: DRY DENSITY: 28.1 pcf
	INITIAL: VOID RATIO: 4.89
	INITIAL: SATURATION: 100% (assumed)
	BORING ID : B-2 | SAMPLE NO.: 4
	DEPTH/ELEV. : 8 feet | DATE: 5/22/15
	TECH: SAS | CHECKED:
	REMARKS: Gs assumed 2.65; γ_{water} = 62.4pcf
	CELL PRESSURE= 5.6psi
	Best sample obtained, but slightly short of 2:1 H:D ratio

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc. Test results are applicable only to the specific sample on which they were performed, and should not be interpreted as representative of any other samples obtained at other times, depths or locations, or generated by separate operations or processes.

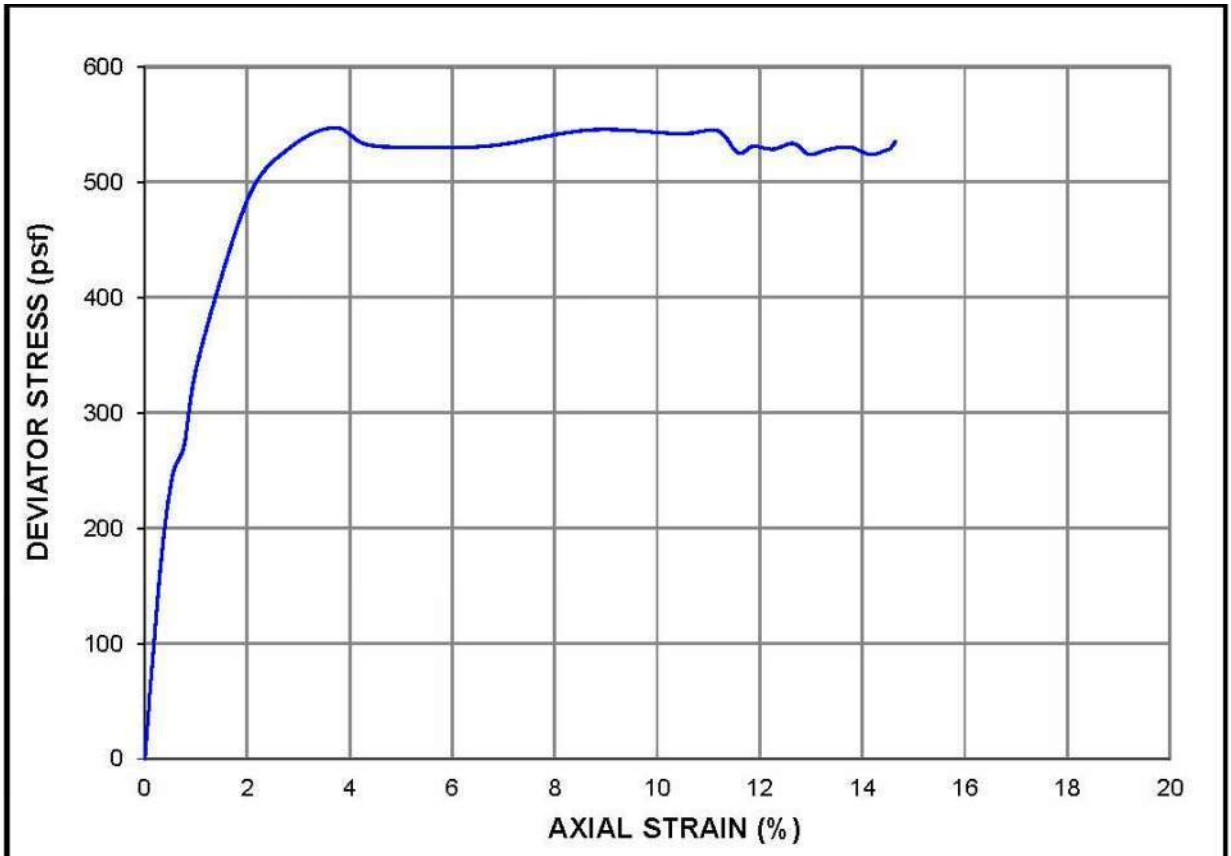
The consolidation test results were obtained in general accordance with ASTM D 2850.

UU Triaxial Compression Test Report

Northside Levee
Aberdeen, Washington

GeoEngineers

Figure A-28



SPECIMEN AT FAILURE	
	DESCRIPTION : Silt (ML)
	SPECIMEN TYPE: Shelby tube
	APPROXIMATE AXIAL STRAIN RATE: 1% / min
	Su: 275 psf
	AXIAL STRAIN AT FAILURE: 7.0%
	CLASSIFICATION: n/a
	LL: n/a | PL: n/a | PI: n/a
	INITIAL: HEIGHT : 6.06 in
	INITIAL: EFFECTIVE DIAMETER: 2.87 in
	INITIAL: HEIGHT/DIAMETER: 2
	INITIAL: WATER CONTENT: 29.9%
	INITIAL: DRY DENSITY: 75.0 pcf
	INITIAL: VOID RATIO: 1.2
	INITIAL: SATURATION: 100% (assumed)
	BORING ID : B-2 | SAMPLE NO.: 7
	DEPTH/ELEV. : 13 feet | DATE: 5/26/15
	TECH: SAS | CHECKED:
	REMARKS: Gs assumed 2.65; γ_{water} = 62.4pcf
	CELL PRESSURE=9.0 psi

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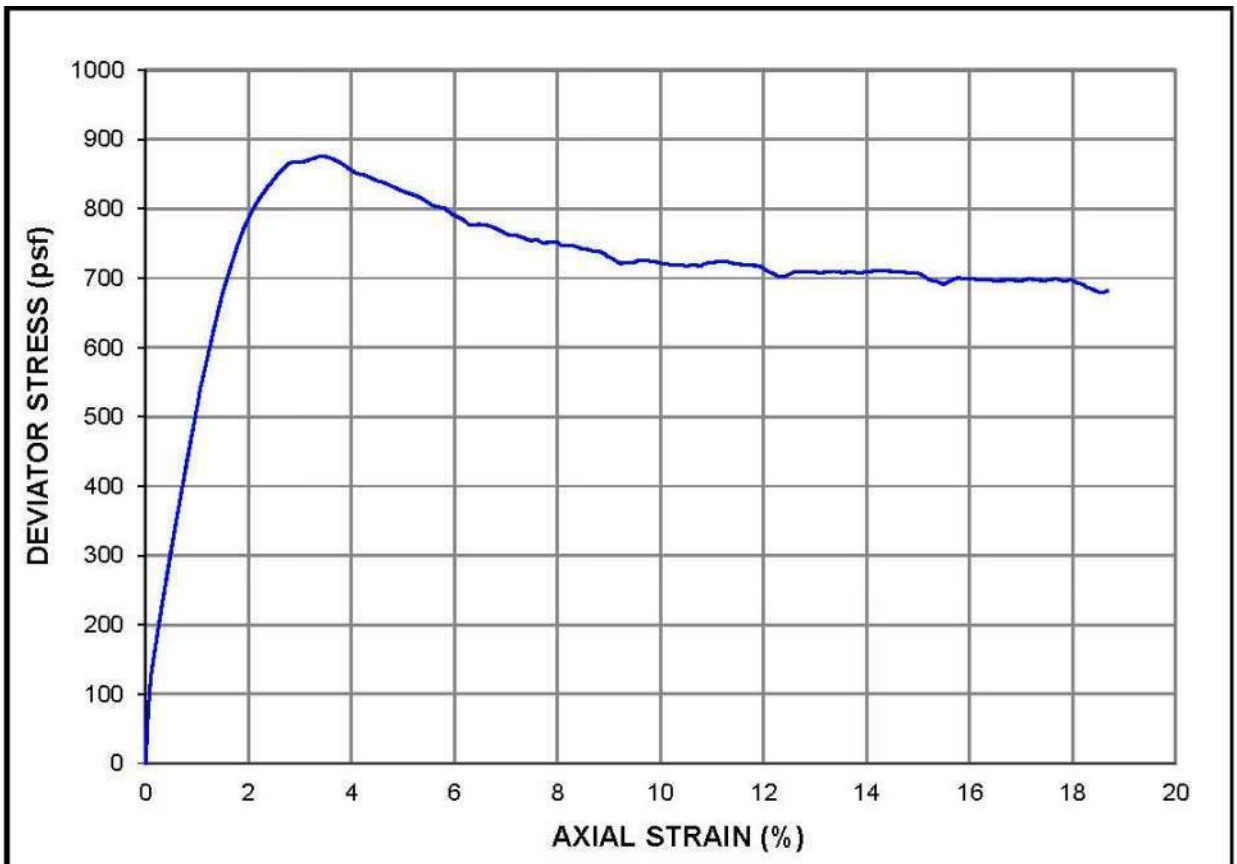
The consolidation test results were obtained in general accordance with ASTM D 2850.

UU Triaxial Compression Test Report

Northside Levee
Aberdeen, Washington

GeoEngineers

Figure A-29



SPECIMEN AT FAILURE	
	DESCRIPTION : Silt (ML)
	SPECIMEN TYPE: Shelby tube
	APPROXIMATE AXIAL STRAIN RATE: 1% / min
	Su: 438 psf
	AXIAL STRAIN AT FAILURE: 3.4%
	CLASSIFICATION: n/a
	LL: n/a | PL: n/a | PI: n/a
	INITIAL: HEIGHT : 6.10 in
	INITIAL: EFFECTIVE DIAMETER: 2.87 in
	INITIAL: HEIGHT/DIAMETER: 2
	INITIAL: WATER CONTENT: 93.0%
	INITIAL: DRY DENSITY: 46.4 pcf
	INITIAL: VOID RATIO: 2.56
	INITIAL: SATURATION: 100% (assumed)
	BORING ID : B-2 | SAMPLE NO.: 11
	DEPTH/ELEV. : 23 feet | DATE: 5/26/15
	TECH: SAS | CHECKED:
	REMARKS: Gs assumed 2.65; γ_{water} = 62.4pcf
	CELL PRESSURE=16 psi

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The consolidation test results were obtained in general accordance with ASTM D 2850.

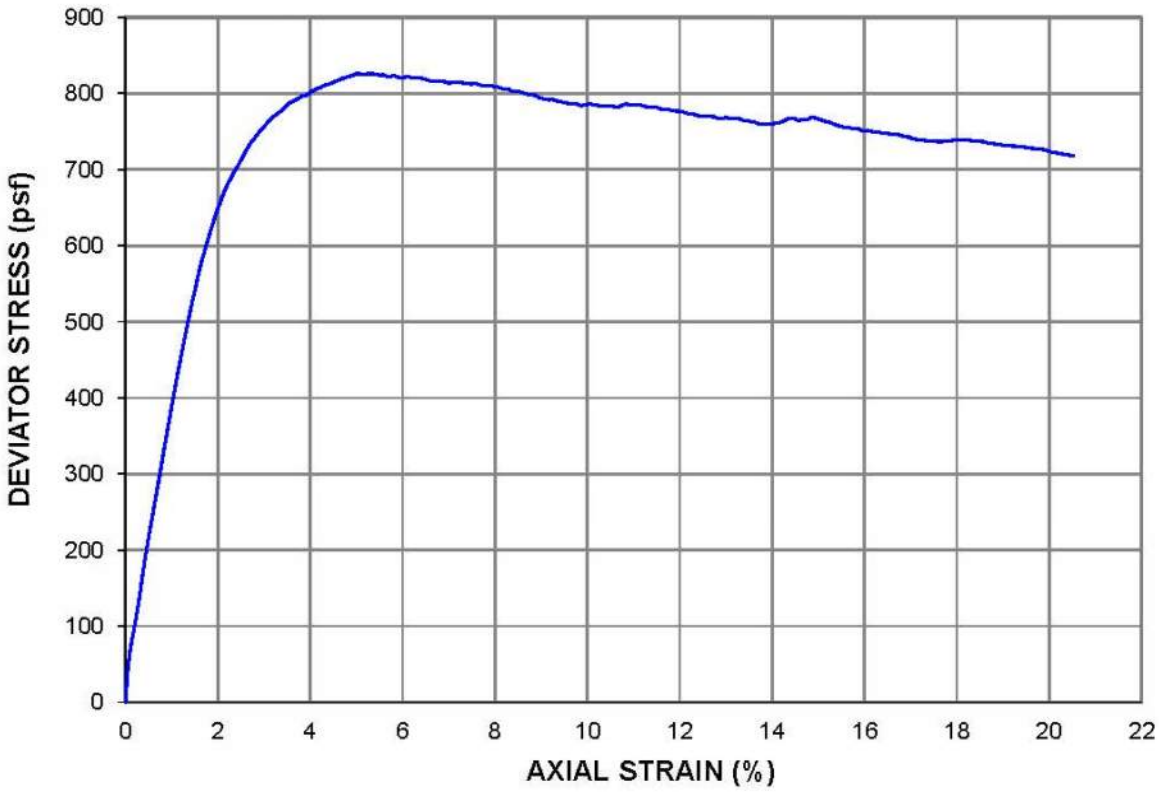
UU Triaxial Compression Test Report

Northside Levee
Aberdeen, Washington

GeoEngineers

Figure A-30

0201-008-00 Date Exported: 07311015



SPECIMEN AT FAILURE	
	DESCRIPTION : Silt (ML)
	SPECIMEN TYPE: Shelby tube
	APPROXIMATE AXIAL STRAIN RATE: 1% / min
	Su: 413 psf
	AXIAL STRAIN AT FAILURE: 5.0%
	CLASSIFICATION: n/a
	LL: n/a | PL: n/a | PI: n/a
	INITIAL: HEIGHT : 6.06 in
	INITIAL: EFFECTIVE DIAMETER: 2.87 in
	INITIAL: HEIGHT/DIAMETER: 2
	INITIAL: WATER CONTENT: 55.2%
	INITIAL: DRY DENSITY: 62.4 pcf
	INITIAL: VOID RATIO: 1.7
	INITIAL: SATURATION: 100% (assumed)
	BORING ID : B-3alt | SAMPLE NO.: 8
	DEPTH/ELEV. : 18 feet | DATE: 5/26/15
	TECH: SAS | CHECKED:
	REMARKS: Gs assumed 2.65; γ_{water} = 62.4pcf
	CELL PRESSURE=12.5 psi

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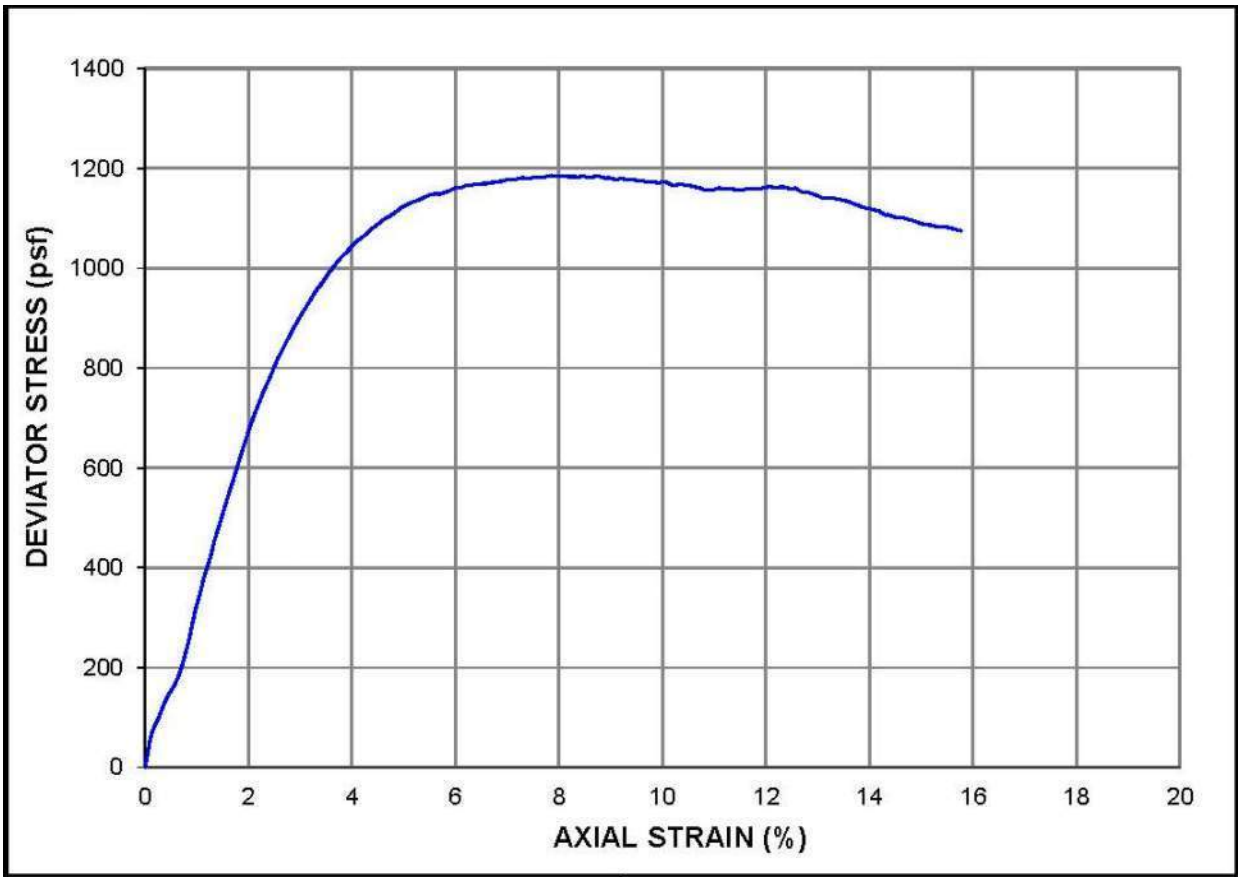
The consolidation test results were obtained in general accordance with ASTM D 2850.

UU Triaxial Compression Test Report

Northside Levee
Aberdeen, Washington

GeoEngineers

Figure A-31



SPECIMEN AT FAILURE			
	DESCRIPTION : Peat with silt (ML)		
	SPECIMEN TYPE: Shelby tube		
	APPROXIMATE AXIAL STRAIN RATE: 1% / min		
	Su: 593 psf		
	AXIAL STRAIN AT FAILURE: 7.9%		
	CLASSIFICATION: n/a		
	LL: n/a	PL: n/a	PI: n/a
	INITIAL: HEIGHT : 6.10 in		
	INITIAL: EFFECTIVE DIAMETER: 2.87 in		
	INITIAL: HEIGHT/DIAMETER: 2		
	INITIAL: WATER CONTENT: 113.3%		
	INITIAL: DRY DENSITY: 38.8 pcf		
	INITIAL: VOID RATIO: 3.3		
	INITIAL: SATURATION: 100% (assumed)		
	BORING ID : B-5	SAMPLE NO.: 5	
	DEPTH/ELEV. : 13 feet	DATE: 6/5/15	
	TECH: SAS	CHECKED:	
	REMARKS: Gs assumed 2.65; γ_{water} = 62.4pcf		
	CELL PRESSURE= 9.0 psi		

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The consolidation test results were obtained in general accordance with ASTM D 2850.

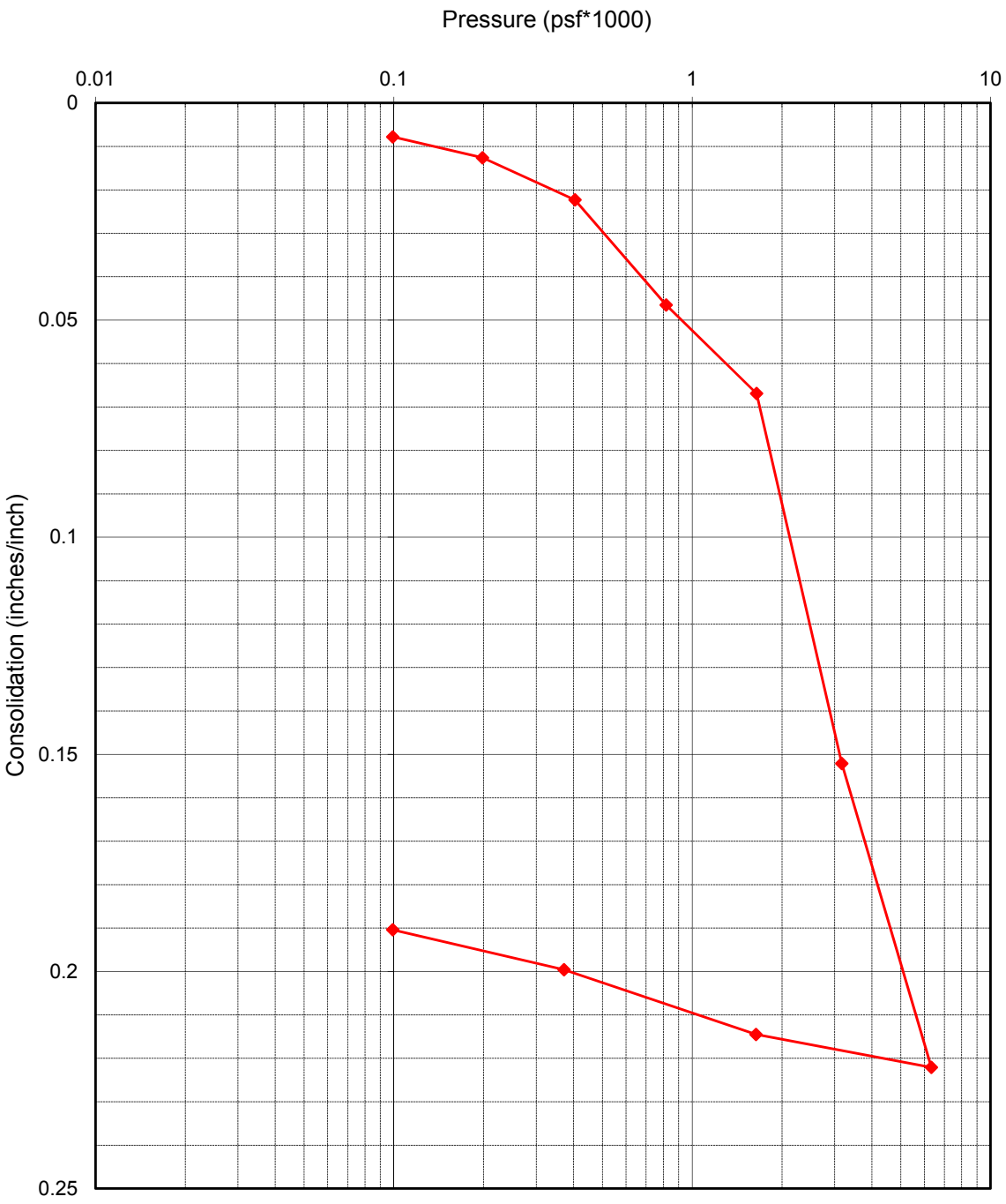
UU Triaxial Compression Test Report

Northside Levee
Aberdeen, Washington

GeoEngineers

Figure A-32

0201-008-00 Date Exported: 07311015



Boring Number	Depth (feet)	Soil Description	Initial Moisture (%)	Initial Dry Density (lbs/ft^3)
B-1	28	Silt with occasional organic matter (ML)	71.2	53.9

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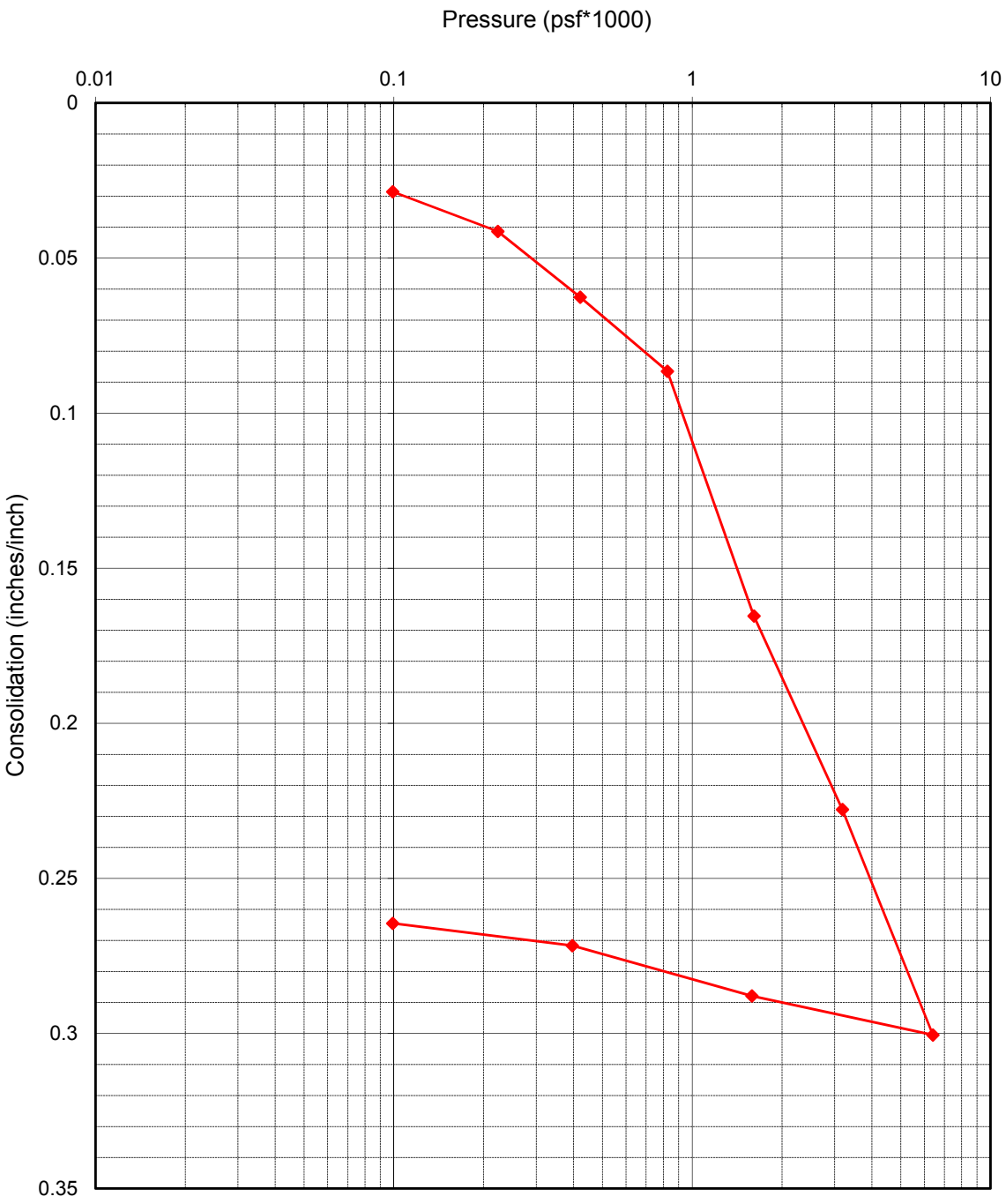
The consolidation test results were obtained in general accordance with ASTM D 2435.

