Geotechnical Engineering Report
Kitsap County Pump Station 3 Upgrades and Silverdale Waterfront Center
Silverdale, Washington

November 11, 2021

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LIST OF ABBREVIATIONS AND ACRONYMS

ASCE	American Society of Civil Engineers
ASTM	ASTM International
bgs	below ground surface
BHC	BHC Consultants, LLC
County	Kitsap County
EFD	equivalent fluid density
EPS	expanded polystyrene
ft	foot/feet
ft/day	feet per day
H:V	horizontal to vertical
LAI	Landau Associates, Inc.
pcf	pounds per cubic foot
Port	Port of Silverdale
PS-3	Pump Station 3
psf	pounds per square foot
q_s	surcharge pressure
WSDOT	Washington State Department of Transportation

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1.0 INTRODUCTION

This report summarizes the results of geotechnical engineering services provided by Landau Associates, Inc. (LAI) in support of the Kitsap County Pump Station 3 Upgrades and Port of Silverdale Waterfront Center project in Silverdale, Washington (site; Figure 1).

1.1 Project Understanding

On March 12, 2021, BHC Consultants, LLC (BHC; PS-3 project civil engineer) subcontracted LAI to provide geotechnical engineering services in support of Kitsap County's (County) Silverdale Pump Station 3 (PS-3) Upgrades project. On June 18, 2021, the Port of Silverdale (Port) contracted LAI to provide geotechnical engineering services for its Waterfront Center project, located near PS-3.

The geotechnical recommendations herein are applicable to the design and construction of both projects. Proposed structures will be designed to accommodate rising sea levels. All elevations are provided in North American Vertical Datum of 1988.

1.1.1 Kitsap County Pump Station 3 Upgrades

The County plans to increase the capacity of PS-3 and replace outdated pumping equipment to satisfy current design standards. Larger pumps and motors will be installed to accommodate flow increases and wastewater conveyance upgrades will be made upstream of PS-3. A new wet well and control building will be constructed north of the existing PS-3 site (Figure 2A). A rectangular wet well, measuring 16 feet (ft) wide by 20 ft long by 30 ft deep, is proposed. Excavations extending approximately 15 ft below ground surface (bgs) will be used to connect the improvements to existing conveyance pipes.

The County proposes to improve wastewater conveyance by installing approximately 720 linear feet of 15-inch-diameter gravity sewer lines along Northwest Carlton Street and extending the sanitary sewer force main along McConnell Avenue Northwest, between Northwest Byron Street and Northwest Carlton Avenue (Figure 2B). The new gravity sewer main invert elevation will be approximately 8 to 12 ft bgs, and the force main invert elevation will be approximately 5 ft bgs. Excavations will extend 1 to 2 ft below the invert elevation of the pipes.

1.1.2 Port of Silverdale Waterfront Center

The Port proposes to construct a new community waterfront center on property located south of Northwest Byron Street, between McConnell Avenue Northwest and Washington Avenue Northwest. The development will include one- or two-story structures (a boating center and community living room), open spaces, and covered plazas. Conceptual design drawings indicate that the new structures will be located in two general areas: Sites A and B (Figure 2A). Other proposed site improvements include new hardscapes (asphalt pavement), landscaping, and stormwater management facilities.

2.0 SITE CONDITIONS

The following sections describe the geologic setting of the site and the surface and subsurface conditions observed during LAI's field investigation. Interpretations of site conditions are based on LAI's review of available geologic and geotechnical data and on the results of the site reconnaissance, subsurface explorations, and geotechnical laboratory testing.

2.1 Geologic Setting

Geologic information for the site and the surrounding area was obtained from the *Geologic Map of the Seabeck and Poulsbo 7.5-minute Quadrangles, Kitsap and Jefferson Counties, Washington* (Polenz et al. 2013). Surficial deposits along the project alignment are mapped as:

- **Vashon recessional alluvial and delta fan deposits (Qgoaf):** This unit typically consists of unconsolidated, moderately to poorly sorted deposits of gravel, sand, silt, and boulders. Alluvial and delta fan deposits form concentric lobes where meltwater streams emerge from valleys.
- **Artificial fill (af):** This unit typically consists of sand, cobbles, pebbles, boulders, silt, clay, organic matter, and construction debris, placed as engineered or non-engineered fill. Artificial fill is mapped where verifiable and extensive, to depths of 5 ft or greater. The mapped limits of undocumented fill are shown on Figure 2A.

The soils observed in LAI's August 2021 explorations were generally consistent with the mapped geology. Glacially consolidated soil (glacial drift) and undocumented fill were also observed in the explorations.

2.2 Surface Conditions

The PS-3 and Waterfront Center sites are located within a commercially developed area known as "Old Town Silverdale." The PS-3 site consists of the lawn/grassy area north of the existing pump station and south of an asphalt-paved parking lot. The proposed wastewater conveyance upgrades will be made in the area along McConnell Avenue Northwest and Northwest Carlton Street. Both roadways are surrounded by commercial development.

The Waterfront Center site includes the area south of Northwest Byron Street, extending south to the shoreline of Dyes Inlet. This area is developed with one- to two-story commercial buildings, parking lots, and lawn/grassy areas.

Topography south of Northwest Byron Street is relatively flat and slopes from southeast to northwest, with a topographic relief of approximately 2 ft. The site slopes upward along the northern extent of McConnell Avenue Northwest, with a topographic relief of approximately 10 ft along the pipe alignment. Site grades along Carlton Avenue Northwest slope upward from east to west, with a topographic relief of approximately 15 ft along the pipe alignment. Existing surface conditions are shown on Figures 2A and 2B.

2.3 Subsurface Conditions

On August 29 and 30, 2021, LAI explored site subsurface conditions by advancing six hollow-stem auger borings (B-1 through B-6) 20.8 to 56.5 ft bgs. The approximate locations of the explorations are shown on Figures 2A and 2B.

LAI personnel coordinated and monitored the field explorations, collected representative soil samples, and maintained a detailed record of the subsurface soil and groundwater conditions observed. LAI subcontracted the drill rig and operator. Additional information about the field explorations, including summary boring logs, is provided in Appendix A.

Samples were transported to LAI's soils laboratory for further examination and testing. Test results and a description of LAI's geotechnical laboratory testing program are provided in Appendix B.

Historical logs of borings others completed on, and adjacent to, the site are provided in Appendix C. The locations of the historical borings are shown on Figures 2A and 2B.

2.3.1 Soil Conditions

The soils observed underlying existing surface conditions (i.e., asphalt and sod) were categorized into four general units:

- **Fill:** Documented and undocumented fill was encountered in borings B-1 through B-4 and B-6 and consisted of gravel with variable sand and silt content, of sand with variable silt and gravel content, or of silt. The fill extended 3 to 5 ft bgs and was in a loose/soft to dense, moist condition. The fill encountered adjacent to structures or beneath roadway sections appeared to be engineered fill (i.e., controlled density fill).
- **Peat:** Peat was encountered beneath the fill in borings B-2 and B-3 and consisted of amorphous-granular peat with little to no wood or fine fibers. The peat was in a very loose, moist to wet condition.
- **Glacial outwash:** Glacial outwash was observed in all six borings and consisted of gravel with variable sand and silt content; of sand with variable gravel, silt, and organic content; of silt with variable sand and gravel content; and of clayey silt with sand. The glacial outwash was in a loose/soft to very dense/hard, moist to wet or wet condition. Drilling chatter, indicative of cobble inclusion, was observed in the glacial outwash unit. Borings B-1 and B-5 were terminated in this unit.

  The glacial outwash generally consisted of permeable, granular soil overlying fine-grained material. The fine-grained material at the base of the glacial outwash unit appears to act as an aquitard between the saturated portion of the glacial outwash unit and the underlying glacial drift unit.
- **Glacial drift:** Glacial drift was encountered beneath the glacial outwash in borings B-2, B-3, B-4, and B-6. This unit was observed to consist of silty gravel with variable sand content; of sand with variable silt and gravel content; or of silt with sand and gravel. The glacial drift unit was encountered in a dense to very dense/hard, moist to wet or wet condition. Drilling chatter,

indicative of cobble inclusion, was observed in the glacial outwash unit. Borings B-2, B-3, B-4, and B-6 were terminated in this unit.

The composition of the glacial drift was observed to be consistent with subglacial meltout till and advance outwash deposits. Though its permeability is highly variable, the glacial drift should not be considered an impermeable material. Confining layers or layers of low permeability are present within this unit.

Though not encountered in LAI's explorations, cobbles and boulders are often present in glacially derived soils and are included in the mapped soil unit descriptions (Polenz et al. 2013). Where noted on the boring logs, drilling chatter should be considered indicative of cobble presence.

2.3.2 Groundwater Conditions

Based on the subsurface conditions observed in LAI's geotechnical explorations and a review of historical groundwater data (Shannon and Wilson 2020), two aquifers are present at the site: an unconfined upper aquifer and a confined lower aquifer. The upper aquifer includes the permeable portion of the glacial outwash unit. The lower aquifer is confined by the fine-grained aquitard ("ML" or "SM" on the boring logs in Appendix A) portion of the glacial outwash unit. It should be assumed that permeable seams within the aquitard provide a conduit between the two aquifers.

The groundwater levels in Table 1 were recorded during LAI's August 2021 field investigation. Open standpipe piezometers (monitoring wells) and pressure transducers were installed in borings B-1 and B-2 to observe site groundwater fluctuations over time. Both monitoring wells were installed within the upper aquifer.

Table 1. Groundwater Levels Observed at Time of Drilling

Well Number	Groundwater Level (ft bgs)	Approximate Elevation
B-1	8.8	14.2
B-2	9.1	4.4
B-3	6.0	7.5
B-4	4.0	11.0
B-5	12.0	16.0
B-6	8.6	5.4

bgs = below ground surface
ft = feet

Groundwater monitoring data recorded between August and October 2021 are provided on Figure 3. Maximum groundwater elevations of 16.3 ft (6.7 ft bgs) and 10.4 ft (3.1 ft bgs) were observed in borings B-1 and B-2, respectively.

A maximum tidal fluctuation of 0.15 ft was noted in groundwater monitoring data collected from boring B-1. Historical site data indicate a maximum tidal fluctuation of 0.8 ft in the upper aquifer at historical boring B-1W and a fluctuation of 1.5 to 4 ft in the lower aquifer. Piezometric levels in the lower aquifer are approximately 3 to 7 ft higher than piezometric levels in the upper aquifer (Shannon and Wilson 2020). Soil heave reported at time of drilling is indicative of pressurized/flowing groundwater conditions in the lower aquifer.

The groundwater conditions reported herein are for the specific locations and dates indicated and may not be representative of other locations and/or times. Site groundwater elevations will vary depending on local subsurface conditions, weather conditions, and other factors. Tidal effects of nearby Dyes Inlet could cause groundwater levels along the project alignment to fluctuate daily. Seasonal fluctuations also are anticipated, with maximum groundwater levels occurring during late winter and early spring.

2.3.3 Groundwater Salinity

LAI's scope of services did not include groundwater-salinity measurements; however, salinity measurements were collected as part of the County Bayshore and Washington Improvements project, located adjacent to the PS-3 site. Groundwater samples collected from historical monitoring well B-1W yielded salinity measurements of 0.08 parts per thousand (Shannon and Wilson 2020).

3.0 SEISMIC DESIGN CONSIDERATIONS

The site is located in the seismically active Pacific Northwest and could be subject to ground shaking during a major seismic event. The following sections include seismic design parameters and an evaluation of seismic hazards present at the site.

3.1 Seismic Design Parameters

The *2018 International Building Code* (IBC) recommends using a 2-percent-in-50-year exceedance rate design-level earthquake (ICC 2017). Seismic design parameters determined in accordance with the 2018 IBC are presented in Table 2. The site class in Table 2 was determined using standard penetration test N-values and guidance in Section 20.4.2 and Table 20.3-1 of the American Society of Civil Engineers' (ASCE) *Minimum Design Loads and Associated Criteria for Buildings and Other Structures (ASCE 7-16).*

Table 2. *2018 International Building Code* Seismic Design Parameters

Site Class	Modal Moment Magnitude[a]	PGA (g)	F_{PGA}	S_S (g)	F_a	S_1 (g)	F_v
D	7.11	0.628	1.1	1.478	1.0	0.525	1.775[b]

(a) Sourced from the U.S. Geological Survey's 2014 National Seismic Hazards Mapping project (accessed August 6, 2021).
(b) When using the coefficient F_v = 1.775, adhere to Exception 2 requirements for a ground motion hazard analysis in Section 11.4.8 of the American Society of Civil Engineers' *Minimum Design Loads and Associated Criteria for Buildings and Other Structures (ASCE 7-16).*
F_a, F_v = acceleration (0.2-second period) and velocity (1.0-second period) site coefficients, respectively
F_{PGA} = peak ground acceleration coefficient
g = force of gravity
PGA = peak ground acceleration
S_s, S_1 = 0.2-second and 1.0-second period spectral accelerations, respectively

The parameters in Table 2 were selected for liquefaction and lateral spreading analyses.

3.2 Liquefaction and Lateral Spreading

Liquefaction occurs when a soil mass experiences a significant rise in pore water pressure during earthquake-induced, cyclic shaking. The rise in pore water pressure decreases stress between soil particles, reducing the overall strength of the soil and creating a semi-solid slurry. Deposits of loose, granular soil below the water table are most susceptible to liquefaction, though non-plastic and low-plasticity silts and clays are also susceptible.

Lateral spreading is a phenomenon in which lateral ground displacements occur as a result of soil liquefaction. Lateral spreading typically is observed on sloping ground or on level ground near shoreline slopes.

Liquefaction analysis was performed using the simplified procedure developed by Boulanger and Idriss (2014). The extent of lateral spreading was estimated using the method proposed by Youd et al. (2002). The results of LAI's analyses indicate that several zones within the glacial outwash unit are susceptible to liquefaction and lateral spreading could occur within 300 ft of the Dyes Inlet shoreline.

The risk of seismically induced lateral ground deformation is considered low, with estimated lateral deformations of less than 1 inch. Lateral spreading risks are considered negligible, and mitigation design is not warranted. There is a high risk that seismically induced settlement could occur at the site, and the structural design should account for this possibility.

3.2.1 Liquefaction Consequences and Seismic Risks

Soil liquefaction concerns for the projects are threefold:

1. Liquefaction may reduce the soil resistance needed to support foundation loads.
2. Liquefaction may cause the ground surface—and thus, the structure— to settle.
3. Liquefaction could cause uplift (due to buoyancy) or settlement of buried structures (due to loss of soil bearing strength or ground settlement).

Liquefaction potential varies widely across the site. Table 3 includes estimated liquefaction-induced ground surface settlement at the boring locations where soil conditions were identified as susceptible to liquefaction.

Table 3. Liquefaction-Induced Ground Surface Settlement

Boring	B-2	B-3	B-4	B-6
Liquefaction-induced Settlement (inches)	5	2	1	2
Depth to Liquefiable Layer with Thickness > 2 ft	6	9	11	9

ft = feet

Based on the results of its analysis, LAI concludes that the risk of liquefaction-induced damage is most severe in the southern portion of the site (PS-3 and Waterfront Center Site B) and near the Dyes Inlet shoreline. The foundation design recommendations in Sections 4.0 and 5.0 account for the estimated liquefaction effects.

4.0 PUMP STATION 3 DESIGN RECOMMENDATIONS

Based on the results of LAI's geotechnical field investigation and laboratory testing, subsurface conditions along the project alignment are suitable for the proposed PS-3 and wastewater-conveyance improvements. The following recommendations should be incorporated into the project design:

- **Construction dewatering:** Groundwater conditions vary along the project alignment. Groundwater is likely to be encountered in earthwork excavations, and the need for construction dewatering should be anticipated. Dewatering systems will need to account for dewatering induced settlement of the peat soil unit.

  The magnitude of construction dewatering will depend on the depth and location of the excavation. A combination of watertight shoring, internal/external dewatering, and groundwater recharge will be required for excavations extending below the aquitard layer, such as those required for construction of the proposed PS-3 wet well.

  Excavations that do penetrate the aquitard layer will require variable dewatering effort. To limit the scope of dewatering, construction should be completed during the relatively dry period between late summer and early fall.
- **Temporary shoring:** Temporary shoring requirements along the project alignment will vary and may include open-cut construction and watertight shoring. Watertight shoring will be required at the PS-3 site to limit groundwater inflow into construction excavations.
- **Aquitard penetrations:** The proposed wet well construction will penetrate the aquitard layer, creating a conduit between the two aquifers and alteration of site groundwater conditions. LAI recommends placing a layer of low-permeability fill to maintain the groundwater conditions and restore the aquitard.
- **Vibration and settlement monitoring:** Pile driving vibrations and groundwater drawdown could cause ground settlement. A vibration and settlement monitoring plan should be prepared for settlement-sensitive structures located adjacent to construction areas.
- **Settlement:** The project design should account for the presence of settlement-sensitive soils. The PS-3 site is underlain by compressible, organic soil (peat) and silt, requiring near-surface structures to be supported on driven pile foundations. Pockets of organic soil were observed in LAI's study and historical boring B-1W (Shannon & Wilson 2020) and should be anticipated in the area south of the undocumented fill limits shown on Figure 2A. Compressible soils also are present to the east of the proposed gravity sewer alignment.

  Groundwater recharge wells may be required where dewatering of the lower aquifer will reduce groundwater levels in the upper aquifer. Dewatering of soil above or within organic/peat soil deposits will increase loading on highly compressible soil and settlement will occur. Site grades should not be raised; if grades are raised, lightweight fill should be used to create a zero-net increase in bearing pressure.
- **Obstructions:** The site is underlain by glacially derived soil and fill that may contain oversized material (construction debris, cobbles, and boulders). The contractor should be prepared to manage oversized material encountered during construction.

4.1 Temporary Shoring and Construction Dewatering

Dewatering and temporary shoring will be required during construction of the proposed improvements. Historical data for the PS-3 site indicate that dewatering wells are capable of providing dry construction conditions in excavations extending approximately 15 ft bgs (Shannon and Wilson 2020). The contractor should be responsible for the design, permitting, installation, monitoring, and maintenance of dewatering system(s). The grain size information in Appendix B can be used to design dewatering systems.

Shoring requirements along the project alignment will vary. Conventional shoring methods, such as trench boxes, can be used to install the force main and the majority of the gravity sewer main. Watertight shoring will be required in excavations at the PS-3 site and in the eastern 100 ft of gravity sewer along Northwest Carlton Avenue. Given the proximity to Dyes inlet, non-watertight shoring and construction dewatering is not considered feasible for PS-3 wet well construction. Driven sheet pile shoring is considered feasible where excavations will remain above the aquitard and within the upper aquifer. Table 4 includes watertight shoring methods that can be used to construct the PS-3 wet well.

Table 4. Pump Station 3 Wet Well Shoring Options

Method	Description	Comments
Sheet Piles	Interlocking steel sheet piles act as a barrier to groundwater inflow. Steel sheets typically are installed with vibratory pile-driving hammers. Sheet pile shoring systems are often braced/anchored or cantilevered.	**Pros:** • Construction costs significantly lower than other watertight shoring methods. • Installation can be completed without construction dewatering. • Common construction technique that can be completed by many contractors. • Method can be adapted for irregularly shaped excavations.
		Cons: • A significant external dewatering effort will be required to reduce embedment depth. • Inability to lower groundwater levels sufficiently via dewatering may make this method infeasible. • Pre-drilling and/or excavation ahead of driving will be required to advance sheet piles. • Obstructions can damage sheets and comprise interlock. • Vibration-sensitive structures may be damaged during pile installation.