Consolidation Test Results

Northside Levee
Aberdeen, Washington

GeoEngineers

Figure A-33



Boring Number	Depth (feet)	Soil Description	Initial Moisture (%)	Initial Dry Density (lbs/ft^3)
B-2	3	Silt (ML)	113.9	40.3

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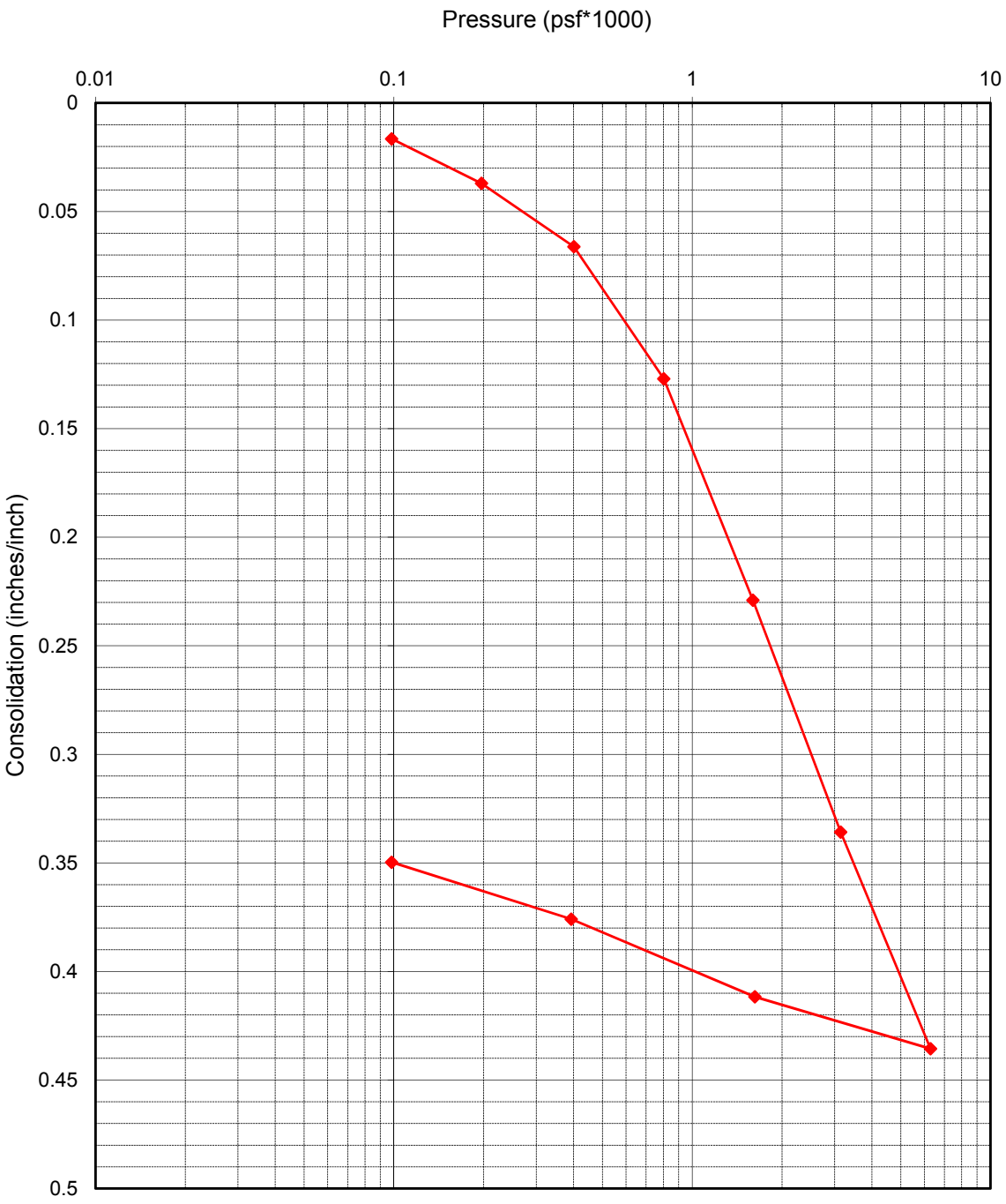
The consolidation test results were obtained in general accordance with ASTM D 2435.

Consolidation Test Results

Northside Levee
Aberdeen, Washington

GeoEngineers

Figure A-34



Boring Number	Depth (feet)	Soil Description	Initial Moisture (%)	Initial Dry Density (lbs/ft^3)
B-2	8	Peat with trace silt (ML)	189.7	24.7

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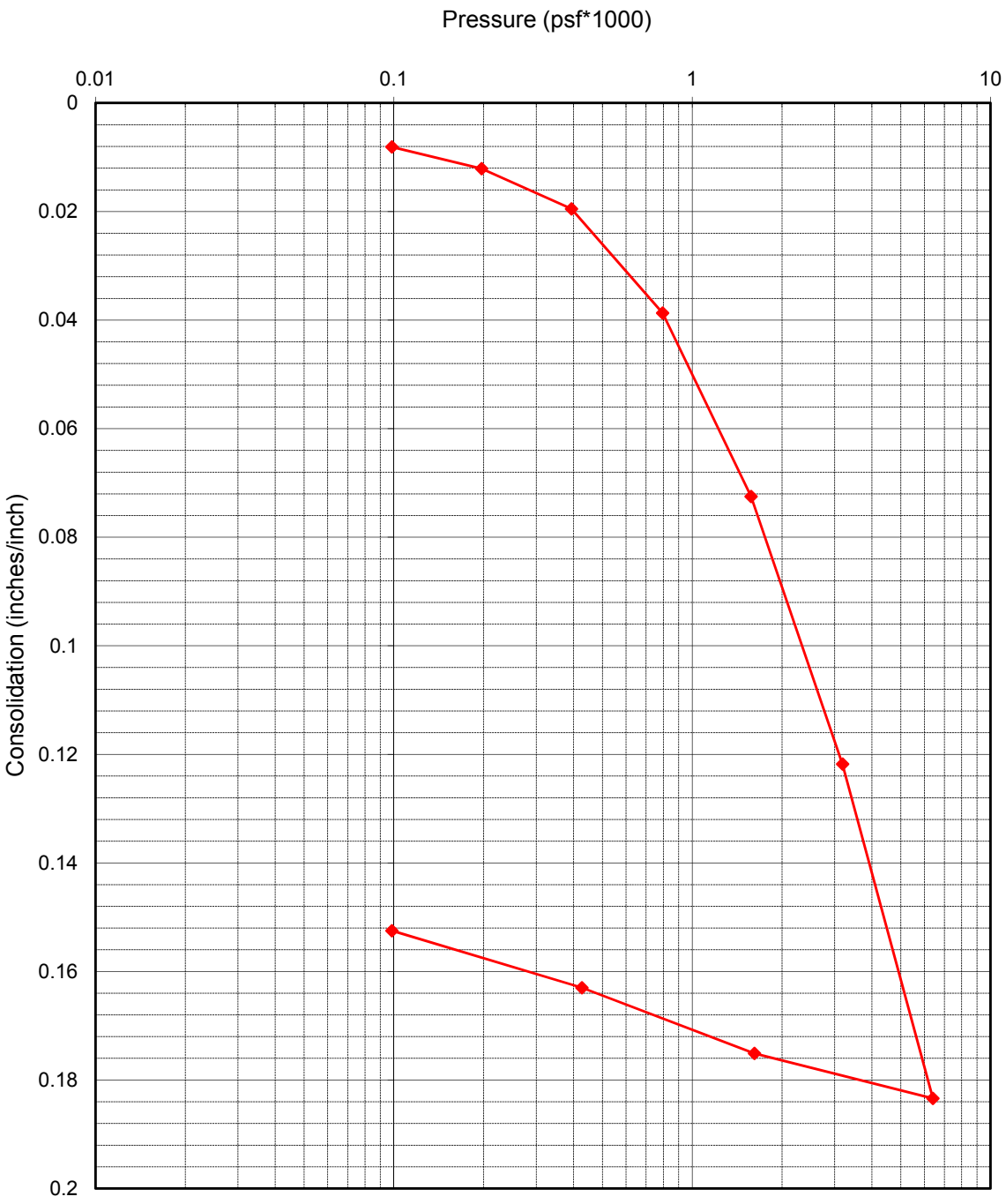
The consolidation test results were obtained in general accordance with ASTM D 2435.

Consolidation Test Results

Northside Levee
Aberdeen, Washington

GeoEngineers

Figure A-35



Boring Number	Depth (feet)	Soil Description	Initial Moisture (%)	Initial Dry Density (lbs/ft^3)
B-2	13	Silt (ML)	36.2	73.4

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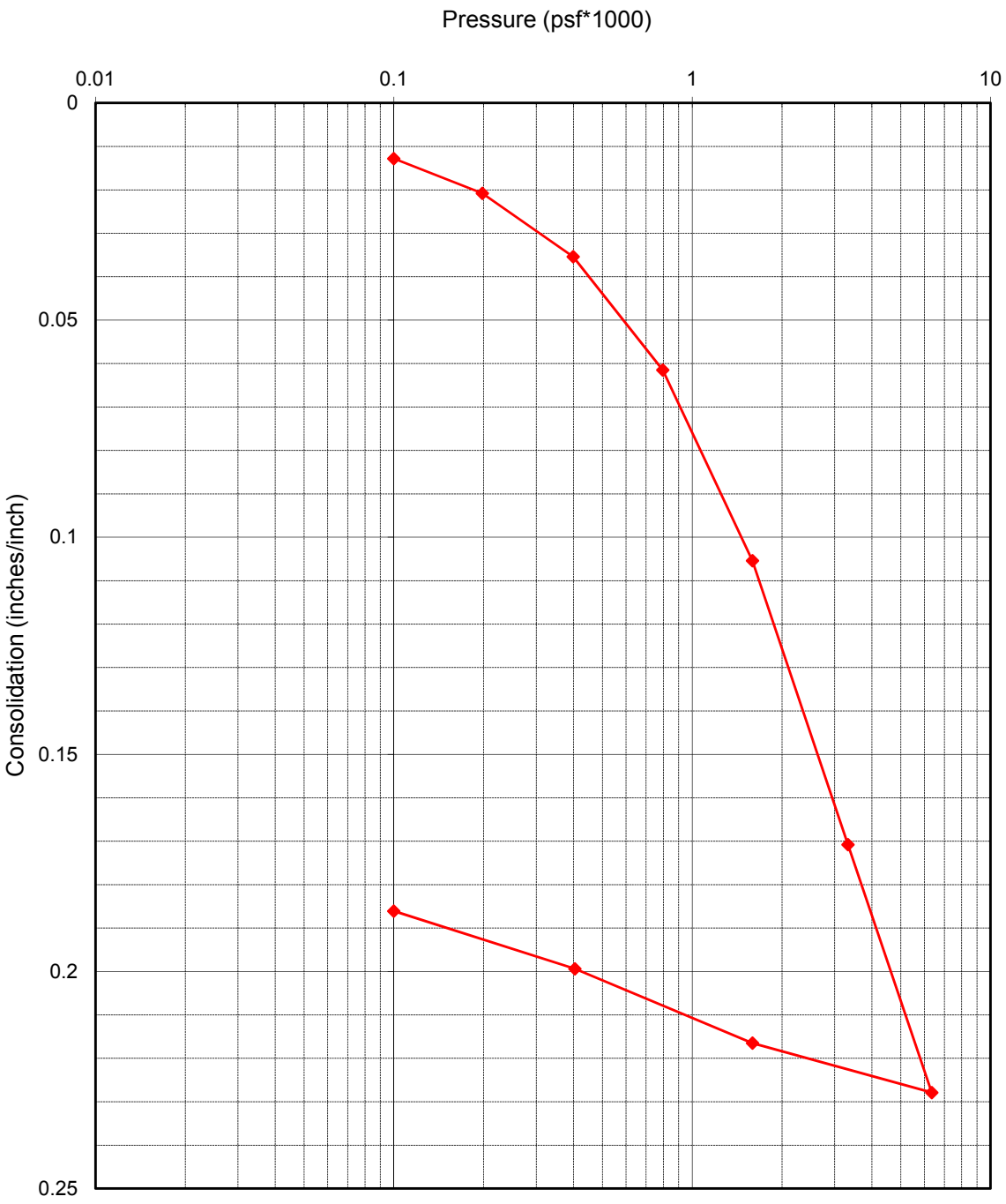
The consolidation test results were obtained in general accordance with ASTM D 2435.

Consolidation Test Results

Northside Levee
Aberdeen, Washington

GeoEngineers

Figure A-36



Boring Number	Depth (feet)	Soil Description	Initial Moisture (%)	Initial Dry Density (lbs/ft^3)
B-3alt	18	Silt (ML)	55.0	61.2

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The consolidation test results were obtained in general accordance with ASTM D 2435.

Consolidation Test Results

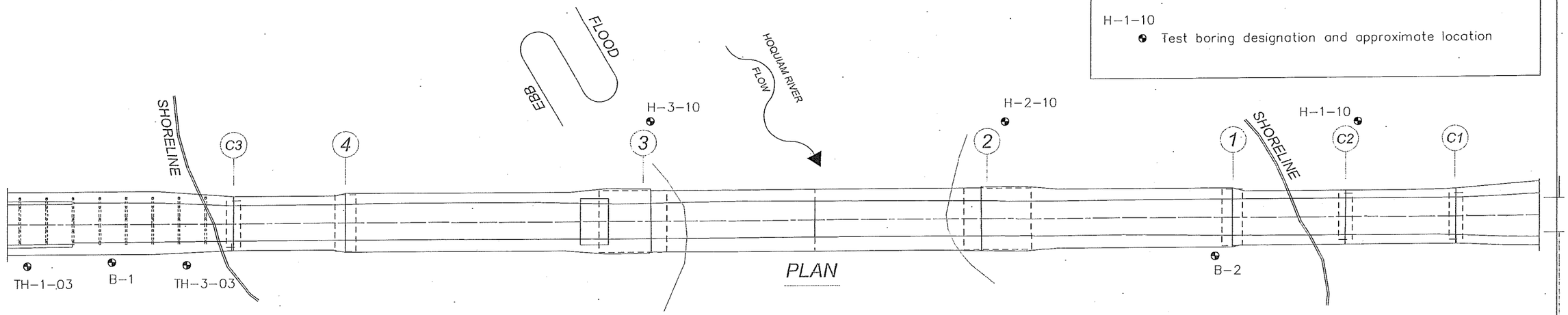
Northside Levee
Aberdeen, Washington

GeoEngineers

Figure A-37

WSDOT 2010

H–1–10
Test boring designation and approximate location



Soil Descriptions
Unit 1: very loose sandy silt
Unit 2: loose to medium dense silty sand to sand
Unit 3: soft to medium stiff plastic silt
Unit 4: dense to very dense silty gravel to gravel
Unit 5: Very loose organic soil

JOB# XL-3812 STATE ROUTE 101 MILEPOST(S) 87.99

FIGURE 1:
BRIDGE PLAN AND PROFILE

SR 101
Simpson Avenue Bridge

Washington State Department of Transportation
GEOTECHNICAL DIVISION

PREPARED BY Dale Gietz DATE August 26, 2010

File Location: J:\projects\XL-3812 SR101_Simpson Ave Bridge\Layout.dgn

Washington State Department of Transportation

Test Boring Legend

Sampler Symbols

	Standard Penetration Test
	Oversized Penetration Test (Dames & Moore, California)
	Shelby Tube
P	Piston Sample
	Washington Undisturbed
	Vane Shear Test
	Core
	Becker Hammer
B	Bag Sample

Well Symbols

	Cement Surface Seal
	Piezometer Pipe in Granular Bentonite Seal
	Piezometer Pipe in Sand
	Well Screen in Sand
	Granular Bentonite Bottom Seal
	Inclinometer Casing in Concrete Bentonite Grout

Laboratory Testing Codes

UU	Unconsolidated Undrained Triaxial
CU	Consolidated Undrained Triaxial
CD	Consolidated Drained Triaxial
UC	Unconfined Compression Test
DS	Direct Shear Test
CN	Consolidation Test
GS	Grain Size Distribution
MC	Moisture Content
SG	Specific Gravity
OR	Organic Content
DN	Density
AL	Atterberg Limits
PT	Point Load Compressive Test
SL	Slake Test
DG	Degradation
LA	LA Abrasion
HT	Hydrometer Test

Soil Density Modifiers

Gravel, Sand & Non-plastic Silt		Elastic Silts and Clay	
SPT Blows/ft	Density	SPT Blows/ft	Consistency
0-4	Very Loose	0-1	Very Soft
5-10	Loose	2-4	Soft
11-24	Medium Dense	5-8	Medium Stiff
25-50	Dense	9-15	Stiff
>50	Very Dense	16-30	Very Stiff
		31-60	Hard
		>60	Very Hard

Angularity of Gravel & Cobbles

Angular	Coarse particles have sharp edges and relatively plane sides with unpolished surfaces.
Subangular	Coarse grained particles are similar to angular but have rounded edges.
Subrounded	Coarse grained particles have nearly plane sides but have well rounded corners and edges.
Rounded	Coarse grained particles have smoothly curved sides and no edges.

Soil Moisture Modifiers

Dry	Absence of moisture; dusty, dry to touch
Moist	Damp but no visible water
Wet	Visible free water

Soil Structure

Stratified	Alternating layers of varying material or color at least 6mm thick; note thickness and inclination.
Laminated	Alternating layers of varying material or color less than 6mm thick; note thickness and inclination.
Fissured	Breaks along definite planes of fracture with little resistance to fracturing.
Slickensided	Fracture planes appear polished or glossy, somtimes striated.
Blocky	Cohesive soil that can be broken down into smaller angular lumps which resist further breakdown.
Disrupted	Soil structure is broken and mixed. Infers that material has moved substantially - landslide debris.
Homogeneous	Same color and appearance throughout.

HCL Reaction

No HCL Reaction	No visible reaction.
Weak HCL Reaction	Some reaction with bubbles forming slowly.
Strong HCL Reaction	Violent reaction with bubbles forming imediately.

Degree of Vesicularity of Pyroclastic Rocks

Slightly Vesicular	5 to 10 percent of total
Moderately Vesicular	10 to 25 percent of total
Highly Vesicular	25 to 50 percent of total
Scoriaceous	Greater than 50 percent of total

Washington State Department of Transportation

Test Boring Legend

Grain Size

Fine Grained	< 1mm	Few crystal boundaries/grains are distinguishable in the field or with hand lens.
Medium Grained	1mm to 5mm	Most crystal boundaries/grains are distinguishable with the aid of a hand lens.
Coarse Grained	> 5mm	Most crystal boundaries/grains are distinguishable with the naked eye.

Weathered State

Term	Description	Grade
Fresh	No visible sign of rock material weathering; perhaps slight discoloration in major discontinuity surfaces.	I
Slightly Weathered	Discoloration indicates weathering of rock material and discontinuity surfaces. All the rock material may be discolored by weathering and may be somewhat weaker externally than its fresh condition.	II
Moderately Weathered	Less than half of the rock material is decomposed and/or disintegrated to soil. Fresh or discolored rock is present either as a continuous framework or as core stones.	III
Highly Weathered	More than half of the rock material is decomposed and/or disintegrated to soil. Fresh or discolored rock is present either as discontinuous framework or as core stone.	IV
Completely Weathered	All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact.	V
Residual Soil	All rock material is converted to soil. The mass structure and material fabric is destroyed. There is a large change in volume, but the soil has not been significantly transported.	VI

Relative Rock Strength

Grade	Description	Field Identification	Uniaxial Compressive Strength approx
R1	Very Weak	Specimen crumbles under sharp blow from point of geological hammer, and can be cut with a pocket knife.	1 to 25 MPa
R2	Moderately Weak	Shallow cuts or scrapes can be made in a specimen with a pocket knife. Geological hammer point indents deeply with firm blow.	25 to 50 MPa
R3	Moderately Strong	Specimen cannot be scraped or cut with a pocket knife, shallow indentation can be made under firm blows from a hammer.	50 to 100 MPa
R4	Strong	Specimen breaks with one firm blow from the hammer end of a geological hammer.	100 to 200 MPa
R5	Very Strong	Specimen requires many blows of a geological hammer to break intact sample.	Greater than 200 MPa

Discontinuities

Spacing	
Very Widely	Greater than 3 m
Widely	1 m to 3 m
Moderately	0.3 m to 1 m
Closely	50 mm to 300 mm
Very Closely	Less than 50 mm

RQD (%)

$$\frac{100(\text{length of core in pieces} > 100\text{mm})}{\text{Length of core run}}$$

Condition	
Excellent	Very rough surfaces, no separation, hard discontinuity wall
Good	Slightly rough surfaces, separation less than 1 mm, hard discontinuity wall.
Fair	Slightly rough surfaces, separation greater than 1 mm, soft discontinuity wall.
Poor	Slickensided surfaces, or soft gouge less than 5 mm thick, or open discontinuities 1 to 5 mm.
Very Poor	Soft gouge greater than 5 mm thick, or open discontinuities greater than 5 mm.

Fracture Frequency (FF) is the average number of fractures per 300 mm of core.
Does not include mechanical breaks caused by drilling or handling.

Washington State Department of Transportation

LOG OF TEST BORING

Start Card S-42548

HOLE No. H-1-10

Sheet 1 of 6

Job No. XL-3812 SR 101 Elevation 10.3 ft

Project SR 101 Simpson Avenue Bridge Driller Nelson, Brad Lic# 2969

Site Address Vic. Of Summer Ave. & 20th St. Inspector Nelson, Dave #1678

Start August 10, 2010 Completion August 11, 2010 Well ID# Equipment CME 55 (9C7-1) - AH

Station 11+73.14 Offset 24.6 Rt Hole Dia (inches) 5 Method Mud Rotary

Northing 616861.80 Easting 797961.39 Collected by Region Survey Crew Datum State Plane South

County Grays Harbor Subsection SE1/4 of NE1/4 Section 11 Range 10 WWM Township 17 N

Depth (ft)	Elevation (ft)	Profile	Field SPT (N) / Moisture Content / RQD (20 40 60 80)	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	10.0							Fill/Rip-Rap based on observation.		
								Creosote piles encountered at 1'		
						S-1		No Recovery		
5	5.0			1 2 3 (5)		D-2		No Recovery		
						S-3		Sandy SILT, with organics, gray, wet		
10	0.0			1 0 1 (1)		D-4	GS MC AL	ML, MC=69%, PI=11 SILT with sand, with organics, very loose, gray, wet, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
						S-5		Sandy SILT, with organics, gray, wet		
15	-5.0			0 0 0 (0)		D-6	GS MC AL	ML, MC=60%, LL=37 Sandy SILT, very loose, gray, wet, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
						S-7		Sandy SILT, gray, wet		
20										

SOILA_TEST XL-3812 SR 101 SIMPSON AVENUE BRIDGE.GPJ SOIL.GDT 9/1/10

Washington State Department of Transportation

LOG OF TEST BORING

Start Card S-42548

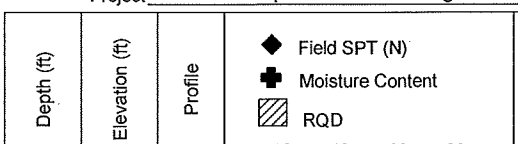
HOLE No. H-1-10

Job No. XL-3812 SR 101 Elevation 10.3 ft

Sheet 2 of 6

Project SR 101 Simpson Avenue Bridge

Driller Nelson, Brad Lic# 2969



Depth (ft)	Elevation (ft)	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	-10	0 0 1 (1)		D-8		Sandy SILT, laminated with sand, very loose, gray, wet, laminated, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
		0 0 1 (1)		D-9	GS MC AL	ML, MC=70%, PI=11 Sandy SILT, laminated with sand, very loose, gray, wet, laminated, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
25	-15							
				S-10		Sandy SILT, gray, wet		
30	-20	2 1 2 (3)		D-11	GS MC	SM, MC=30%, Silty SAND, very loose, gray, wet, homogenous, HCl not tested. Length Recovered:0.9 ft. Length Retained:0.9 ft.		
		3 3 7 (10)		D-12		Silty SAND, loose, gray, wet, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
35	-25							
				S-13		Silty SAND, gray, wet		
40	-30	4 5 10 (15)		D-14		Poorly graded SAND, stratified with silt, medium dense, gray, wet, stratified, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
		1 2		D-15	GS MC	SM, MC=37%, Silty SAND, stratified with silt, loose, gray, wet, stratified,		
45								

SOILA_TEST XL-3812 SR 101 SIMPSON AVENUE BRIDGE.GPJ SOIL.GDT 9/1/10

Washington State Department of Transportation

LOG OF TEST BORING

Start Card S-42548

HOLE No. H-1-10

Job No. XL-3812 SR 101 Elevation 10.3 ft

Sheet 3 of 6

Project SR 101 Simpson Avenue Bridge

Driller Nelson, Brad Lic# 2969

Depth (ft)	Elevation (ft)	Profile	Field SPT (N) / Moisture Content / RQD (20 40 60 80)	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	-35			8 (10)				HCl not tested. Length Recovered:1.0 ft. Length Retained:1.0 ft.		
						S-16		Silty SAND, gray, wet		
50	-40			1 4 9 (13)		D-17	GS MC AL	SM, MC=44%, LL=NA, PL=NP Silty SAND, stratified with silt, medium dense, gray, wet, stratified, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
				1 2 5 (7)		D-18		Silty SAND, loose, gray, wet, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
55	-45									
						S-19		Sandy SILT, gray, wet		
60	-50			2 4 7 (11)		D-20		Silty SAND, medium dense, gray, wet, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
				4 6 8 (14)		D-21		Silty SAND, with sea shells/organic/silt/laminations, medium dense, gray, wet, laminated, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
65	-55									
						S-22		Silty SAND, gray, wet		
70										

SOILA_TEST XL-3812 SR 101 SIMPSON AVENUE BRIDGE.GPJ SOIL.GDT 9/1/10

Washington State Department of Transportation

LOG OF TEST BORING

Start Card S-42548

HOLE No. H-1-10

Job No. XL-3812 SR 101 Elevation 10.3 ft

Sheet 4 of 6

Project SR 101 Simpson Avenue Bridge

Driller Nelson, Brad Lic# 2969

Depth (ft)	Elevation (ft)	Profile	Field SPT (N) / Moisture Content / RQD (20 40 60 80)	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	-60			1 1 7 (8)		D-23	GS MC	SP-SM, MC=28%, Poorly graded SAND with silt, loose, gray, wet, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
				3 3 5 (8)		D-24		Silty SAND, stratified with silt, loose, gray, wet, stratified, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
75	-65									
						S-25		Sandy SILT, gray, wet		
80	-70			2 2 2 (4)		D-26	GS MC AL	ML, MC=54%, LL=NA, PL=NP Sandy SILT, laminated with sand/slit/organic, loose, gray, wet, laminated, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
				3 3 5 (8)		D-27		Silty SAND, laminated with sand/slit/organic, loose, gray, wet, laminated, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
85	-75									
						S-28		Sandy SILT, gray, wet		
90	-80			2 6 17 (23)		D-29		Silty SAND, medium dense, gray, wet, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
				8 16		D-30	GS MC	SM, MC=31%, Silty SAND, dense, gray, moist, homogenous, HCl not		
95										

SOIL_TEST XL-3812 SR 101 SIMPSON AVENUE BRIDGE.GPJ SOIL.GDT 9/1/10

Washington State Department of Transportation

LOG OF TEST BORING

Start Card S-42548

HOLE No. H-1-10

Job No. XL-3812 SR 101 Elevation 10.3 ft

Sheet 5 of 6

Project SR 101 Simpson Avenue Bridge

Driller Nelson, Brad Lic# 2969

Depth (ft)	Elevation (ft)	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	-85	19 (35)				tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
		2 2 3 (5)		D-31	GS MC AL	MH, MC=70%, PI=15 Elastic SILT with sand, stratified with silt, loose, gray, wet, stratified, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
100	-90							
				S-32		Sandy SILT, gray, wet		
105	-95	1 1 1 (2)		D-33		Sandy SILT, stratified with silt/organics, very loose, gray, wet, stratified, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
		3 4 3 (7)		D-34		Sandy SILT, stratified with silt/organics/sand, loose, gray, wet, stratified, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
110	-100							
				S-35		Sandy SILT, gray, wet		
115	-105							
						The implied accuracy of the borehole location information displayed on this boring log is typically sub-meter in (X,Y) when collected by the HQ Geotech Division and sub-centimeter in (X,Y,Z) when collected by the Region Survey Crew.		
120								

Field SPT (N) ◆ Moisture Content ✚ RQD ▨ 20 40 60 80

SOILA_TEST XL-3812 SR 101 SIMPSON AVENUE BRIDGE.GPJ SOIL.GDT 9/1/10

Washington State
Department of Transportation

LOG OF TEST BORING

Start Card S-42548

HOLE No. H-1-10

Job No. XL-3812 SR 101 Elevation 10.3 ft

Sheet 6 of 6

Project SR 101 Simpson Avenue Bridge

Driller Nelson, Brad Lic# 2969

Depth (ft)	Elevation (ft)	Profile	Field SPT (N) / Moisture Content / RQD (20 40 60 80)	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	-110							End of test hole boring at 116 ft below ground elevation. This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data. Note: REF = SPT Refusal		
125	-115									
130	-120									
135	-125									
140	-130									
145										

SOILA_TEST XL-3812 SR 101 SIMPSON AVENUE BRIDGE.GPJ SOIL.GDT 9/1/10

Washington State Department of Transportation

LOG OF TEST BORING

Start Card SE-07833

HOLE No. H-2-10

Sheet 1 of 6

Job No XL-3812 SR 101 Elevation -24.0 ft

Project SR 101 Simpson Avenue Bridge

Driller Tunison, Scott / CRUX Lic# 2628

Site Address SR-101/ Simpson Avenue Bridge

Inspector Fetterly, Jamie #2507

Start August 13, 2010 Completion August 17, 2010 Well ID#

Equipment Burley 4500 - Cathead Hammer

Station Offset Hole Dia (inches) 4 Method Wet Rotary

Northing 616876.90 Easting 797753.84 Collected by HQ Geotech Division Datum State Plane South

County Grays Harbor Subsection SW1/4 of NW1/4 Section 12 Range 10 WWM Township 17 N

Depth (ft)	Elevation (ft)	Profile	Field SPT (N) / Moisture Content / RQD (20 40 60 80)	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	-25.0							Bore hole was drilled fairly even to end of protector wall and south facing pier wall as close as we could get.		
			◆ ✚	1 3 5 (8)		D-1	GS MC	SM, MC=33%, Silty SAND, stratified with a 2" silt layer, loose, very dark gray, wet, stratified, HCl not tested. Length Recovered:1.0 ft. Length Retained:1.0 ft.		
5	-30.0									
			◆	1 2 5 (7)		D-2		Silty SAND, stratified with sandy silt, loose, very dark gray, wet, stratified, HCl not tested. Length Recovered:1.0 ft. Length Retained:1.0 ft.		
10	-35.0									
			◆ ✚	1 1 1 (2)		D-3	GS MC	SP-SM, MC=34%, Poorly graded SAND with silt, with scattered shell fragments, very loose, dark gray, wet, homogenous, HCl not tested. Length Recovered:0.8 ft. Length Retained:0.8 ft.		
15	-40.0									
			✚		P	P-4	GS MC AL DS	ML, MC=48%, LL=26 Silty SAND, dark gray		
			◆ ✚	1		D-5	GS	SM, MC=45%, LL=30		
20										

SOILA_TEST XL-3812 SR 101 SIMPSON AVENUE BRIDGE.GPJ SOIL.GDT 9/1/10

Washington State Department of Transportation

LOG OF TEST BORING

Start Card SE-07833

HOLE No. H-2-10

Job No XL-3812 SR 101 Elevation -24.0 ft

Sheet 2 of 6

Project SR 101 Simpson Avenue Bridge

Driller Tunison, Scott / CRUX Lic# 2628

Depth (ft)	Elevation (ft)	Profile	Field SPT (N) / Moisture Content / RQD (20 40 60 80)	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
				2 1 (3)			MC AL HT	Silty SAND, laminated with sandy silt interbeds, trace shells, very loose, dark gray, wet, laminated, HCl not tested, laminae is 1 mm to 2 mm. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
25	-45									
	-50									
30			◆ ✚	3 7 7 (14)		D-6	GS MC	SM, MC=33%, Silty SAND, with scattered shell fragments and laminated with silt interbeddings, medium dense, dark gray, wet, stratified, laminated, HCl not tested, sand is coarse grain. Length Recovered:1.2 ft. Length Retained:1.2 ft.		
	-55									
35			◆	3 14 18 (32)		D-7		Silty SAND, laminated with sandy silt interbeds, stratified with silty sand with gravel and wood debris, dense, gray, wet, stratified, laminated, HCl not tested, sample was split into two bags, A & B. Length Recovered:1.3 ft. Length Retained:1.3 ft.		
	-60									
40			◆ ✚	2 4 5 (9)		D-8	GS MC AL HT	SM, MC=48%, LL=NA, PL=NP Silty SAND, loose, gray, wet, homogenous, HCl not tested. Length Recovered:1.3 ft. Length Retained:1.3 ft.		
	-65									
45			◆							

SOILA_TEST XL-3812 SR 101 SIMPSON AVENUE BRIDGE.GPJ SOIL.GDT 9/1/10

Washington State Department of Transportation

LOG OF TEST BORING

Start Card SE-07833

HOLE No. H-2-10

Job No. XL-3812 SR 101 Elevation -24.0 ft

Sheet 3 of 6

Project SR 101 Simpson Avenue Bridge

Driller Tunison, Scott / CRUX Lic# 2628

Depth (ft)	Elevation (ft)	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
		3 2 3 (5)	D	D-9		Silty SAND, stratified with sandy silt laminated with silt interbeddings, loose, gray, wet, stratified, laminated, HCl not tested, laminate is 1 mm. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
	-70							
50			P	P-10		Sandy SILT, gray		
	-75	1 2 3 (5)	D	D-11	GS AL	ML, LL=NA, PL=NP SILT with sand, with organics, laminated with 2 (6-mm) organic lenses with 1 to 2 mm sand lenses between, loose, gray, wet, stratified, laminated, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
55								
	-80	2 1 1 (2)	D	D-12	GS MC	SP, MC=33%, Poorly graded SAND, with scattered shell fragments, very loose, dark gray, wet, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
60								
	-85		P	P-13		SILT, with organics, dark gray		
		1 0 0 (0)	D	D-14	GS MC AL	MH, MC=114%, PI=19 Elastic SILT, with organics, very loose, gray, wet, homogenous, HCl not tested. Length Recovered:0.8 ft. Length Retained:0.8 ft.		
65								
	-90							
70								

Field SPT (N) ◆ Moisture Content ✚ RQD ▨ 20 40 60 80

SOILA_TEST XL-3812 SR 101 SIMPSON AVENUE BRIDGE.GPJ SOIL.GDT 9/1/10

Washington State Department of Transportation

LOG OF TEST BORING

Start Card SE-07833

HOLE No. H-2-10

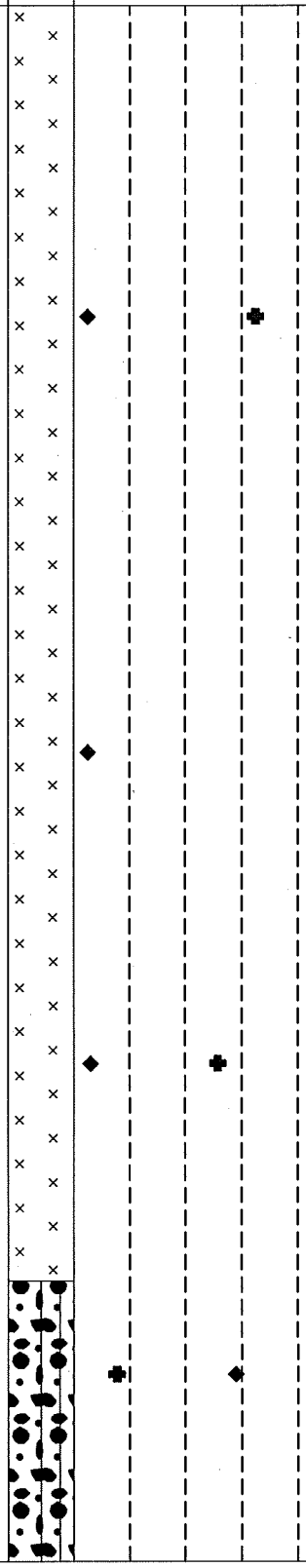
Job No. XL-3812 SR 101 Elevation -24.0 ft

Sheet 4 of 6

Project SR 101 Simpson Avenue Bridge

Driller Tunison, Scott / CRUX Lic# 2628

Depth (ft)	Elevation (ft)	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
				P-15		SILT, with organics, gray		
	-95		D					
75		2 2 3 (5)		D-16	GS MC AL	MH, MC=65%, PI=22 Elastic SILT, with organics, medium stiff, dark gray, wet, homogenous, HCl not tested, field tests include dilatency, dry strength, and plasticity. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
	-100							
80				S-17		Lean CLAY, with organics, gray		
	-105							
		2 2 3 (5)		D-18		Lean CLAY, with organics, medium stiff, very dark greenish gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
85								
	-110							
		2 3 3 (6)		D-19	GS MC AL	MH, MC=52%, PI=18 Elastic SILT, with scattered organics, loose, dark greenish gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
90								
	-115					Gravel contact, as indicated by drilling.		
		10 20 38 (58)		D-20	GS MC	GP-GM, MC=16%, Poorly graded GRAVEL with silt and sand, sub-rounded, very dense, dark gray, wet, homogenous, HCl not tested. Length Recovered:1.0 ft. Length Retained:1.0 ft.		
95								



SOILA_TEST XL-3812 SR 101 SIMPSON AVENUE BRIDGE.GPJ SOIL.GDT 9/1/10

Washington State Department of Transportation

LOG OF TEST BORING

Start Card SE-07833

HOLE No. H-2-10

Job No. XL-3812 SR 101 Elevation -24.0 ft

Sheet 5 of 6

Project SR 101 Simpson Avenue Bridge

Driller Tunison, Scott / CRUX Lic# 2628

Depth (ft)	Elevation (ft)	Profile	Field SPT (N) / Moisture Content / RQD (20 40 60 80)	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	-120			12 17 14 (31)		D-21		Silty GRAVEL, sub-rounded, dense, dark gray, wet, homogenous, HCl not tested. Length Recovered:1.0 ft. Length Retained:1.0 ft.		
100	-125			38 20 18 (38)		D-22		Poorly graded GRAVEL with sand, sub-rounded, and trace silt, dense, very dark bluish gray, wet, homogenous, HCl not tested. Length Recovered:0.9 ft. Length Retained:0.9 ft.		
105	-130									
110	-135			34 15 17 (32)		D-23		Poorly graded GRAVEL, sub-rounded, dense, greenish black, wet, homogenous, HCl not tested, driving a large gravel. Length Recovered:0.1 ft. Length Retained:0.1 ft.		
115	-140									
120				10 9 11 (20)		D-24	GS MC	GP, MC=7%, Poorly graded GRAVEL with sand, sub-rounded, medium dense, dark gray, wet, homogenous, HCl not tested. Length Recovered:0.6 ft. Length Retained:0.6 ft.		

SOILA_TEST XL-3812 SR 101 SIMPSON AVENUE BRIDGE.GPJ SOIL.GDT 9/1/10

Washington State Department of Transportation

LOG OF TEST BORING

Start Card SE-07833

HOLE No. H-2-10

Job No XL-3812 SR 101 Elevation -24.0 ft

Sheet 6 of 6

Project SR 101 Simpson Avenue Bridge

Driller Tunison, Scott / CRUX Lic# 2628

◆ Field SPT (N)
✚ Moisture Content
▨ RQD

Depth (ft)	Elevation (ft)	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
125	-145							
	-150							
130		23 34 18 (52)		D-25	GS MC	GW, MC=8%, Well graded GRAVEL with sand, sub-rounded, very dense, dark gray, wet, homogenous, HCl not tested. Length Recovered:0.7 ft. Length Retained:0.7 ft.		
	-155							
135								
	-160							
140		13 34 50 (84)		D-26		Well graded GRAVEL, sub-rounded, very dense, greenish gray, wet, homogenous, HCl not tested. Length Recovered:0.2 ft. Length Retained:0.2 ft.		
	-165					The implied accuracy of the borehole location information displayed on this boring log is typically sub-meter in (X,Y) when collected by the HQ Geotech Division and sub-centimeter in (X,Y,Z) when collected by the Region Survey Crew. End of test hole boring at 140 ft below ground elevation. This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data. Note: REF = SPT Refusal		
145								

SOILA_TEST XL-3812 SR 101 SIMPSON AVENUE BRIDGE.GPJ SOIL.GDT 9/1/10

Washington State Department of Transportation

LOG OF TEST BORING

Start Card SE-07833

HOLE No. H-3-10

Sheet 1 of 7

Job No. XL-3812 SR 101 Elevation -15.0 ft

Project SR 101 Simpson Avenue Bridge Driller Tunison, Scott / CRUX Lic# 2628

Site Address SR-101/Simpson Avenue Bridge Inspector Fetterly, Jamie #2507

Start August 18, 2010 Completion August 21, 2010 Well ID# Equipment Burley 4500 - Cathead Hammer

Station 0. Offset 0. Hole Dia (inches) 4 Method Wet Rotary

Northing 616800.00 Easting 797700.00 Collected by HQ Geotech Division Datum State Plane South

County Grays Harbor Subsection SW1/4 of NW1/4 Section 12 Range 10 WWM Township 17 N

Field SPT (N) ◆ Moisture Content ✚ RQD ▨ 20 40 60 80

Depth (ft)	Elevation (ft)	Profile	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
5	-20.0		>> 1 0 0 (0)		D-1	GS MC	SM, MC=131%, Silty SAND with organics, very loose, brown, wet, homogenous, HCl not tested. Length Recovered:0.9 ft. Length Retained:0.9 ft.		
10	-25.0		>> 1 0 1 (1)		D-2	MC LOI	MC=177%, ORGANIC Soil, with trace silt, very loose, brown, wet, homogenous, HCl not tested. Length Recovered:0.2 ft. Length Retained:0.2 ft.		
15	-30.0						Note: samples D-2 and D-3 were combined for testing.		
20	-35.0		0 0 1 (1)		D-3	LOI	ORGANIC Soil, very loose, brown, wet, homogenous, HCl not tested. Length Recovered:0.2 ft. Length Retained:0.2 ft.		

SOILA_TEST XL-3812 SR 101 SIMPSON AVENUE BRIDGE.GPJ SOIL.GDT 9/1/10

Washington State Department of Transportation

LOG OF TEST BORING

Start Card SE-07833

Job No. XL-3812 SR 101 Elevation -15.0 ft HOLE No. H-3-10

Sheet 2 of 7

Project SR 101 Simpson Avenue Bridge Driller Tunison, Scott / CRUX Lic# 2628

Depth (ft)	Elevation (ft)	Profile	Field SPT (N) / Moisture Content / RQD (20 40 60 80)	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
			>>		P	P-4	GS MC UU	SM, MC=219%, ORGANIC Soil, brown, wet		
25	-40			2 1 1 (2)		D-5		Silty SAND, with organics and shell fragments, very loose, gray, wet, homogenous, HCl not tested. Length Recovered:1.2 ft. Length Retained:1.2 ft. Note: wood chunks 1-2 inches in diameter in sample.		
30	-45									
			>>	0 0 1 (1)		D-6	GS MC AL HT	MH, MC=101%, LL=50 Elastic SILT with sand, stratified with sandy silt, very loose, dark gray, wet, stratified, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
35	-50									
				0 0 1 (1)		D-7		Silty SAND, stratified with sandy silt with scattered organics, very loose, dark gray, wet, stratified, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
40	-55									
				0 1 1 (2)		D-8		Silty SAND, with scattered organics, very loose, dark gray, wet, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
45	-60									

SOILA_TEST XL-3812 SR 101 SIMPSON AVENUE BRIDGE.GPJ SOIL.GDT 9/1/10

Washington State Department of Transportation

LOG OF TEST BORING

Start Card SE-07833

HOLE No. H-3-10

Job No. XL-3812 SR 101 Elevation -15.0 ft

Sheet 3 of 7

Project SR 101 Simpson Avenue Bridge

Driller Tunison, Scott / CRUX Lic# 2628

◆ Field SPT (N)
✚ Moisture Content
▨ RQD
20 40 60 80

Depth (ft)	Elevation (ft)	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
				P-9	GS MC AL HT UU	MH, MC=78%, PI=21 Elastic SILT, gray, wet		
		2 1 1 (2)		D-10		Sandy SILT, with scattered organics, very loose, dark gray, wet, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
50	-65							
55	-70							
		1 1 3 (4)		D-11	GS MC AL HT	ML, MC=60%, LL=38 SILT with sand, stratified with silt, very loose, gray, wet, stratified, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
60	-75							
		2 2 3 (5)		D-12		Poorly graded SAND, loose, dark gray, wet, homogenous, HCl not tested. Length Recovered:1.3 ft. Length Retained:1.3 ft.		
65	-80							
		3 2 3 (5)		D-13	GS MC	SM, MC=48%, Silty SAND, trace organics, stratified with silt, loose, gray, wet, stratified, HCl not tested. Length Recovered:1.3 ft. Length Retained:1.3 ft.		
70	-85							

SOILA_TEST XL-3812 SR 101 SIMPSON AVENUE BRIDGE.GPJ SOIL.GDT 9/11/10

Washington State Department of Transportation

LOG OF TEST BORING

Start Card SE-07833

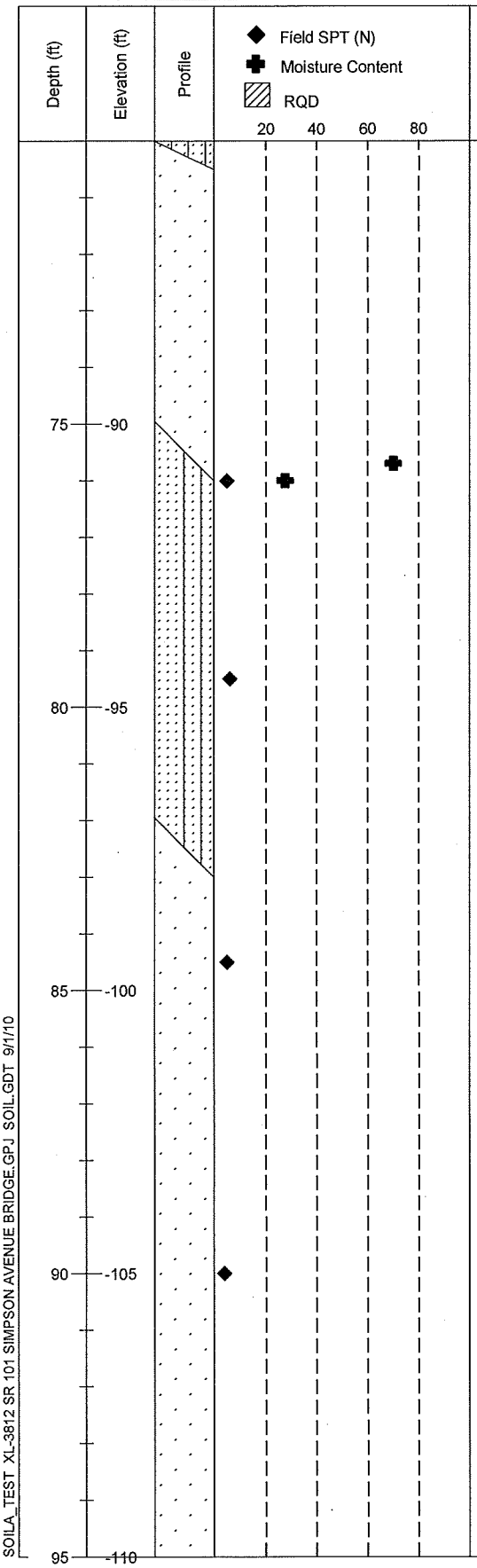
HOLE No. H-3-10

Job No. XL-3812 SR 101 Elevation -15.0 ft

Sheet 4 of 7

Project SR 101 Simpson Avenue Bridge

Driller Tunison, Scott / CRUX Lic# 2628



Depth (ft)	Elevation (ft)	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
				P-14	GS MC AL HT UU	ML, MC=70%, LL=39 SILT with sand, with scattered organics, brown		
75	-90	2 3 2 (5)		D-15	GS MC	SP-SM, MC=28%, Poorly graded SAND with silt, loose, dark gray, wet, homogenous, HCl not tested. Length Recovered:0.8 ft. Length Retained:0.8 ft.		
80	-95	3 3 3 (6)		D-16		Poorly graded SAND, loose, dark gray, wet, homogenous, HCl not tested. Length Recovered:0.5 ft. Length Retained:0.5 ft.		
85	-100	2 2 3 (5)		D-17	AL	MH, PI=12 Elastic SILT, stratified with silty sand, loose, gray, moist, stratified, HCl not tested. Length Recovered:1.2 ft. Length Retained:1.2 ft.		
				P-18		No Recovery		
90	-105	2 1 3 (4)		D-19		SILT, with scattered organics, very loose, gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
				P-20		No Recovery		
95	-110							

SOILA_TEST XL-3812 SR 101 SIMPSON AVENUE BRIDGE.GPJ SOIL.GDT 9/1/10

Washington State Department of Transportation

LOG OF TEST BORING

Start Card SE-07833

HOLE No. H-3-10

Job No. XL-3812 SR 101 Elevation -15.0 ft

Sheet 5 of 7

Project SR 101 Simpson Avenue Bridge

Driller Tunison, Scott / CRUX Lic# 2628

Depth (ft)	Elevation (ft)	Profile	Field SPT (N) / Moisture Content / RQD (20 40 60 80)	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
				5 6 4 (10)		D-21		SILT, medium dense, dark gray, wet, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
						S-22	GS MC AL HT UU	MH, MC=62%, PI=13 Elastic SILT, dark gray, wet		
100	-115									
				1 2 2 (4)		D-23	AL	MH, PI=15 Elastic SILT, with scattered organics, very loose, dark gray, wet, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
105	-120									
								Gravel contact		
				31 27 23 (50)		D-24	GS MC	GP-GM, MC=11%, Poorly graded GRAVEL with silt and sand, sub-rounded, very dense, very dark gray, wet, homogenous, HCl not tested. Length Recovered:1.2 ft. Length Retained:1.2 ft.		
110	-125									
115	-130									
				10 12 16 (28)		D-25		Poorly graded GRAVEL with sand, sub-rounded, dense, very dark gray, wet, homogenous, HCl not tested. Length Recovered:0.8 ft. Length Retained:0.8 ft.		
120	-135									

SOILA_TEST XL-3812 SR 101 SIMPSON AVENUE BRIDGE.GPJ SOIL.GDT 9/1/10

Washington State Department of Transportation

LOG OF TEST BORING

Start Card SE-07833

HOLE No. H-3-10

Job No. XL-3812 SR 101 Elevation -15.0 ft

Sheet 6 of 7

Project SR 101 Simpson Avenue Bridge

Driller Tunison, Scott / CRUX Lic# 2628

Depth (ft)	Elevation (ft)	Profile	Field SPT (N) / Moisture Content / RQD (20 40 60 80)	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
125	-140									
				33 21 25 (46)		D-26	GS MC	GW, MC=9%, Well graded GRAVEL with sand, sub-rounded, dense, dark gray, wet, homogenous, HCl not tested. Length Recovered:1 ft. Length Retained:1 ft. Jamie Fetterly took over inspecting from Jamie Wilson		
130	-145									
135	-150									
				>> 42 50/4 (REF)		D-27		Well graded GRAVEL with sand, sub-rounded, very dense, gray, wet, homogenous, HCl not tested. Length Recovered:0.7 ft. Length Retained:0.7 ft.		
140	-155									
145	-160			>>						

SOILA_TEST XL-3812 SR 101 SIMPSON AVENUE BRIDGE.GPJ SOIL.GDT 9/1/10

Washington State Department of Transportation

LOG OF TEST BORING

Start Card SE-07833

Job No. XL-3812 SR 101 Elevation -15.0 ft

HOLE No. H-3-10

Sheet 7 of 7

Project SR 101 Simpson Avenue Bridge

Driller Tunison, Scott / CRUX Lic# 2628

Depth (ft)	Elevation (ft)	Profile	Field SPT (N) / Moisture Content / RQD (20 40 60 80)	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
				50/5 (REF)		D-28		Well graded GRAVEL, sub-rounded, very dense, dark gray, wet, homogenous, HCl not tested. Length Recovered:0.3 ft. Length Retained:0.3 ft.		
150	-165			22 14 21 (35)		D-29		Well graded GRAVEL with sand, sub-rounded, dense, greenish gray, wet, homogenous, HCl not tested. Length Recovered:0.7 ft. Length Retained:0.7 ft.		
155	-170									
								The implied accuracy of the borehole location information displayed on this boring log is typically sub-meter in (X,Y) when collected by the HQ Geotech Division and sub-centimeter in (X,Y,Z) when collected by the Region Survey Crew.		
160	-175									
								End of test hole boring at 154.5 ft below ground elevation. This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data. Note: REF = SPT Refusal		
165	-180									
170	-185									

SOILA_TEST XL-3812 SR 101 SIMPSON AVENUE BRIDGE.GPJ SOIL.GDT 9/1/10

Shannon & Wilson 2000

Seismic Retrofit Study
WSDOT SR12/12S Wishkah River/Heron Street Bridge
Aberdeen, Washington

September 1999

SHANNON & WILSON, INC.

GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

At Shannon & Wilson, our mission is to be a progressive, well-managed professional consulting firm in the fields of engineering and applied earth sciences. Our goal is to perform our services with the highest degree of professionalism with due consideration to the best interests of the public, our clients, and our employees.

Submitted To:
EQE International
1411 4th Avenue, Suite 500
Seattle, WA 98101-2207

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

W-8639-01

Details of the existing foundation elements for the SR 12/12S Bridge were obtained from drawings in WSDOT files; however, subsurface data and generalized subsurface profiles from the original design were not available.

2.0 SITE AND PROJECT DESCRIPTION

The SR 12/12S is a 2-lane steel girder bridge spanning the Wishkah River. Plan and elevation views of the existing bridge are presented in Figure 2. The bridge is approximately 238 feet long, including both approach spans, and the bridge deck elevation varies from El. 12.85 feet to El. 18.8 feet.

Sixty-four existing timber piles, approximately 59 feet in length, currently support the pivot pier. Based on construction drawings, the elevation of the bottom of the pivot pier pile cap is at about El. –26 feet. The proposed seismic retrofit involves the installation of four 6-foot diameter drilled shafts at the pivot pier, adjacent to the existing timber pile foundation, which would bear in medium dense to very dense glaciofluvial sediments. We understand that the proposed drilled shafts at the pivot pier will be used solely to support dynamic loads under seismic loading conditions and that under static loading conditions, the shafts will be subjected only to their self-weight.

3.0 FIELD EXPLORATIONS AND LABORATORY TESTING

The field explorations consisted of one boring and one seismic cone penetration test at the approximate locations indicated on Figure 2. Laboratory tests consisted of mechanical grain size analyses, water content determinations, and Atterberg limits. Subsurface explorations were located in the field using tape measurements from existing site features and should be considered approximate.

3.1 Soil Boring

Boring B-1 was drilled on May 11 and 12, 1999 over water at the approximate location shown in Figure 2 to a depth of about 91 ½ feet. The boring was advanced using mud rotary methods by Gregory Drilling of Redmond, Washington, under subcontract to Shannon & Wilson, using a CME 850 track-mounted drill rig. The drill rig was placed on a barge (provided by Quigg Bros., Inc of Aberdeen, Washington under subcontract to Shannon & Wilson), and the boring was advanced through a moon hole in the barge.

Standard Penetration Tests (SPT) were performed in the boring at 5-foot intervals for the entire depth of the boring. The SPT consisted of driving a 2-inch O.D. split-spoon sampler a total distance of 18 inches into the bottom of the boring with a 140-pound CME auto-hammer falling 30 inches. The number of blows required to advance the sampler for each six-inch increment were recorded. The blow counts recorded the last 12 inches of penetration are designated as the Standard Penetration resistance or N-value. When penetration resistances exceeded 50 to 100 blows for 6 inches or less of penetration, the test was terminated, and the number of blows and the corresponding penetration recorded. The log of boring B-1, including Standard Penetration Test N-values, is presented in Figure 3.