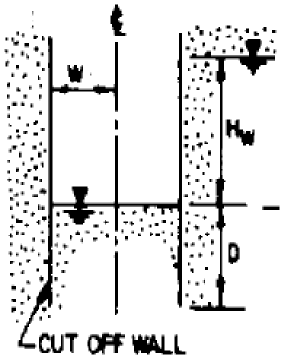
Method	Description	Comments
		• Installation could cause settlement of the ground and adjacent structures, within a limited distance of the pump station.
Soil Freezing	Refrigeration plants and pumps are used to circulate chilled brine through temporary pipes (freeze pipes). The brine forms a frozen soil-water matrix that is used to resist lateral earth and hydrostatic pressures during excavation. The soil freezing method is limited by the locations in which pipes can be installed/the locations where there is sufficient moisture to create a solid, frozen mass. Soil can be frozen by the direct-injection method, where a liquefied gas, such as nitrogen or carbon dioxide, is injected into the ground, and heat is removed as it evaporates. Chilled brine freezes soil over a 4-week period; direct-injection is a quicker but more expensive method.	**Pros:** • This shoring method reduces groundwater migration and requires the least amount of dewatering. • The bottom of the excavation can be targeted as a freezing zone, potentially eliminating the need for a tremie slab. • Method can be adapted for construction of irregular shoring shapes (i.e., pump station inlet/outlet).
		Cons: • Ground is frozen over a period of 4 weeks. • Method may not work in granular soils with groundwater gradient. • The ground must remain frozen for the duration of the excavation. • Thawing may induce ground subsidence.
Secant Pile Wall	A secant pile wall consists of a system of interlocking drilled and grouted primary and secondary piles, 3 feet in diameter. Primary piles, spaced approximately 5 to 5½ feet on center, are drilled and grouted first. Before the grout achieves full strength, secondary piles are drilled between and over the primary piles. This overlap (the secant) creates a nearly watertight interlock. Secondary piles may be reinforced for additional lateral resistance.	**Pros:** • Tried-and-trued method with which many contractors have experience. • If designed by an engineer, the secant pile wall can be used as part of the permanent wet well casing.
		Cons: • Largest temporary construction area impacted (Large equipment, laydown area for casing, space for concrete trucks and pumper). • Installation results in more excavated soil/spoils than other methods.

The contractor should be solely responsible for the type, design, and layout of engineered shoring systems. Development of earth pressures to be used in shoring design should be the responsibility of the contractor. Structural shoring design should be completed by an engineer licensed in the State of Washington. The contractor should be prepared to manage oversized material (construction debris, cobbles, and boulders) encountered during shoring installation. Geotechnical recommendations for shoring and dewatering of specific project elements are included in the following sections.

4.1.1 Pump Station 3

At time of drilling, groundwater was observed at 9.1 ft bgs in boring B-2 and at 6.0 ft bgs in boring B-3. The contractor should assume that groundwater levels will rise during the wet season. Maximum groundwater levels are anticipated to be higher than those shown on Figure 3. Excavations for the PS-3 wet well are anticipated to extend approximately 31 to 32 ft bgs. The upper and lower aquifers will likely be encountered during construction of PS-3 improvements. The contractor should anticipate the need for watertight shoring and construction dewatering. The magnitude of construction dewatering will depend on the configuration and type of shoring selected. To limit the potential for dewatering-induced settlement, drawdown of the upper aquifer should be avoided. Recharge wells should be installed within the upper aquifer if dewatering activities cause drawdown in the upper aquifer. LAI anticipates 1-inch of dewatering induced settlement, where groundwater is drawn down below peat soil deposits. The following key points should be considered when preparing for wet well construction:

- Shoring systems that extend below the base of the excavation and lengthen the groundwater-flow path may require only internal dewatering. LAI estimates that watertight shoring would need to extend to a depth (D) equal to 60 to 80 percent of the groundwater drawdown height (Hw; Detail 1; NAVFAC 1986). Dewatering wells placed outside of the excavation and screened in the lower aquifer can be used to limit embedment depths.



Detail 1. Shoring system.

- Where shoring systems do not sufficiently lengthen the groundwater-flow path, a concrete/grout tremie seal should be placed at the base of the wet well excavation. The shoring systems should extend beneath the base of the excavation to a depth that allows for placement of the tremie seal. The seal should be designed to resist uplift forces caused by hydrostatic pressure in the lower aquifer.

For PS-3 excavations that do not extend below the aquitard layer (elevation -4 ft in boring B-2), sheet pile shoring systems can be used to limit construction dewatering efforts. Dewatering likely will be limited to sumps and pumps, where sheet piles are used to shore excavations with maximum depths of 15 ft bgs.

4.1.2 McConnell Gravity Force Main

Groundwater was observed between 6 and 12 ft bgs along the proposed force main alignment. Excavations for the force main are anticipated to extend approximately 6 to 7 ft bgs. The contractor should expect to encounter localized zones of shallow, perched groundwater along the force main alignment and in areas where excavations cross existing utility lines/trenches. The static groundwater table is likely to remain below maximum excavation depths if construction is completed during late summer and early fall. Excavations may extend below the static groundwater table during the wet season, when groundwater levels are elevated.

Where perched groundwater seepage is encountered, conventional sumps and pumps should be sufficient to limit the amount of groundwater that enters excavations. If static groundwater levels rise above the base of the excavations, conventional sumps and pumps may not provide a dry, stable work area, and multiple trash pumps or cutoff walls may be required. More substantial dewatering efforts (i.e., well points) may be required. Completing construction during the relatively dry period between summer and early fall will reduce dewatering needs.

Where open cuts are not feasible, trench boxes will provide suitable support for shallow excavations. The trench should be properly dewatered, and no settlement-sensitive structures or utilities should be located adjacent to the excavation.

4.1.3 Carlton Gravity Sewer

Groundwater was observed at 12 ft bgs in boring B-5. Additionally, groundwater was observed between 2 and 4 ft bgs in historical borings advanced along Washington Avenue Northwest, east of the proposed gravity sewer connection. Excavations for the gravity sewer line are anticipated to extend to a maximum depth of 12 ft bgs. Watertight shoring with internal dewatering will be required for the 100-ft segment of gravity sewer line farthest to the east. Once the sewer alignment gains sufficient topographic rise, conventional shoring and dewatering methods will be sufficient.

To limit the potential for dewatering-induced settlement, drawdown of groundwater in the upper aquifer should be avoided. Recharge wells should be installed within the upper aquifer if dewatering activities cause groundwater levels to dip below the typical seasonal low elevation.

Groundwater conditions along the gravity sewer alignment will vary. Where perched groundwater seepage is encountered, conventional sumps and pumps should be sufficient to limit the amount of groundwater that enters excavations. If static groundwater levels are above the base of the excavation, conventional sumps and pumps may not provide a dry, stable work area, and more substantial dewatering efforts (i.e., well points) may be required. Completing construction during summer and early fall will reduce dewatering needs.

A system of driven sheet piles should be used to shore excavations for the eastern 100 ft of gravity sewer main. Where open cuts are not feasible, conventional shoring methods, such as trench boxes, will provide suitable support for shallow excavations. The trench should be properly dewatered, and no settlement-sensitive structures or utilities should be located adjacent to the excavation.

4.1.4 Vibration and Settlement Monitoring

LAI recommends that a vibration and settlement monitoring specification be prepared for the project. The specification should require the contractor to submit a vibration and settlement monitoring plan that includes a list of proposed equipment, anticipated vibration levels, and corrective measures for vibrations or settlement that exceed project tolerances.

The contractor should be required to complete a pre-construction survey to establish baseline information about the condition of existing, nearby structures and baseline elevations of settlement-sensitive site features (utilities or structures). Photographs of nearby structures should be included in the survey.

4.2 Pump Station Design

The following sections include geotechnical design recommendations for the proposed PS-3 improvements.

4.2.1 Control Building Foundation Support

The PS-3 site is underlain by compressible, organic soils, susceptible to liquefaction-induced settlement. Loose to medium dense fill is anticipated at the proposed foundation elevations of on-grade structures. As such, pin pile-supported foundations, rather than shallow foundations, are recommended for the control building and other near-surface structures.

Pin piles consist of steel pipe sections, nominally 2 to 8 inches in diameter with ¼-inch-thick walls. Pipe sections typically conform to ASTM standard A53, *Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless*, and are fabricated from Schedule 40 or 80 steel and joined with weldless compression fittings. Table 5 includes nominal resistances for 6- and 8-inch-diameter pin piles, including downdrag loads caused by soil liquefaction and consolidation settlement. To provide full capacity, pin piles should include at least 3 ft of center-to-center spacing.

Table 5. Pin Pile Design Parameters

Pile Section (diameter)	Allowable Axial Resistance[(a)] (kips)	Downdrag Load (kips)	Minimum Tip Elevation (ft)	Estimated Tip Elevation (ft)
6 inch	30.0	8.3	-15	-25
8 inch	45.0	11.0	-15	-25

(a) Allowable axial resistances include a factor of safety of at least 2 on the calculated ultimate values.
ft = feet

When calculating the axial resistances in Table 5, LAI assumed that open-end pin piles would be driven to refusal. If the first pile installed (test pile) does not refuse at the estimated tip elevation, the pile length should be extended until refusal is achieved.

Axial resistance should be proven in the field by load testing at least 5 percent of the production piles or a minimum of one pile. Load testing should be completed in accordance with the "Quick Test" method in ASTM standard test method D1143, *Standard Test Methods for Deep Foundation Elements Under Static Axial Compressive Load.* Testing cannot be completed on a battered pile; a sacrificial pile may be required if all production piles are battered.

Lateral resistance, using the soil response against pile foundations, should not be relied upon. LAI recommends that lateral resistance is achieved with battered piles or grade beams. Pin piles with a batter angle up to 25 degrees from vertical can be designed, if axial and lateral resistances will act parallel with and normal to the pile axis, respectively.

4.2.2 Wet Well Foundation Support

Dense to very dense glacial drift soil is anticipated at the proposed wet well foundation elevation. LAI recommends a net allowable soil bearing pressure of 3,500 pounds per square foot (psf) for shallow foundations that are established on glacial drift soil or on structural fill extending to such soil. This allowable soil bearing pressure applies to long-term dead and live loads, exclusive of the weight of the footing and any overlying backfill. It includes a factor of safety of at least 3.0 on the calculated ultimate bearing capacity. The allowable soil bearing pressure can be increased by one-third for total loads, including transient loads, such as those induced by wind and seismic forces.

If construction is completed as recommended herein, LAI estimates that footings will settle 1 inch or less. Additionally, LAI estimates ½ inch or less of differential settlement across the width of the wet well structure. Settlement will likely occur as building loads are applied during construction.

4.2.3 Lateral Resistance

The design parameters in Table 6 should be used in conjunction with the complete recommendations in this report.

Table 6. Lateral Resistance Design Parameters

Parameter	Value
Passive earth pressure (pcf)	270
Allowable coefficient of sliding	0.35

pcf = pounds per cubic foot

When calculating frictional resistance acting on the base of footings, the allowable coefficient of sliding resistance should be applied to vertical dead loads only. The allowable coefficient of sliding resistance includes a factor of safety of 1.5 on the calculated ultimate value. The value for the foundation passive earth pressure has been reduced by a factor of 1.5 to limit deflections to less than 2 percent of the embedded depth. The passive earth pressure and friction components can be combined, provided the passive component does not exceed two-thirds of the total. The top 2 ft of soil should be excluded from the calculation, unless the foundation perimeter will be covered by a slab-on-grade or pavement.

4.2.4 Lateral Earth Pressures

Lateral earth pressures that can be used to design the wet well structure are shown on Figure 4. In general, the wet well structure should be designed to resist at-rest earth pressure, hydrostatic water pressure, temporary construction surcharge, and seismic lateral earth pressures.

4.2.5 Uplift Resistance

Buried, tank-like structures, such as the proposed wet well, will experience an upward, buoyant force when the groundwater level outside of the structure is higher than the fluid level inside the structure. The weight of the structure and sidewall soil friction can be used to provide uplift resistance. Extending the base of the wet well foundation beyond the outside of its perimeter will also provide uplift resistance.

If an extended base slab is used, the weight of the soil overlying the footing can be calculated with an effective wedge (NAVFAC 1986), as shown on Figure 5. Uplift should be calculated using a soil unit weight of 63 pounds per cubic foot (pcf) for buoyant conditions.

Alternatively, sidewall soil friction between the outside of the structure and the surrounding backfill can be used to resist uplift. To calculate frictional resistance, LAI recommends using a lateral soil earth pressure of 30 pcf and a coefficient of friction (tanδ) of 0.35 for epoxy-coated structures, 0.57 for cast-in-place structures, and 0.45 for pre-cast concrete structures.

Sidewall soil friction and extended base slabs are alternative methods of uplift resistance and should not be used in conjunction.

4.2.6 Slabs-On-Grade

A modulus of vertical subgrade reaction (subgrade modulus) can be used to design slabs-on-grade for the proposed pump station structures. The subgrade modulus will vary based on the dimensions of the slab and the magnitude of applied loads on the slab surface; slabs with larger dimensions and loads will be influenced by soils to a greater depth. To design slabs-on-grade, LAI recommends using a subgrade modulus of 150 pounds per cubic inch. This subgrade modulus is for a 1-ft by 1-ft square plate and is not the overall modulus of a larger area.

4.2.7 Lightweight Fill

The exterior grades of the control building may be raised to accommodate rises in sea level. Fill soils are underlain by compressible, organic soil, presenting a risk for long-term consolidation settlement where new loads are applied. To mitigate long-term settlement risks, LAI recommends using lightweight fill to create a zero-net increase in soil loads. Cellular concrete and expanded shale aggregate are suitable options for lightweight fill. Alternatively, expanded polystyrene (EPS) geofoam with sufficient cover to resist buoyancy could be used. LAI is available to assist with selection of a lightweight fill material once site grades have been finalized.

4.2.8 Low-Permeability Fill

Excavations, extending into the confined aquifer lower aquifer, are planned for construction of the new wet well. The excavations will need to be backfilled with low- permeability fill soil in order to create a seal and limit groundwater seepage to surface from the underlying confined aquifer after construction dewatering is shut off. The design should assume low-permeability fill for wet well structure backfill from elevations -4 to -14. Though not available on site, glacial till is generally well-suited for use as low-permeability fill. Soil used for low-permeability fill should meet the gradation requirements set forth in Table 7.

Table 7. Low-Permeability Soil Gradation

Sieve Size	Percent Passing
6 inch	100
4 inch	90–100
No. 4	70–100
No. 200	40

No. = number

Low-permeability fill is highly moisture sensitive, and small changes in moisture content will make reaching the required compaction criteria difficult. Low-permeability fill should be placed in loose, horizontal lifts, not exceeding 6-inch thickness, and compacted to 95 of the maximum dry density (MDD) as determined by ASTM International (ASTM) test method D698 (i.e., standard Proctor). LAI recommends that low-permeability fill is placed at 1 percent below to 3 percent above optimum moisture content.

LAI should be contacted to review project plans and provide notes regarding appropriate locations for low-permeability fill. Controlled density fill (CDF) may be an alternative to consider during final design.

4.3 Earthwork

The following sections include earthwork construction recommendations for the PS-3 project.

4.3.1 Subgrade Preparation

LAI anticipates that the majority of trench and structural excavations will expose loose to medium dense fill or glacial outwash soil at the subgrade elevation. The wet well excavation likely will expose dense to very dense glacial drift soil. The contractor should assume that the upper 1 ft of subgrade will need to be scarified; moisture conditioned; and compacted to a firm, unyielding condition before pipes, formwork, or structural fill is placed.

Accessible subgrades should be proof-rolled in the presence of a qualified civil or geotechnical engineer. In areas of limited access, a steel T-probe can be used to evaluate subgrades. Soft/unsuitable soils should be overexcavated and replaced with structural fill.

4.3.2 Utility Trench Excavation and Backfill

LAI anticipates that utility trenches will be excavated in medium dense to very dense fill or glacial outwash soil. A heavy-duty hydraulic excavator should be able to excavate trenches to the required depths. A smooth-bladed bucket should be used to remove loose and/or disturbed soil from the trench bottom. The final trench bottom should be firm and free of roots, topsoil, lumps of silt and clay, and organic and inorganic debris. Unsuitable soil should be overexcavated and replaced with suitable foundation material. Trench backfill should be placed in loose, horizontal lifts, no more than 8 inches thick. The backfill should be compacted to at least 95 percent of the maximum density, determined in accordance with the compaction control tests in Section 2-03.3(14)D of the Washington State Department of Transportation's 2021 *Standard Specifications for Road, Bridge, and Municipal Construction* (*2021 WSDOT Standard Specifications*). Alternatively, the maximum dry density can be determined using ASTM standard test method D1557, *Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft*^{3} *(2,700 kN-m/m*^{3}*)).* Cobbles and boulders are often found in glacial deposits and may be encountered throughout the site. Construction debris also may be encountered in the fill unit.

4.3.3 Site Soil

The granular site soils (i.e., Unified Soil Classification System soils SP, SP-SM, GP, GP-GM, and GM) observed along McConnell Avenue Northwest and Northwest Carlton Street are suitable for reuse as trench backfill or structural fill. Constituents greater than 6 inches in diameter should be screened and removed from the soil prior to compaction. Soil contain organics should not be considered suitable for reuse. Soil may require significant moisture conditioning (wetting or drying) to achieve compaction requirements.

Soil encountered in excavations at the PS-3 site should be considered unsuitable for reuse.

4.3.4 Import Soil

Imported trench backfill or structural fill should meet the requirements for Select Borrow or Gravel Borrow in Section 9-03.14 of the *2021 WSDOT Standard Specifications.* Trenches may also be backfilled with Bank Run Gravel for Trench Backfill that conforms to the requirements in Section 9-03.19 of the *2021 WSDOT Standard Specification.* If wet weather construction is anticipated, the amount of fines should be less than 5 percent by weight, based on the minus ¾-inch fraction.

4.3.5 Structural Fill Compaction

Structural fill should be placed and compacted in accordance with the requirements in Section 2-03.3(14)C, Method C of the *2021 WSDOT Standard Specifications.* Each layer of structural fill should be compacted to at least 95 percent of the maximum density, determined in accordance with the compaction control tests in Section 2-03.3(14)D of the *2021 WSDOT Standard Specifications.*

4.3.6 Temporary Excavations

The majority of temporary excavations will be advanced in loose to medium dense glacial soil. A heavy-duty hydraulic excavator with sufficient reach should be able to excavate to the proposed depths. A smooth-bladed bucket should be used to remove loose and/or disturbed soil from the base of the excavations. Cobbles and boulders are often found in glacial deposits and may be encountered throughout the site. Construction debris also may be encountered in the fill unit.

Temporary excavations should be completed in accordance with the requirements in Section 2-09 of the *2021 WSDOT Standard Specifications.* The contractor should be responsible for trench configurations and the maintenance of safe working conditions, including temporary excavation stability. All applicable local, state, and federal safety codes should be followed.

Temporary excavations should be no steeper than 1½ horizontal to 1 vertical (1½H:1V), in accordance with the regulations for safe excavation in the State of Washington (Chapter 296-155 of the Washington Administrative Code). If groundwater seepage is present, flatter slopes, temporary shoring, and/or dewatering may be required. Section 4.1 of this report includes design recommendations for engineered shoring systems.

5.0 WATERFRONT CENTER DESIGN RECOMMENDATIONS

Based on the results of LAI's geotechnical field investigation and laboratory testing, site subsurface conditions present several design challenges for the Waterfront Center project. The proposed improvements are considered feasible, provided the following recommendations are incorporated into the project design:

- **Unsuitable foundation material:** In LAI's opinion, the soil conditions at Waterfront Center Site B are not suitable for shallow foundations. Based on the subsurface conditions observed in borings B-2 and B-3, up to 1 ft of long-term consolidation settlement could occur under typical design loads (i.e., 2,000 psf). Driven pile foundations should be used for structures in Site B.
- **Settlement:** The project design should account for the presence of settlement-sensitive soils. Pockets of organic soils were observed in borings B-2 and B-3 and in historical boring B-1W (Shannon & Wilson 2020). Organic soils should be anticipated in the area south of the undocumented fill limits shown on Figure 2A. Raising of site grades could result in long-term consolidation settlement. Long-term consolidation settlement is not a concern for structures on Site A.
- **Obstructions:** The Waterfront Center site is underlain by glacially derived soil and fill that may contain oversized material (construction debris, cobbles, and boulders). The contractor should be prepared to manage oversized material encountered during construction.

The following sections include geotechnical conclusions and recommendations to support design of the Waterfront Center project.

5.1 Site A Structural Design Recommendations

Based on the results of LAIs liquefaction analyses (Section 3.0), up to 2 inches of liquefaction-induced settlement could occur at Waterfront Center Site A. Two inches of liquefaction-induced differential settlement could occur over a 50-ft horizontal span.

Foundation ties are required for structures that could experience differential settlement in excess of the limits specified in Table 12.13-3 of the ASCE's *Minimum Design Loads and Associated Criteria for Buildings and Other Structures (ASCE 7-16).* Given the estimated differential settlement for Waterfront Center Site A, LAI recommends reviewing the foundation structural design requirements in Table 12.13-3. The risk of lateral spreading is negligible at the proposed building locations between borings B-4 and B-6.

Based on the results of LAI's liquefaction analysis, a 5-ft-thick, liquefiable soil layer is present at approximately 9 ft bgs. The foundation design parameters in Table 8 are applicable only for footings embedded within 2 to 6 ft of ground surface and with lengths less than or equal to 50 ft. If the footing exceeds the embedment depth or length, reduced bearing capacity due to liquefaction could occur. LAI should be contacted for further analysis if the embedment depth or length of footing will be exceeded.

5.1.1 Shallow Foundation and Retaining Wall Design Parameters

Bearing capacities at the site are controlled by settlement and the presence of potentially liquefiable material below the footings. As shown in Table 8, these factors reduce allowable bearing capacities as footing sizes grow. Table 8 includes design parameters that the structural engineer can use to design shallow foundations and retaining walls at Waterfront Center Site A. The parameters should be used in conjunction with the complete recommendations in this report.

Table 8. Summary of Design Parameters for Shallow Foundations and Retaining Walls

Footing Width (ft)	2	3	4	6
Allowable Soil Bearing Pressure$^{(a–b)}$ (psf)	3,500	2,800	2,500	2,200
Passive Earth Pressure EFD	300 pcf			
At-rest Earth Pressure EFD	50 pcf			
Active Earth Pressure EFD	31.2 pcf			
Surcharge Pressure	$0.26q_s$			
Seismic Increment Earth Pressure	15H pcf			
Minimum Foundation Width	24 inches (continuous), 24 inches (isolated)			

(a) Allowable soil bearing pressure limits foundation elastic settlement to 1 inch or less. Values may be increased by one-third for transient loads, such as wind and seismic forces.
(b) This recommendation is applicable for footings up to 50 ft long. LAI should be contacted if the footing size needs to be increased.
(c) This recommendation is applicable for footings up to 6 ft deep. LAI should be contacted if the footing depth needs to be increased.
EFD = equivalent fluid density
ft = feet
H = exposed height of wall in feet
pcf = pounds per cubic foot
psf = pounds per square foot
q_s = surcharge pressure

When developing foundation design parameters, LAI assumed that shallow foundations would be established on 1 ft of import structural fill. The geotechnical engineer should evaluate native subgrades prior to placement of structural fill.

LAI recommends that the allowable soil bearing pressure and footing size in Table 8 are used to design shallow foundations. The allowable soil bearing pressure applies to long-term dead and live loads, exclusive of the weight of the footing and any overlying backfill. The bearing pressure can be increased by one-third for transient loads, such as those induced by wind and seismic forces.

LAI recommends a footing embedment depth of 2 ft to achieve the bearing capacities in Table 8. This embedment depth will also satisfy frost-protection requirements. Shallow foundation settlement, under static loading, will depend on the foundation size and bearing pressure as well as the strength and compressibility characteristics of the bearing soil. LAI estimates that continuous and isolated foundations will settle 1 inch or less if constructed as recommended. LAI estimates that ½ inch or less of static differential settlement could occur between similarly loaded foundation elements or along 50 ft of continuous footing. Settlement will likely occur as building loads are applied during construction.

When developing the equivalent fluid densities in Table 8, LAI assumed that walls and exterior footings would be surrounded by free-draining backfill (i.e., no hydrostatic or saturated conditions within the earth pressure zone). Footing/wall drains also should be provided around the walls and exterior footings. Footing drains should not be connected to roof drains.

Active earth pressure conditions are appropriate for walls that can translate or rotate about 0.005H, where H is the exposed height of the wall. At-rest earth pressure conditions should be used for rigid or braced walls (e.g., basement walls). The seismic increment should be added to the active or at-rest earth pressure to compute the total earth pressure during a seismic event.

An allowable coefficient of sliding resistance of 0.45, applied to vertical dead loads only, can be used to compute frictional resistance acting on the base of footings. This coefficient includes a factor of safety of 1.5 on the calculated ultimate value and is based on the assumption that footings will be cast on structural fill.

The passive resistance of properly compacted structural fill placed against the sides of foundations or walls can be considered equivalent to a fluid with a density of 300 pcf. The foundation passive earth pressure has been reduced by a factor of 1.5 to limit deflections to less than 2 percent of the embedded depth. The passive earth pressure and friction components can be combined, provided the passive component does not exceed two-thirds of the total. The top 2 ft of soil should be excluded from the calculation, unless the foundation perimeter will be covered by a slab-on-grade.

Typically, a surcharge load (q_s) of 250 psf is used to account for temporary construction equipment and vehicle traffic behind retaining walls. LAI recommends using $0.26q_s$ to compute wall pressures. Surcharge loading may be greater than the recommended 250 psf, depending on actual loading conditions. Surcharge loads should be evaluated during final design.

5.2 Site B Structural Design Recommendations

Waterfront Center Site B is underlain by highly compressible organic soils. In these soil conditions, shallow foundations will not provide suitable support for the proposed structures. Based on the conditions observed in borings B-2 and B-3, LAI estimates that approximately 1 ft of long-term consolidation settlement could occur under typical design loads (i.e., 2,000 psf). Conditions similar to those observed in borings B-2 and B-3 may be present in the area south of the undocumented fill limits shown on Figure 2A.

The foundation design recommendations in Section 4.2.1 should be used for Waterfront Center Site B. LAI is available to provide driven-pile recommendations, if greater axial capacities are required.

5.3 Settlement Considerations

Given the risk for long-term settlement of compressible, organic soils, LAI recommends that grades south of Waterfront Center Site A are not altered. Further, damage could occur if grades are raised in areas where settlement-sensitive utilities are located above compressible soils. Soil preloading is considered feasible in areas without settlement-sensitive structures and/or utilities.

Based on the conditions observed in boring B-3, LAI estimates that approximately 1 inch of long-term settlement will occur for every 1 ft that site grades are raised. In the 2 to 3 months after fill is placed, approximately 80 to 90 percent of total settlement will likely occur as primary consolidation settlement. The other 10 to 20 percent of settlement will likely occur as secondary compression settlement, with a linear relationship between settlement and the logarithm of time. Long-term, secondary compression settlement will be most substantial in the 20 years after construction. After 20 years, secondary compression settlement will continue at a reduced rate.

Grades for walkways/patios within Waterfront Center Site B may be raised to accommodate rises in sea level. To mitigate long-term settlement of organic soils, LAI recommends using lightweight fill to create a zero-net increase in soil loads. Cellular concrete and expanded shale aggregate are suitable options for lightweight fill. Alternatively, EPS geofoam with sufficient cover to resist buoyancy could be used. LAI is available to assist with selection of lightweight fill material once site grades have been finalized.

5.4 Stormwater Management

Given the high groundwater levels and undocumented fill observed in LAI’s August 2021 explorations, onsite stormwater infiltration is not considered feasible. Additionally, the site has a history of environmental remediation that makes onsite stormwater infiltration untenable. During construction of previous improvements at the Waterfront Park, hydrocarbon-contaminated soil may have been remediated and used to fill beneath pavement sections (Applied Geotechnology Inc. 1993).

With its proximity to Dyes Inlet, the site likely will be flow control-exempt. The design of new stormwater facilities should be commensurate with that of existing site infrastructure (i.e., below-grade water quality treatment vaults). High groundwater conditions may cause buoyancy in below-grade structures. The design of below-grade treatment vaults should account for groundwater at surface. Uplift resistance for vault structures should be designed in accordance with the recommendations in Section 4.2.5.

5.5 Pavement Design

Pavement sections should be constructed on a uniformly firm, unyielding subgrade or on structural fill extending to such subgrade soils. When developing the pavement design recommendations in Table 9, LAI assumed a 20-year pavement design life and maximum equivalent single-axle loads of 50,000 for the standard-duty pavement section and 500,000 for the heavy-duty section. LAI is available to provide ridged pavement sections recommendations upon request.

Table 9. Recommended Asphalt Pavement Design Sections

Pavement Section Type	Asphalt Concrete Pavement Thickness	Crushed Surfacing Thickness
Standard Duty	3 inches	4 inches
Heavy Duty	4 inches	8 inches

Crushed surfacing should be compacted to at least 95 percent of the maximum dry density, determined in accordance with ASTM standard test method D1557 or the compaction control tests in Section 2-03.3(14)D of the *2021 WSDOT Standard Specifications.* Crushed surfacing should meet the requirements for Crushed Surfacing Base Course in Section 9-03.9(3) of the *2021 WSDOT Standard Specifications.* To facilitate fine surface grading, the upper 2 inches of crushed surfacing could consist of Crushed Surfacing Top Course. Prevention of road-base saturation is essential for pavement durability; efforts should be made to limit the amount of water entering the base course.

Asphalt concrete should be Class B aggregate material or hot-mix asphalt, class ½-inch, PG58H-22 binder, conforming to the requirements in Section 8 of WSDOT's 2018 *Pavement Policy.* The asphalt should be compacted to at least 91 percent of the Rice density.

5.6 Earthwork

The following sections include earthwork construction recommendations for the Waterfront Center project.

5.6.1 Subgrade Preparation

LAI anticipates that loose to medium dense fill or glacial outwash will be encountered at subgrade elevation in the majority of trench or structural excavations. The upper 1 ft of subgrade should be scarified; moisture conditioned; and compacted to a firm, unyielding condition before formwork or structural fill is placed.

Accessible subgrades should be proof-rolled in the presence of a qualified civil or geotechnical engineer. A steel T-probe can be used to evaluate subgrades in areas of limited access. Soft/unsuitable soils should be overexcavated and replaced with structural fill.

5.6.2 Utility Trench Excavation and Backfill

The recommendations in Section 4.3.2 should be used to excavate and backfill utility trenches for the Waterfront Center project.

5.6.3 Site Soil

Granular soils (i.e., Unified Soil Classification System soils SP, SP-SM, and GP-GM) will likely be encountered in Site A excavations; these soils are considered suitable for reuse as trench backfill or structural fill. Constituents greater than 6 inches in diameter should be screened and removed from soil selected for reuse. Soil contain organics should not be considered suitable for reuse. Site A soils should be considered moisture sensitive; significant moisture conditioning (wetting or drying) may be required to achieve compaction requirements.

Soils encountered in Site B excavations are not considered suitable for reuse.

5.6.4 Import Soil

The recommendations in Section 4.3.4 should be used for soil imported for the Waterfront Center project.

5.6.5 Structural Fill Compaction

The recommendations in Section 4.3.5 should be used to compact structural fill for the Waterfront Center project.

5.6.6 Permanent Slopes

Permanent cut-and-fill slopes should be no steeper than 2H:1V. Permanent and temporary slopes should be protected from erosion and reseeded or revegetated as soon as practical.

5.6.7 Construction Dewatering

During the wet season, zones of perched groundwater may be encountered throughout the Waterfront Center site. Based on the conditions observed in LAI's August 2021 borings, groundwater may be encountered between 4 and 8 ft bgs. Temporary excavations should be dewatered to allow construction to be completed in the dry. Where groundwater seepage is encountered, conventional sumps and pumps should be sufficient to dewater excavations. More substantial dewatering efforts will be required where excavations extend below the groundwater table. Groundwater drawdown should be avoided in organic soils, as recommended in Section 4.1.

Watertight sheet piling may be required to dewater elevator pits or other excavations that extend below existing grades. Sheet piles may be difficult to advance in dense to very dense glacial outwash soil. The contractor should be prepared to manage oversized material encountered during construction. The contractor should be responsible for the design, monitoring, and maintenance of dewatering systems.

5.6.8 Temporary Excavations

The recommendations in Section 4.3.6 should be used to complete temporary excavations for the Waterfront Center project.

6.0 CONSTRUCTION SUPPORT

LAI recommends that geotechnical monitoring, testing, and consultation are provided during construction. These construction support services would allow LAI to confirm that site subsurface conditions are consistent with those observed in its field explorations; to provide updated recommendations should conditions differ from those anticipated; and to evaluate whether geotechnical construction activities comply with the project plans and specifications and the recommendations in this report. Geotechnical construction activities include preparation of utility subgrades, deep foundation installation, placement and compaction of backfill material, and other earthwork services. LAI would be pleased to provide construction support services.

7.0 USE OF THIS REPORT

Landau Associates has prepared this report for the exclusive use of BHC Consultants, LLC; Kitsap County; the Port of Silverdale; and their designated representatives for specific application to the Kitsap County Pump Station 3 Upgrades and Silverdale Waterfront Center projects in Silverdale, Washington. No other party is entitled to rely on the information, conclusions, and recommendations included in this document without the express written consent of Landau Associates. Reuse of the information, conclusions, and recommendations provided herein for extensions of the project or for any other project, without review and authorization by Landau Associates, shall be at the user's sole risk. Landau Associates warrants that, within the limitations of scope, schedule, and budget, its services have been provided in a manner consistent with that level of skill and care ordinarily exercised by members of the profession currently practicing in the same locality, under similar conditions as this project. Landau Associates makes no other warranty, either express or implied.

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Data Source: Esri.

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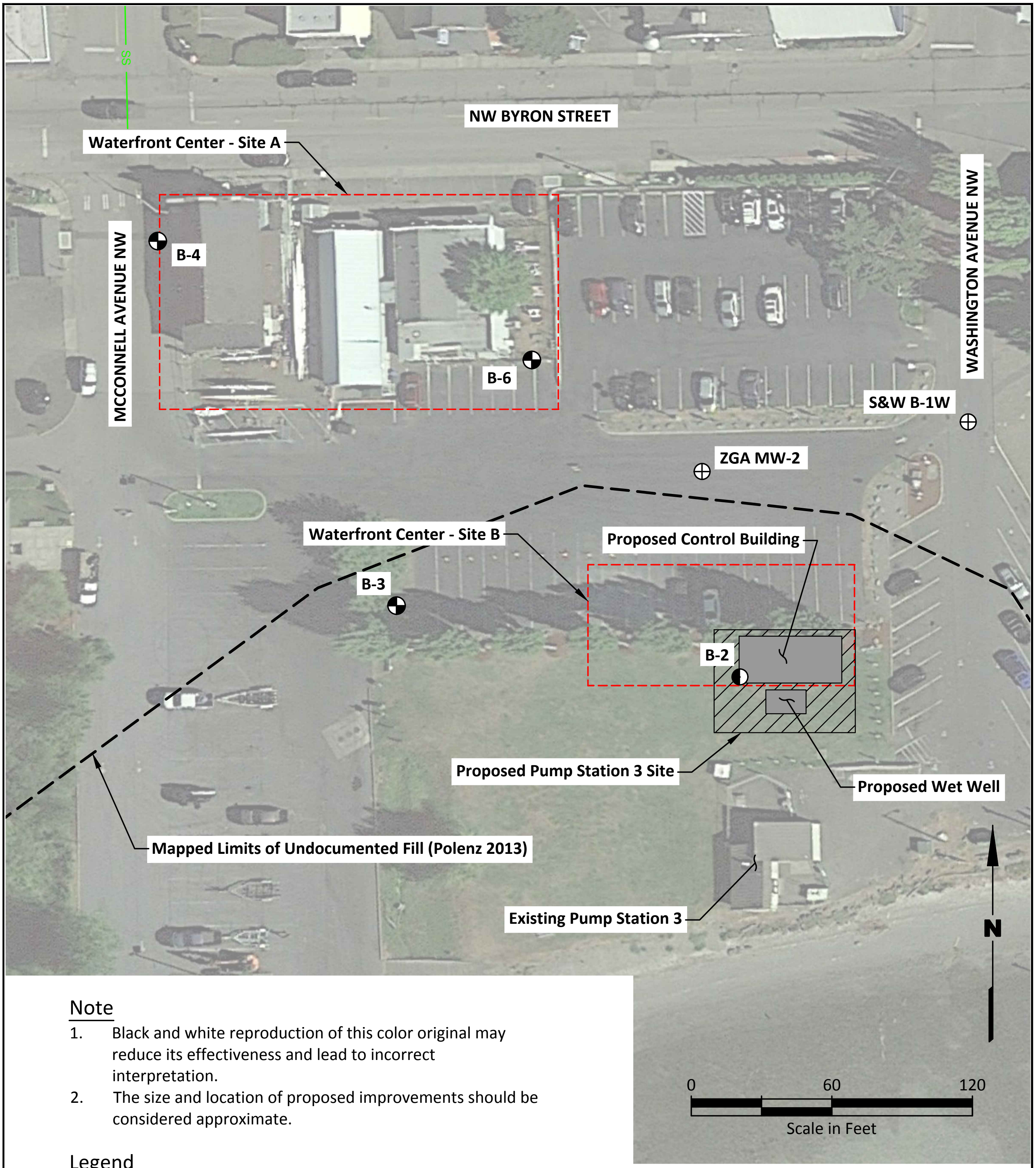
Landau Associates

Pump Station 3 Upgrades and
Waterfront Center
Silverdale, Washington

Vicinity Map

Figure
1



Note

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.
2. The size and location of proposed improvements should be considered approximate.

Legend

B-3 ◐	Approximate Boring Location and Designation
B-2 ◐	Approximate Boring with Monitoring Well Location and Designation
S&W B-1W ⊕	Approximate Historical Boring Location and Designation (Shannon And Wilson Inc. 2020)
ZGA MW-2 ⊕	Approximate Historical Boring Location and Designation (Zipper Geo Associates, LLC 2020)

Source: Google Imagery 2020

Landau Associates | Y:\CAD\1073\020.020\021_CAL.dwg | 9/13/2021 1:37 PM | bford

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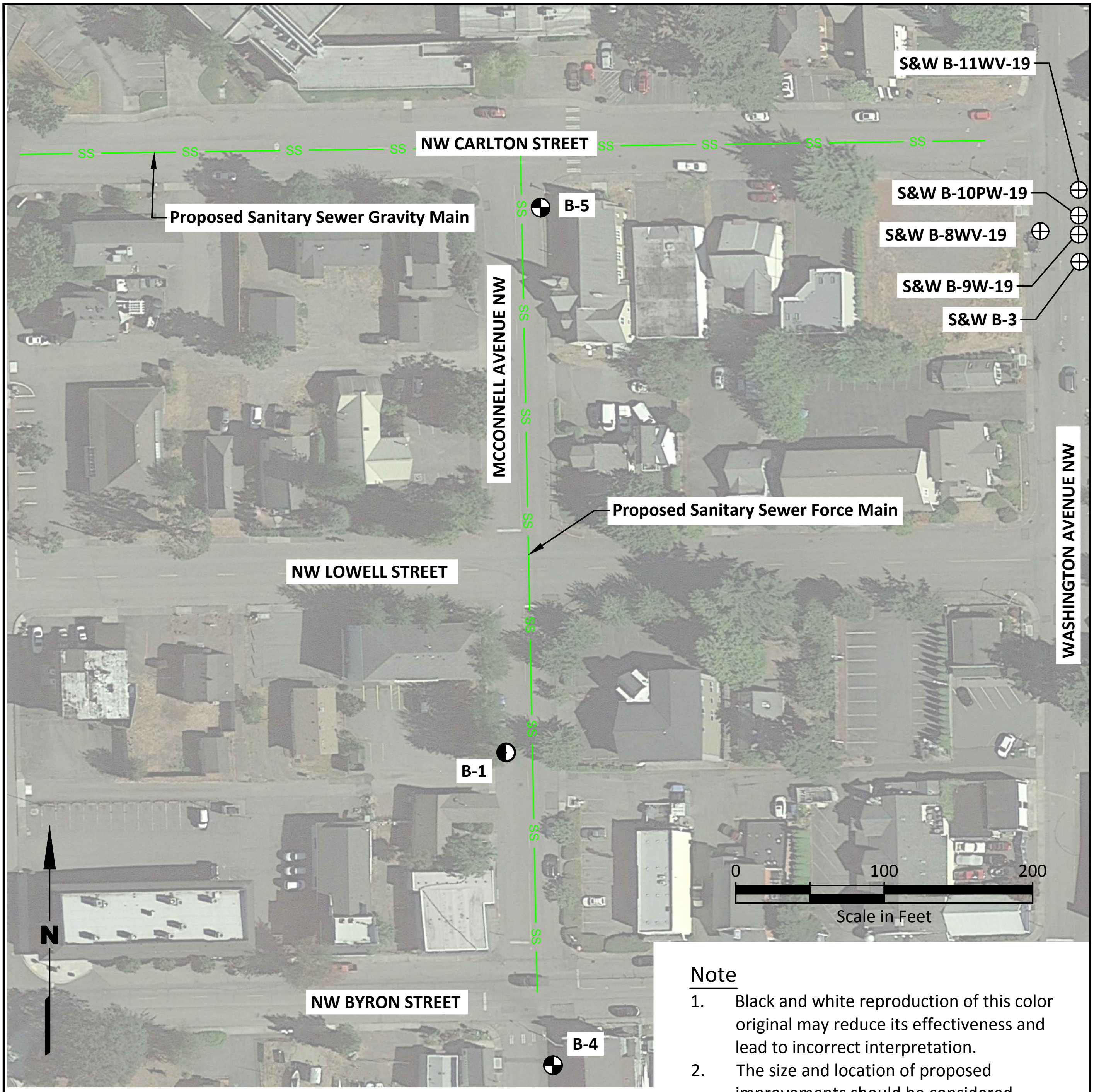
Pump Station 3 Upgrades
and Waterfront Center
Silverdale, Washington

Site and Exploration Plan

Figure
2A



Note

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.
2. The size and location of proposed improvements should be considered approximate.