Mr. David Young of Shannon & Wilson was present during drilling to observe operations, retrieve representative soil samples for subsequent laboratory testing, and prepare a descriptive field log of the boring and subsurface conditions. Mr. Young also measured the depth to the mudline at the boring location using a tape with a weighted end from a point of known elevation on the bridge deck. The elevation of the point on the bridge deck was surveyed in the field during the drilling and was provided to Mr. Young by WSDOT personnel.

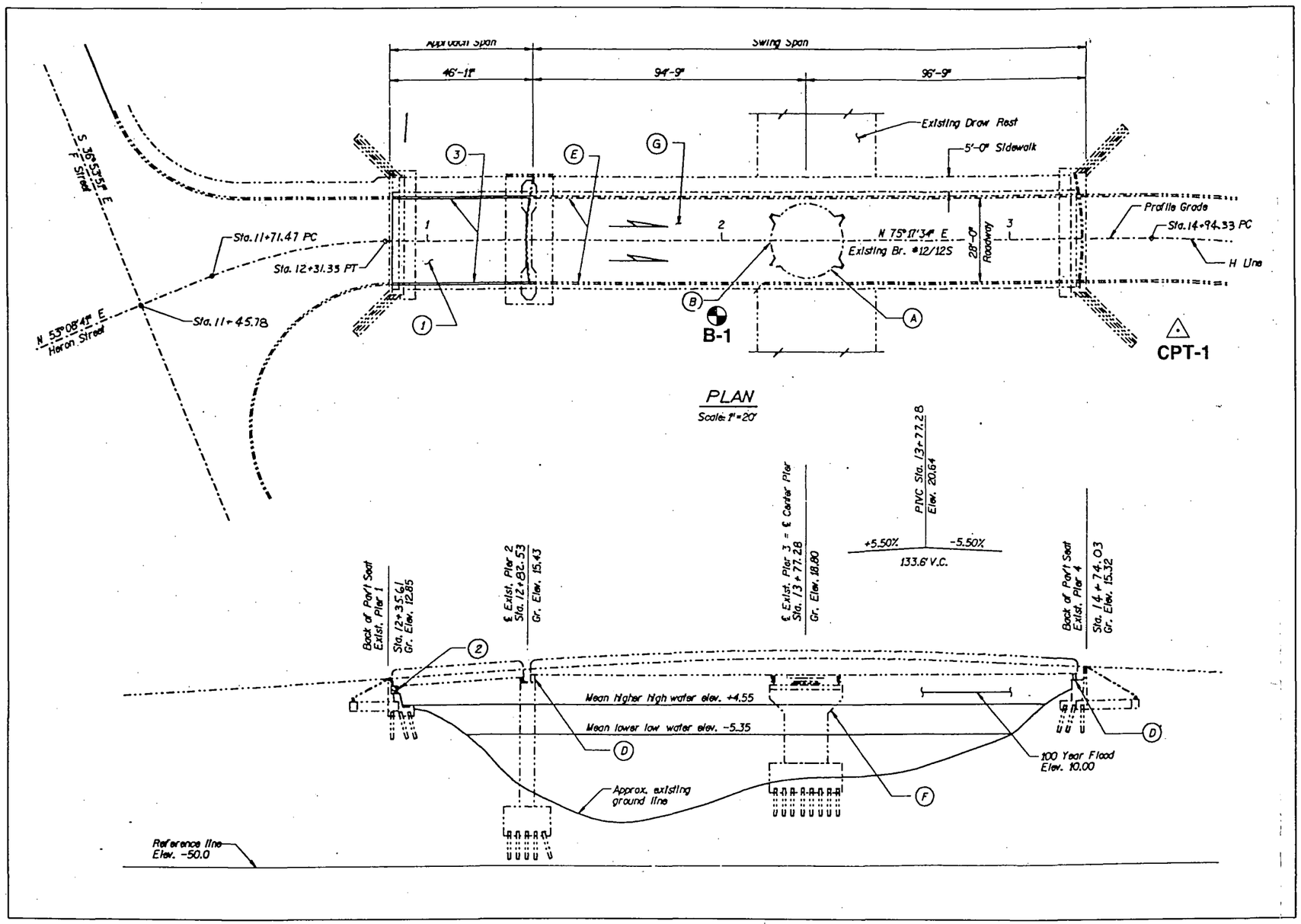
3.2 Seismic Cone Penetration Test

Under subcontract to Shannon & Wilson, Mr. Keith Brown of Northwest Cone Exploration of Redmond, Washington, performed one onshore seismic cone penetration test (CPT) on March 31, 1999. As shown in Figure 2, CPT-1 was pushed near the east abutment to a depth of about 90 feet below the ground surface. The tip resistance, skin friction, inferred soil type, and estimated soil properties with depth are presented in Figure 4.

The shear wave velocity (V_s) profile was measured at 1-meter intervals. Vertically propagating shear waves were generated at the ground surface by pinning a 10-foot long steel H-beam between the ground and the hydraulic jacks on the cone rig and striking on the ends of the H-beam with a sledge hammer. The sledge hammer was instrumented, and a geophone was placed in the stationary cone tip so that the shear wave arrival time and corresponding shear wave velocity were measured. The resulting plot of shear wave velocity with depth is shown in Figure 4.

3.3 Laboratory Testing

Soil samples retrieved in conjunction with the Standard Penetration Tests in the borings were returned to our laboratory in Seattle for further visual classification and laboratory testing to



N

0 40 80

Scale in Feet

LEGEND

B-1 Boring Designation and Approximate Location

CPT-1 Cone Penetration Test Designation and Approximate Location

NOTES

1. Base map prepared by WSDOT, dated June 1989.
2. Boring and Cone Penetration Test locations were determined in the field by tape measurements from existing site features and are therefore approximate.

Seismic Retrofit Study
SR 12/12S Wishkah River/Heron St. Bridge
Aberdeen, Washington

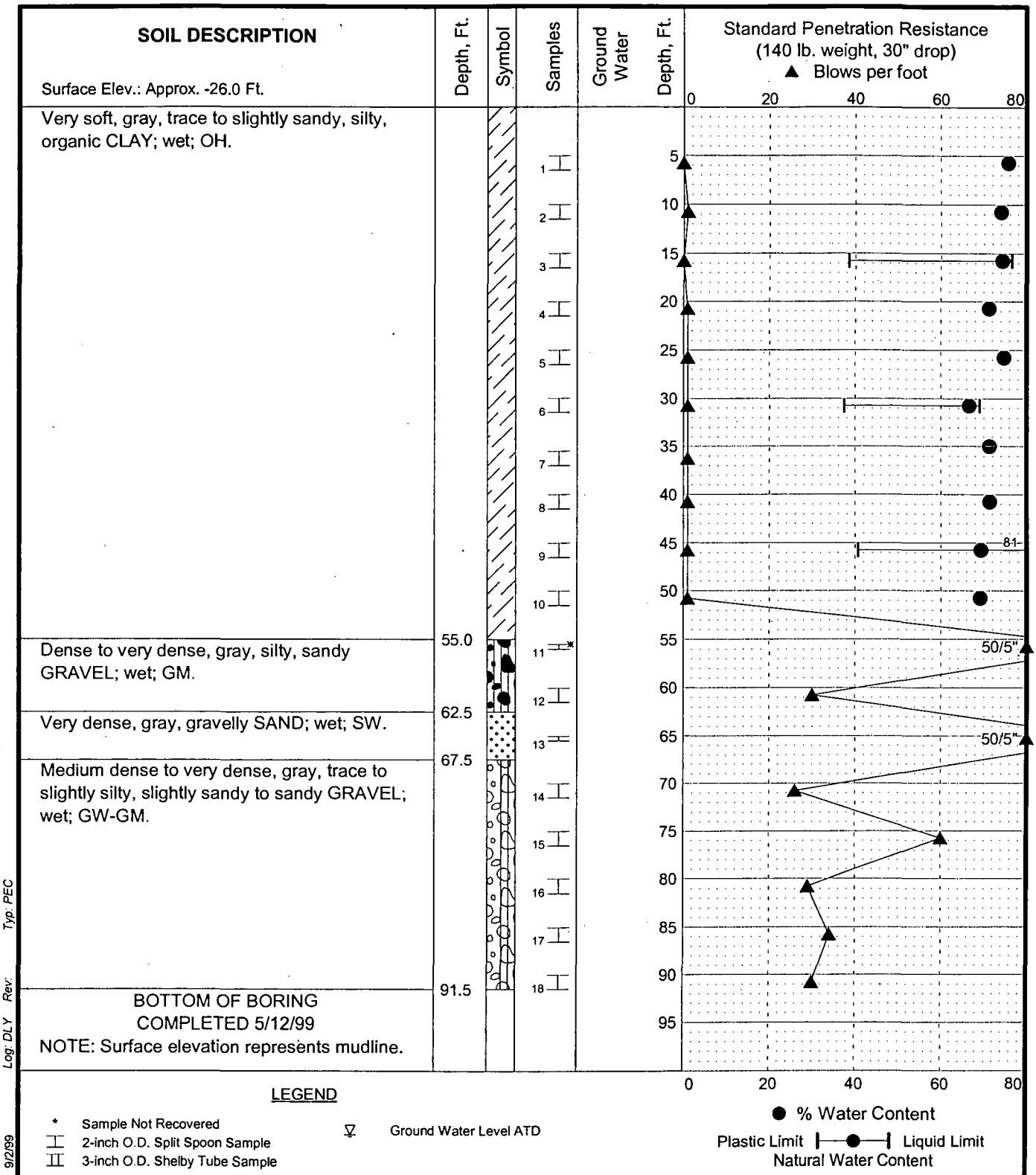
SITE AND EXPLORATION PLAN

July 1999 W-8639-01

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 2

File: W-8639-01 Fig. 2.dwg Date: 7-16-99



LEGEND

* Sample Not Recovered
2-inch O.D. Split Spoon Sample
3-inch O.D. Shelby Tube Sample
▽ Ground Water Level ATD

NOTES

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

Seismic Retrofit Study
SR 12/12S Wishkah River/Heron Street Bridge
Aberdeen, Washington

LOG OF BORING B-1

September W-8639-01

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 3

MASTER LOG W8639-01.GPJ SHAN WIL.GDT 9/2/99 Log: DLY Rev: Typ: PEC

WSDOT 1983

Foundations

JOHN SPELLMAN
Governor

DUANE BERENTSON
Secretary

STATE OF WASHINGTON

DEPARTMENT OF TRANSPORTATION

Transportation Building • Olympia, Washington 98504 • (206) 753-6005

November 28, 1984

Mr. C.S. Gloyd
Bridge and Structures Engineer
Olympia, WA 98504

RE: SR-12, C.S. 1405, L-7726
Wishkah River Bridge #12/12N
West Approach Replacement
Foundation Report

Dear Mr. Gloyd:

This report presents our foundation recommendations for the replacement of the west approach to the Wishkah River Bridge in Aberdeen. The existing bridge and approaches were constructed in the 1930's and now carry the two westbound lanes over the Wishkah River. The west approach consists of a span between the main bridge and the at-grade city streets, Wishkah Street and Fuller Way. The existing approach consists of a concrete slab deck over a timber floor that is supported by a timber trestle resting on continuous spread footings. The length along center-line is 76 feet for this irregularly shaped slab. There are low retaining walls around the perimeter of the approach bridge, except where it is connected to the main bridge.

The foundation investigation consisted of drilling two test borings, laboratory testing, and foundation engineering analysis. Information from the project records for the existing bridge was also used. It was originally proposed to remove the existing trestle and replace it with earth fill. This concept was discussed in our IDC to J.D. Zirkle, dated December 14, 1983. This IDC is included in Appendix D. Our preliminary estimate was that six feet of fill would settle two to three feet. This magnitude of settlement has been confirmed by laboratory testing and we understand that this option is not considered feasible because of the time delay for settlement to occur and the uncertain effect that the fill would have on the existing bridge abutment.

The foundation recommendations herein are based on the specific project description as shown by the bridge layout drawing and the site conditions encountered during our field explorations. These exploratory borings are assumed to be representative of the subsurface conditions throughout the bridge site area and subsurface conditions between borings are assumed not to differ significantly from those revealed by our investigation. If subsurface conditions encountered during construction are different from those found by our explorations, we should be notified so that we may assist you in analysis of the conditions and reevaluation of our foundation recommendations.

Field Explorations

The two test borings were drilled during November, 1983. These are noted as B-1 and C-1 and each was drilled to a depth of 144 feet which corresponds to an elevation of approximately -135 feet. The ground surface varies between elevations +8 to +10, and the deck of the approach structure varies from elevation +12 up to elevation +17.

The test boring locations are shown on the Soil Profile Drawing, Appendix A, which presents a generalization of the subsoil conditions. The Test Boring Logs are presented in Appendix B.

Soil samples were generally recovered at 5-foot intervals. Disturbed type soil samples were taken in conjunction with performing the Standard Penetration Test from which blows per foot (N-values) are recorded. A total of 16 additional undisturbed samples were taken from Boring C-1. All samples were visually classified in the field and then transmitted to the Materials Laboratory for a more detailed classification based on laboratory testing.

Laboratory Testing

The samples were visually examined in the laboratory and representative samples were selected and tested to verify the field descriptions and to classify the soils with respect to the Unified Soil Classification System. Laboratory testing consisted of 58 sieve analyses and moisture content determinations, three Atterberg Limit tests, and four consolidation tests.

The soil sample descriptions indicated on the test boring logs have been edited to reflect the additional information from the laboratory testing. Laboratory test results are presented in Appendix C.

Site Geology

During Pleistocene time, the level of the Pacific Ocean was greatly reduced allowing the coastal rivers to deeply incise their valleys into the underlying bedrock. This site is close to the mouth of the Wishkah River where it empties into the Chehalis River. Because the Chehalis River is large, bedrock is probably at or near the lowest base level possible. The lower Chehalis Valley has never contained glacial ice. Therefore, the sediment found at the site has been supplied through transport by running water.

Recursion of the glacial ice from Puget Sound and the Olympic Mountains supplied large quantities of water and various sized sediments. The Puget Sound meltwater flowed south and met the Chehalis River in the vicinity of the town of Rochester and then downstream to the ocean. During the same time, the Olympic Mountains were also supplying water and sediments to the Chehalis.

In general, three types of native material were found at the site: coarse sand and gravel below elevation -80 down to the bottom of the test holes at elevation -135, silts and fine sands between elevations -30 and -80, and silts with fine sands

and organic material above elevation -30. The lower coarse sand and gravel is interpreted to be glacio-fluvial in origin, the middle silts with fine sands would be normal aluvium, and the upper fine-grained organic soil is the material to be expected in a quiet embayment.

The native soils have been covered with approximately 10 feet of fill. The fill contains large pieces of wood and there are logs at the base of the fill.

Groundwater is controlled by the river, which is tidal. River levels shown on the Bridge Layout Drawing are 4.72 feet for M.H.H.W. and -5.38 for M.L.L.W.

Approach Fill

There are existing retaining walls that act as end abutments at the transitions from the approach structure to Wishkah Street and Fuller Way. We understand that these walls will remain in place. This west approach structure is, in effect, an approach slab. No additional approach slabs are recommended. This project requires no filling.

Bridge Foundation Support

We recommend that the west approach replacement be supported on driven displacement piles. The new structure will weigh significantly more than the existing timber structure that is supported on a combination of continuous spread footings and the existing main bridge abutment. We estimate that the maximum settlement of a spread footing option would be in the order of four inches during the first two years and an additional four inches over the following 50 years. Also, there is a potential for additional greater settlements due to decomposition of wood and logs in the fill. Consequently, we do not recommend the use of spread footings.

We understand that the preliminary design by the Bridge and Structures Branch, based on our preliminary report, is to use the standard 55-ton allowable load, 12-inch diameter cast-in-place concrete piles. These would be spaced at 10 feet center to center in both directions.

Cast-in-place concrete piles appear to be the most suitable type to use at this site because of the great depth down to the bearing stratum and because of the ease with which the steel pipes can be either spliced or cut in order to bring the concrete piles up to the cross beam. The piles should be assumed to act primarily as side friction units. Precast concrete piles are less desirable because it is not possible to make a precise estimate of the tip elevations that the piles must be driven to in order to develop the minimum allowable bearing.

We have analyzed the subsoils at this site relative to two standard sizes of steel pipe piles that would be driven with closed ends. The standard 12-inch diameter steel pipes may be designed for allowable loads up to 55 tons and the standard 14-inch diameter steel pipes may be designed for allowable loads up to 70 tons.

The upper 95 feet of soil down to approximately elevation -85 is very loose and will provide very little side friction or lateral support for piles. Piling must be driven into the dense to very dense sands and gravels. We estimate the piling will penetrate 15 to 20 feet into the sand and gravel bearing strata. We recommend a minimum tip elevation at elevation -90. Our estimated tip elevations are -110 feet for 55-ton piles and -115 feet for 70-ton piles. These elevations correspond to maximum pile lengths of approximately 120 to 130 feet. These elevations are summarized on the attached Foundation Design Recomendations sheet along with other related information.

We were unable to find any driving records or other design information for the piles supporting the main bridge. It is our understanding that the west abutment, adjacent to the west approach, is supported on piles and they may be battered into the area where new piles would be driven. We recommend either a determination as to pile location be obtained from "as-built" plans or that the west end of the abutment be exposed by making an excavation so that these pile locations and inclinations can be measured. This will minimize the potential for the new piles to become tangled with the old. The Layout Drawing for the existing bridge shows the bottom of the end pier to be close to elevation -4 and the piles are vertical. However, this drawing is not marked "as built." The excavation will probably have to be shored and underpinning may be needed for the existing west approach.

A summary of P-Y values is attached so that horizontal deflections may be calculated. Please note that the upper 90 feet of very loose soil down to elevation 80 has a potential for liquefaction and should be assumed to provide zero lateral resistance under earthquake loading. Also, the existing low retaining walls are not suitable for providing horizontal resistance to earthquake loads because these walls would be unstable if liquefaction were to occur.

Our estimated maximum settlement of a single pile is 0.5 inches and the maximum differential settlement between adjacent piles on 10-foot centers is 0.25 inches.

Construction Considerations

Obstructions to pile driving are present. The 1937 drawings for construction of the existing west approach shows an old concrete slab situated under the spread footings. The horizontal extent of this slab is not shown. Wood and logs were encountered in the upper 12 feet of the test holes and pieces of wood were encountered down to 70 feet. These pieces of wood are an indication that logs could be present.

The minimum tip elevations specified in this report should be included in the contract, directing the contractor to drive the piling to the required bearing strata. Pointed pile tips, jetting and/or spudding may be necessary to achieve minimum tip elevations. Two test piles should be driven and these should be located close to where the test holes were drilled.

We recommend that the piles be driven so that there is sufficient penetration into the dense sand and gravel such that this bearing stratum will carry all of the design load. To do this, a 55-ton pile should be driven to an allowable load of 67 tons, and a 70-ton pile should be driven to an allowable load of 85 tons.

Foundation recommendations have been summarized on the attached Foundation Design Recommendations sheet. Also, attached are P-Y values to use for calculating lateral pile deflections, Appendix A - Soil Profile Drawing, Appendix B - Logs of Test Borings, Appendix C - Laboratory Test Data, and Appendix D - December 14, 1983 IDC.

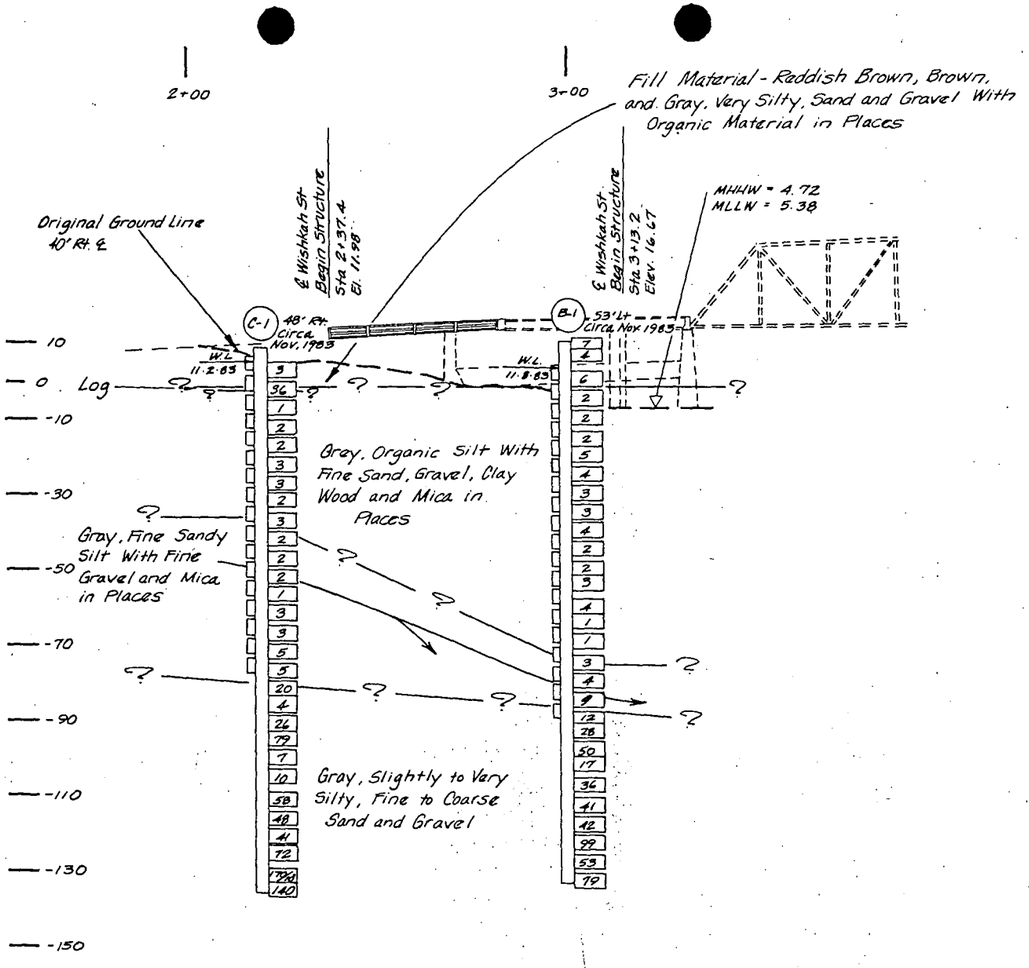
Please note that Section 1-02.4 of the Standard Specifications allows the potential bidders to inspect all factual information which includes the Logs of Test Borings and Laboratory Test Data.

Very truly yours,

A.J. Peters, P.E.
Materials Engineer

AJP:djb
JMH
Attach.

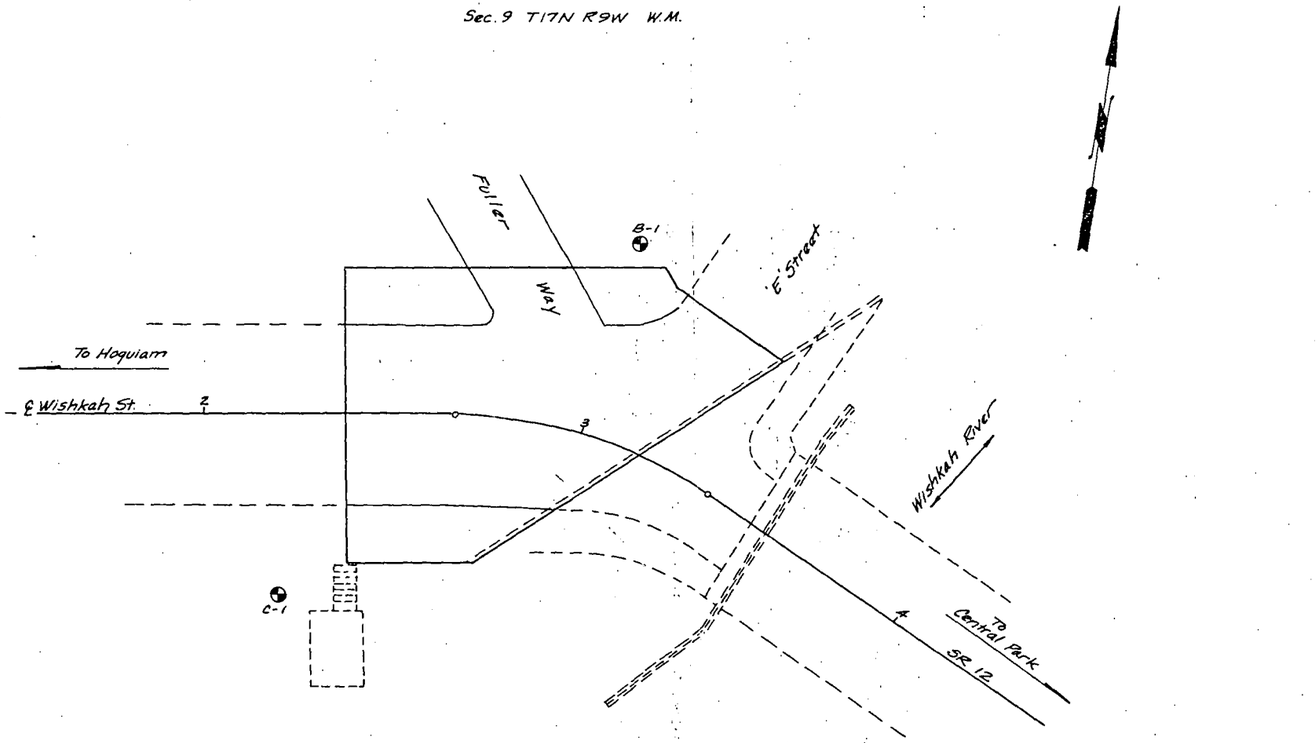
cc: A.H. Walley
S.A. Moon
J.D. Zirkle
D.J. Morrow
G.L. Edwards
Project Engineer



HOLE NO.	SAMPLE NUMBERS
B-1	E5142-1 to E5145-12
C-1	E5095-1 to E5121-14

DATUM

N. G. V. D. of 1929



PLAN VIEW SHOWING WEST BRIDGE APPROACH AND TEST HOLE LOCATIONS

THIS PRINT REDUCED 50%

JOB L-7726 S.R. 12 C.S. 1405 Layout 1544

WISHKAH RIVER BRIDGE WEST APPROACH
BRIDGE 12/12N

WASHINGTON STATE TRANSPORTATION COMMISSION
DEPARTMENT OF TRANSPORTATION
MATERIALS BRANCH

A.J. PETERS Materials Engineer

DATE October 1984
SCALE 1"=20' VER
1"=20' HOR
SHEET 1 OF 1

LOG OF TEST BORING WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

___ S.H. ___ S.R. 12 SECTION Wishkah River Bridge Approach Job No. L-7726

Hole No. B-1 Sub Section West Approach Cont. Sec. 1405

Station 3+01 Offset 53' Lt. Ground El. 9.7

Type of Boring Augers Casing 4" Augers to W.T. El. 2.7

Inspector ___ Date November 8, 1983 Sheet 1 of 7

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
	7		2 3 4 5 STD PEN 1	Loose, reddish-brown, moist, slightly organic, fine to coarse sandy, very silty GRAVEL.
	4		3 2 2 3 STD PEN 2	Very loose, reddish-brown, moist, silty, fine to coarse sandy GRAVEL.
5				
			S- 3	No Recovery.
10	6		5 3 3 2 STD PEN 4	Loose, brown, wet, silty, fine to coarse sandy GRAVEL.
			S- 5	Gray, wet, fine gravelly, very silty, fine to coarse SAND - with pieces of wood.
15	2		1 1 1 1 STD PEN 6	Soft, gray, wet, fine sandy, slightly clayey SILT - with pieces of wood.
			S- 7	Gray, wet, fine gravelly, fine to coarse sandy, highly organic SILT - with pieces of wood.
20	2		1 1 STD PEN	Soft, gray, wet, fine sandy, organic SILT - with pieces of wood.

DOT FORM 351-003 REVISED 12/79

Original to Materials Engineer
Copy to Bridge Engineer
Copy to District Administrator

Copy to ___

HWY Form 351-003-a (H. F. 26.66-A).
Revised S-67.

Hole No. B-1 Sub Section Wishkah River Bridge - West Approach Sheet 2 of 7

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			1 8 1	
			S- 9	Gray, wet, fine sandy, organic SILT - with mica and a trace of medium sand.
25			1/ STD 12" PEN	Very loose, gray, wet, slightly micaceous and organic, fine sandy SILT.
	2		1 10 1	
			S- 11	Gray, wet, fine sandy, organic SILT - with pieces of wood, mica and a trace of medium sand.
30	5		2 STD 2 PEN	Loose, gray, wet, micaceous, slightly organic, fine gravelly, fine sandy SILT - with a trace of medium to coarse sand and shells.
			3 12 3	
			S- 13	Gray, wet, fine sandy, organic SILT - with fibrous material and a trace of medium sand.
35	4		1 STD 1 PEN	Very loose, gray, wet, micaceous, slightly organic, fine gravelly, fine sandy SILT - with pieces of wood and a trace of medium to coarse sand.
			3 14 3	
			S- 15	Gray, wet, fine sandy, organic SILT - with mica and a trace of medium sand.
40	3		3 STD 1 PEN	Soft, gray, saturated, organic, clayey SILT - with fine sand and pieces of wood.
			2 16 2	
			S- 17	Gray, wet, fine sandy, organic SILT - with mica and a trace of medium sand.
45	3		1 STD 2 PEN	Soft, gray, wet, micaceous, fine sandy, clayey SILT - with pieces of wood.

HWY Form 351-003-a (H. F. 26.66-A).
Revised 5-67.

Hole No. B-1 Sub Section Wishkah River Bridge - West Approach Sheet 3 of 7

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			1 2 ↓ 18	
			S- 19 ↑	Gray, saturated, fine sandy, organic SILT - with a trace of medium sand.
50	4		1 2 STD PEN ↑	Very loose, gray, wet, micaceous, fine sandy SILT - with a trace of marine shells.
			2 1 ↓ 20	
			S- 21 ↑	Gray, saturated, fine sandy, organic SILT - with a trace of medium sand.
55	2		1 1 STD PEN ↑	Very loose, gray, wet, micaceous, fine sandy SILT.
			1 1 ↓ 22	
			S- 23 ↑	Gray, saturated, fine sandy, organic SILT - with a trace of medium sand.
60	2		1 1 STD PEN ↑	Very loose, gray, wet, micaceous, fine sandy SILT.
			1 1 ↓ 24	
			S- 25 ↑	Gray, wet, fine sandy SILT - with a trace of mica.
65	3		1 2 1 STD PEN ↑ 26 ↓ 2	Very loose, gray, wet, micaceous, organic, fine sandy SILT - with pieces of wood.
			S- 27 ↑	Gray, wet, fine sandy SILT - with a trace of mica and pocket of organic material.
70			1/ 12" STD PEN ↑	Very loose, gray, wet, micaceous, organic, fine sandy SILT - with pieces of wood.

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Revised 5-67.

Hole No. B-1 Sub Section Wishkah River Bridge - West Approach Sheet 4 of 7

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
	4		2 2 28	
			S- 29	Gray, wet, fine sandy SILT - with a trace of mica.
75	1		1/ 12" STD PEN	Very loose, gray, wet, fine sandy SILT - with pieces of wood and a trace of medium sand.
			2 2 30	
			S- 31	Gray, saturated, fine sandy, organic SILT - with mica.
80	1		1/ 12" STD PEN	Very loose, gray, wet, micaceous, fine sandy SILT - with a trace of medium sand.
			1 2 32	
			S- 33	Gray, wet, organic SILT - with fine sand layers and mica.
85	3		1 1 STD PEN	Very loose, gray, wet, micaceous, fine sandy SILT - with a trace of medium sand.
			2 2 34	
			S- 35	Gray, wet SILT - with fine sand layers and mica.
90	4		1 1 STD PEN	Very loose, gray, moist, micaceous, fine sandy SILT - with sand layers and a trace of medium sand.
			3 4 36	
			S- 37	Gray, wet, micaceous, fine sandy, organic SILT - with pockets of fine to medium sand and organic material.
95	9		1 3 STD PEN	Loose, gray, wet, fine gravelly, fine sandy SILT - with a trace of medium to coarse sand.

HWY Form 351-003-a (H. F. 26.66-A).
Revised 5-67.

Hole No. B-1 Sub Section Wishkah River Bridge - West Approach Sheet 5 of 7

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			6 38 7	
			S- 39	Gray, wet, very silty, fine gravelly, fine to coarse SAND.
100	12		8 STD 8 PEN 4 40 5	Medium dense, gray, wet, slightly silty, fine gravelly, fine to coarse SAND.
	28		8 STD 8 PEN 20 41 82	Dense, gray, wet, gravelly, very silty, fine to coarse SAND.
105				
	50		13 STD 23 PEN 27 42 35	Dense, gray, wet, silty, fine to coarse sandy GRAVEL.
110				
	17		12 STD 10 PEN 7 43 19	Medium dense, gray, wet, slightly silty, fine gravelly, fine to medium SAND - with a trace of coarse sand.
115				
	36		9 STD 14 PEN 22 44 26	Dense, gray, wet, organic, fine gravelly, very silty, fine to coarse sand.
120				

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Revised 5-67.

Hole No. B-1 Sub Section Wishkah River Bridge - West Approach Sheet 6 of 7

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
	41		17 STD 20 PEN 21 45 29	Dense, gray, moist, very silty, fine gravelly, fine to coarse SAND.
125				
	42		8 STD 19 PEN 23 46 23	Dense, gray, moist, very silty, fine gravelly, fine to coarse SAND.
130				
	99		27 STD 44 PEN 55 47 35	Very dense, gray, moist, very silty, fine gravelly, fine to coarse SAND.
135				
	53		32 STD 21 PEN 32 48 35	Very dense, gray, moist, silty, gravelly, fine to coarse SAND.
140				
	79		11 STD 43 PEN 36 49 26	Very dense, gray, moist, silty, fine gravelly, fine to coarse SAND.
145				Test boring stopped 144' below ground elevation.

HWY Form 351-003-a (H. F. 26.66-A).
Revised 5-67.

Hole No. B-1 Sub Section Wishkah River Bridge - West Approach Sheet 7 of 7

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
				NOTE: This is a summary Log of Test Boring. Soil/Rock
				descriptions are derived from visual field identifications
				and laboratory test data.

LOG OF TEST BORING WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

___ S.H. ___ S.R. 12 SECTION Wishkah River Bridge Approach Job No. L-7726

Hole No. C-1 Sub Section West Approach Cont. Sec. 1405

Station 2+19 Offset 48' Rt. Ground El. 8.2

Type of Boring Augers Casing 3" Augers to W.T. El. 6.2

Inspector ___ Date November 2, 1983 Sheet 1 of 7

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			ID U-	Gray and brown, wet, very silty, fine to medium SAND - with a trace of coarse sand and fine gravel, and chunks of siltstone.
5			ONLY 1	
	3		1 STD 2 PEN 1 2 1	Very loose, gray, wet, micaceous, fine sandy SILT - with large pieces of decomposed wood.
			A U-	
10			3	
	36		22 STD 28 PEN 8 4 7	One ft log - Brownish-black decomposed wood.
			U-	No Recovery.
15			5	
	1		1/ STD 12" PEN 1/ 6 12"	Very loose, gray, wet, organic, fine sandy SILT - with pieces of wood and a trace of mica.
			B C U-	Gray, wet SILT - with a trace of fine sand and mica.
20			D E 7	

DOT FORM 351-003 REVISED 12/79

Original to Materials Engineer
Copy to Bridge Engineer
Copy to District Administrator

Copy to ___

HWY Form 351-003-a (H. F. 26.66-A).
Revised 5-67.

Hole No. C-1 Sub Section Wishkah River Bridge - West Approach Sheet 2 of 7

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			1/ 12" STD PEN 8	Very loose, gray, wet, fine sandy SILT - with mica.
	2		1 1	
			A B C U- 9	
25			D	
			1 1 STD PEN 10	Very loose, gray, wet, micaceous, fine sandy SILT - with pieces of wood and a trace of medium sand.
	2		1 1	
			A B C U- 11	
30				
			2 2 STD PEN 12	Very loose, gray, wet, fine sandy SILT - with pieces of wood and a trace of medium sand.
	3		1 1	
			A B U- 13	
35				
			1 1 STD PEN 14	Very loose, gray, wet, micaceous, slightly organic, fine sandy SILT - with pieces of wood.
	3		2 1	
			B C U- 15	
40			D	
			1 1 STD PEN 16	Very loose, gray, wet, micaceous, slightly organic, fine sandy SILT - with pieces of wood.
	2		1/ 12"	
			A B C U- 17	
45				

HWY Form 351-003-a (H. F. 26.66-A).
Revised 5-67.

Hole No. C-1 Sub Section Wishkah River Bridge - West Approach Sheet 3 of 7

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
	3		1 2 STD PEN 1 1 18	Very loose, gray, wet, micaceous, fine sandy SILT - with pieces of wood.
			A B C U- 19	
50				
	2		1 1 STD PEN 1 2 20	Very loose, gray, wet, micaceous, fine sandy SILT - with pieces of wood.
			A B C U- 21	
55				
	2		1 1 STD PEN 1 1 22	Very loose, gray, wet, micaceous, fine sandy SILT.
			A B C U- 23	
60				
	2		1 1 STD PEN 1 1 24	Very loose, gray, wet, micaceous, fine sandy SILT.
			A B C U- 25	
65				
	1		1/ 12" STD PEN 1 2 26	Very loose, gray, wet, micaceous, fine sandy SILT.
			A U- 27	
70				

HWY Form 351-003-a (H. F. 26.66-A).
Revised 5-67.

Hole No. C-1 Sub Section Wishkah River Bridge - West Approach Sheet 4 of 7

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
	3		1 1 STD PEN 2 2 28	Very loose, gray, wet, micaceous, fine sandy SILT.
			A U- 29	
75				
	3		1 1 STD PEN 2 2 30	Very loose, gray, wet, micaceous, fine sandy SILT.
			A U- 31	
80				
	5		2 2 STD PEN 3 2 32	Medium stiff, gray, wet, micaceous, fine sandy, clayey SILT.
			A U- 33	
85				
	5		2 3 STD PEN 2 1 34	Loose, gray, wet, fine gravelly , fine to medium sandy SILT - with a trace of coarse sand.
90			2 STD	
	20		10 10 PEN 4 35	Medium dense, gray, wet, silty, fine gravelly, fine to coarse SAND.
95	4		2 2 STD PEN	Very loose, gray, wet, fine sandy SILT - with a trace of medium to coarse sand and fine gravel.

HWY Form 351-003-a (H. F. 26.66-A).
Revised 5-67.

Hole No. C-1 Sub Section Wishkah River Bridge - West Approach Sheet 5 of 7

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			2 36 2	
100	26		19 STD 7 PEN 19 37 34	Dense, gray, moist, fine gravelly, very silty, fine to coarse SAND.
105	79		25 STD 37 PEN 42 38 43	Very dense, gray, wet, silty, fine gravelly, fine to coarse SAND.
110	7		4 STD 2 PEN 5 39 7	Loose, gray, moist, alternating layers of SILT and fine SAND - with a trace of medium sand.
115	10		3 STD 4 PEN 6 40 17	Loose, gray, moist, very silty, fine to medium SAND - with a trace of coarse sand and fine gravel.
120	58		20 STD 25 PEN	Very dense, gray, wet, slightly silty, fine to coarse sandy GRAVEL.

HWY Form 351-003-a (H. F. 26.66-A).
Revised 5-67.

Hole No. C-1 Sub Section Wishkah River Bridge - West Approach Sheet 6 of 7

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			33 41 35	
125	48		23 STD 17 PEN 31 42 33	Dense, gray, wet, silty, fine gravelly, fine to coarse SAND.
130	41		12 STD 15 PEN 26 43 27	Dense, gray, wet, silty, gravelly, fine to coarse SAND.
135	72		10 STD 20 PEN 52 44 72	Very dense, gray, wet, silty, fine to coarse sandy GRAVEL.
140	170/10"		57 STD 70 PEN 100/ 45 4"	Very dense, gray, wet, silty, fine to coarse sandy GRAVEL.
145	140		85 STD 47 PEN 93 46	Very dense, gray, wet, slightly silty, fine to coarse sandy GRAVEL.

HWY Form 351-003-a (H. F. 26.66-A).
Revised 5-67.

Hole No. C-1 Sub Section Wishkah River Bridge - West Approach Sheet 7 of 7

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
				Test boring stopped 144' 6" below ground elevation.
				NOTE: This is a summary Log of Test Boring. Soil/Rock
				descriptions are derived from visual field identifications
				and laboratory test data.

Lowe Study 1977

REPORT
SOILS AND FOUNDATIONS INVESTIGATION
SANITARY SEWER SYSTEM IMPROVEMENTS
FOR ABERDEEN NORTH OF THE CHEHALIS RIVER
CITY OF ABERDEEN, WASHINGTON
RLA PROJECT NO. 165-13

REPORT NO. 28

ROGER LOWE ASSOCIATES

ROGER LOWE ASSOCIATES
EARTH SCIENCES

July 25, 1977

URS Company
Suite 200
Fourth and Vine Building
Seattle, Washington 98121

Attention: Mr. Per E. Zimmerlund
Project Director

Report
Soils and Foundations Investigation
Sanitary Sewer System Improvements
for Aberdeen North of the Chehalis River
City of Aberdeen, Washington
Project No. 165-13

Gentlemen:

With this letter we transmit 25 copies of our report, "Soils and Foundations Investigation, Sanitary Sewer System Improvements for Aberdeen North of the Chehalis River, City of Aberdeen, Washington." Our investigation was performed as described in our letter proposal to you dated October 8, 1976, for which a subcontract agreement was signed on October 20, 1976 and authorization to proceed was received from you effective December 30, 1976.

We have made specific recommendations on an area by area basis regarding bottom heave potential of sewer trenches, types of and placement procedures for pipe bedding and trench backfill materials for manholes and sewers, design recommendations for the proposed pump station in West Aberdeen, as well as estimates of total and differential post-construction settlements and comments relative to precautions to be taken during construction.

We appreciate having had the opportunity to work with you on this interesting project and would like to thank you for the assistance you and members of your staff have given.

Please call us if you have any questions about the conclusions and recommendations presented in this report.

Very truly yours,
ROGER LOWE ASSOCIATES

Ronald E. Bucknam

REB:ls

Ronald E. Bucknam, Associate

MAIL — POST OFFICE BOX 530, MERCER ISLAND, WA 98040, TELEPHONE (206) 232-5325
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SOILS AND FOUNDATIONS INVESTIGATION
SANITARY SEWER SYSTEM IMPROVEMENTS
FOR THE
CITY OF ABERDEEN, WASHINGTON

INTRODUCTION

This report presents the results of our subsurface soils and foundation investigation related to proposed sanitary sewer system improvements for the City of Aberdeen, Washington on the north side of the Chehalis River.

We undertook this investigation in accordance with the scope of work detailed in our proposal to the URS Company dated October 8, 1976, for which a subcontract agreement was signed on October 20, 1976 and authorization to proceed was received effective December 30, 1976.

The proposed sanitary sewer system improvements in Aberdeen consist of replacement of approximately 200,000 linear feet of sewer and manholes, as well as construction of one sanitary pump station.

Fifty-nine hollow-stem auger borings (Borings 301-349 and 351-360) were made near proposed sewer lines to depths ranging between 11.5 and 19.0 feet. Twenty-one rotary wash borings (Borings 209-229) were made near proposed sewer locations in sections of Aberdeen near the Wishkah River and ranged in depth from 11.5 to 17.5 feet. One hollow-stem auger boring (Boring 350) was made at the location of the proposed pump station to a depth of 39.0 feet. In addition, field vane shear tests were run at selected depths near invert elevations at 14 boring locations. Exploration locations are shown on the Subsurface Exploration Plan, Plate 1 of this report.

All subsurface investigations were observed on a full-time basis by a member of our field engineering staff. A detailed description of the methods of subsurface exploration is presented in Appendix A of this report. Logs of the bore holes are shown on Plates A-2 through A-67.

Summaries of the results of our extensive laboratory testing program conducted in conjunction with this project are also presented in the Appendix.

BORING 215

DEPTH IN FEET	MOISTURE CONTENT	DRY DENSITY (PCF)	BLOWS PER FOOT	GRAPHIC LOG	SOIL DESCRIPTION
0				ML	GREEN SILT AND ORGANICS (VERY SOFT, WET)
	49.0		15	ML	GRAY SILT WITH SOME GRAVEL AND ORGANICS (MEDIUM DENSE, WET)
5	53.4		10	ML	GRAY SILT WITH SOME ORGANICS (MEDIUM STIFF, WET)
	54.4	68.1	5		SANDY
10	74.3	55.9	2		SOFT
	71.2	57.0	3		
15	65.5	62.1	6		MEDIUM STIFF
20					

BORING TERMINATED AT 17.5 FEET

ON 3/9/77

ROGER LOWE ASSOCIATES | LOG OF EXPLORATION

BORING 220

DEPTH IN FEET	MOISTURE CONTENT	DRY DENSITY (PCF)	BLOWS PER FOOT	GRAPHIC LOG	SOIL DESCRIPTION
0	49.8	70.7	8	ML	BROWN SILT WITH A TRACE OF SAND AND GRAVEL SCATTERED LENSES OF ORGANIC SILT (MEDIUM STIFF, WET)
5	71.5		5		GRAY, VERY SOFT
	90.9		3		
10	79.2	58.3	PUSH		
	69.7	57.8	4		SANDY (SOFT)
15					

BORING TERMINATED AT 15.0 FEET

ON 3/11/77

OBSERVATION WELL INSTALLED
SEE TEXT FOR WATER LEVEL DATA

BORING 221

DEPTH IN FEET	MOISTURE CONTENT	DRY DENSITY (PCF)	BLOWS PER FOOT	GRAPHIC LOG	SOIL DESCRIPTION
0					ASPHALT
	92.3		1/18"	ML	BROWN SILT WITH A TRACE OF SAND (VERY SOFT, WET) WOOD
5	134.6	35.1	8		SOME ORGANICS AND LENSES OF WOOD
	60.9	63.5	4		TRACE OF ORGANICS (MEDIUM STIFF)
10	72.3	60.8	PUSH		SOFT
	72.6	55.5	2		
15					

BORING TERMINATED AT 15.0 FEET

ON 3/14/77

OBSERVATION WELL INSTALLED
SEE TEXT FOR WATER LEVEL DATA

BORING 222

DEPTH IN FEET	MOISTURE CONTENT	DRY DENSITY (PCF)	BLOWS PER FOOT	GRAPHIC LOG	SOIL DESCRIPTION
0				GP	GRAY GRAVEL (LOOSE, DAMP)
	71.8		9	ML	BROWN SILT WITH A TRACE OF SAND (MEDIUM STIFF, WET)
5	87.8	49.6	3		GRAY WITH A TRACE OF ORGANICS (SOFT)
	192.1	26.5	3	OL	DARK BROWN ORGANIC SILT WITH SOME WOOD (VERY SOFT, WET)
10	116.0	40.6	1	ML	SILT WITH A TRACE OF ORGANICS (VERY SOFT, WET)
	90.2	48.9	1		
15	78.2	55.4	2		
20					

BORING TERMINATED AT 17.5 FEET

ON 3/14/77

BORING 223

DEPTH IN FEET	MOISTURE CONTENT	DRY DENSITY (PCF)	BLOWS PER FOOT	GRAPHIC LOG	SOIL DESCRIPTION
0				GP	BROWN SANDY GRAVEL WITH SOME RUBBLE (LOOSE, WET)
			13	SP	GRAY SILTY SAND (MEDIUM DENSE, WET)
	128.6	35.5	3	ML	GRAY SILT WITH SOME SAND (SOFT, MOIST)
5					
	138.6	42.7	5		SCATTERED ORGANIC LENSES
10	59.9	64.7	4		
	74.3	54.7	2		
15					
	70.7	58.1	3		LENSES OF FINE SAND (VERY SOFT, WET)
20					

BORING TERMINATED AT 17.5 FEET

ON 3/15/77

BORING 226

DEPTH IN FEET	MOISTURE CONTENT	DRY DENSITY (PCF)	BLOWS PER FOOT	GRAPHIC LOG	SOIL DESCRIPTION
0	41.2		11	ML	BROWN SANDY SILT WITH TRACE OF GRAVEL (STIFF, WET)
5	42.4	79.2	9		
	32.7	89.0	12		SOME GRAVEL - LENSES OF FINE SILTY SAND TO 2" (SM)
10	29.6	95.7	27	SM	LIGHT BROWN SILTY FINE SAND WITH TRACE OF GRAVEL (MEDIUM DENSE, MOIST)
	29.9	90.8	36		DENSE
15					

BORING TERMINATED AT 15 FEET

ON 3/11/77

BORING 227

DEPTH IN FEET	MOISTURE CONTENT	DRY DENSITY (PCF)	BLOWS PER FOOT	GRAPHIC LOG	SOIL DESCRIPTION
0				SM	
			5		GRAY AND BROWN MOTTLED SILTY FINE SANDS (LOOSE, MOIST)
5	51.7	70.9	5	ML	GRAY SILT WITH A TRACE OF SAND AND ORGANICS (MEDIUM STIFF, WET)
	71.0	57.2	3		SOFT
10	75.6	55.0	1		VERY SOFT
	71.3	56.7	2		
15					

BORING TERMINATED AT 15 FEET

ON 3/15/77

ROGER LOWE ASSOCIATES | LOG OF EXPLORATION

BORING 308

DEPTH IN FEET	MOISTURE CONTENT	DRY DENSITY (PCF)	BLOWS PER FOOT	GRAPHIC LOG	SOIL DESCRIPTION
0				GP	3" ASPHALT BROWN SANDY GRAVEL (FILL)
				SP	GREEN FINE SAND (FILL)
	64.9	60.8	4	ML	BROWN GRAY SILT WITH A TRACE OF ORGANICS (SOFT, MOIST)
5					
	71.6	59.2	PUSH		
10			1		
15					

BORING TERMINATED AT 11.5' ON 5/31/77

BORING 309

DEPTH IN FEET	MOISTURE CONTENT	DRY DENSITY (PCF)	BLOWS PER FOOT	GRAPHIC LOG	SOIL DESCRIPTION
0				ML	3" ASPHALT GRAY SILT WITH A TRACE OF ORGANICS (SOFT, MOIST)
	86.1	49.0	2		
5					
	49.6	72.7	PUSH		WITH TRACE OF WOOD
10	75.6	54.8	2		
15					

BORING TERMINATED AT 11.5' ON 5/31/77

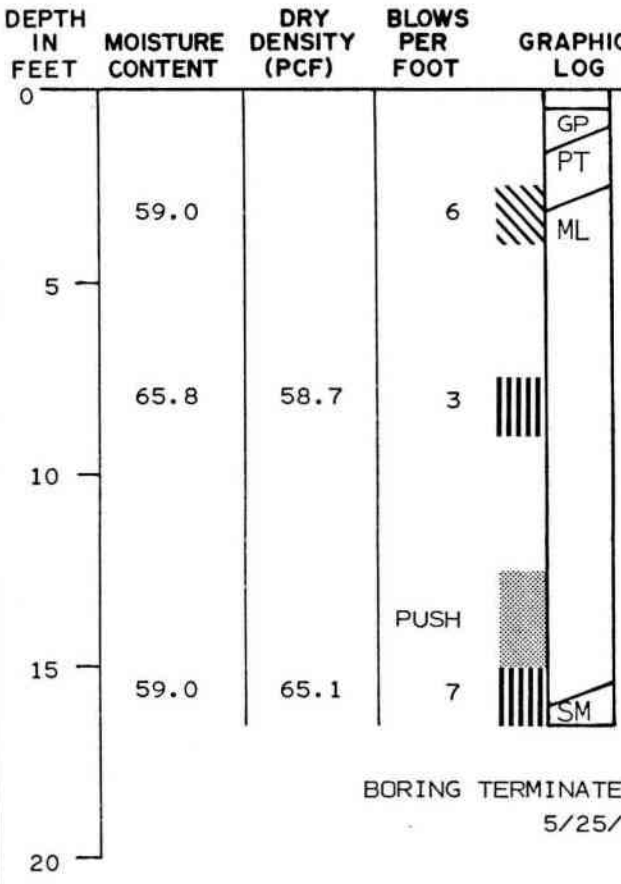
BORING 310

DEPTH IN FEET	MOISTURE CONTENT	DRY DENSITY (PCF)	BLOWS PER FOOT	GRAPHIC LOG	SOIL DESCRIPTION
0				GP	BROWN SANDY GRAVEL (FILL)
			4	ML	GRAY SILT WITH SOME WOOD (SOFT, MOIST)
5					
			2		DARK BROWN SILT WITH SOME ORGANICS (VERY SOFT, MOIST)
10					
			PUSH		GRAY SILT WITH A TRACE OF FINE SAND (SOFT, MOIST)
15	55.8	58.5	4		
20					

BORING TERMINATED AT 16.5' ON 5/31/77

ROGER LOWE ASSOCIATES | LOG OF EXPLORATION

BORING 323



BORING TERMINATED AT 16.5' ON 5/25/77

ROGER LOWE ASSOCIATES | LOG OF EXPLORATION

BORING 324

DEPTH IN FEET	MOISTURE CONTENT	DRY DENSITY (PCF)	BLOWS PER FOOT	GRAPHIC LOG	SOIL DESCRIPTION
0				GP	1" ASPHALT GRAY SANDY GRAVEL (FILL)
				ML	GRAY SILT WITH A TRACE OF ORGANICS AND WOOD (VERY SOFT, MOIST)
5			1		
10	55.9	66.6	PUSH		
	70.4	55.9	4		BECOMES SOFT
15					

BORING TERMINATED AT 14.0' ON 5/25/77

BORING 325

DEPTH IN FEET	MOISTURE CONTENT	DRY DENSITY (PCF)	BLOWS PER FOOT	GRAPHIC LOG	SOIL DESCRIPTION
0				GP	6" CONCRETE SANDY GRAVEL (FILL)
				ML	GRAY SILT (VERY SOFT, MOIST)
	80.0				
5					

BORING TERMINATED AT 4.0' DUE TO OBSTRUCTION 5/27/77

BORING 331

DEPTH IN FEET	MOISTURE CONTENT	DRY DENSITY (PCF)	BLOWS PER FOOT	GRAPHIC LOG	SOIL DESCRIPTION
0				GP	3" ASPHALT GRAY-BROWN SANDY GRAVEL (FILL)
	102.0	73.1	5	ML	BROWN SILT WITH A TRACE OF ORGANICS (SOFT, MOIST)
5	91.1		48		ENCOUNTERED WOOD
	66.9	59.4	7		BECOMES GRAY (VERY SOFT, MOIST)
10	61.3		PUSH		WITH A TRACE OF FINE SAND
			5	SM	GRAY SILTY FINE SAND WITH A TRACE OF ORGANICS (VERY LOOSE, MOIST)
15					