Legend

B-5 ◕	Approximate Boring Location and Designation
B-1 ◐	Approximate Boring with Monitoring Well Location and Designation
S&W B-1W ⊕	Approximate Historical Boring Location and Designation (Shannon And Wilson Inc. 2020)

Source: Google Imagery 2020

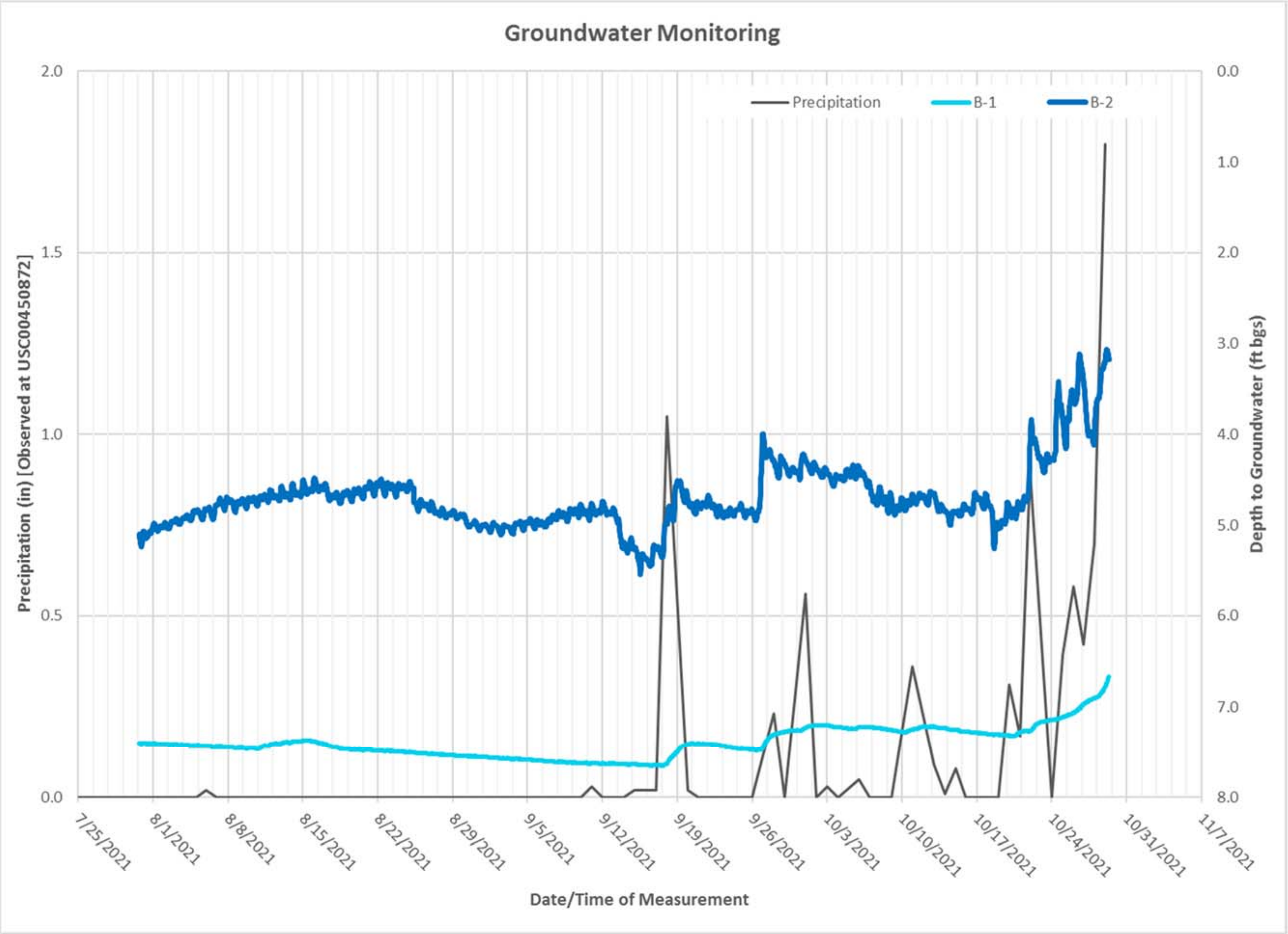
Landau Associates | Y:\CAD\1073\020.020\021_CAL.dwg | 9/13/2021 1:37 PM | bford

Landau Associates

Pump Station 3 Upgrades
and Waterfront Center
Silverdale, Washington

Site and Exploration Plan

Figure
2B



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Pump Station 3 Upgrades
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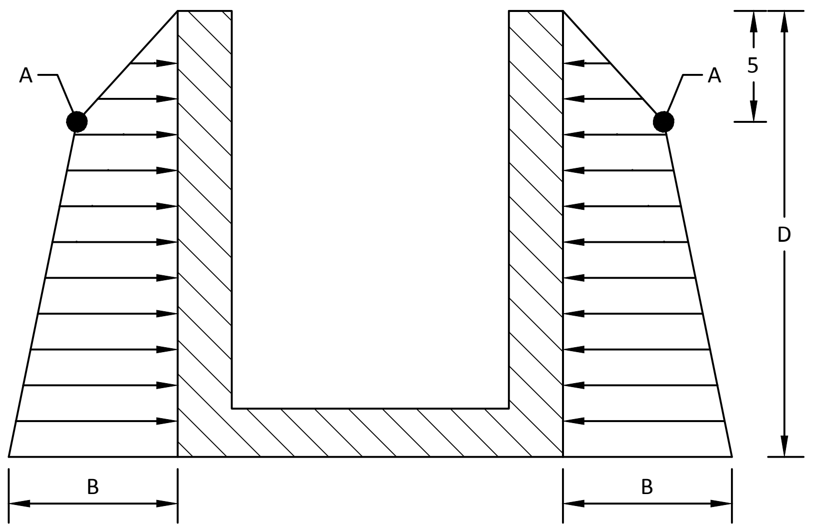
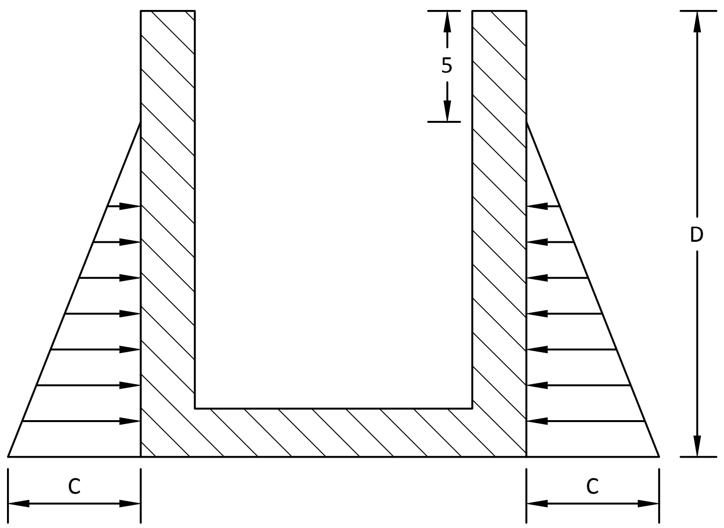
Silverdale, Washington

Groundwater Monitoring Data

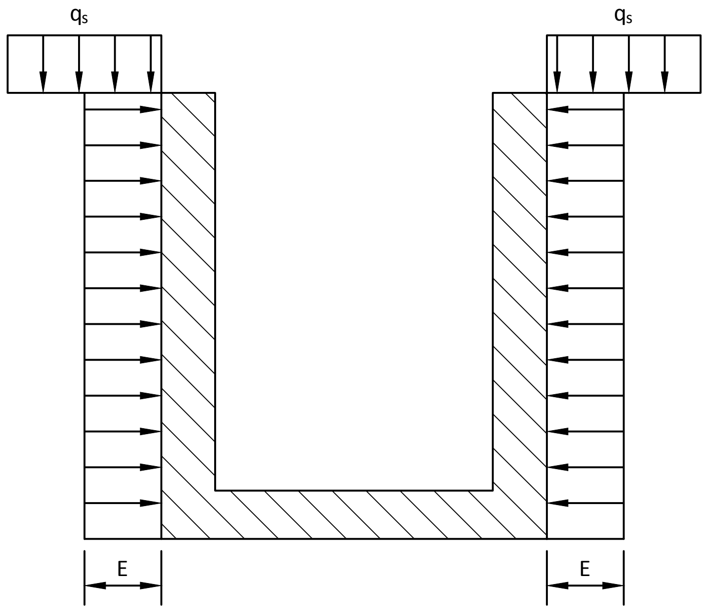
Figure
3



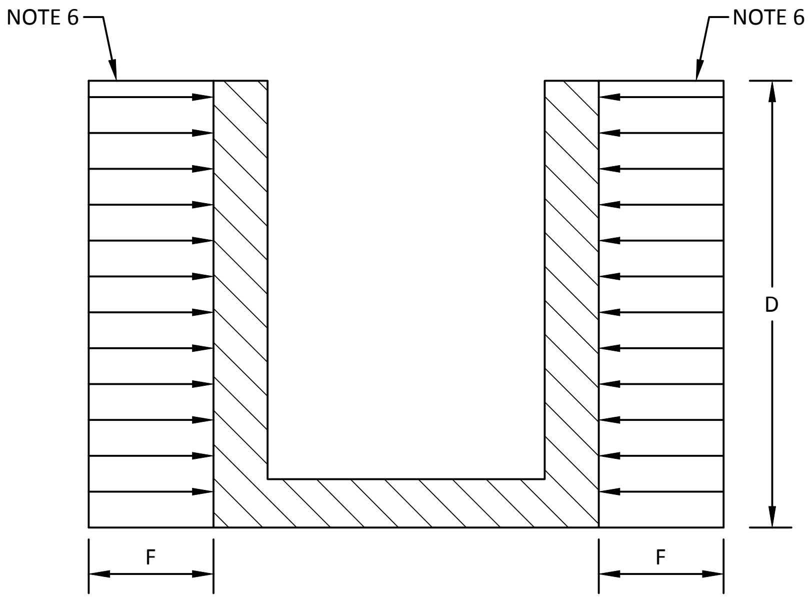
WET WELL WALL AT-REST EARTH PRESSURE



HYDROSTATIC PRESSURE



TRAFFIC OR TEMPORARY CONSTRUCTION SURCHARGE



SEISMIC INCREMENT

TABLE 1: RECOMMENDED UNFACTORED LATERAL PRESSURES				
A	B	C	E	F
275	A+25(D-5)	62.4 (D-5)	0.44q_s	16D

TABLE 2: SOIL PARAMETERS						
	K_a	K_o	K_p	γ_m/γ_{sat}	c (psf)	ϕ (deg)
SOFT/LOOSE TO MEDIUM DENSE SILT AND SAND	0.28	0.44	3.54	120	0	34

LATERAL EARTH PRESSURE NOTES

1. ALL PRESSURES PRESENTED ARE IN POUNDS PER SQUARE FOOT (PSF), WITH ALL DIMENSIONS IN FEET.
2. IT IS STANDARD PRACTICE TO ACCOMMODATE TRAFFIC AND CONSTRUCTION EQUIPMENT SURCHARGES (q_S) WITH A UNIFORM PRESSURE OF 250 PSF. SURCHARGE LOADS GREATER THAN 250 PSF, SUCH AS CRANES OR TALL STOCKPILES, SHOULD ALSO BE INCORPORATED INTO WALL DESIGN.
3. SEISMIC INCREASE WAS OBTAINED USING THE MONONOBE-OKABE METHOD.
4. A DESIGN GROUNDWATER DEPTH (H) OF 5 FEET BELOW GROUND SURFACE IS RECOMMENDED FOR HYDROSTATIC PRESSURE.
5. LATERAL EARTH PRESSURES ARE BASED ON RIGID WALL AND AT-REST CONDITIONS.
6. SEISMIC INCREMENT ACTS ON APPROXIMATELY ONE HALF OF THE WELL STRUCTURE AT ANY GIVEN TIME DURING A SEISMIC EVENT. STATIC EARTH AND HYDROSTATIC PRESSURES MAY BE CONSIDERED AXISYMMETRIC ABOUT THE VERTICAL STRUCTURE AXIS, BUT SEISMIC STRUCTURAL DESIGN OF THE WELL SHOULD INCLUDE AN UNBALANCED SEISMIC PRESSURE.

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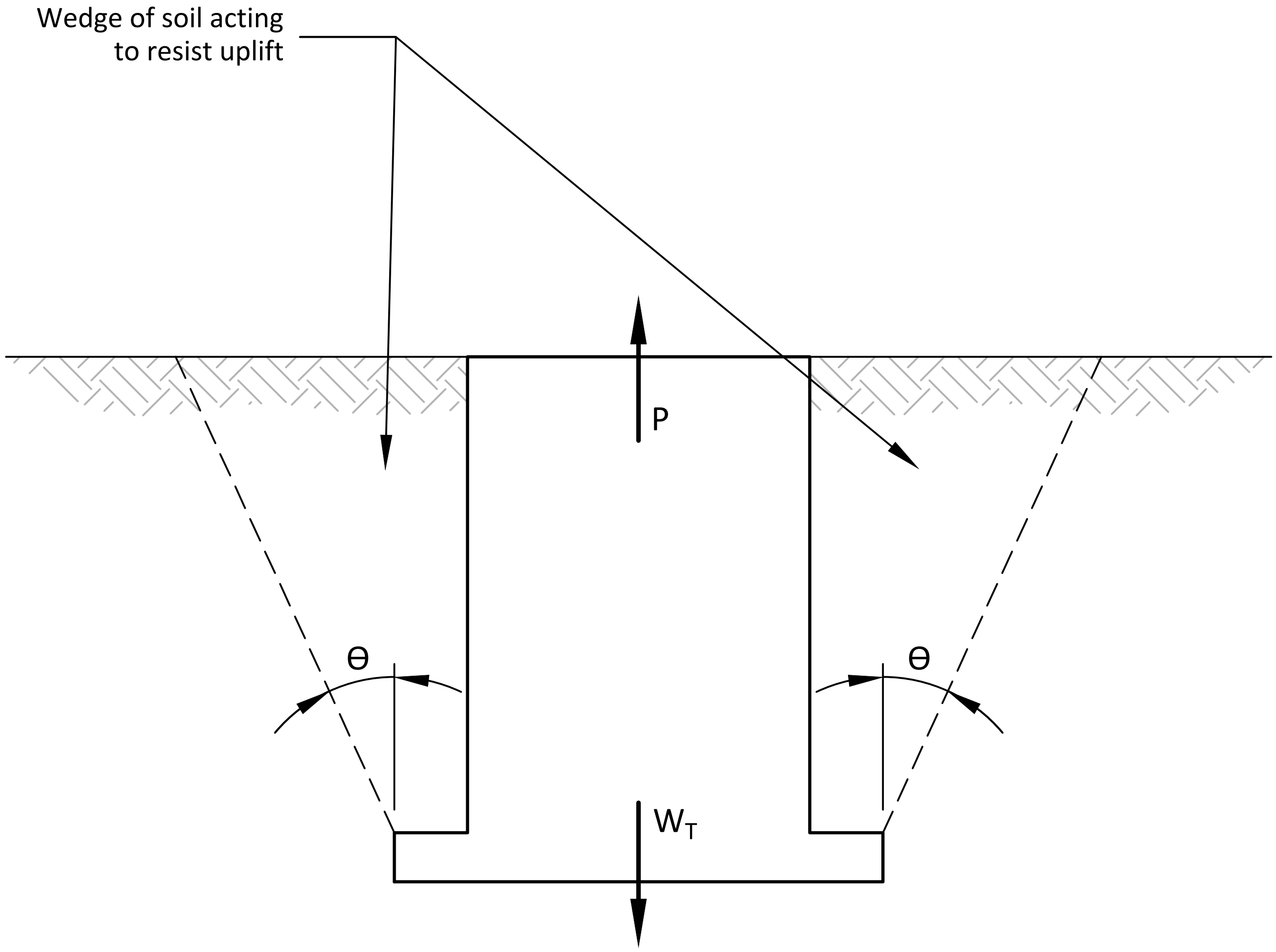
Silverdale, Washington

Lateral Earth Pressure Diagrams

Figure
4



Legend

W_T = Weight of structure plus weight of soil wedge. Use γ_B = 63 pounds per cubic foot for soil weight.

P = Buoyancy force

Factor of Safety = W_T/P

Θ = 20°

Source: Naval Facilities Engineering Command Design Manual 7.2 1986

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Silverdale, Washington

Uplift Footings

Figure
5

APPENDIX A

Field Explorations

APPENDIX A
FIELD EXPLORATIONS

On July 29 and 30, 2021, Holocene Drilling, Inc., subcontracted by Landau Associates, Inc. (LAI), advanced six hollow-stem auger borings at the approximate locations shown on Figure 2. The borings were advanced 20.8 to 56.5 feet (ft) below ground surface.

LAI personnel coordinated and monitored the field explorations, collected representative soil samples, maintained a detailed record of the subsurface soil and groundwater conditions observed, and described the soil encountered by visual and textural examination. Each representative soil type was described using the soil classification system shown on Figure A-1, in general accordance with ASTM International standard test method D2488, *Standard Practice for Description and Identification of Soils (Visual-Manual Procedures)*.

Summary boring logs are provided on Figures A-2 through A-7. The stratigraphic contacts shown on the logs represent the approximate boundaries between soil types; actual transitions may be more gradual. The soil and groundwater conditions depicted are for the specific dates and locations indicated and may not be representative of other locations and/or times.

Disturbed and undisturbed soil samples were obtained from the borings at 2.5- or 5-ft intervals. Samples were collected with a 1.5-inch-inside-diameter, standard penetration test split-spoon sampler. A 140-pound automatic hammer, falling approximately 30 inches, was used to drive the sampler 18 inches (or a portion thereof) into the undisturbed soil. The number of blows required to drive the sampler the final 12 inches (or a portion thereof) of soil penetration is noted on the boring logs, adjacent to the appropriate sample notation.

Upon completion of drilling and sampling, the boreholes were decommissioned in general accordance with the requirements in Washington Administrative Code Chapter 173-160.

Samples were transported to LAI’s soils laboratory for further examination and testing. Test results and a discussion of the testing procedures are provided in Appendix B.