BORING TERMINATED AT 14.0' ON 5/23/77

OBSERVATION WELL INSTALLED
SEE TEXT FOR WATER LEVEL DATA

BORING 332

DEPTH IN FEET	MOISTURE CONTENT	DRY DENSITY (PCF)	BLOWS PER FOOT	GRAPHIC LOG	SOIL DESCRIPTION
0				GP	2" ASPHALT GRAY SANDY GRAVEL (FILL)
			6	ML	GRAY SILT WITH A TRACE OF ORGANICS (SOFT, MOIST)
5					
	97.3	45.5	PUSH		WITH TRACE OF FINE GRAVEL
10			3		BECOMES VERY SOFT
15					

BORING TERMINATED AT 11.5' ON 5/23/77

ROGER LOWE ASSOCIATES | LOG OF EXPLORATION

BORING 333

DEPTH IN FEET	MOISTURE CONTENT	DRY DENSITY (PCF)	BLOWS PER FOOT	GRAPHIC LOG	SOIL DESCRIPTION
0				GP	3" ASPHALT BROWN SANDY GRAVEL (FILL)
			5	ML	GRAY SILT WITH A TRACE OF ORGANICS (SOFT, MOIST)
5					
	27.4		4		
10					
	55.6		PUSH		
15					
	42.7	77.4	PUSH		WITH SOME FINE SAND
	63.5	61.7	4		
20					

BORING TERMINATED AT 19' ON 5/19/77

ROGER LOWE ASSOCIATES | LOG OF EXPLORATION

BORING 334

DEPTH IN FEET	MOISTURE CONTENT	DRY DENSITY (PCF)	BLOWS PER FOOT	GRAPHIC LOG	SOIL DESCRIPTION
0					1" ASPHALT
				GP	BROWN SANDY GRAVEL (FILL)
			4	ML	GRAY BROWN SILT WITH A TRACE OF ORGANICS (SOFT, MOIST)
5					
	89.8	47.4	3		BECOMES VERY SOFT
10					
				SM	GRAY SILTY FINE SAND WITH SOME WOOD (VERY LOOSE, MOIST)
	74.7	76.0	PUSH		
15	55.0	67.2	5	ML	GRAY SILT WITH SOME FINE SAND AND A TRACE OF ORGANICS (SOFT, MOIST)
20					

BORING TERMINATED AT 16.5' ON 5/23/77

BORING 342

DEPTH IN FEET	MOISTURE CONTENT	DRY DENSITY (PCF)	BLOWS PER FOOT	GRAPHIC LOG	SOIL DESCRIPTION
0				GP	3" ASPHALT BROWN SANDY GRAVEL (FILL)
	58.4	78.6	7	ML	GRAY SILT WITH A TRACE OF ORGANICS (MEDIUM STIFF, MOIST)
5			2		BECOMES VERY SOFT, WET
10	70.0	57.0	6		BECOMES MEDIUM STIFF
15					

BORING TERMINATED AT 11.5' ON 5/19/77

BORING 343

DEPTH IN FEET	MOISTURE CONTENT	DRY DENSITY (PCF)	BLOWS PER FOOT	GRAPHIC LOG	SOIL DESCRIPTION
0				ML	BROWN SANDY SILT (FILL)
			4	ML	BROWN GRAY SILT WITH TRACE OF ORGANICS (SOFT, MOIST)
5					
	71.3	54.1	3		
10				SM	GRAY SILTY FINE SAND (LOOSE, MOIST)
	40.9	79.1			
	56.1	66.6	PUSH		
15			13		WITH A TRACE OF ORGANICS
20					

BORING TERMINATED AT 16.5' ON 5/18/77

BORING 351

DEPTH IN FEET	MOISTURE CONTENT	DRY DENSITY (PCF)	BLOWS PER FOOT	GRAPHIC LOG	SOIL DESCRIPTION
0				ML	GRAY AND BROWN SANDY SILT WITH SOME GRAVEL (FILL)
	54.0	68.6	6	ML	GRAY SILT WITH A TRACE OF ORGANICS (SOFT, MOIST)
5					
	61.1	62.4	2		
10					
	56.1	66.6	PUSH		WITH A TRACE OF FINE SAND
15			3		WITH SOME FINE SAND
20					

BORING TERMINATED AT 16.5' ON 5/17/77

ROGER LOWE ASSOCIATES | LOG OF EXPLORATION

BORING 357

DEPTH IN FEET	MOISTURE CONTENT	DRY DENSITY (PCF)	BLOWS PER FOOT	GRAPHIC LOG	SOIL DESCRIPTION
0					3" ASPHALT
				SP	BROWN SAND AND GRAVEL (FILL)
	88.8	46.6	6	ML	BROWN SILT WITH A TRACE OF ORGANICS (SOFT, MOIST)
5					
	74.2	55.3	2		BECOMES GRAY
10					
				SM	GRAY SILTY FINE SAND (VERY LOOSE, MOIST)
	35.2	81.7	PUSH		
15			5		
20					

BORING TERMINATED AT 16.5' ON 5/16/77

BORING NUMBER	DEPTH (FT.)	SHEAR STRENGTH (LBS/FT^2)
213	8.0	192
	10.0	537
	12.0	480
	14.0	588
217	9.0	405
	10.5	645
	12.0	504
	14.0	>1110
	15.0	570
223	8.0	810
	10.0	966
	12.0	987
	14.0	720
227	6.0	1008
	8.0	582
	10.0	798
	12.0	486
310	8.0	1014
	10.0	840
	12.0	699
	14.0	840
319	4.0	444
333	4.0	186
	6.0	810
	8.0	675
	10.0	519
335	8.0	444
	10.0	597
	12.0	540
	14.0	549
340	8.0	564
	10.0	666
	12.0	555
	14.0	483
342	4.0	951
	6.0	675
	8.0	477
	10.0	>1140
	11.0	1170

BORING NUMBER	DEPTH (FT.)	SHEAR STRENGTH (LBS/FT^2)
348	5.0	378
	8.0	360
	11.0	345
	14.0	750
	17.0	540
350	3.0	690
	4.0	360
	5.5	288
	7.0	315
	8.5	420
	10.0	345
	11.5	330
	13.0	330
	14.5	390
	16.0	444
	17.5	690
	19.0	1080
	20.5	990
	22.0	1134
	23.5	936
	25.0	900
352	6.0	393
	8.0	510
	10.0	435
	12.0	468
356	6.0	285
	8.0	258
	10.0	375
	12.0	516

ROGER LOWE ASSOCIATES

DIRECT SHEAR TEST RESULTS

EXPLORATION NUMBER	SAMPLE DEPTH (FT)	MOISTURE CONTENT %	DRY DENSITY (LBS/FT^2)	CONFINING PRESSURE (LBS/FT^2)	SHEAR RATE* (IN./MIN.)	INDICATED STRENGTH (LBS/FT^2)	
						YIELD	PEAK
336	10.0			208		144	201
343	2.5			832		268	603
343	15.0			208		144	297
356	12.5	57.8	65.8	416		191	383
356	12.5	57.8	65.8	1040		287	478

KEY: * ALL TESTS ARE RUN ON SATURATED SAMPLES AT A STRAIN RATE OF 0.05 INCHES PER MINUTE UNLESS NOTED OTHERWISE.

Aberdeen Sewer Replacement Project

Plate A-70

ROGER LOWE ASSOCIATES

TRIAXIAL SHEAR TEST RESULTS

EXPLORATION NUMBER	SAMPLE NUMBER	SAMPLE DEPTH (FT)	MOISTURE CONTENT (%)	DRY DENSITY (LBS/FT^2)	CONFINING PRESSURE (PSI)	FAILURE STRAIN (%)	SHEAR STRENGTH (LBS/FT^2)
211	4	10.0	82.2	51.6	4	8.9	335
212	3	8.0	56.4	65.5	5	13.8	251
214	4	11.0	83.6	50.2	8	16.8	211
215	4	10.0	74.3	55.9	7	16.6	262
215	5	13.0	71.2	57.0	10	18.0	245
216	4	10.0	76.4	52.5	3	18.9	186
216	5	13.0	54.1	69.2	2	11.7	442
219	5	10.0	87.2	52.0	4	12.9	176
220	4	10.0	79.2	58.3	8	12.2	285
221	4	10.0	72.3	60.8	3	13.7	410
222	5	13.0	90.2	48.9	5	17.0	135
223	5	13.0	74.3	54.7	6	11.3	268
227	4	10.0	75.6	55.0	7	15.6	168
309	2	7.5	49.6	72.7	0	20.0	161
309	3	10.0	75.6	54.8	0	12.0	290
310	3	12.5	---	---	0	11.9	573
311	2	7.5	72.4	55.8	0	14.5	281
314	2	10.0	32.7	89.8	0	7.1	556
320	1	5.0	111.9	39.6	0	9.9	70
321	2	7.5	135.8	34.5	0	11.0	340
321	3	12.5	67.7	60.1	0	10.9	462
322	2	7.5	117.3	37.9	0	6.9	211
322	3	12.5	43.9	75.5	0	7.7	672
322	4	15.0	62.9	62.0	0	14.7	304

ROGER LOWE ASSOCIATES

TRIAXIAL SHEAR TEST RESULTS

EXPLORATION NUMBER	SAMPLE NUMBER	SAMPLE DEPTH (FT)	MOISTURE CONTENT (%)	DRY DENSITY (LBS/FT^2)	CONFINING PRESSURE (PSI)	FAILURE STRAIN (%)	SHEAR STRENGTH (LBS/FT^2)
323	2	7.5	65.8	58.7	0	13.3	261
323	3	12.5	---	---	0	21.3	151
324	2	10.0	55.9	66.6	0	8.9	259
324	3	12.5	70.4	55.9	0	10.9	437
325	1	2.5	80.0	---	0	18.0	99
325A	1	2.5	74.5	---	0	12.1	146
325A	3	10.0	156.5	29.6	0	11.0	72
326	2	7.5	69.8	54.9	0	12.5	306
326	3	12.5	69.4	60.0	0	11.2	419
327	2	7.5	80.6	51.5	0	17.8	70
327	3	12.5	76.9	54.0	0	11.8	282
329	2	10.0	90.1	---	0	18.0	169
330	1	2.5	59.5	59.9	0	11.1	299
330	2	5.0	188.5	28.3	0	13.2	110
331	3	10.0	66.9	59.4	0	11.4	543
332	2	7.5	97.3	45.5	0	14.0	209
332	3	10.0	---	---	0	20.4	269
333	4	15.0	42.7	77.9	0	9.8	339
333	5	17.5	63.5	61.7	0	18.9	188
334	2	7.5	89.8	47.4	0	18.6	84
334	3	12.5	74.7	76.0	0	10.6	532
334	4	15.0	55.0	67.2	0	9.1	220
337	3	12.5	34.2	75.2	0	11.0	490
340	2	7.5	78.5	52.3	0	12.8	477

ROGER LOWE ASSOCIATES

TRIAXIAL SHEAR TEST-RESULTS

EXPLORATION NUMBER	SAMPLE NUMBER	SAMPLE DEPTH (FT)	MOISTURE CONTENT (%)	DRY DENSITY (LBS/FT^2)	CONFINING PRESSURE (PSI)	FAILURE STRAIN (%)	SHEAR STRENGTH (LBS/FT^2)
340	3	12.5	65.1	60.9	0	11.9	167
340	4	15.0	52.4	76.3	0	8.0	842
341	2	7.5	77.0	---	0	7.5	393
341	3	15.0	---	---	0	20.6	140
342	1	2.5	58.4	78.6	0	7.7	437
342	3	10.0	70.0	57.0	0	9.9	758
343	3	12.5	56.1	66.6	0	9.6	338
344	1	2.5	61.6	58.9	0	9.2	189
345	2	10.0	51.3	70.3	0	13.2	328
345	3	12.5	69.7	---	0	20.3	75
348	1	2.5	46.6	52.0	0	11.3	144
348	2	7.5	85.3	51.2	0	13.7	113
348	3	10.0	82.9	52.1	0	12.1	127
349	3	10.0	84.4	---	0	7.9	343
349	4	12.5	---	---	0	8.8	249
350	1	2.5	150.6	32.1	0	6.0	311
350	3	12.5	71.1	56.0	0	11.0	135
350	4	20.0	67.3	58.4	0	17.0	203
350	5	22.5	65.4	61.1	0	12.1	245
351	2	7.5	61.1	62.4	0	17.0	176
351	3	12.5	56.1	66.6	0	15.8	426
351	4	15.0	---	---	0	13.5	318
352	2	10.0	---	---	0	14.3	158
352	3	12.5	---	---	0	19.5	154

Aberdeen Sewer Replacement Project

Plate A-73

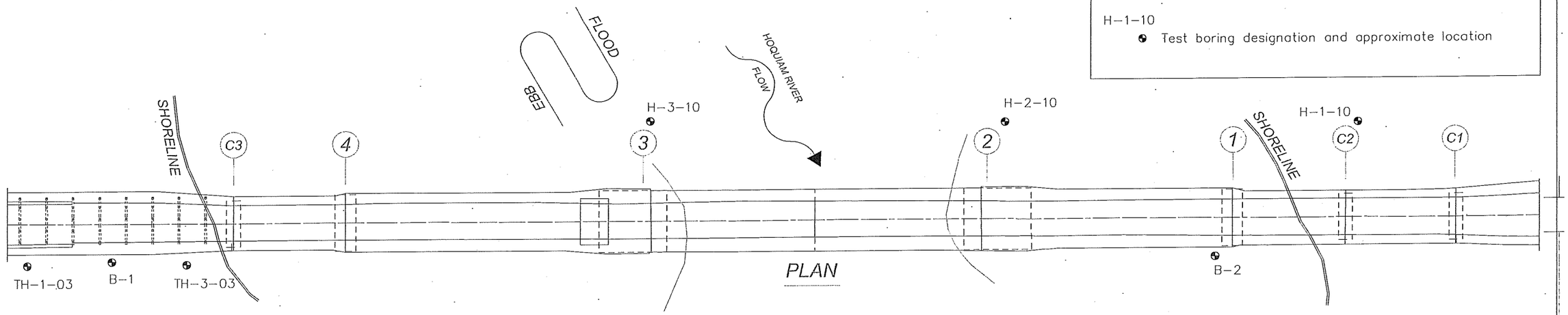
EXPLORATION NUMBER	SAMPLE NUMBER	SAMPLE DEPTH (FT)	MOISTURE CONTENT (%)	DRY DENSITY (LBS/FT^2)	CONFINING PRESSURE (PSI)	FAILURE STRAIN (%)	SHEAR STRENGTH (LBS/FT^2)
353	2	7.5	58.1	64.4	0	17.0	207
356	1	5.0	61.5	62.5	0	21.3	312
356	2	10.0	57.8	65.8	0	14.6	338
357	1	2.5	88.8	46.6	0	11.0	250
360	2	7.5	32.7	87.3	0	10.0	281
360	3	10.0	67.3	54.2	0	7.0	454

ROGER LOWE ASSOCIATES

TRIAXIAL SHEAR TEST RESULTS

WSDOT 1976

H–1–10
Test boring designation and approximate location



Soil Descriptions
Unit 1: very loose sandy silt
Unit 2: loose to medium dense silty sand to sand
Unit 3: soft to medium stiff plastic silt
Unit 4: dense to very dense silty gravel to gravel
Unit 5: Very loose organic soil

JOB# XL-3812 STATE ROUTE 101 MILEPOST(S) 87.99

FIGURE 1:
BRIDGE PLAN AND PROFILE

SR 101
Simpson Avenue Bridge

Washington State Department of Transportation
GEOTECHNICAL DIVISION

PREPARED BY Dale Gietz DATE August 26, 2010

File Location: J:\projects\XL-3812 SR101_Simpson Ave Bridge\Layout.dgn

W-1440-02 (177)

WY Form 351-003 (H. F. 26.66)
(Revised 5-67).

WASHINGTON
STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS

Original to Materials Engineer
Copy to Bridge Engineer
Copy to District Engineer
Copy to _____

LOG OF TEST BORING

S.H. _____ S.R. 101 Section Hoquiam River Bridge Job No. L-4919
Hole No. B-2 Sub Section Simpson Ave. Cont. Sec. 1412
tation 12+45 Offset 20' Lt. Ground El. 13.5
Type of Boring Wash and Chop Casing 3' to 105' W.T. El. Not determined
nspector Larry M. Moore Date May 7, 1976 Sheet 1 of 5

EPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
	6		1 2 Std Pen 4 3 1	SILT, GRAVEL and wood, brown
			U-2	SANDY GRAVELLY SILT with wood, organic
5				
	2		1 1 Std Pen 1 1 3	GRAVELLY SILT, gray
			U-4	
				SILT with wood and occasional gravel, gray
10				
			U-5	
	2		1 Std Pen 1 1 6	SILT - organic, gray, with pieces of wood
15				
			A B C U-7	
			D E F	
	2		1 1 Std Pen 1 1 8	
20				

ole No. B-2 Sub Section Simpson Ave. Sheet 2 of 5

TH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			D E F U-9	
			1 Std	
			1 Pen	
	2		1 10	
			1	
25				
			C	SILT, organic, gray, with pieces of wood
			D	
			E U-11	
			1 Std	
	2		1 Pen	
			1 12	
			1	
30				
			U-13	
			3 Std	
	10		3 Pen	
			7 14	
35			5	SAND with silt lenses, gray
			4 Std	
	21		8 Pen	
			13 15	
			17	
40				
			9 Std	
	18		8 Pen	
			10 16	
			11	
45				

Hole No. B-2 Sub Section Simpson Ave. Sheet 3 of 5

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			U-17	
	4		2 Std 2 Pen 2 18 2	
50				
	2		1 Std 1 Pen 1 19 3	
55				
	6		2 Std 2 Pen 4 20 6	SAND with silt lenses, pieces of wood and seashells, gray
60				
	13		3 Std 4 Pen 9 21 17	
65				
	12		4 Std 4 Pen 8 22 16	
70				SAND AND SILT, layered, with lenses of wood, gray

ole No. B-2 Sub Section Simpson Ave. Sheet 4 of 5

TH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			3 Std 2 Pen	
	9		7 23 12	SAND AND SILT, layered, and lenses of wood, gray
75				
			1 Std 3 Pen	
	7		4 24 6	
				SAND WITH SILT lenses and pieces of wood,
80				gray
			3 Std 3 Pen	
	7		4 25 5	
85				
			6 Std 5 Pen	
	9		4 26 4	SILT WITH SAND lenses and pieces of wood, gray
90				
			3 Std 3 Pen	
	10		7 27 4	SAND AND SILT layers with pieces of wood, gray
95				Sand, gray

ole No. B-2 Sub Section Simpson Ave. Sheet 5 of 5

PTH.	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			10 Std	
			18 Pen	
	39		21 28	
			24	SAND, gray
100				
			2 Std	
			2 Pen	
	5		3 29	
			3	SILT - highly organic, gray
105			U-30	
				SAND WITH SILT lenses and some wood, gray
				U-31 as I.D. sample
			U-31	
			4 Std	
110			4 Pen	SILT - organic, gray
	10		6 32	
			7	
				Test drilling stopped at 111'

WSDOT 1968

SEC 11 T17N R10W WM

FED. ROAD DIV. NO.	STATE	FED. AID PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
8	WASH.				

6TH STREET
P.I. 164+16.05
Δ 37°27'15" Lt.
R 150'
T 50.85'
L 98.05'
S None

LEVEE STREET
P.I. 163+87.08
Δ 64°30'00" Rt.
R 114'
T 68.50'
L 123.36'
S None

N.P.R.R.
D 7°00'

S.R. 101
P.I. 158+92.76
Δ 39°45'30" Lt.
R 250'
T 87.34'
L 169.12'
S .08% Ft.

Dim's on ℄ P.S. 4 No. 2
Shoulder Line 2
Edge of Pavt.
Stub & Cap
Toe of Slope
2" Conduit in Sawk
158+93 Lighting Std. Anchorage
465'-0" Bk. to Bk. of Pavt. Seats
234'-0"
161+13 Lighting Std. Anchorage
℄ S.R. 101 S 83°14'15" W
Crown Pt., Profile Grade & Pivot Point
Face of Pier Protection
Pier Protection
Typical fender light - 180° Red
Operators House (Root Line) (Foundation Line)
Toe of Rip-rap Slope
℄ Exist Water Line (To be removed)
℄ Exist. Harbor Television Cable (Will be moved at owners expense)
℄ Exist Gas Line
Proposed 14" Water Main
℄ 6TH Street
℄ Levee Street
℄ N.P.R.R.
2" Conduit in Sawk
163+31 Lighting Std. Anchorage Toe of Riprap Slope
Min. 50' Clr.
PLAN

Air Navigation Light

SUPERELEVATION PROFILE
Design "A"

Note: Bk. of Pavt Seat Pier No. 1 & ℄ Piers No. 2, 3, 4 & 5 are normal to ℄ S.R. 101

+0.5000 % +4.8552% P.I.V.C. Sta 160+33 El. 13.16 90' V.C.
+4.8552 % -6.0000% P.I.V.C. Sta 161+78 El. 20.20 200' V.C.
-6.0000% -2.0000 % P.I.V.C. Sta 162+43 El. 11.80 80' V.C.

Bk. Pavt Seat Pier No. 1 Sta 159+81.00 Gr. El. 12.40
Pier No. 2 Sta 159+34.00 Gr. El. 12.67
Pier No. 3 Sta 159+86.00 Gr. El. 12.74
Pier No. 4 Sta 160+38.00 Gr. El. 13.14
Pier No. 5 Sta 160+90.00 Gr. El. 13.55
Pier No. 1 Sta 162+83.00 Gr. El. 13.91
Pier No. 6 Sta 163+26.00 Gr. El. 11.28
Bk. Pavt Seat Sta 163+69.00 Gr. El. 10.56
Bk. Pavt Seat Sta 163+92.00 Gr. El. 10.56
Bk. Pavt Seat Sta 164+32.00 Gr. El. 10.56

2:1 Slope
Riprap
E.N.P.R.R.
Normal to E.N.P.R.
Max. H.W. El. 8.3
M.H.H.W. El. 4.7
M.L.L.W. El. -5.0
El. 0.86
360° Green (North & South Truss) when lift span is fully raised
180° Red (North & South Truss) at all times until lift span is fully raised.
Exist Ground Line 18' Rt. of ℄

ELEVATION
Grade elevations shown are finish grades on ℄ S.R. 101 and are equal to profile grade.

LOADING: HS-20 OR 2~24K AXLES @ 4' CTRS

ADT 1975 2
DHV 1975 2

DATUM
U.S.G.S.

DATE	REVISION	BY	APP'D
6-19-68	Revised Pier Protection and added navigation lights, Removed Signs	A.F.M.	
5-2-68	Added Operators House, Pier 7 & 5 Wall Bot. Chgd.	B.K.	
4-23-68	Added Fix. Exp. Brgs.; Chg'd Conduit size	T.L.M.	
4-16-68	Added Pier Protection & Proposed Water Main per Dist. Print	R.Z.	
3-28-68	Revised East approach from two to three spans and changed Pier numbers	G.T.M.	
-	Tower Strut Removed, S.R. 101 Crown Pt. added	T.L.M.	
10-16-67	Revised per Dist. print received 10-16-67	R.Z.	Not sent out
9-18-67	Test Holes H-1 & H-2 added	R.Z.	
8-25-67	Grade adjusted per Dist. request	R.Z.	
8-23-67	Revised per Dist. print received 8-16-67 and P.I.V.C. Sta's. adjusted	R.Z.	

Bridge Design Engineer
Supervising Bridge Engr.
Designed
Design Checked
Quantities
Quantities Signed
Quantities Checked

6-26-68

CS/417 BL520 31032'8A SR 101 Hoquiam River Bridge

T. 17 N. R. 10 W. W.M.

TOWN OF HOQUIAM

HOQUIAM RIVER

Tidal

CAMPBELL'S

LEVEE ST

STA. 164+63.25 P.T.

END OF PLAN

Govt. Lot 5
Sec. 11

Govt. Lot 6
Sec. 11

14TH ST

15TH ST

16TH ST

6TH ST

S 89° 44' 58" E
2626.09
1/4 Cor. To Sec Cor

Found
3/4" I.P.

S 00° 02' 11" E
837.11' M.C. To Sec Cor

S 83° 14' 15" W
PSH 9 (SR 101)

S 45° 47' 00" W

N 72° 51' 12" E
766.06'

S 12° 00' 26" E
141.65'

N 8° 46' 27" W
140.73'

S 35° 00' 33" E
345.15'

N 40° 32' 12" W
300.84'

S 56° 23' 30" E
158+24

N 56° 23' 30" W
50'

N 38° 00' 15" W
645.50'

S 52° 34' 07" E
84.18'

N 56° 32' 06" W
645.50'

N 56° 31' 45" W
34.48'

P.O.T. 153+16.32

M.C.

Tie to plat
N 31° 18½ E 1502.1'

802.63' To Sec Cor

MAY 18 1967

Tbr. Bulkhead

Dolphin

Truck Down Ramp

Ho House

Ho

Office

Dock

Shop

Shop

Semi-tangent distance

Sta. 164+63.25 P.C.

Sta. 164+63.25 P.T.

Sta. 163+52.0 P.C.

Sta. 159+73.96 P.T.

Sta. 158+04.84 P.C.

Sta. 154+27.02 A.P.

Sta. 156+32.12
BEGIN. OF PLAN

N 23° 39' 30" W
350.17'

S 26° 20' 30" E
356.00'

S 40° 37' 22" E
214.98'

S 47° 34' 35" E
220.27'

N 46° 06' 50" W
310.68'

RIVERSIDE AVE

5'

NORTHERN PACIFIC RAILWAY

LEGEND

Property Ownership Numbers (3 - 123)
Property Lines
Scale Bar 100 50 0 100

CURVE DATA

PI STATION	Δ	R	T	L	
158 + 92.78	38° 45' 30" Lt.	250.00'	87.94	169.12'	SI..06/Ft.
164 + 63.25	37° 27' 15" Lt.	150.00'	50.85'	98.05'	

OWNERSHIPS

PARCEL NO.	NAME	TOTAL AREA	TAKE	REMAINDER LT.	REMAINDER RT.
3-1175	QUIGG BROS-McDONALD	0.93 Ac.	0.30 Ac	0.47 Ac	0.16 Ac.
3-1176	QUIGG BROS. McDONALD	0.21 Ac	0.09 Ac	0.12 Ac	
3-1177	WESTERN ASPHALT CO.	0.15 Ac	.05 Ac	0.10 Ac	
3-1178	NORTHWESTERN LUMBER CO.	4420 □'	190 □'	4230 □'	
3-1179	STATE OF WASHINGTON	2625 □'	1490 □'		1135 □'
3-1180	CITY OF HOQUIAM	0.86 Ac.	0.05 Ac	0.3 Ac.	