Soil Classification System

MAJOR DIVISIONS			GRAPHIC SYMBOL	USCS LETTER SYMBOL(1)	TYPICAL DESCRIPTIONS (2)(3)
COARSE-GRAINED SOIL (More than 50% of material is larger than No. 200 sieve size)	GRAVEL AND GRAVELLY SOIL (More than 50% of coarse fraction retained on No. 4 sieve)	CLEAN GRAVEL (Little or no fines)	▨	**GW**	Well-graded gravel; gravel/sand mixture(s); little or no fines
			▨	**GP**	Poorly graded gravel; gravel/sand mixture(s); little or no fines
		GRAVEL WITH FINES (Appreciable amount of fines)	▨	**GM**	Silty gravel; gravel/sand/silt mixture(s)
			▨	**GC**	Clayey gravel; gravel/sand/clay mixture(s)
	SAND AND SANDY SOIL (More than 50% of coarse fraction passed through No. 4 sieve)	CLEAN SAND (Little or no fines)	▨	**SW**	Well-graded sand; gravelly sand; little or no fines
			▨	**SP**	Poorly graded sand; gravelly sand; little or no fines
		SAND WITH FINES (Appreciable amount of fines)	▨	**SM**	Silty sand; sand/silt mixture(s)
			▨	**SC**	Clayey sand; sand/clay mixture(s)
FINE-GRAINED SOIL (More than 50% of material is smaller than No. 200 sieve size)	SILT AND CLAY (Liquid limit less than 50)		▨	**ML**	Inorganic silt and very fine sand; rock flour; silty or clayey fine sand or clayey silt with slight plasticity
			▨	**CL**	Inorganic clay of low to medium plasticity; gravelly clay; sandy clay; silty clay; lean clay
			▨	**OL**	Organic silt; organic, silty clay of low plasticity
	SILT AND CLAY (Liquid limit greater than 50)		▨	**MH**	Inorganic silt; micaceous or diatomaceous fine sand
			▨	**CH**	Inorganic clay of high plasticity; fat clay
			▨	**OH**	Organic clay of medium to high plasticity; organic silt
	HIGHLY ORGANIC SOIL		▨	**PT**	Peat; humus; swamp soil with high organic content

OTHER MATERIALS	GRAPHIC SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
PAVEMENT	■ ▨	**AC** or **PC**	Asphalt concrete pavement or Portland cement pavement
ROCK	▨	**RK**	Rock (See Rock Classification)
WOOD	▨	**WD**	Wood, lumber, wood chips
DEBRIS	▨	**DB**	Construction debris, garbage

Notes:
1. USCS letter symbols correspond to symbols used by the Unified Soil Classification System and ASTM classification methods. Dual letter symbols (e.g., SP-SM for sand or gravel) indicate soil with an estimated 5-15% fines. Multiple letter symbols (e.g., ML/CL) indicate borderline or multiple soil classifications.
2. Soil descriptions are based on the general approach presented in the Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), outlined in ASTM D 2488. Where laboratory index testing has been conducted, soil classifications are based on the Standard Test Method for Classification of Soils for Engineering Purposes, as outlined in ASTM D 2487.
3. Soil description terminology is based on visual estimates (in the absence of laboratory test data) of the percentages of each soil type and is defined as follows:

   Primary Constituent: > 50% - "GRAVEL," "SAND," "SILT," "CLAY," etc.
   Secondary Constituents: > 30% and ≤ 50% - "very gravelly," "very sandy," "very silty," etc.
   > 15% and ≤ 30% - "gravelly," "sandy," "silty," etc.
   Additional Constituents: > 5% and ≤ 15% - "with gravel," "with sand," "with silt," etc.
   ≤ 5% - "with trace gravel," "with trace sand," "with trace silt," etc., or not noted.

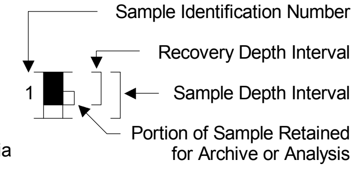
4. Soil density or consistency descriptions are based on judgement using a combination of sampler penetration blow counts, drilling or excavating conditions, field tests, and laboratory tests, as appropriate.

Drilling and Sampling Key

SAMPLER TYPE

Code	Description
a	3.25-inch O.D., 2.42-inch I.D. Split Spoon
b	2.00-inch O.D., 1.50-inch I.D. Split Spoon
c	Shelby Tube
d	Grab Sample
e	Single-Tube Core Barrel
f	Double-Tube Core Barrel
g	2.50-inch O.D., 2.00-inch I.D. WSDOT
h	3.00-inch O.D., 2.375-inch I.D. Mod. California
i	Other - See text if applicable
1	300-lb Hammer, 30-inch Drop
2	140-lb Hammer, 30-inch Drop
3	Pushed
4	Vibrocore (Rotosonic/Geoprobe)
5	Other - See text if applicable

SAMPLE NUMBER & INTERVAL



Field and Lab Test Data

Code	Description
PP = 1.0	Pocket Penetrometer, tsf
TV = 0.5	Torvane, tsf
PID = 100	Photoionization Detector VOC screening, ppm
W = 10	Moisture Content, %
D = 120	Dry Density, pcf
-200 = 60	Material smaller than No. 200 sieve, %
GS	Grain Size - See separate figure for data
AL	Atterberg Limits - See separate figure for data
GT	Other Geotechnical Testing
CA	Chemical Analysis

Groundwater

▽ Approximate water level at time of drilling (ATD)
▼ Approximate water level at time after drilling/excavation/well

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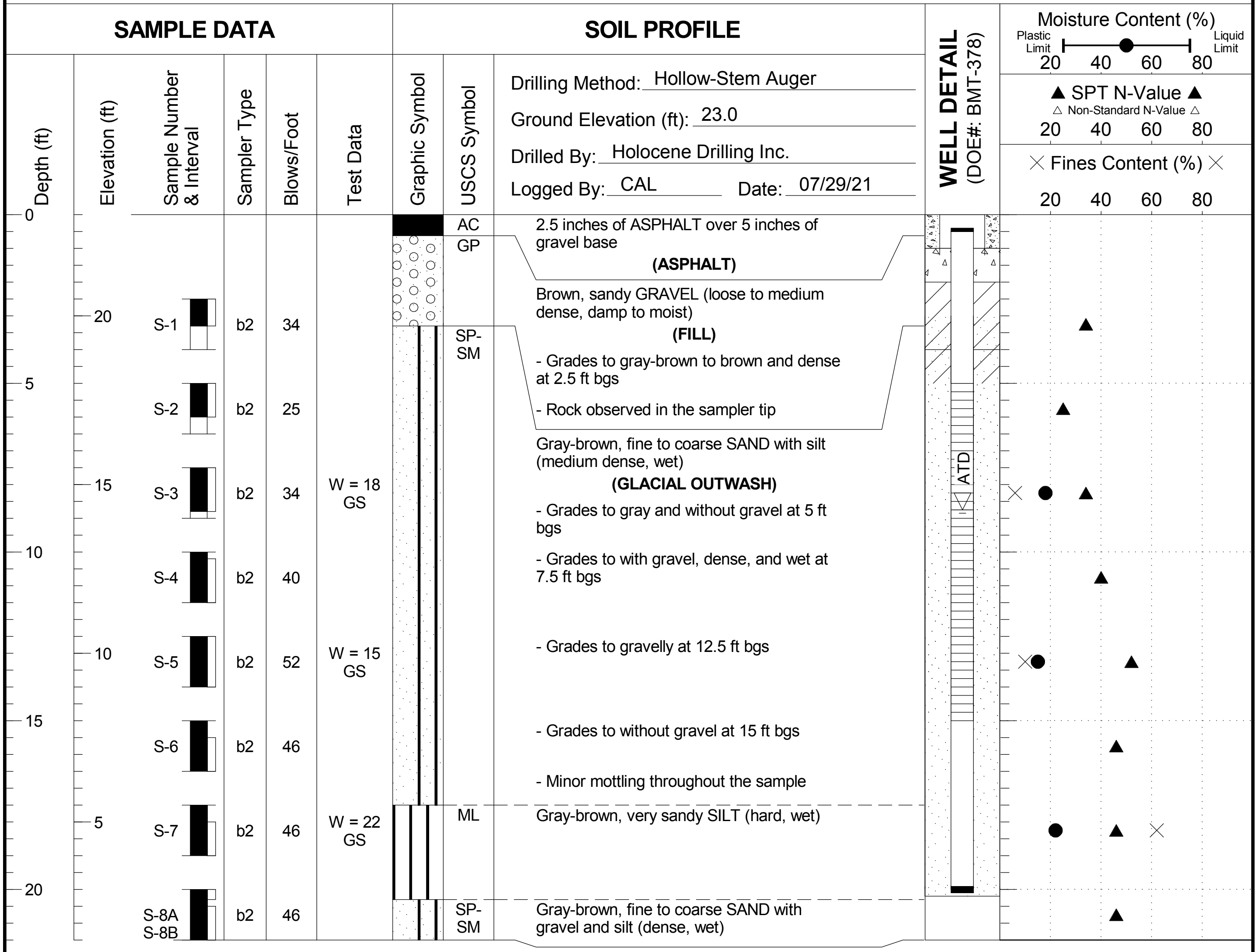
Silverdale, Washington

Soil Classification System and Key

Figure
A-1

B-1

LAI Project No: 1073020.020.021



Drilling Method: Hollow-Stem Auger

Ground Elevation (ft): 23.0

Drilled By: Holocene Drilling Inc.

Logged By: CAL Date: 07/29/21

Sample Number & Interval	Sampler Type	Blows/Foot	Test Data
S-1	b2	34	
S-2	b2	25	
S-3	b2	34	W = 18 GS
S-4	b2	40	
S-5	b2	52	W = 15 GS
S-6	b2	46	
S-7	b2	46	W = 22 GS
S-8A S-8B	b2	46	

USCS Symbol	Description
AC	2.5 inches of ASPHALT over 5 inches of gravel base **(ASPHALT)**
GP	Brown, sandy GRAVEL (loose to medium dense, damp to moist) **(FILL)** - Grades to gray-brown to brown and dense at 2.5 ft bgs - Rock observed in the sampler tip
SP-SM	Gray-brown, fine to coarse SAND with silt (medium dense, wet) **(GLACIAL OUTWASH)** - Grades to gray and without gravel at 5 ft bgs - Grades to with gravel, dense, and wet at 7.5 ft bgs - Grades to gravelly at 12.5 ft bgs - Grades to without gravel at 15 ft bgs - Minor mottling throughout the sample
ML	Gray-brown, very sandy SILT (hard, wet)
SP-SM	Gray-brown, fine to coarse SAND with gravel and silt (dense, wet)

Boring Completed 07/29/21
Total Depth of Boring = 21.5 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Pump Station 3 Upgrades
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Silverdale, Washington

Log of Boring B-1

Figure
A-2

B-2

LAI Project No: 1073020.020.021

Drilling Method: Hollow-Stem Auger
Ground Elevation (ft): 13.5
Drilled By: Holocene Drilling Inc.
Logged By: CAL
Date: 07/30/21

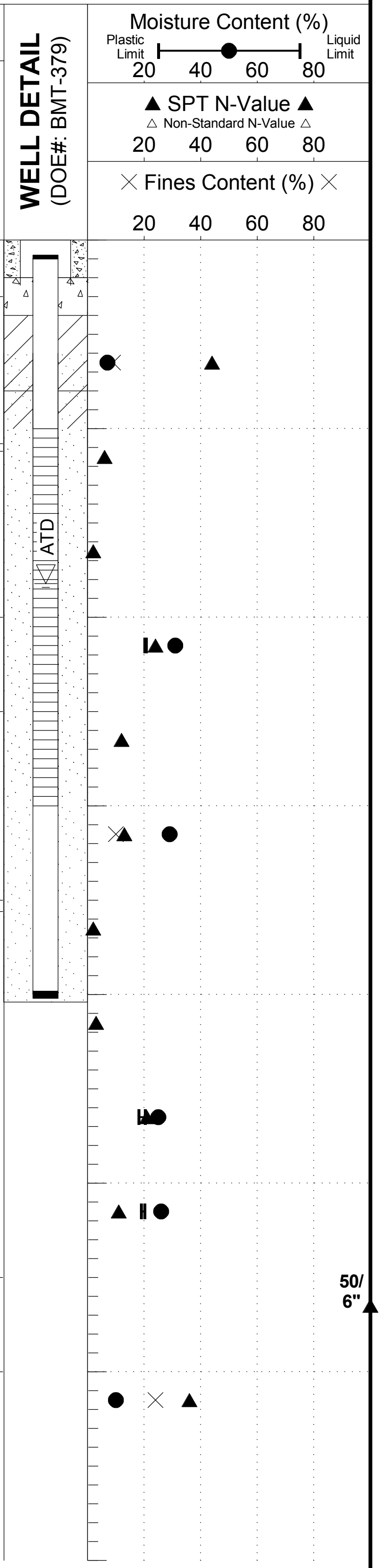
SAMPLE DATA

Depth (ft): 0, 5, 10, 15, 20, 25, 30, 35

Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data
10	S-1	b2	44	W = 7 GS
	S-2	b2	6	
5	S-3	b2	2	
	S-4	b2	24	W = 31 AL
0	S-5	b2	12	
	S-6	b2	13	W = 29 GS
-5	S-7B S-7A	b2	2	
	S-8	b2	3	
-10	S-9	b2	21	W = 25 AL
	S-10	b2	11	W = 26 AL
-15	S-11	b2	50/ 6"	
	S-12	b2	36	W = 10 GS
-20				

SOIL PROFILE

USCS Symbol	Description
SM	1/2 inch of sod over brown, sandy SILT with gravel (medium dense, moist) **(FILL)**
SP-SM	Gray, very gravelly, fine to coarse SAND with silt (dense, moist to wet) - Moderate chatter observed between 1.5 and 5 ft bgs - Organic sample odor observed between 2.5 and 5.6 ft bgs - Grades to loose at 5 ft bgs
PT	Dark brown to black PEAT (very soft, moist to wet) **(PEAT)**
SM	Gray, silty, fine to coarse SAND (very loose, wet) **(GLACIAL OUTWASH)**
ML	Gray SILT with trace organics (very stiff, wet)
SP-SM	Gray, gravelly, fine to coarse SAND with silt (medium dense, wet) - Grades to without gravel at 15 ft bgs
SM	Light gray to gray-brown, silty, fine to medium SAND with organics (very soft, moist to wet)
ML	Gray-brown SILT (very soft, moist to wet) - Grades to soft and wet at 20 ft bgs - Grades to gray and very stiff at 22.5 ft bgs - Grades to stiff at 25 ft bgs
GM	Gray, silty, sandy, fine to coarse GRAVEL (very dense, wet) **(GLACIAL DRIFT)**
SM	Gray, silty, gravelly, fine to coarse SAND (dense, wet)



Notes:
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3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

1073020.020.021 11/10/21 Y:\1073\020.020\021\T1073020.020.021.GPJ SOIL BORING LOG WITH GRAPH

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Silverdale, Washington

Log of Boring B-2

Figure
A-3
(1 of 2)

B-2

LAI Project No: 1073020.020.021

SAMPLE DATA

SOIL PROFILE

Drilling Method: Hollow-Stem Auger

Ground Elevation (ft): 13.5

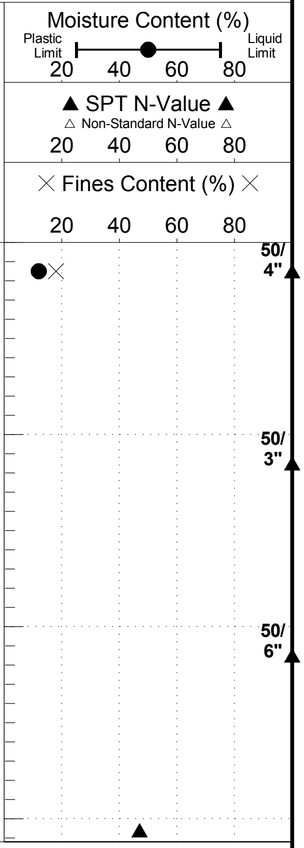
Drilled By: Holocene Drilling Inc.

Logged By: CAL Date: 07/30/21

WELL DETAIL (DOE#: BMT-379)

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	USCS Symbol	Description
35		S-13	b2	50/ 4"	W = 12 GS	SM	Gray, silty, gravelly, fine to coarse SAND (dense, wet) - Grades to very dense
	-25						- Moderate chatter observed between 39 and 42.5 ft bgs
40		S-14	b2	50/ 3"			
	-30						
45		S-15	b2	50/ 6"			
	-35						
50		S-16	b2	47		SP-SM	Dark gray, fine to coarse SAND with silt (dense, wet)

Boring Completed 07/30/21
Total Depth of Boring = 50.6 ft.



Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Pump Station 3 Upgrades
and Waterfront Center
Silverdale, Washington

Log of Boring B-2

Figure
A-3
(2 of 2)

B-3

LAI Project No: 1073020.020.021

SAMPLE DATA

SOIL PROFILE

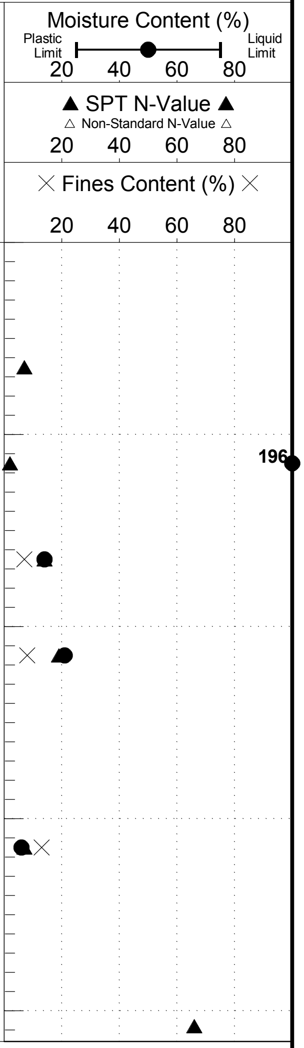
Drilling Method: Hollow-Stem Auger

Ground Elevation (ft): 13.5

Drilled By: Holocene Drilling Inc.

Logged By: CAL Date: 07/30/21

Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	USCS Symbol	Description	Groundwater
				SM	1 inch of sod over brown, silty SAND with gravel (medium dense, moist to wet) **(FILL)**	
S-1B S-1A	b2	7		ML SM	Blue-gray SILT (soft, moist to wet) Gray-brown, silty, fine to coarse SAND with gravel (loose, moist to wet)	
S-2	b2	2	W = 196	PT	Dark brown PEAT (very loose, wet) **(PEAT)**	ATD ▽
S-3	b2	14	W = 14 GS	SP-SM	Gray, gravelly, fine to coarse SAND with silt (medium dense, wet) **(GLACIAL OUTWASH)**	
S-4	b2	19	W = 21 GS		- Grades to with gravel	
				SM	Gray, silty SAND (medium dense, wet)	
S-6	b2	7	W = 6 GS	ML	Gray SILT with sand and gravel (medium stiff, wet)	
S-8	b2	66		GM	Gray, very silty, fine to coarse GRAVEL with sand (very dense, wet) **(GLACIAL DRIFT)**	



Depth (ft): 0, 5, 10, 15, 20, 25, 30, 35

Elevation (ft): 10, 5, 0, -5

Boring Completed 07/30/21
Total Depth of Boring = 20.8 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Pump Station 3 Upgrades
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Silverdale, Washington

Log of Boring B-3

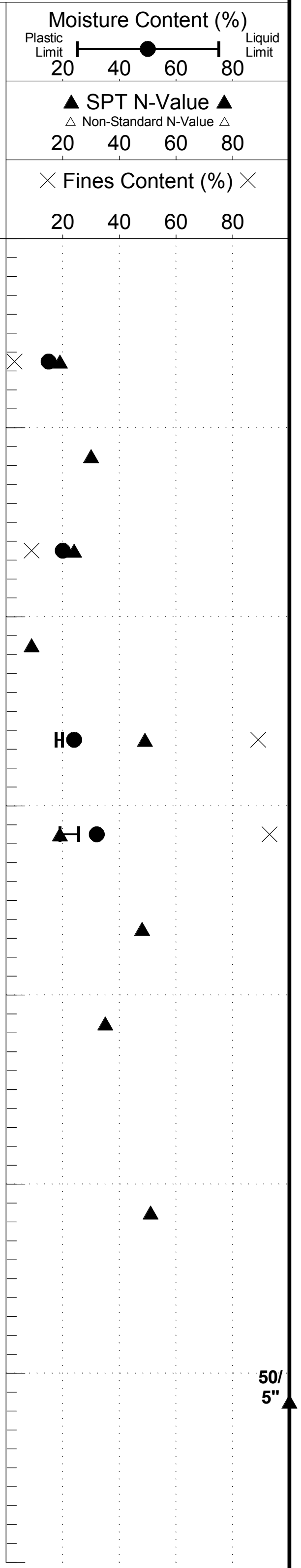
Figure
A-4

B-4

LAI Project No: 1073020.020.021

Drilling Method: Hollow-Stem Auger
Ground Elevation (ft): 15.0
Drilled By: Holocene Drilling Inc.
Logged By: CAL Date: 07/29/21

SAMPLE DATA						SOIL PROFILE		
Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	USCS Symbol		Groundwater
0	15					AC	2.5 inches of ASPHALT over 7.5 inches of gravel base **(ASPHALT)**	
						SP	Dark gray, gravelly, fine to coarse SAND (medium dense, wet) **(FILL)**	
		S-1	b2	19	W = 15 GS			ATD ▽
5	10					SP-SM	Gray-brown to brown, fine to medium SAND with silt (medium dense, wet) **(GLACIAL OUTWASH)**	
		S-2	b2	30				
		S-3	b2	24	W = 20 GS			
10	5						- Grades to gray at 10 ft bgs	
		S-4	b2	9				
		S-5	b2	49	W = 24 -200 = 89 AL	ML	Gray SILT with sand (hard, wet)	
15	0	S-6	b2	19	W = 32 -200 = 93 AL	CL-ML	Gray, clayey SILT with sand (very stiff, wet) - Minor orange-brown mottling observed at 16.2 ft bgs	
		S-7	b2	48		SP-SM	Gray, fine to coarse SAND with silt and gravel (dense, wet) **(GLACIAL DRIFT)**	
20	-5	S-8	b2	35			- Grades to without gravel at 20.7 ft bgs	
25	-10	S-9	b2	51		SP	Gray, fine to coarse SAND with gravel (very dense, wet)	
30	-15	S-10	b2	50/ 5"		ML	Gray SILT with sand and gravel (hard, moist to wet) - Heavy chatter observed between 31 and 34 ft bgs	
35	-20							



Notes:
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2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Pump Station 3 Upgrades
and Waterfront Center
Silverdale, Washington

Log of Boring B-4

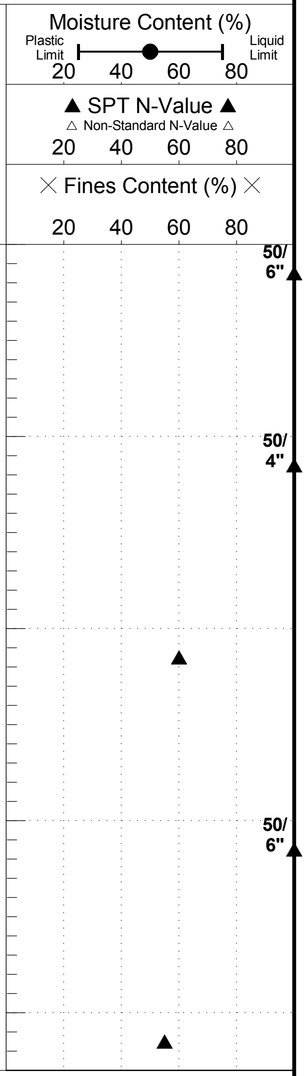
Figure
A-5
(1 of 2)

B-4

LAI Project No: 1073020.020.021

Drilling Method: Hollow-Stem Auger
Ground Elevation (ft): 15.0
Drilled By: Holocene Drilling Inc.
Logged By: CAL Date: 07/29/21

SAMPLE DATA						SOIL PROFILE			
Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Description	Groundwater
35	-20	S-11	b2	50/ 6"			ML	Gray SILT with sand and gravel (hard, moist to wet) - Minor chatter observed between 35 and 40 ft bgs	
40	-25	S-12	b2	50/ 4"				- Grades to moist at 40 ft bgs	
							SP	Dark gray, fine to coarse SAND (very dense, wet)	
45	-30	S-13	b2	60					
50	-35	S-14	b2	50/ 6"			SP- SM	Dark gray, fine to medium SAND with silt (very dense, moist to wet)	
55	-40	S-15	b2	55					



Boring Completed 07/29/21
Total Depth of Boring = 56.5 ft.

60

65

70

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Pump Station 3 Upgrades
and Waterfront Center
Silverdale, Washington

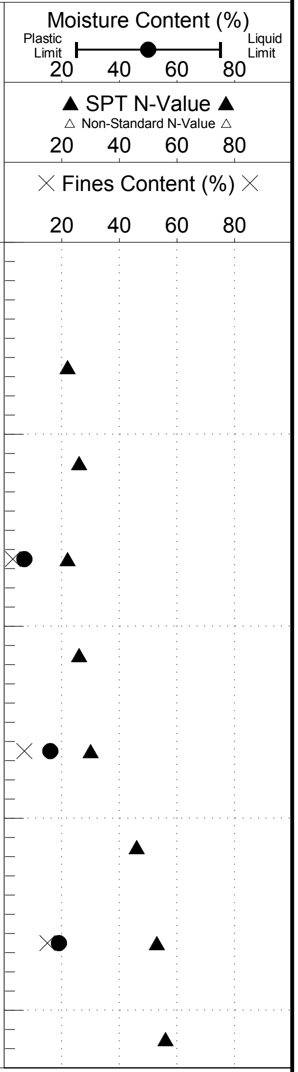
Log of Boring B-4

B-5

LAI Project No: 1073020.020.021

Drilling Method: Hollow-Stem Auger
Ground Elevation (ft): 28.0
Drilled By: Holocene Drilling Inc.
Logged By: CAL
Date: 07/29/21

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	USCS Symbol	Soil Profile	Groundwater
0						AC	2.5 inches of ASPHALT over 5 inches of crushed rock **(ASPHALT)**	
						GP	Brown, very sandy, fine to coarse GRAVEL (medium dense, damp to moist) **(GLACIAL OUTWASH)**	
	25	S-1	b2	22				
5								
		S-2	b2	26		SP	Gray-brown, fine to coarse SAND (medium dense, damp to moist)	
	20	S-3	b2	22	W = 7 GS		- Grades to with gravel and moist to wet at 7.5 ft bgs	
10						SP-SM	Gray-brown, fine to coarse SAND with gravel and silt (medium dense, wet)	
		S-4	b2	26				ATD
	15	S-5	b2	30	W = 16 GS		- Grades to with gravel	
15								
		S-6	b2	46			- Grades to without gravel and dense at 15 ft bgs	
	10	S-7	b2	53	W = 19 GS	SM	- Grades to very dense at 17.5 ft bgs Gray, silty, fine to coarse SAND (very dense, wet)	
20								
		S-8	b2	56				
						ML	Mottled gray, sandy SILT (hard, wet)	
25								
30								
35								



Boring Completed 07/29/21
Total Depth of Boring = 21.5 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

1073020.020.021 11/10/21 Y:\1073\020.020\021\T\1073020.020.021.GPJ SOIL BORING LOG WITH GRAPH

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Log of Boring B-5

Figure
A-6

B-6

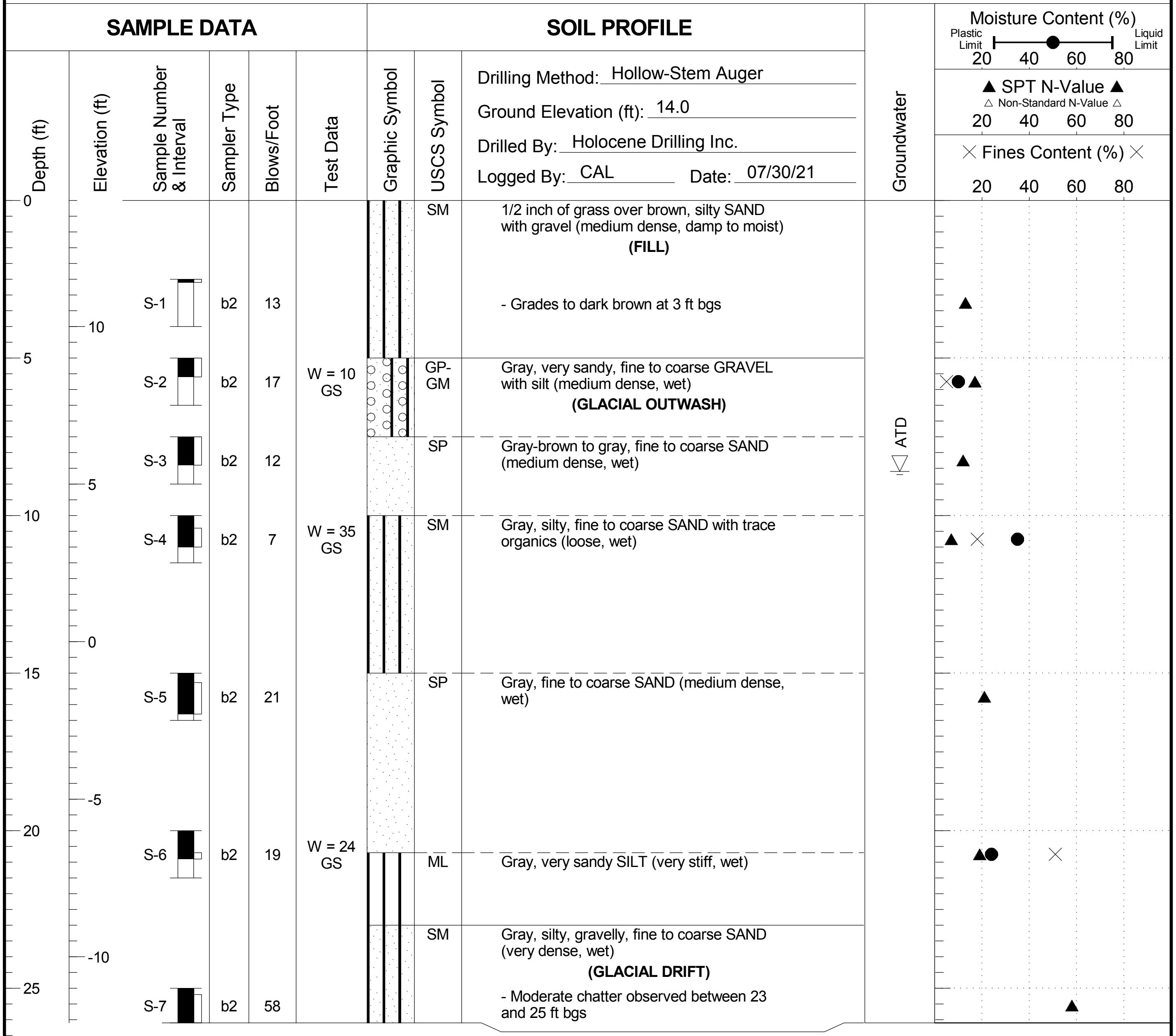
LAI Project No: 1073020.020.021

Drilling Method: Hollow-Stem Auger

Ground Elevation (ft): 14.0

Drilled By: Holocene Drilling Inc.

Logged By: CAL Date: 07/30/21



Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	USCS Symbol	Description	Groundwater
				SM	1/2 inch of grass over brown, silty SAND with gravel (medium dense, damp to moist) **(FILL)**	
S-1	b2	13			- Grades to dark brown at 3 ft bgs	
S-2	b2	17	W = 10 GS	GP-GM	Gray, very sandy, fine to coarse GRAVEL with silt (medium dense, wet) **(GLACIAL OUTWASH)**	
S-3	b2	12		SP	Gray-brown to gray, fine to coarse SAND (medium dense, wet)	ATD
S-4	b2	7	W = 35 GS	SM	Gray, silty, fine to coarse SAND with trace organics (loose, wet)	
S-5	b2	21		SP	Gray, fine to coarse SAND (medium dense, wet)	
S-6	b2	19	W = 24 GS	ML	Gray, very sandy SILT (very stiff, wet)	
				SM	Gray, silty, gravelly, fine to coarse SAND (very dense, wet) **(GLACIAL DRIFT)**	
S-7	b2	58			- Moderate chatter observed between 23 and 25 ft bgs	

Boring Completed 07/30/21
Total Depth of Boring = 26.1 ft.

30

35

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Log of Boring B-6

Figure
A-7

APPENDIX B

Laboratory Testing

APPENDIX B
LABORATORY TESTING

Samples were transported to Landau Associates, Inc.'s soils laboratory for further examination and testing. Testing was performed in general accordance with the ASTM International (ASTM) standard test methods noted below. The field log descriptions were reviewed against the soil samples and updated, where appropriate, in accordance with ASTM standard test method D2487, *Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).*

Natural Moisture Content

Natural moisture content determinations were performed on select soil samples in accordance with ASTM standard test method D2216, *Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.* The natural moisture content is shown as "W = xx" (i.e., percent of dry weight) in the "Test Data" column on the summary boring logs in Appendix A.

Grain Size and Hydrometer Analysis

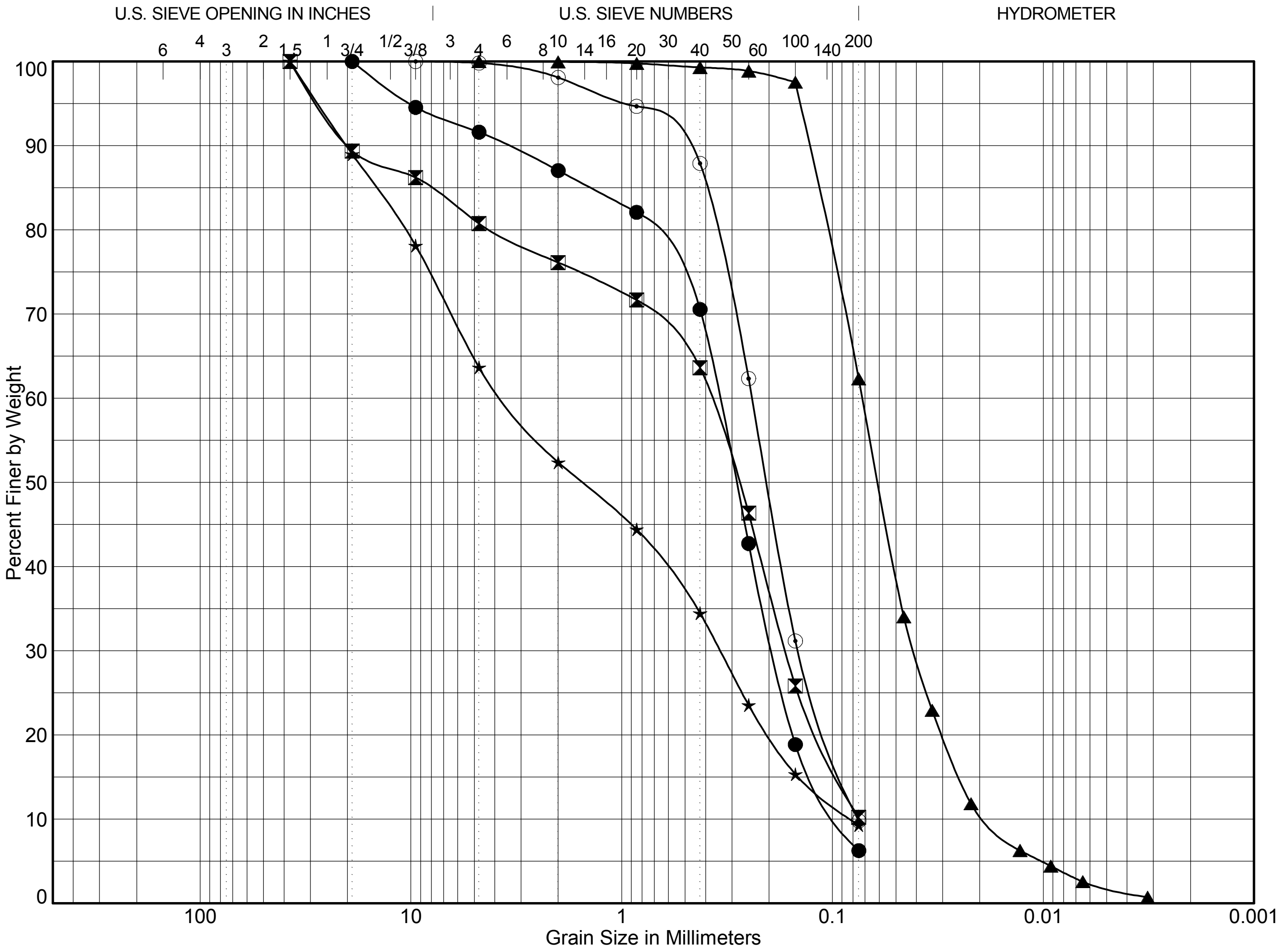
To provide an indication of the grain size distribution of site soils, sieve analyses were completed in accordance with ASTM standard test method D6913, *Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis.* Hydrometer analyses also were performed in accordance with ASTM standard test method D7928, *Standard Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis.* Samples selected for grain size and hydrometer analyses are designated with a "GS" in the "Test Data" column on the summary boring logs in Appendix A. The results of the grain size analyses are presented on Figures B-1 through B-4.

U.S. No. 200 Wash

To assess the fines content, select soil samples were washed over a U.S. No. 200 sieve in accordance with ASTM standard test method C117, *Standard Test Method for Materials Finer Than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing.* Samples selected for U.S. No. 200 washes are designated with a "–200 = xx" in the "Test Data" column on the summary boring logs in Appendix A.

Atterberg Limits Tests

To provide an indication of the plasticity of fine-grained site soils, Atterberg limits tests were performed in accordance with ASTM standard test method D4318, *Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.* Samples selected for Atterberg limits tests are designated with an "AL" in the "Test Data" column on the summary boring logs in Appendix A. The results of the Atterberg limits tests are presented on Figure B-5.



Cobbles	Gravel		Sand			Silt or Clay
	coarse	fine	coarse	medium	fine	

	Point	Depth	Classification	LL	PL	PI	C_c	C_u
●	B-1	7.5	Fine to medium SAND with gravel and silt (SP-SM)				1.13	3.77
⧗	B-1	12.5	Gravelly, fine to coarse SAND with silt (SP-SM)				0.98	5.12
▲	B-1	17.5	Very sandy SILT (ML)				1.26	3.90
★	B-2	2.5	Very gravelly, fine to coarse SAND with silt (SP-SM)				0.40	44.08
⊙	B-2	15.0	Fine to coarse SAND with silt (SP-SM)				1.15	3.19

	Point	Depth	D_{100}	D_{60}	D_{50}	D_{30}	D_{10}	%Coarse Gravel	% Fine Gravel	% Coarse Sand	% Medium Sand	% Fine Sand	% Fines
●	B-1	7.5	19	0.348	0.287	0.19	0.092	0.0	8.4	4.6	16.5	64.3	6.3
⧗	B-1	12.5	37.5	0.38	0.28	0.166		10.6	8.6	4.6	12.5	53.4	10.2
▲	B-1	17.5	4.75	0.072	0.061	0.041	0.018	0.0	0.0	0.0	0.7	37.0	62.3
★	B-2	2.5	37.5	3.589	1.549	0.342	0.081	11.0	25.3	11.3	17.9	25.2	9.3
⊙	B-2	15.0	9.5	0.241	0.204	0.144	0.076	0.0	0.2	1.7	10.2	78.1	9.8

$C_c = D_{30}^2/(D_{60} * D_{10})$ To be well graded: 1 < C_c < 3 and

$C_u = D_{60}/D_{10}$ C_u > 4 for GW or C_u > 6 for SW

1073020.020.021 11/10/21 Y:\1073\020.020\021\T\1073020.020.021.GPJ GRAIN SIZE W/STATS

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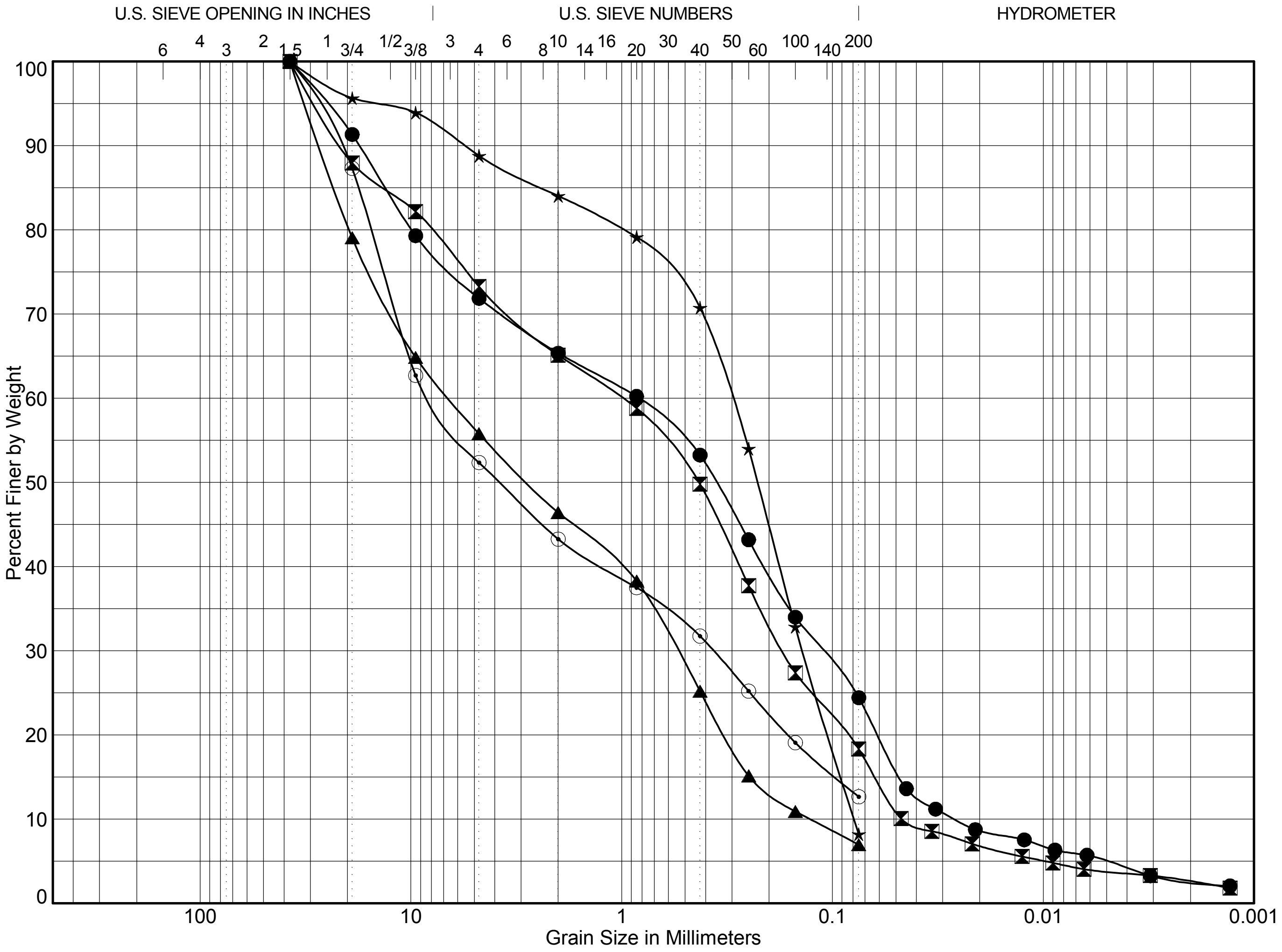
Grain Size Test Data