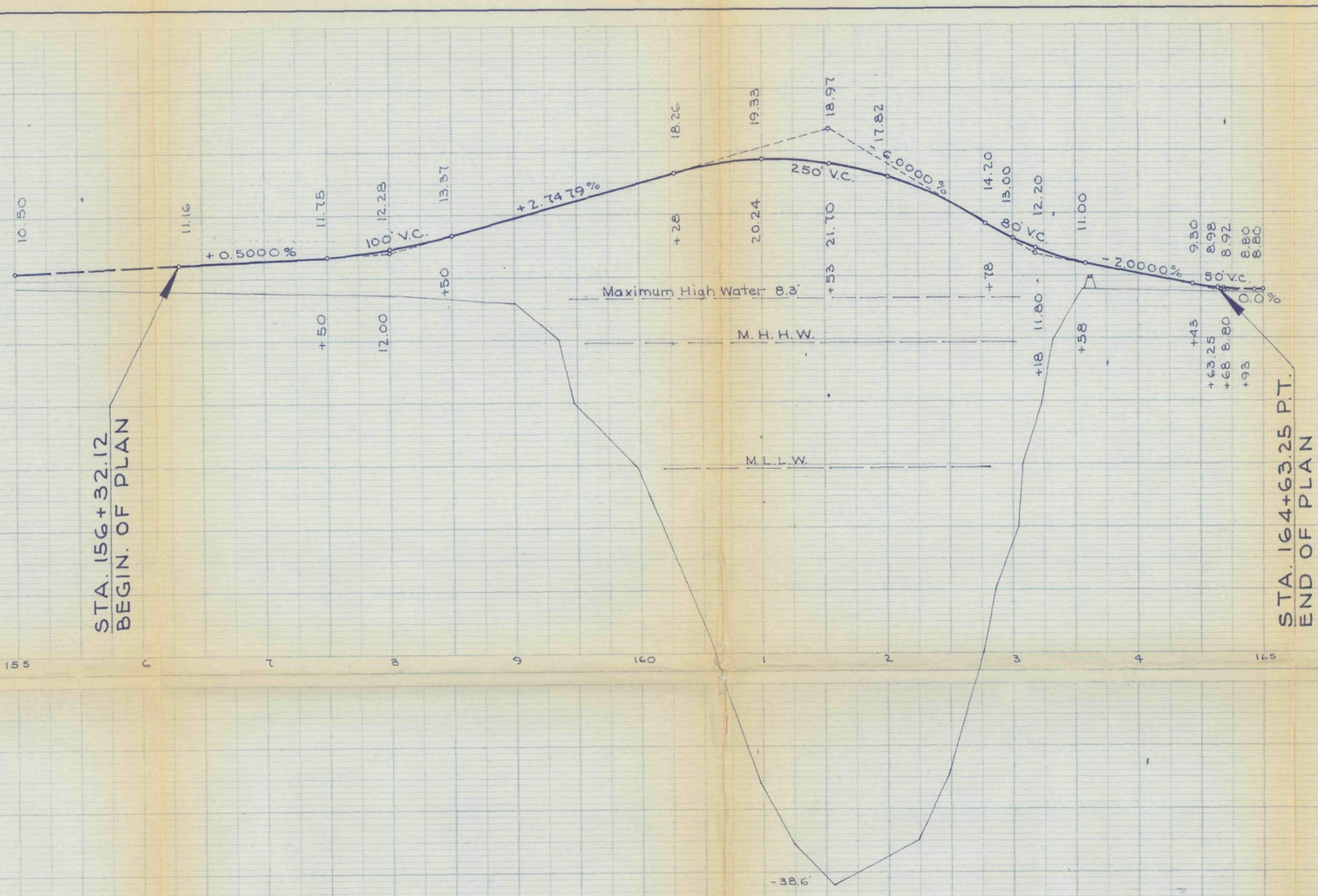
PSH 9 (SR 101) L-3092
Aberdeen-Hoquiam One Way Couplet
Sheet 1 of 2 Sheets

REGION NO.	STATE	FED. AID PROJECT NO.	SHEET NO.
8	WASH.		

ALIGNMENT CHECKED	BY	DATE
RIGHT OF WAY		
DRAWN		
TRACED		
CHECKED		
QUANTITIES		
STRUCTURE NOTATIONS		

DATUM

USGS



DRAWN	BY	DATE
TRACED		
CHECKED	SJB	8-67
QUANTITIES	J.L. Hart	
DIST. ENGR.	R.W. Karsiako	

MAY 18 1967

FED. AID (SER. 101) I-3092
Anacortes - Hoquiam Cnty. Wng Co. Proj. 1
Sheet 2 of 2 Sheets

H. F. 26.66 (Rev. 5-67)

WASHINGTON
STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS

Original to Materials Engineer
Copy to Bridge Engineer
Copy to District Engineer
Copy to _____

LOG OF TEST BORING

P. S.H. 9 S.R. 101 Section Aberdeen-Hoquiam one Way Couplet Job No. I-3092
Hole No. H-1 Sub Section 6th St. Bridge: Pier 1 Cont. Sec. 1416
Station 159+08 Offset On ℄ Ground El. 7.6
Type of Boring Auger 8C48-8 Casing Auger 73.0 W.T. El. 1.6
Inspector Calvin Lockwood Date 29-Aug-1967 Sheet 1 of 4

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			1 Std. Pen.	
	3		2	SILT, SAND, & PEAT-6" layer sod - then- very
			1 1	
			2	loose, brown, silt with small amount
				extremely fine sand & bits of peat
				mixed throughout
5				
				CLAYEY SILT - very soft, grey, with small
			B C U-2	amount extremely fine sand & bits of
			D	peat mixed throughout
			Std. Pen.	
	1		2/24" 3	(lost sample)
10				
			Std. Pen.	
	1		2/24" 4	
			A B C U-5	
15				
				CLAYEY SILT & SAND - very soft, grey,
			C U-6	extremely fine sand mixed - with trace
			D E	of peat
			Std. Pen.	
	3/24"		3/24" 7	
20				

Hole No. H-1 Sub Section 6th St. Bridge: Pier 1 Sheet 2 of 4

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			B C U-8	
			D	
			Std. Pen.	
	1		2/ 24" 9	
25				
			U-10	
			D E F	
			1 1 Std. Pen.	
	2		1 1 11	
30				
				SAND & GRAVEL - Loose, Grey, Silty, Fine
			B C. U-12	Sand & Fine Gravel Mixed - Small
			D	Amount Organic Material
			2 2 Std. Pen.	
	5		3 3 13	
35				
				SILT & SAND - Loose, Grey-Green, Fine
			2 3 Std. Pen.	Sand-With All sizes Decomposed Sand &
	5		2 3 14	Organic Material Mixed In
40				
				SAND - Very Loose, Grey, Very Fine- Slightly Silty
			A B C U-15	
45				

H. F. 26.66-A (Rev. 5-67)

Hole No. H-1 Sub Section 6th St. Bridge: Pier 1 Sheet 3 of 4

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
	3		1 Std. 2 Pen. 1 16 1	
50				
			U-17	
			B_C D	CLAYEY SILT & SAND - Very Soft, Grey,
				Extremely Fine - Small Amount Organic
				Material
55				
			Std.	
	3/24"		3/24" Pen. 18	
60				
			U-19	
			D_{E_F}	
65				
			Std.	
	2		4/24" Pen. 20	
70				

H. F. 26.66-A (Rev. 5-67)

Hole No. H-1 Sub Section 6th St. Bridge: Pier 1 Sheet 4 of 4

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
	100/4"		4"-100 Std. Pen. 21	SANDSTONE - Very Dense, Grey, Decomposed
			C	SANDSTONE BEDROCK - Grey, Shattered
75			O	
			R	
			E	
			22	
				Test Boring Stopped At 78.0'
80				
				Water Level: -6.0 But Will Fluctuate
				With Tidal Differences
				Samples Wet 6.0' On
				Auger to 73.0' - Core 73.0' to 78.0'

H. F. 26.66 (Rev. 5-67)

WASHINGTON
STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS

Original to Materials Engineer
Copy to Bridge Engineer
Copy to District Engineer
Copy to _____

LOG OF TEST BORING

P. S.H. 9 S.R. 101 Section Aberdeen-Hoquiam One Way Couplet Job No. L-3092
Hole No. H-2 Sub Section 6th St. Bridge Cont. Sec. 1416
Station 163+37 Offset 30' LT. ℄ Ground El. 8.4 Below Sea Level
Type of Boring Auger & Washbore 8C48-8 Casing Auger 91.0 W.T. El. -5.6
Inspector Calvin Lockwood Date 30-Aug-to31-Aug-1967 Sheet 1 of 7

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
				FOREIGN FILL-SILT, SAND, GRAVEL, &
				RUBBLE - Loose, Brown
5				
	2		4/24" Std. Pen. 1	CLAYEY SILT - Very Soft, Grey, With Small Amount Extremely Fine Sand & Bits of Peat Mixed Throughout
10				
			U-2 C D E	
	3		1 2 Std. Pen. 3 1 2	
15				
			U-4 C D E	CLAYEY SILT & SAND - Very Soft, Grey, Extremely Fine Sand Mixed - With Trace Of Peat
	3		1 1 Std. Pen. 5 2 2	
20				

H. F. 26.66-A (Rev. 5-67)

Hole No. H-2 Sub Section 6th St. Bridge Sheet 2 of 7

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
20				
			U-6	
			D E F	
			2 Std.	
	3		1 Pen.	
			2 7	
25			2	
			U-8	
			C	
			D E	
			1 Std.	
	3		1 Pen.	
			2 9	
30			4	
			U-10	
			C	(Trace Clam Shell This Area)
			D E	
			Std.	
	3/24"		3/24" Pen.	
			11	
35				
			U-12	
			C	SAND - Loose, Grey, Very Fine - Slightly Silty
			D	
			3 Std.	
	8		3 Pen.	(Pieces Decomposed Wood This Area)
			5 13	
40			6	
			U-14	
			C	
			D E	
			1 Std.	
	4		1 Pen.	
			3 15	
45			4	

H. F. 26.66-A (Rev. 5-67)

Hole No. H-2 Sub Section 6th Street Bridge Sheet 3 of 7

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			8 Std.	
	9		4 Pen.	
			5 16	
			5	
50				
			B_C U-17	
			D	
				CLAYEY SILT & SAND - Very Soft, Grey,
55				Extremely Fine
			2 Std.	
	4		2 Pen.	
			2 18	
			1	
60				
			A_{B_C} U-19	
65				
				SAND - Loose To Slightly Compact, Grey
			1 Std.	
	5		1 Pen.	Very Fine - With Spots & Lenses Of Silt-
			4 20	(Silt Sometimes Brown)
			5	
70				

H. F. 26.66-A (Rev. 5-67)

Hole No. H-2 Sub Section 6th St. Bridge Sheet 4 of 7

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			B_C U-21	
			D	
75				
			6 Std.	
	17		11 Pen.	
			14 22	
	25		11	SILTY SAND & GRAVEL- Slightly Compact
				To Compact, Grey, All Sizes Sand & Fine
80				Gravel
			5 Std.	
	22		8 Pen.	
			14 23	
			17	
85				
			9 Std.	
	20		12 Pen.	
			8 24	
			7	
90				
			3 Std.	
	5		2 Pen.	CLAYEY SILT - Soft To Stiff, Grey, With
			3 25	
			2	Small Amount Extremely Fine Sand
95				

H. F. 26.66-A (Rev. 5-67)

Hole No. H-2 Sub Section 6th St. Bridge Sheet 5 of 7

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			3 Std.	
	6		3 Pen.	
			3 26	
			3	
100				
			5 Std.	
	6		3 Pen.	
			3 27	
			2	
105				
			C U-28	
			D	
			E	
110				
115				
			4 Std.	
	11		4 Pen.	
			7 29	
			7	
120				

Hole No. H-2 Sub Section 6th St. Bridge: Sheet 6 of 7

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
125				
			5 Std. 4 Pen.	
	11		7 30 12	
130				
135				
			3 Std. 4 Pen.	
	11		7 31 9	
140				
145				

H. F. 26.66-A (Rev. 5-67)

Hole No. H-2 Sub Section 6th St. Bridge Sheet 7 of 7

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			8 Std.	(Higher Percentage Sand)
	15		8 Pen.	
			7 32	
			7	
150				
155				
			8 Std.	
	17		9 Pen.	
			8 33	
			8	
160				
	100/1"		1"-100	(161.5) SANDSTONE BEDROCK - Very Hard, Grey (Rock Chips Only Recovered) El. 8.4 ± below sea lev
				Test Boring Stopped At 161.6
				Water Level: -14.0 But Will Fluctuate With Tidal Differences
165				Samples Wet Throughout Hole
				Auger To 91.0 - Wash Bore 91.0 To 161.5
				Bedrock Driven On With Penetrometer
				So Hard That Bit Collapsed

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DEPARTMENT OF HIGHWAYS

Original to Materials Engineer
Copy to Bridge Engineer
Copy to District Engineer
Copy to _____

LOG OF TEST BORING

P S.H. 9 S.R. 101 Section Aberdeen-Hoquiam 1 way Couplet Job No. L-3092
Hole No. H-3 Sub Section 6th St. Bridge: Pier 3 Cont. Sec. 1416
Station 160 + 20 Offset 5' Lt. ℄ Ground El. River Bed -7.0
Type of Boring Wash. & Rotary Casing W.T. El. Tidal Fluctuation
Inspector Calvin Lockwood Date Oct 2 to Oct. 5, 1967 Sheet 1 of 4

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			Std. Pen. 1	River Bed:- CLAYEY SILT - very soft, black, - with small amount extremely fine sand
	0			(Settled 2 feet under own weight without hammer) (pushed 2 feet by hand)
5				
	3/24"		3/24" Std. Pen. 2	CLAYEY SILT - very soft, grey, - with small amount extremely fine sand
10				
	3/24"		3/24" Std. Pen. 3	
15				
	0		Std. Pen. 4	Pushed in by hand
20				

H. F. 26.66-A (Rev. 5-67)

Hole No. H-3 Sub Section 6th St. Bridge : Pier 3 Sheet 2 of 4

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
20				
25	6		3 Std. 3 Pen. 3 3 5	SILT & SAND - very soft to soft, grey, silt & extremely fine sand - with small amount fine gravel & bits of wood.
	4		2 Std. 2 Pen. 2 1 6	
30				CLAYEY SILT - very soft, grey - with small amount extremely fine sand
	3		1 Std. 1 Pen. 2 3 7	
35				
	3		1 Std. 2 Pen. 1 1 8	
40				
	2		1 Std. 1 Pen. 1 1 9	
45				

H. F. 26.66-A (Rev. 5-67)

Hole No. H-3 Sub Section 6th St. Bridge: Pier 3 Sheet 3 of 4

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
45				
			2 Std.	(Bits of peat this sample area)
	5		2 Pen.	
			3	
			2 10	
50				
55				
			2 Std.	
	5		3 Pen.	
			2	
			2 11	
60				
				SAND & GRAVEL - Loose, grey, silty all
				grades sand, & fine & medium gravel
			10 Std.	
65	8		6 Pen.	
			2	
			3 12	SILT & SAND - very soft to stiff, grey
				clayey silt & extremely fine to fine
				sand-with occasional piece fine or
				medium gravel
70				

H. F. 26.66-A (Rev. 5-67)

Hole No. H-3 Sub Section 6th St. Bridge: Pier 3 Sheet 4 of 4

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
70			2 Std.	
	10		5 Pen.	
			5	
			9 13	
75			12 Std.	
			5 Pen.	
	10		5 14	
			5	
				SAND & GRAVEL - compact, grey, silty, all
			13 Std.	
	19		12 Pen.	grades sand , & fine & medium gravel
80			7 15	
			12	? conglomerate ?
				DECOMPOSED SANDSTONE - very dense, grey
	100/6"		100 Std. Pen. 16	
				SANDSTONE BEDROCK - grey, shattered
			C	
85			O	
			R	
			E 17	Test boring stopped at 86.0
				Water level: tidal variation above river bed
				Samples wet throughout hole
				casing to 82.0 below river bed - Core 82.0 to 86.0
90				
				Hole offset due to existing float on ℄ of pier.
				Further coring not done due to time element
				to contend with tides; & quality of stone better than at H-1.
				Several logs were hit in starting casing & possibility
				of many more on bottom at this area.

H. F. 26.66 (Rev. 5-67)

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STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS

Original to Materials Engineer
Copy to Bridge Engineer
Copy to District Engineer
Copy to _____

LOG OF TEST BORING

P S.H. 9 S.R. 162 Section Aberdeen-Hoquiam 1 way Couplet Job No. L-3092
Hole No. H-4 Sub Section 6th St. Bridge Cont. Sec. 1416
Station 162 + 75 Offset ℄ Ground El. -20.5
Type of Boring Wash Bore & Core Casing 3" X 76' W.T. El. See Note
Inspector E. E. Duvall Date Oct. 9 to Oct.16, 1967 Sheet 1 of 6

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
	½'		1 Std. Pen. 1	SILT - very loose, black, scattered sand, shells, & wood, saturated
	½'		1 Std. Pen. 2	
5				
				Sandy Silt & Silty Sand, mixed, fine, gray, scattered sand, shells, & wood, trace fine gravel, saturated
10				
	½'		1 Std. Pen. 3	
15			5	
	5		3 Std. 2 Pen. 4	
20			5 Std. 6 Pen.	

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Hole No. H-4 Sub Section 6th St. Bridge Sheet 2 of 6

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
	13		7 9 ↓ 5	Sandy silt & Silty sand - mixed fine,
				gray, scattered sand, shells, & wood,
				trace fine gravel, saturated
25				
	2		1 ↑ Std. 1 Pen. 1 1 ↓ 6	
30				
	9		2 ↑ Std. 3 Pen. 6 6 ↓ 7	
35				
	11		6 ↑ Std. 5 Pen. 6 8 ↓ 8	Lens, fine gravel, thin
40				
	20		10 ↑ Std. 10 Pen. 10 16 ↓ 9	
45				

H. F. 26.66-A (Rev. 5-67)

Hole No. H-4 Sub Section 6th St. Bridge Sheet 3 of 6

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			9 Std.	
	18		6 Pen.	GRAVEL - fine, with fine sandy silt, gray,
			12	
			18 10	saturated
50				
				Silty Sand - Fine to coarse, gray, with
				pea gravel, saturated
			12 Std.	
55	8		6 Pen.	
			2	
			2 11	SILT & SANDY SILT - fine, loose, gray
				fine sand lenses, trace organic matter,
				wood, & fine gravel, saturated
			2 Std.	
60	5		3 Pen.	
			2	
			3 12	
65			2	
			1 Std.	
	3		2 Pen.	
			2 13	
70				

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Hole No. H-4 Sub Section 6th St. Bridge Sheet 4 of 6

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			2 Std.	
	4		2 Pen.	SILT & SANDY SILT - fine, loose, gray
			2	
			3 14	fine sand lenses, trace organic matter
				wood, & fine gravel, saturated
75				
			3 Std.	
	6		3 Pen.	
			3	
			4 15	
80				
			4 Std.	
	5		2 Pen.	
			3	
			3 16	
85				
			5 Std.	
	13		7 Pen.	
			6	
90			8 17	
95				

H. F. 26.66-A (Rev. 5-67)

Hole No. H-4 Sub Section 6th St. Bridge Sheet 5 of 6

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
				SILT & SANDY SILT - fine, loose, gray,
	11		5 4 Std. Pen. 7 9 18	fine sand lenses, trace organic matter,
				wood, & fine gravel, saturated
100				
	14		4 7 Std. Pen. 7 6 19	
105				
110				
	11		5 6 Std. Pen. 5 7 20	
				SILT - Compact, gray, fine sandy, slightly
115				clayey, damp.
			10 9 Std. Pen. 14 20 21	
120	23			

H. F. 26.66-A (Rev. 5-67)

Hole No. H-4 Sub Section 6th St. Bridge Sheet 6 of 6

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
				SILT - compact, gray fine sandy, slightly
				clayey, damp.
125				
	25		10 12 13 17 Std. Pen. 22	
130				
				SANDSTONE - gray, decomposed
	15 9/4"		150 Std. Pen.	SANDSTONE - Gray, hard
			23	
135			89% CORE	
			24	
				TEST BORING STOPPED AT 138'
				Water table- hole drilled in river.

H.F. 26.66

WASHINGTON
STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS
LOG OF TEST BORING

Original to Mat'ls Engr.
Copy to Bridge Engr.
Copy to District Engr.
Copy to _____

PROPOSED WATER MAIN

P S.H. 9 S.R. 162 Section ABERDEEN-HOQUIAM 1WAY COUPLET Job No. L-3092
Hole No. H-5 Sub Section HOQUIAM RIVER CROSSING (WATER LINE) Cont. Sec. 1416
Station 70' WEST 3/4" IRON PIPE Offset 5' So. ℄ PROPOSED WATER MAIN Ground El. -5
Type of Boring WASH BORE Casing 3"X 20 W.T. El. HOLE DRILLED IN RIVER
Inspector E.E. DUVALL Date OCT 17 TO OCT 18, 67 Sheet 1 of 2

DEPTH	BLOWS PER FT	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
	1/2'		STD. PEN. 1	SILT- VERY LOOSE, BLACK TO GRAY, SATURATED TO WET, SCATTERED SAND, SHELLS, WOOD, BAD ODOR
5				
	1/1'		STD. PEN. 2	
10				SILT- VERY LOOSE, SLIGHTLY CLAYEY, GRAY WITH EXTREMELY FINE SAND, WET, SCATTERED WOOD & SHELLS
	1/1'		STD. PEN. 3	
15				
	1/1'		STD. PEN. 4	SAME- MIXED WITH EXTREMELY FINE SAND & SILTY SAND LAYERS
20				

H.F. 26.66 A

Hole No. H-5 Sub Section HOQUIAM RIVER CROSSING (WATER LINE) Sheet 2 of 3

DEPTH	BLOWS PER FT	PROFILE	SAMPLE TUBE NOS	DESCRIPTION OF MATERIAL
			STD. PEN.	
	2		5	
25				
	2		STD. PEN. 2 6	SAME 26'6" TO 33' - WITH PARTICLES & FRAGMENTS OF HARD GREENISH CLAY
30				
	2		STD. PEN. 7	SILT - VERY LOOSE, CLAYEY, GRAY, WITH EXTREMELY FINE SAND & SILTY SAND, WET
35				
	3		STD. PEN. 2 1 8	
40				
	4		STD. PEN. 3 2 2 1 9	TEST BORING STOPPED AT 42'-0"

WSDOT 1952

OG OF TEST BORING

WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

S.H. ____ S.R. 101 SECTION Chehalis River Bridge at Aberdeen Job No. L-732 (L-6503)

Hole No. 6 Sub Section ____ Cont. Sec. 1401

Station 15+40 (Existing L[5] Line) Offset 35' Rt. (Existing L[5] Line) Ground El. -31.5

Type of Boring Jet Wash Casing 3" W.T. El. unknown

Inspector ____ Date August 27, 1952 Sheet 1 of 3

TH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
				Sandy SILT.
5				Brown, coarse SAND. LOG.
	17		STD PEN 1	Medium dense, brown, fine to coarse SAND. LOG.
10				Brown, medium to coarse SAND.
	8		STD PEN 2	LOG. Loose, blue, medium SAND - with brown, clay seams.
15	20		STD PEN 3	Medium dense, blue, silty, fine to medium SAND - with hard, brown, thin, clay seams.
				Blue, medium to coarse SAND.
20	24		STD PEN 4	Very stiff, brown CLAY. Medium dense, blue, silty, fine to medium SAND.

This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory tests.

Original to Materials Engineer
Copy to Bridge Engineer
Cys. to District Administrator

DOT FORM 351-003 REVISED 12-79

Hole No. 6 Sub Section Chehalis River Bridge at Aberdeen Sheet 2 of 3

...TH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
				Blue, silty CLAY.
				Blue, silty, fine to medium SAND.
25			STD PEN	
	7		5	Loose, blue, sandy SILT.
30				
			STD PEN	Very soft, blue, silty CLAY.
	0		6	
				Blue, silty CLAY - with a trace of sand and wood chips.
				Blue, CLAY.
35				
			STD PEN	
	5		7	Medium stiff, blue, silty CLAY - with a trace of sand.
40				
			STD PEN	
	16		8	Medium dense, blue, silty, fine SAND and brown CLAY.
45				

Hole No. 6 Sub Section Chehalis River Bridge at Aberdeen Sheet 3 of 3

TH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			STD PEN 9	Blue, coarse SAND - with fine gravel.
	5			Medium stiff, brown, silty CLAY - with peat.
			STD PEN 10	Medium dense, blue, silty, coarse SAND.
	17			
0				
				Brown, silty CLAY - with peat.
			STD PEN 11	Medium dense, coarse SAND.
	23			Medium dense, blue, silty, fine SAND.
55				Brown, silty CLAY - with a trace of sand.
			STD PEN 12	Very dense, blue, fine SAND.
	98			
60				
			STD PEN 13	Very dense, blue, clean coarse SAND.
	108			Very dense, blue, silty, sandy GRAVEL.
65				
			STD PEN 14	Very dense, sandy GRAVEL.
	65			
				Test boring stopped at 67.5' below ground elevation.
70				

DOT FORM 351-003A REVISED 4-80

LOG OF TEST BORING

Washington State Department of Transportation

HOLE No. **H-10-52**

PROJECT **SR 101 Chehalis River Brigde #101/115 Seismic Retrofit** Job No. **L-0732**

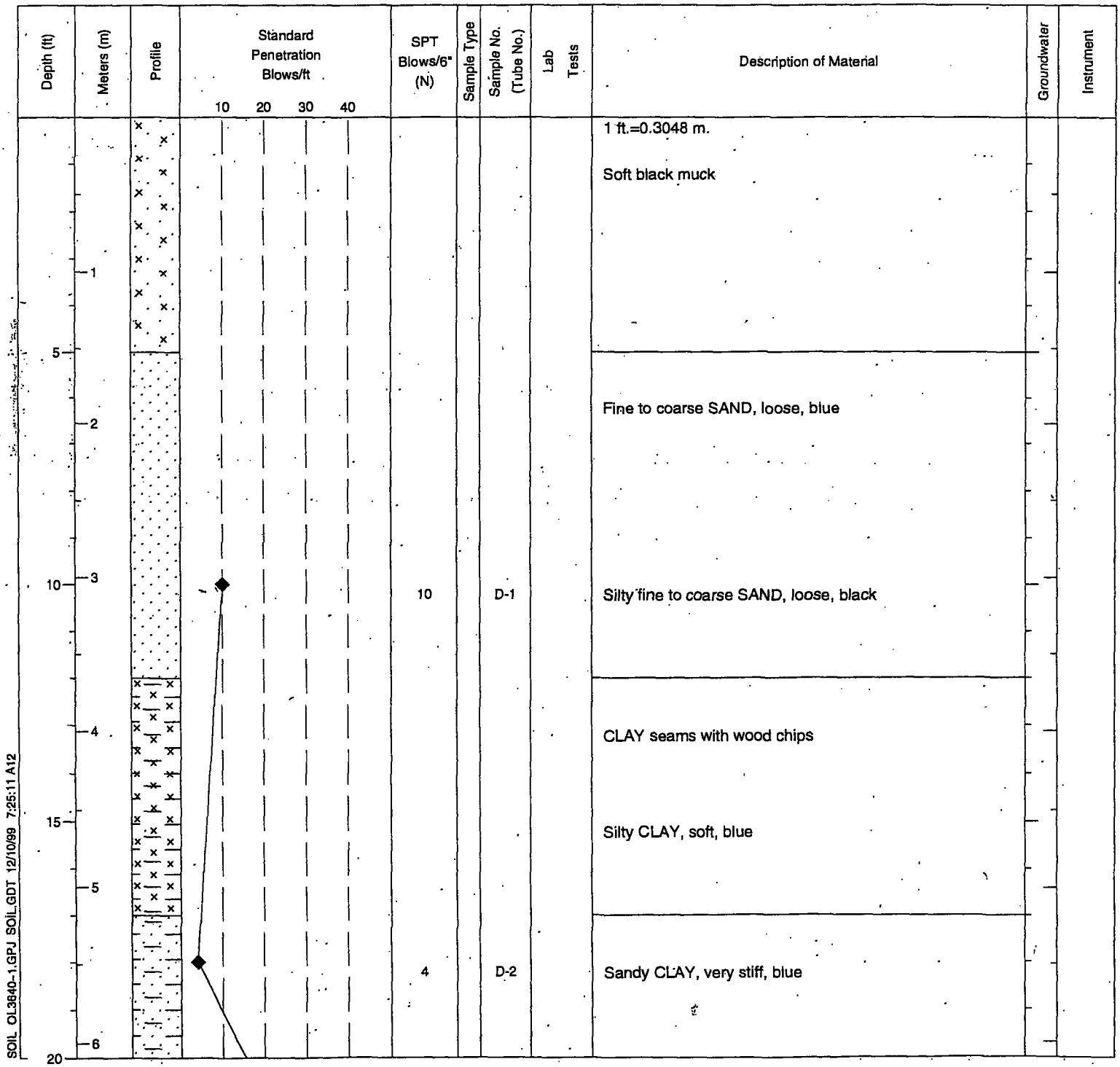
SR 101 Bridge, Pier 15 S.R. **101**

Station **18+60** Offset **15ft Lt** C.S. **1410**

Equipment _____ Casing _____ Ground El **-30.8 (-9.39 m)**

Method of Boring **Jet Wash**

Start Date _____ Completion Date _____ Sheet **1** of **4**



SOIL OL3640-1.GPJ SOIL.GDT 12/10/99 7:25:11 A12

LOG OF TEST BORING

Washington State Department of Transportation

HOLE No. **H-10-52**

Sheet **2** of **4**

PROJECT **SR 101 Chehalis River Brigde #101/115 Seismic Retrofit**

Job No. **L-0732**

Depth (ft)	Meters (m)	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
			27		D-3		Sandy CLAY, very stiff, blue		
25	7								
	8		10		D-4		Silty CLAY with traces of sand and peat, stiff, blue		
30	9								
	10						Fine to coarse SAND, blue		
			19		D-5		Sandy SILT, medium-dense, blue		
35	11								
			2		D-6		Silty CLAY with peat, soft, blue		
40	12								
			11		D-7		Clayey fine sandy GRAVEL, medium dense, blue		
	13						PEAT, soft, brown		
							PEAT with clay, soft, brown		
45									