Figure
B-1



Cobbles	Gravel		Sand			Silt or Clay
	coarse	fine	coarse	medium	fine	

Point		Depth	Classification	LL	PL	PI	C_c	C_u
●	B-2	30.0	Silty, gravelly, fine to coarse SAND (SM)				0.58	31.70
⧗	B-2	35.0	Silty, gravelly, fine to coarse SAND (SM)				0.63	21.43
▲	B-3	7.5	Very gravelly, fine to coarse SAND with silt (SP-SM)				0.36	51.32
★	B-3	10.0	Fine to coarse SAND with gravel and silt (SP-SM)				0.80	3.83
☉	B-3	20.0	Very sandy, fine to coarse GRAVEL with silt (GP-GM)					

Point		Depth	D_{100}	D_{60}	D_{50}	D_{30}	D_{10}	%Coarse Gravel	% Fine Gravel	% Coarse Sand	% Medium Sand	% Fine Sand	% Fines
●	B-2	30.0	37.5	0.832	0.358	0.112	0.026	8.7	19.5	6.5	12.1	28.8	24.4
⧗	B-2	35.0	37.5	0.999	0.432	0.171	0.047	12.1	14.7	8.1	15.3	31.5	18.3
▲	B-3	7.5	37.5	6.559	2.785	0.548	0.128	20.9	23.3	9.4	21.2	18.2	7.0
★	B-3	10.0	37.5	0.302	0.227	0.138	0.079	4.4	6.9	4.8	13.3	62.5	8.2
☉	B-3	20.0	37.5	7.927	3.799	0.369		12.7	35.0	9.1	11.5	19.1	12.7

$C_c = D_{30}^2/(D_{60} * D_{10})$

$C_u = D_{60}/D_{10}$

To be well graded: $1 < C_c < 3$ and $C_u > 4$ for GW or $C_u > 6$ for SW

1073020.020.021 11/10/21 Y:\1073\020.020\021\T\1073020.020.021.GPJ GRAIN SIZE W/STATS

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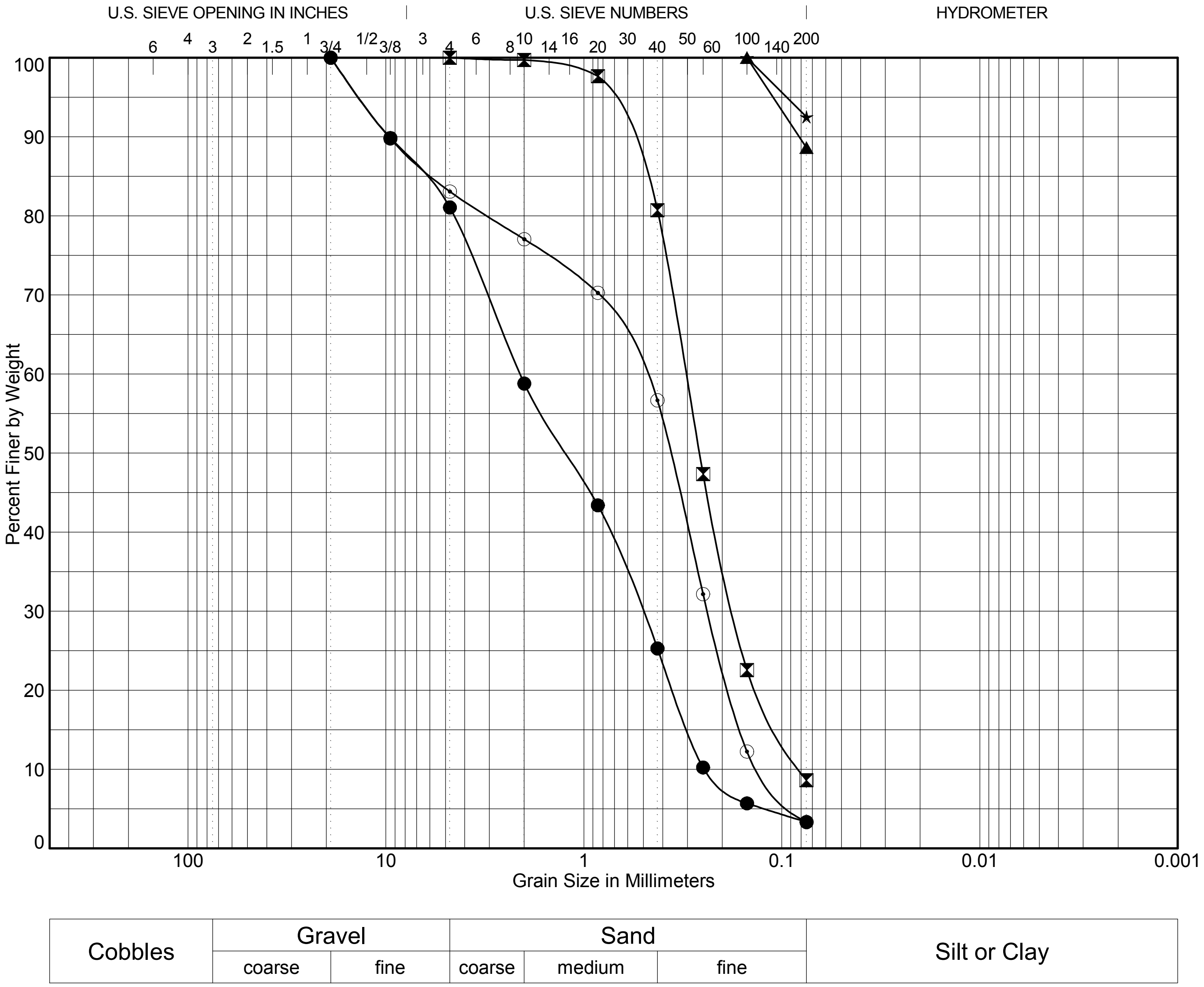
Grain Size Test Data

Figure
B-2



Point		Depth	Classification	LL	PL	PI	C_c	C_u
●	B-4	2.5	Gravelly, fine to coarse SAND (SP)				0.51	8.60
⧗	B-4	7.5	Fine to medium SAND with silt (SP-SM)				1.24	3.81
▲	B-4	12.5	SILT with sand (ML)	18	20	NP		
★	B-4	15.0	Clayey SILT with sand (CL-ML)	26	19	7		
⊙	B-5	7.5	Gravelly, fine to coarse SAND (SP)				0.88	4.00

Point		Depth	D_{100}	D_{60}	D_{50}	D_{30}	D_{10}	%Coarse Gravel	% Fine Gravel	% Coarse Sand	% Medium Sand	% Fine Sand	% Fines
●	B-4	2.5	19	2.096	1.227	0.509	0.244	0.0	18.9	22.3	33.5	22.0	3.3
⧗	B-4	7.5	4.75	0.306	0.261	0.175	0.08	0.0	0.0	0.3	19.0	72.1	8.6
▲	B-4	12.5	0.15					0.0	0.0	0.0	0.0	11.4	88.6
★	B-4	15.0	0.15					0.0	0.0	0.0	0.0	7.5	92.5
⊙	B-5	7.5	19	0.504	0.368	0.237	0.126	0.0	16.9	6.0	20.4	53.4	3.3

$C_c = D_{30}^2/(D_{60} * D_{10})$

$C_u = D_{60}/D_{10}$

To be well graded: 1 < C_c < 3 and

C_u > 4 for GW or C_u > 6 for SW

1073020.020.021 11/10/21 Y:\1073\020.020\021\T\1073020.020.021.GPJ GRAIN SIZE W/STATS

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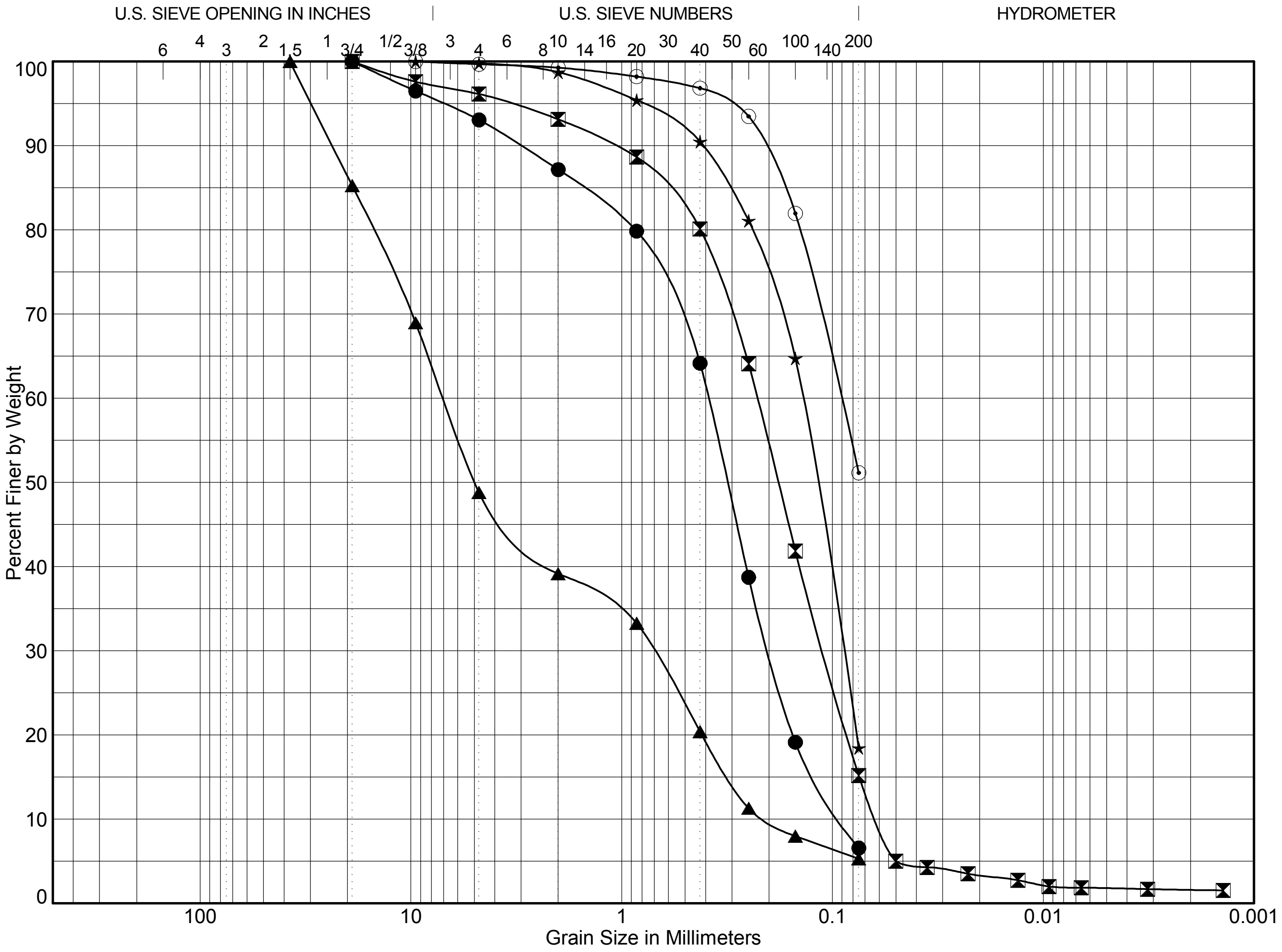
Silverdale, Washington

Grain Size Test Data

Figure
B-3



<table>
<tr><td rowspan="2">Cobbles</td><td colspan="2">Gravel</td><td colspan="3">Sand</td><td rowspan="2">Silt or Clay</td></tr>
<tr><td>coarse</td><td>fine</td><td>coarse</td><td>medium</td><td>fine</td></tr>
</table>

	Point	Depth	Classification	LL	PL	PI	C_c	C_u
●	B-5	12.5	Fine to coarse SAND with gravel and silt (SP-SM)				1.12	4.30
⧗	B-5	17.5	Silty, fine to coarse SAND (SM)				0.87	3.73
▲	B-6	5.0	Very sandy, fine to coarse GRAVEL with silt (GP-GM)				0.36	34.10
★	B-6	10.0	Silty, fine to medium SAND (SM)					
⊙	B-6	20.0	Very sandy SILT (ML)					

	Point	Depth	D_{100}	D_{60}	D_{50}	D_{30}	D_{10}	%Coarse Gravel	% Fine Gravel	% Coarse Sand	% Medium Sand	% Fine Sand	% Fines
●	B-5	12.5	19	0.39	0.316	0.199	0.091	0.0	6.9	5.9	23.0	57.6	6.6
⧗	B-5	17.5	19	0.228	0.181	0.11	0.061	0.0	3.9	3.0	13.0	64.9	15.2
▲	B-6	5.0	37.5	6.982	4.952	0.713	0.205	14.7	36.5	9.6	18.8	15.1	5.3
★	B-6	10.0	9.5	0.14	0.12	0.089		0.0	0.2	1.0	8.2	72.0	18.4
⊙	B-6	20.0	9.5	0.092				0.0	0.3	0.4	2.4	45.7	51.1

$C_c = D_{30}^2/(D_{60} * D_{10})$ To be well graded: $1 < C_c < 3$ and

$C_u = D_{60}/D_{10}$ $C_u > 4$ for GW or $C_u > 6$ for SW

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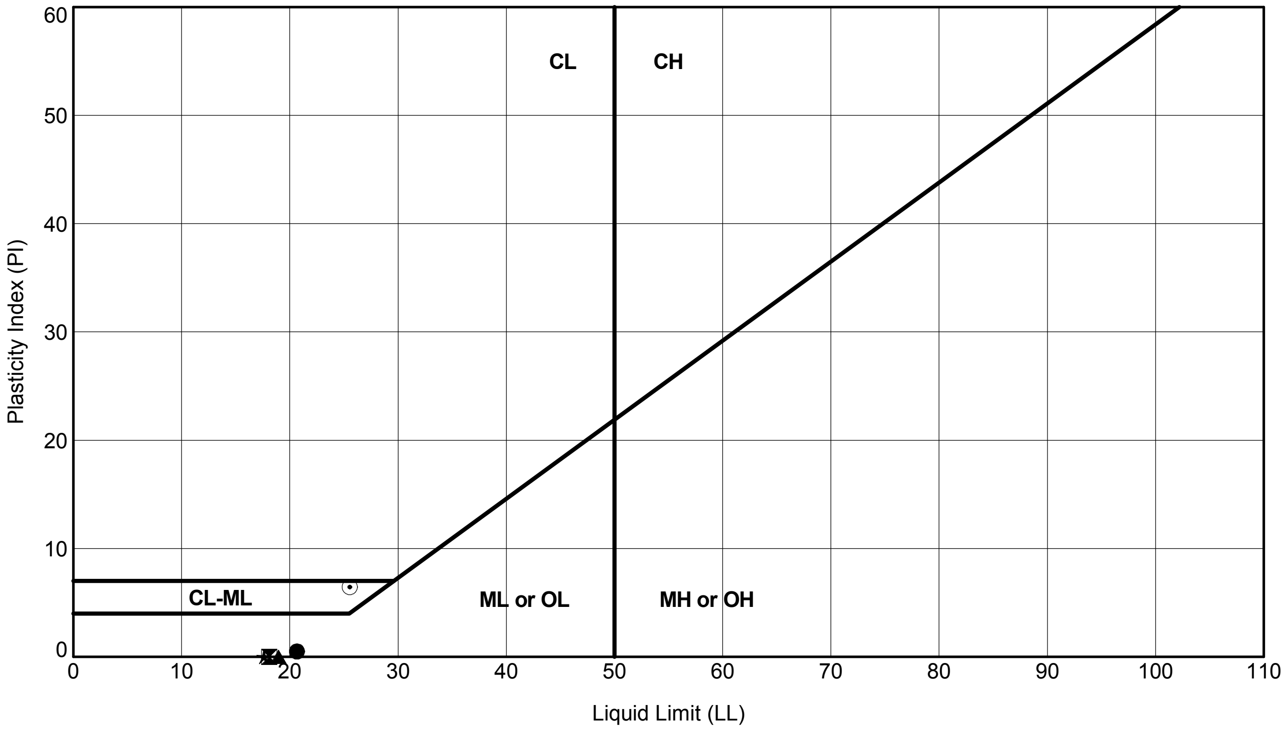
Grain Size Test Data

Figure
B-4



ATTERBERG LIMIT TEST RESULTS

Symbol	Exploration Number	Sample Number	Depth (ft)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Natural Moisture (%)	Soil Description	Unified Soil Classification
●	B-2	S-4	10.0	21	20	1	31	SILT	ML
⧗	B-2	S-9	22.5	18	20	-2	25	SILT	ML
▲	B-2	S-10	25.0	19	20	-1	26	SILT	ML
★	B-4	S-5	12.5	18	20	-2	24	SILT with sand	ML
☉	B-4	S-6	15.0	26	19	7	32	Clayey SILT with sand	CL-ML

ASTM D 4318 Test Method

1073020.020.021 11/10/21 Y:\1073\020.020\021\T1073020.020.021.GPJ ATTERBERG LIMITS FIGURE_PRINTS NP

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Pump Station 3 Upgrades
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Plasticity Chart

Figure
B-5

APPENDIX C

Historical Subsurface Information

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

S&W CLASSIFICATION OF SOIL CONSTITUENTS

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

MOISTURE CONTENT DEFINITIONS

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

ABBREVIATIONS

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

GRAIN SIZE DEFINITION

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

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

RELATIVE DENSITY / CONSISTENCY

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

WELL AND OTHER SYMBOLS

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

Bay Shore and Washington
Improvements Project
Silverdale, Washington

SOIL CLASSIFICATION AND LOG KEY

January 2020 21-1-21829-010

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-1
Sheet 1 of 2

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

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

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

NOTES

1. Dual symbols *(symbols separated by a hyphen, i.e., SP-SM, slightly silty fine SAND)* are used for soils with between 5% and 12% fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.

2. Borderline symbols *(symbols separated by a slash, i.e., CL/ML, silty CLAY/clayey SILT; GW/SW, sandy GRAVEL/gravelly SAND)* indicate that the soil may fall into one of two possible basic groups.