SOIL OL3640-1.GPJ SOIL.GDT 12/10/99 7:25:12 A12

LOG OF TEST BORING

Washington State Department of Transportation

HOLE No. **H-10-52**

Sheet **3** of **4**

PROJECT **SR 101 Chehalis River Brigde #101/115 Seismic Retrofit**

Job No. **L-0732**

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	14							Peaty CLAY, soft, blue		
	15									
50										
	16									
55				4		D-8		Peaty CLAY with fine sand seams, medium, blue		
	17									
	18									
60				10		D-9		Peaty CLAY, blue		
	19									
65				4		D-10		CLAY with wood chips, soft, blue		
	20									
	21									
70										

SOIL OL3640-1.GPJ SOIL.GDT 12/10/99 7:25:12 A12

LOG OF TEST BORING

Washington State Department of Transportation

HOLE No. **H-10-52**

Sheet 4 of 4

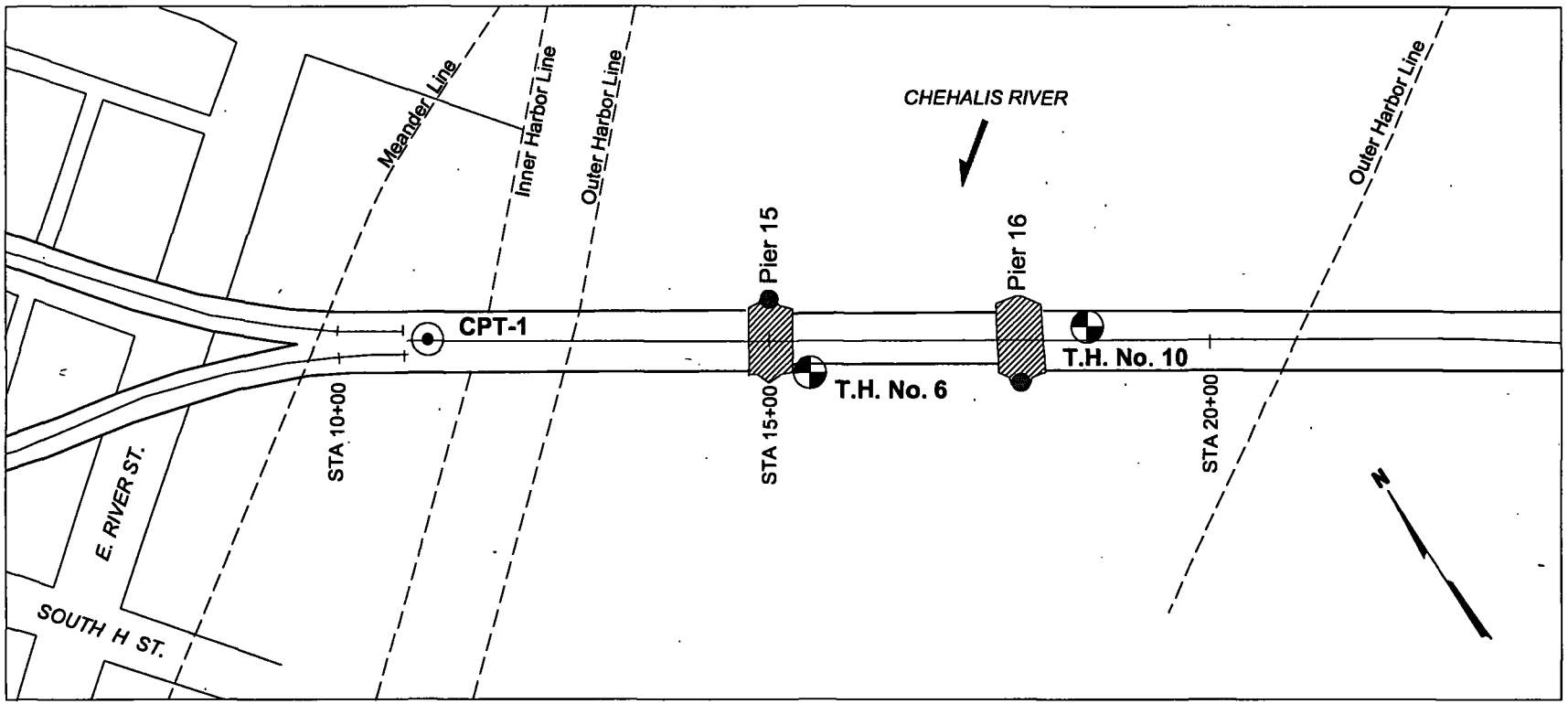
PROJECT **SR 101 Chehalis River Brigde #101/115 Seismic Retrofit**

Job No. L-0732

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
				8		D-11		Silty fine to coarse SAND, blue		
	22									
								CLAY, soft, blue		
75	23									
				10		D-12		Silty CLAY, stiff, blue		
	24									
80								Fine to coarse SAND, blue		
	25									
85										
	26			>> 116		D-13		SAND with gravel, cemented, very dense, blue		
	27									
90								End of Test Hole Boring at 89 feet below ground elevation.		
								This is a summary Log of Test Boring. Soil descriptions were taken off the final records as-built plans. Original test borings are not available.		
	28									
95										

SOIL OL3640-1.GPJ SOIL.GDT 12/10/99 10:29:27 A12

File: I:\Documents\W\W8639\W8639-02 Fig 2.dwg Date: 1-6-2000



0 200 400

Scale in Feet

LEGEND

T.H. No. 6 — 1952 Boring Designation and Approximate Location

CPT-1 — 1999 Seismic Cone Penetration Test Designation and Approximate Location

NOTES

1. Site plan based on WSDOT drawing "Preliminary State Highway No. 13, Chehalis River Bridge in Aberdeen, Grays Harbor County," dated 2-10-53.
2. Subsurface exploration locations should be considered approximate.

Seismic Retrofit Study
SR 101/115 Chehalis River Bridge
Aberdeen, Washington

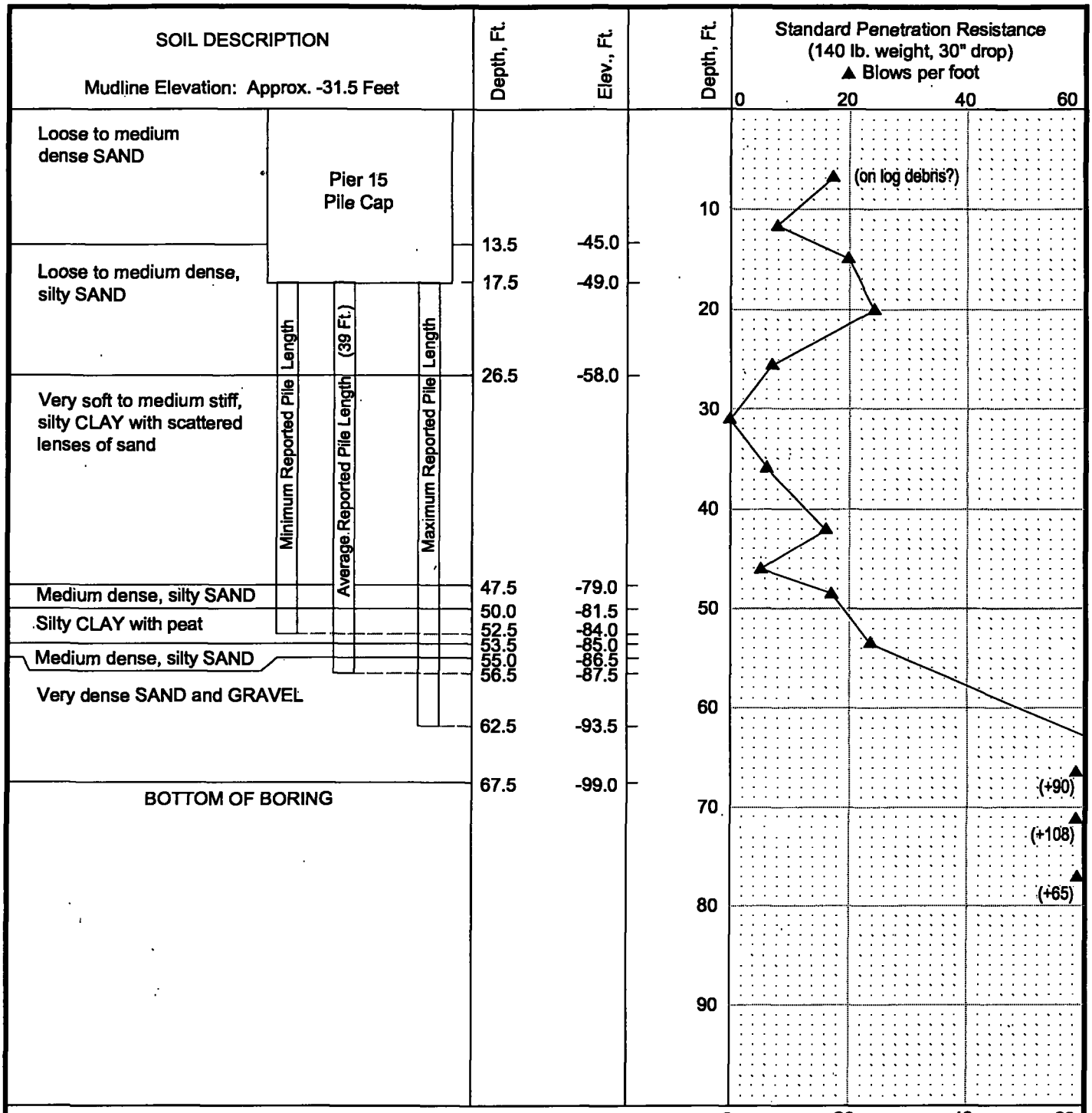
SITE AND EXPLORATION PLAN

January 2000 W-8639-02

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 2

FIG. 2



NOTES

1. The generalized boring log and subsurface conditions are from original design and construction drawings and documents. Variations between the profile and actual subsurface conditions are likely.

2. The generalized boring log is from Test Hole No. 6 on "Test Hole Data" drawing (sheet 2 of 74), dated 2-10-53.

Seismic Retrofit Study
SR 101/115 Chehalis River Bridge
Aberdeen, Washington

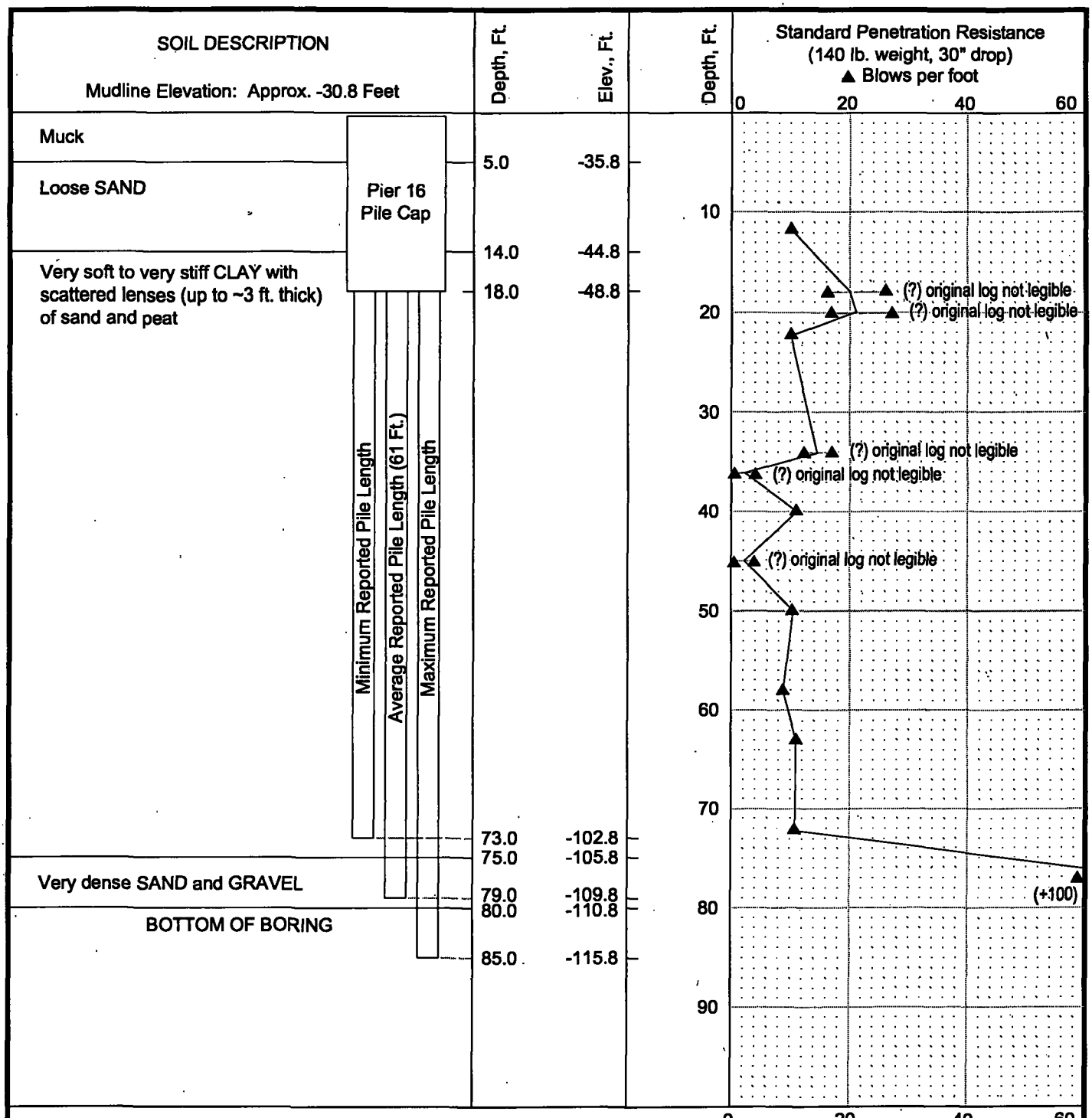
GENERALIZED BORING LOG AND SUBSURFACE CONDITIONS AT PIER 15

January 2000 W-8639-02

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 4

File: W-8639-02 Fig 4.dwg Date: 1-6-2000



NOTES

1. The generalized boring log and subsurface conditions are from original design and construction drawings and documents. Variations between the profile and actual subsurface conditions are likely.

2. The generalized boring log is from Test Hole No. 10 on "Test Hole Data" drawing (sheet 2 of 74), dated 2-10-53.

Seismic Retrofit Study
SR 101/115 Chehalis River Bridge
Aberdeen, Washington

GENERALIZED BORING LOG AND SUBSURFACE CONDITIONS AT PIER 16

January 2000 W-8639-02

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FIG. 5

File: W-8639-02 Fig 5.dwg Date: 1-6-2000

APPENDIX C
Settlement Calculations

Settle3D Analysis Information

Project Settings

Document Name	Wishkah (Levee) (Low Cc-strain)
Date Created	2/8/2017, 3:35:57 PM
Stress Computation Method	Boussinesq
Time-dependent Consolidation Analysis	
Time Units	months
Permeability Units	feet/day
Minimum settlement ratio for subgrade modulus	0.9

Use average properties to calculate layered stresses

Improve consolidation accuracy

Ignore negative effective stresses in settlement calculations

Stage Settings

Stage #	Name	Time [months]
1	Stage 1	0
2	Stage 2	2
3	Stage 3	12
4	Stage 4	120
5	Stage 5	1200

Results

Time taken to compute: 0 seconds

Embankments

1. Embankment: "Embankment Load 1"

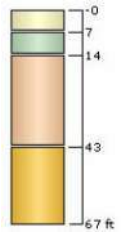
Label	Embankment Load 1
Center Line	(0, -57) to (0, 57)
Number of Layers	1
Near End Angle	26.565 degrees
Far End Angle	26.565 degrees
Base Width	22.8

Layer	Stage	Left Bench Width (ft)	Left Angle (deg)	Height (ft)	Unit Weight (kips/ft^3)	Right Angle (deg)	Right Bench Width (ft)
1	Stage 1 = 0 mon	0	26.565	3.2	0.12	26.565	0

Soil Layers

Ground Surface Drained: Yes

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	12.0 to 5.0 ft	7	0	No
2	5.0 to -2.0 ft	7	7	No
3	-2.0 to -31.0 ft	29	14	No
4	-31.0 to -55.0 ft	24	43	No



Soil Properties

Property	12.0 to 5.0 ft	5.0 to -2.0 ft	-2.0 to -31.0 ft	-31.0 to -55.0 ft
Color				
Unit Weight [kips/ft^3]	0.093	0.093	0.094	0.094
Saturated Unit Weight [kips/ft^3]	0.093	0.093	0.094	0.094
K0	1	1	1	1
Primary Consolidation	Enabled	Enabled	Enabled	Enabled
Material Type	Non-Linear	Non-Linear	Non-Linear	Non-Linear
Cce	0.24	0.38	0.24	0.18
Cre	0.024	0.0684	0.024	0.018
e0	1.1	1.1	1.1	1.1
OCR	19.1	4.9	2.1	1.6
Cv [ft^2/d]	0.115	0.08	0.115	0.11
Cvr [ft^2/d]	0.115	0.08	0.115	0.11
B-bar	1	1	1	1
Undrained Su A [kips/ft2]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8
Piezo Line ID	1	1	1	1

Groundwater

Groundwater method	Piezometric Lines
Water Unit Weight	0.0624 kips/ft^3

Piezometric Line Entities

ID	Depth (ft)
1	0 ft

Query Points

Point #	Query Point Name	(X,Y) Location	Number of Divisions
1	Query Point 1	0, 0	Auto: 57

Settle3D Analysis Information

Project Settings

Document Name	Wishkah (Levee) (High Cc-strain)
Date Created	2/8/2017, 3:35:57 PM
Stress Computation Method	Boussinesq
Time-dependent Consolidation Analysis	
Time Units	months
Permeability Units	feet/day
Minimum settlement ratio for subgrade modulus	0.9

Use average properties to calculate layered stresses

Improve consolidation accuracy

Ignore negative effective stresses in settlement calculations

Stage Settings

Stage #	Name	Time [months]
1	Stage 1	0
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Results

Time taken to compute: 0 seconds

Embankments

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Number of Layers	1
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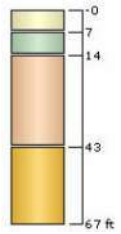
Base Width	22.8

Layer	Stage	Left Bench Width (ft)	Left Angle (deg)	Height (ft)	Unit Weight (kips/ft^3)	Right Angle (deg)	Right Bench Width (ft)
1	Stage 1 = 0 mon	0	26.565	3.2	0.12	26.565	0

Soil Layers

Ground Surface Drained: Yes

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	12.0 to 5.0 ft	7	0	No
2	5.0 to -2.0 ft	7	7	No
3	-2.0 to -31.0 ft	29	14	No
4	-31.0 to -55.0 ft	24	43	No



Soil Properties

Property	12.0 to 5.0 ft	5.0 to -2.0 ft	-2.0 to -31.0 ft	-31.0 to -55.0 ft
Color				
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Saturated Unit Weight [kips/ft^3]	0.093	0.093	0.094	0.094
K0	1	1	1	1
Primary Consolidation	Enabled	Enabled	Enabled	Enabled
Material Type	Non-Linear	Non-Linear	Non-Linear	Non-Linear
Cce	0.32	0.45	0.32	0.23
Cre	0.032	0.081	0.032	0.023
e0	1.1	1.1	1.1	1.1
OCR	19.1	4.9	2.1	1.6
Cv [ft^2/d]	0.115	0.08	0.115	0.11
Cvr [ft^2/d]	0.115	0.08	0.115	0.11
B-bar	1	1	1	1
Undrained Su A [kips/ft2]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8
Piezo Line ID	1	1	1	1

Groundwater

Groundwater method	Piezometric Lines
Water Unit Weight	0.0624 kips/ft^3

Piezometric Line Entities

ID	Depth (ft)
1	0 ft

Query Points

Point #	Query Point Name	(X,Y) Location	Number of Divisions
1	Query Point 1	0, 0	Auto: 57

APPENDIX D
Report Limitations and Guidelines for Use

APPENDIX D
REPORT LIMITATIONS AND GUIDELINES FOR USE[1]

This appendix provides information to help you manage your risks with respect to the use of this report.

Read These Provisions Closely

It is important to recognize that the geoscience practices (geotechnical engineering, geology and environmental science) rely on professional judgment and opinion to a greater extent than other engineering and natural science disciplines, where more precise and/or readily observable data may exist. To help clients better understand how this difference pertains to our services, GeoEngineers includes the following explanatory "limitations" provisions in its reports. Please confer with GeoEngineers if you need to know more how these "Report Limitations and Guidelines for Use" apply to your project or site.

Geotechnical Services are Performed for Specific Purposes, Persons and Projects

This report has been prepared for KPFF Consulting Engineers, Inc. and for the Project(s) specifically identified in the report. The information contained herein is not applicable to other sites or projects.

GeoEngineers structures its services to meet the specific needs of its clients. No party other than the party to whom this report is addressed may rely on the product of our services unless we agree to such reliance in advance and in writing. Within the limitations of the agreed scope of services for the Project, and its schedule and budget, our services have been executed in accordance with our Agreement with KPFF Consulting Engineers, Inc. dated December 11, 2014 and generally accepted geotechnical practices in this area at the time this report was prepared. We do not authorize, and will not be responsible for, the use of this report for any purposes or projects other than those identified in the report.

A Geotechnical Engineering or Geologic Report is based on a Unique Set of Project-Specific Factors

This report has been prepared for the North Shore Levee in Aberdeen and Hoquiam, Washington. GeoEngineers considered a number of unique, project-specific factors when establishing the scope of services for this project and report. Unless GeoEngineers specifically indicates otherwise, it is important not to rely on this report if it was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

For example, changes that can affect the applicability of this report include those that affect:

- the function of the proposed structure;
- elevation, configuration, location, orientation or weight of the proposed structure;
- composition of the design team; or

[1] Developed based on material provided by ASFE, Professional Firms Practicing in the Geosciences; www.asfe.org.

- project ownership.

If changes occur after the date of this report, GeoEngineers cannot be responsible for any consequences of such changes in relation to this report unless we have been given the opportunity to review our interpretations and recommendations. Based on that review, we can provide written modifications or confirmation, as appropriate.

Environmental Concerns are Not Covered

Unless environmental services were specifically included in our scope of services, this report does not provide any environmental findings, conclusions, or recommendations, including but not limited to, the likelihood of encountering underground storage tanks or regulated contaminants.

Subsurface Conditions Can Change

This geotechnical or geologic report is based on conditions that existed at the time the study was performed. The findings and conclusions of this report may be affected by the passage of time, by man-made events such as construction on or adjacent to the site, new information or technology that becomes available subsequent to the report date, or by natural events such as floods, earthquakes, slope instability or groundwater fluctuations. If more than a few months have passed since issuance of our report or work product, or if any of the described events may have occurred, please contact GeoEngineers before applying this report for its intended purpose so that we may evaluate whether changed conditions affect the continued reliability or applicability of our conclusions and recommendations.

Geotechnical and Geologic Findings are Professional Opinions

Our interpretations of subsurface conditions are based on field observations from widely spaced sampling locations at the site. Site exploration identifies the specific subsurface conditions only at those points where subsurface tests are conducted or samples are taken. GeoEngineers reviewed field and laboratory data and then applied its professional judgment to render an informed opinion about subsurface conditions at other locations. Actual subsurface conditions may differ, sometimes significantly, from the opinions presented in this report. Our report, conclusions and interpretations are not a warranty of the actual subsurface conditions.

Geotechnical Engineering Report Recommendations are Not Final

We have developed the following recommendations based on data gathered from subsurface investigation(s). These investigations sample just a small percentage of a site to create a snapshot of the subsurface conditions elsewhere on the site. Such sampling on its own cannot provide a complete and accurate view of subsurface conditions for the entire site. Therefore, the recommendations included in this report are preliminary and should not be considered final. GeoEngineers' recommendations can be finalized only by observing actual subsurface conditions revealed during construction. GeoEngineers cannot assume responsibility or liability for the recommendations in this report if we do not perform construction observation.

We recommend that you allow sufficient monitoring, testing and consultation during construction by GeoEngineers to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes if the conditions revealed during the work differ from those anticipated, and to evaluate whether earthwork activities are completed in accordance with our recommendations. Retaining GeoEngineers for construction observation for this project is the most effective means of managing the risks associated with unanticipated conditions. If another party performs field observation and confirms our expectations, the other party must take full responsibility for both the observations and recommendations. Please note, however, that another party would lack our project-specific knowledge and resources.

A Geotechnical Engineering or Geologic Report Could Be Subject to Misinterpretation

Misinterpretation of this report by members of the design team or by contractors can result in costly problems. GeoEngineers can help reduce the risks of misinterpretation by conferring with appropriate members of the design team after submitting the report, reviewing pertinent elements of the design team's plans and specifications, participating in pre-bid and preconstruction conferences, and providing construction observation.

Do Not Redraw the Exploration Logs

Geotechnical engineers and geologists prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. The logs included in a geotechnical engineering or geologic report should never be redrawn for inclusion in architectural or other design drawings. Photographic or electronic reproduction is acceptable, but separating logs from the report can create a risk of misinterpretation.

Give Contractors a Complete Report and Guidance

To help reduce the risk of problems associated with unanticipated subsurface conditions, GeoEngineers recommends giving contractors the complete geotechnical engineering or geologic report, including these "Report Limitations and Guidelines for Use." When providing the report, you should preface it with a clearly written letter of transmittal that:

- advises contractors that the report was not prepared for purposes of bid development and that its accuracy is limited; and
- encourages contractors to confer with GeoEngineers and/or to conduct additional study to obtain the specific types of information they need or prefer.

Contractors are Responsible for Site Safety on Their Own Construction Projects

Our geotechnical recommendations are not intended to direct the contractor's procedures, methods, schedule or management of the work site. The contractor is solely responsible for job site safety and for managing construction operations to minimize risks to on-site personnel and adjacent properties.

Biological Pollutants

GeoEngineers' Scope of Work specifically excludes the investigation, detection, prevention or assessment of the presence of Biological Pollutants. Accordingly, this report does not include any interpretations, recommendations, findings or conclusions regarding the detecting, assessing, preventing or abating of Biological Pollutants, and no conclusions or inferences should be drawn regarding Biological Pollutants as they may relate to this project. The term "Biological Pollutants" includes, but is not limited to, molds, fungi, spores, bacteria and viruses, and/or any of their byproducts.

A Client that desires these specialized services is advised to obtain them from a consultant who offers services in this specialized field.