BORING CLASS2 21-21829.GPJ SWNEW.GDT 11/11/19

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Silverdale, Washington

SOIL CLASSIFICATION AND LOG KEY

January 2020 21-1-21829-010

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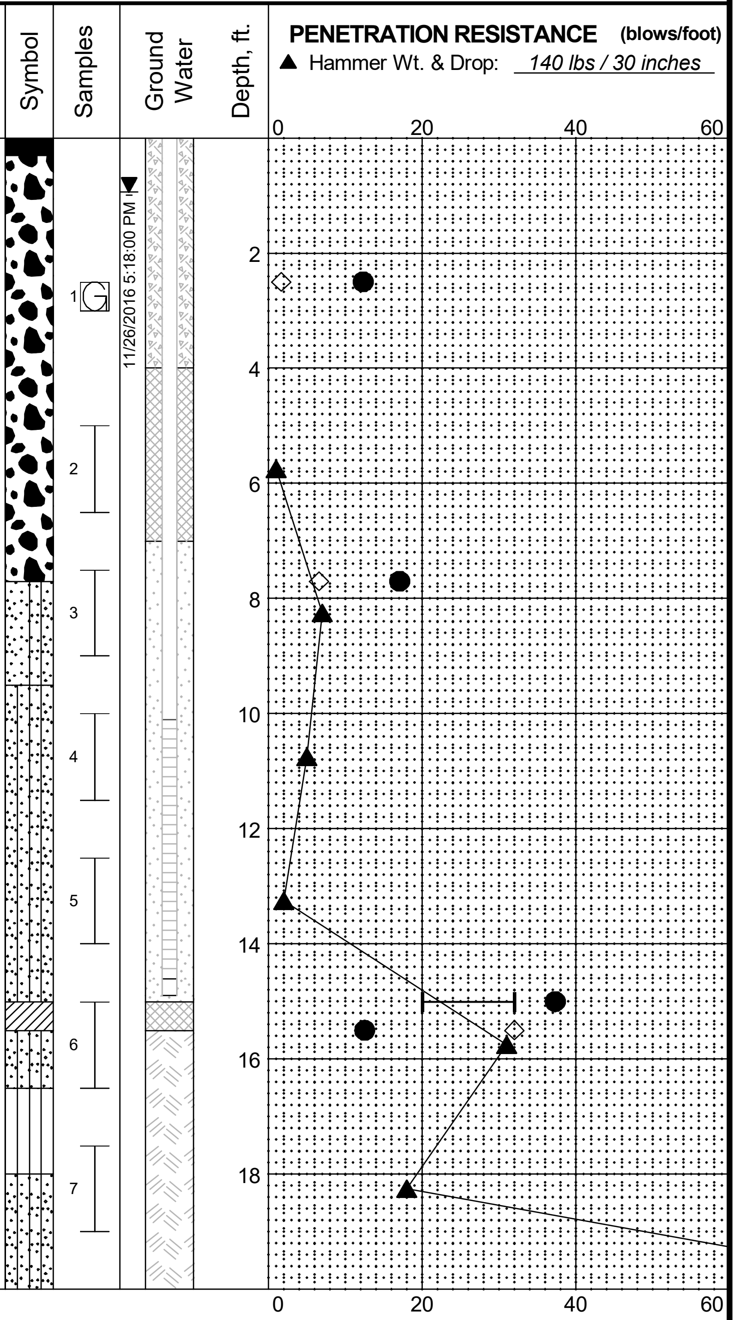
Geotechnical and Environmental Consultants

FIG. A-1
Sheet 2 of 2

Total Depth:	46.25 ft.	Northing:	240,473 ft.	Drilling Method:	Hollow Stem Auger	Hole Diam.:	9 in.
Top Elevation:	12.3 ft.	Easting:	1,181,505 ft.	Drilling Company:	Boart Longyear	Rod Diam.:	2-5/8"
Vert. Datum:	NAVD88	Station:	11+47.0A ft.	Drill Rig Equipment:	Mobile B-59	Hammer Type:	Automatic
Horiz. Datum:	NAD 83	Offset:	17.0R	Other Comments:			

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.
ASPHALT.	0.3
Brown, trace of silt to silty, sandy, fine GRAVEL; moist to wet; scattered organics; GW/GM. - Very loose at 5 feet, with abundant wood fragments. - Faint anaerobic odor below 7 feet.	7.7
Loose, gray, slightly silty, slightly fine gravelly SAND; wet; SP-SM.	9.5
Very loose to loose, brown to gray, trace to slightly gravelly, silty SAND; wet; abundant wood fragments and organics; SM.	15.0
Hard, gray, silty CLAY, trace of sand; wet; trace of wood fragments; CL.	15.5
Dense, gray, slightly fine gravelly, silty SAND; moist to wet; SM.	16.5
Medium dense, gray, sandy SILT, trace of gravel and clay; wet; trace of sand seams, scattered wood fibers; ML.	18.0
Medium dense to very dense, gray, trace of	



CONTINUED NEXT SHEET

LEGEND

*	Sample Not Recovered	⊞	Well Screen and Sand Filter
G	Grab Sample	▧	Bentonite-Cement Grout
I	2.0" O.D. Split Spoon Sample	⊠	Bentonite Chips/Pellets
		▨	Bentonite Grout
		▼	Ground Water Level in Well

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

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

Bay Shore and Washington
Improvements Project
Silverdale, Washington

LOG OF BORING B-1W
(Revised 2019)

January 2020 21-1-21829-010

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-2
Sheet 1 of 3

Log: AXT Rev: CIJ Typ: LKN

MASTER_LOG_E 21-21829.GPJ SHAN_WIL.GDT 11/12/19

REV 3 - Approved for Submittal

Total Depth:	*46.25 ft.*	Northing:	*240,473 ft.*	Drilling Method:	*Hollow Stem Auger*	Hole Diam.:	*9 in.*
Top Elevation:	*12.3 ft.*	Easting:	*1,181,505 ft.*	Drilling Company:	*Boart Longyear*	Rod Diam.:	*2-5/8"*
Vert. Datum:	*NAVD88*	Station:	*11+47.0A ft.*	Drill Rig Equipment:	*Mobile B-59*	Hammer Type:	*Automatic*
Horiz. Datum:	*NAD 83*	Offset:	*17.0R*	Other Comments:			

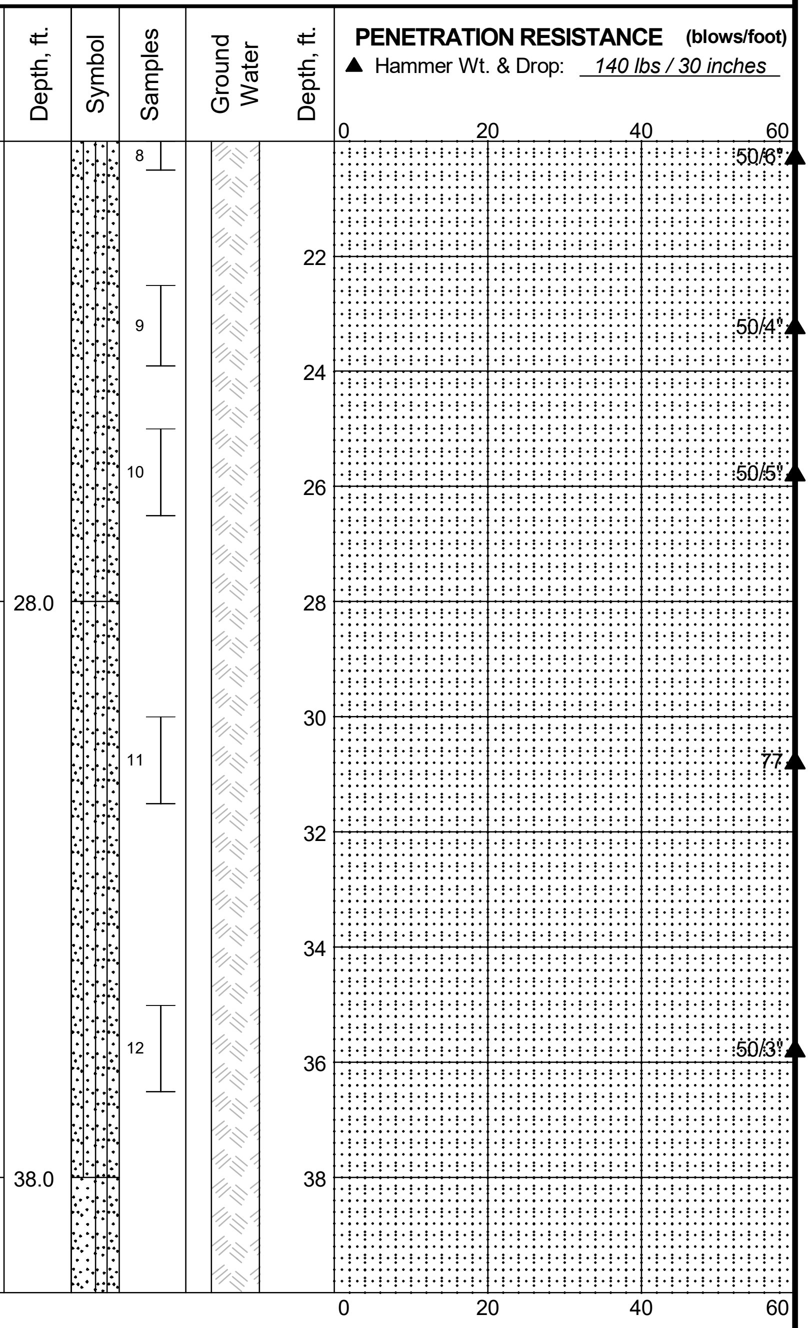
SOIL DESCRIPTION

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

gravel to slightly gravelly, silty SAND; moist to wet; SM.
- Heaved 1 foot at 18 feet.

Very dense, gray, silty, gravelly SAND to silty, sandy GRAVEL; wet; SM/GM.
- Heaved 4 inches at 35 feet.

Very dense, gray, slightly silty, gravelly SAND; wet; SP-SM.



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered	⊡ Well Screen and Sand Filter
G Grab Sample	▧ Bentonite-Cement Grout
⌶ 2.0" O.D. Split Spoon Sample	☒ Bentonite Chips/Pellets
	▨ Bentonite Grout
	▼ Ground Water Level in Well

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

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

Bay Shore and Washington
Improvements Project
Silverdale, Washington

LOG OF BORING B-1W
(Revised 2019)

January 2020 21-1-21829-010

SHANNON & WILSON, INC.
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FIG. A-2
Sheet 2 of 3

REV 3 - Approved for Submittal

Total Depth: 46.25 ft.
Top Elevation: 12.3 ft.
Vert. Datum: NAVD88
Horiz. Datum: NAD 83

Northing: 240,473 ft.
Easting: 1,181,505 ft.
Station: 11+47.0A ft.
Offset: 17.0R

Drilling Method: Hollow Stem Auger
Drilling Company: Boart Longyear
Drill Rig Equipment: Mobile B-59
Other Comments:

Hole Diam.: 9 in.
Rod Diam.: 2-5/8"
Hammer Type: Automatic

SOIL DESCRIPTION

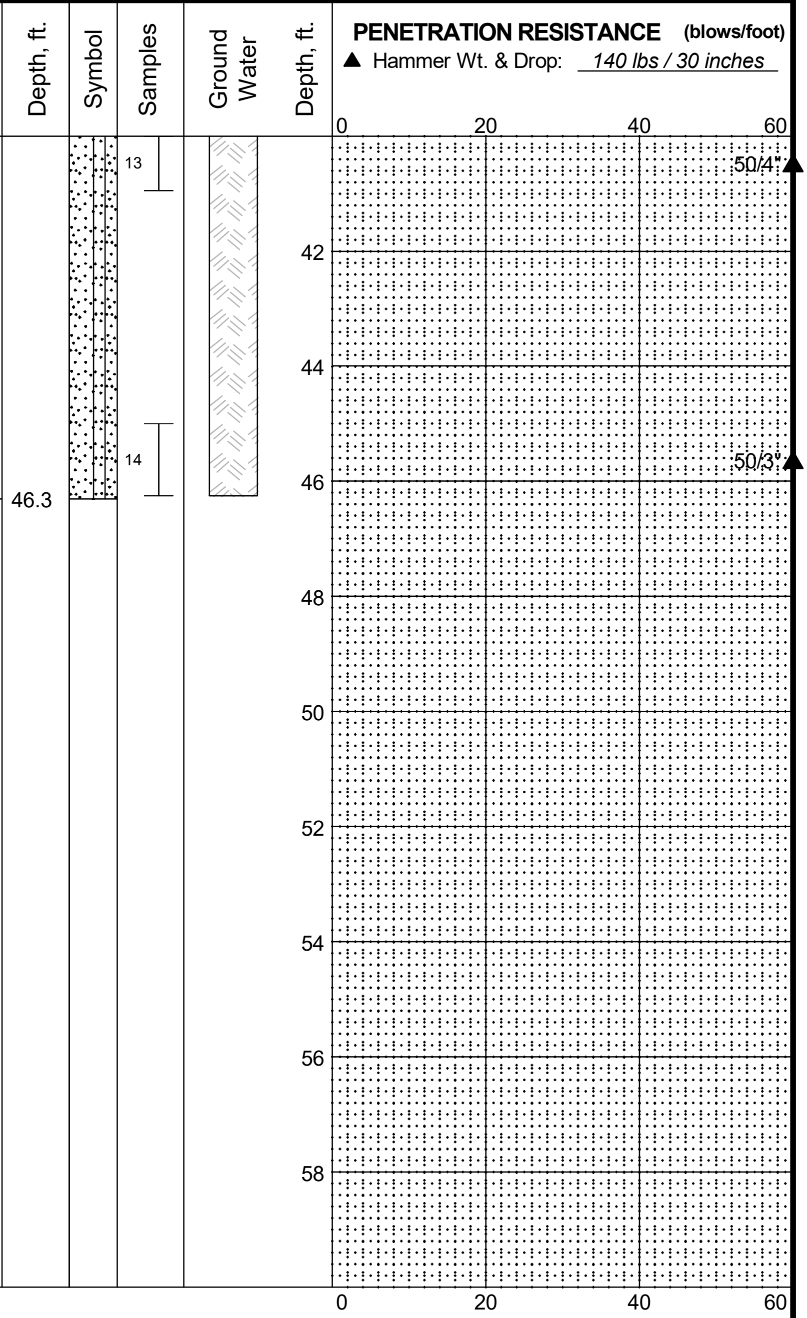
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

- Heaved 1 foot at 40 feet.

- Heaved 1.5 foot at 45 feet.

BOTTOM OF BORING
COMPLETED 4/10/2013

Notes:
1. When the auger was extracted from the borehole, the soil caved and filled the borehole to approximately 5 feet below the ground surface. The boring was redrilled to a depth of about 15.5 feet. A bentonite seal was placed from about 15 to 15.5 feet.
2. Well is constructed of 2-inch ID PVC casing and 10-slot screen, with #10/20 filter pack sand.



Log: AXT Rev: CIJ Typ: LKN

MASTER_LOG_E 21-21829.GPJ SHAN_WIL.GDT 11/12/19

LEGEND

*	Sample Not Recovered
G	Grab Sample
⌶	2.0" O.D. Split Spoon Sample
⊡	Well Screen and Sand Filter
▧	Bentonite-Cement Grout
⊠	Bentonite Chips/Pellets
▨	Bentonite Grout
▼	Ground Water Level in Well

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

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

Bay Shore and Washington
Improvements Project
Silverdale, Washington

LOG OF BORING B-1W
(Revised 2019)

January 2020
21-1-21829-010

SHANNON & WILSON, INC.
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FIG. A-2
Sheet 3 of 3

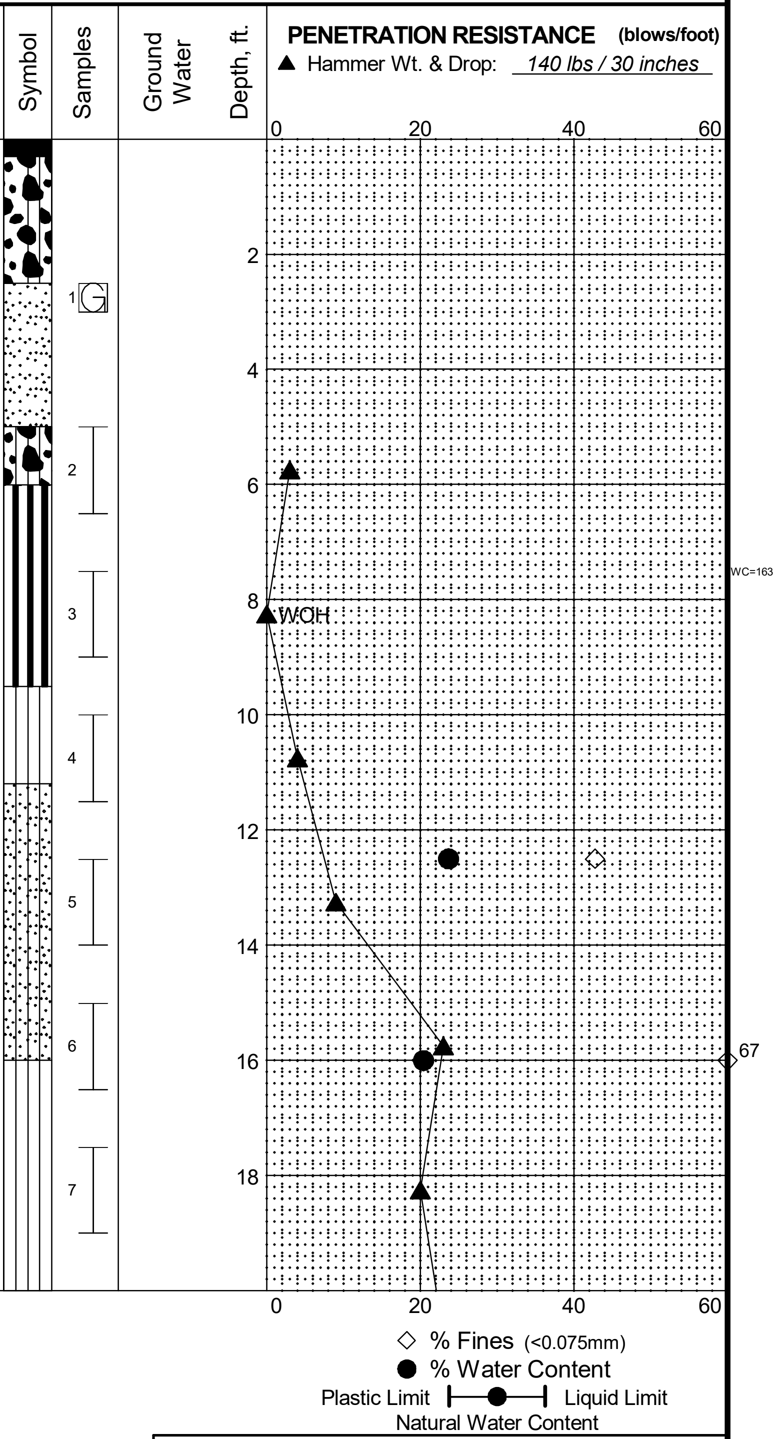
REV 3 - Approved for Submittal

Total Depth: 21.5 ft.
Top Elevation: 15.3 ft.
Vert. Datum: NAVD88
Horiz. Datum: NAD 83
Northing: 241,138 ft.
Easting: 1,181,523 ft.
Station: 18+12.2A ft.
Offset: 15.1R
Drilling Method: Hollow Stem Auger
Drilling Company: Boart Longyear
Drill Rig Equipment: Mobile B-59
Other Comments:
Hole Diam.: 9 in.
Rod Diam.: 2-5/8"
Hammer Type: Automatic

SOIL DESCRIPTION

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

SOIL DESCRIPTION	Depth, ft.
ASPHALT.	0.3
Dark brown, slightly silty, sandy GRAVEL; moist; GW-GM.	2.5
Brown SAND, trace of silt; moist; SP.	5.0
Very loose, red-brown, silty, sandy GRAVEL, trace of clay; wet; numerous organics; GM.	6.0
Very loose, dark brown, slightly sandy, elastic SILT/organic SILT/PEAT, trace of gravel; wet; abundant organics, scattered wood fragments; MH/OL/OH/PT.	9.5
Loose, gray, fine sandy SILT; wet; numerous organic seams; ML.	11.2
Loose, brown, silty, fine SAND; wet; scattered silt partings and seams, iron oxide staining; SM.	16.0
Medium dense, gray, slightly fine sandy to fine sandy SILT, trace of clay; wet; ML.	



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
G Grab Sample
I 2.0" O.D. Split Spoon Sample

NOTES

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

Bay Shore and Washington
Improvements Project
Silverdale, Washington

LOG OF BORING B-3
(Revised 2019)

January 2020
21-1-21829-010

SHANNON & WILSON, INC.
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FIG. A-4
Sheet 1 of 2

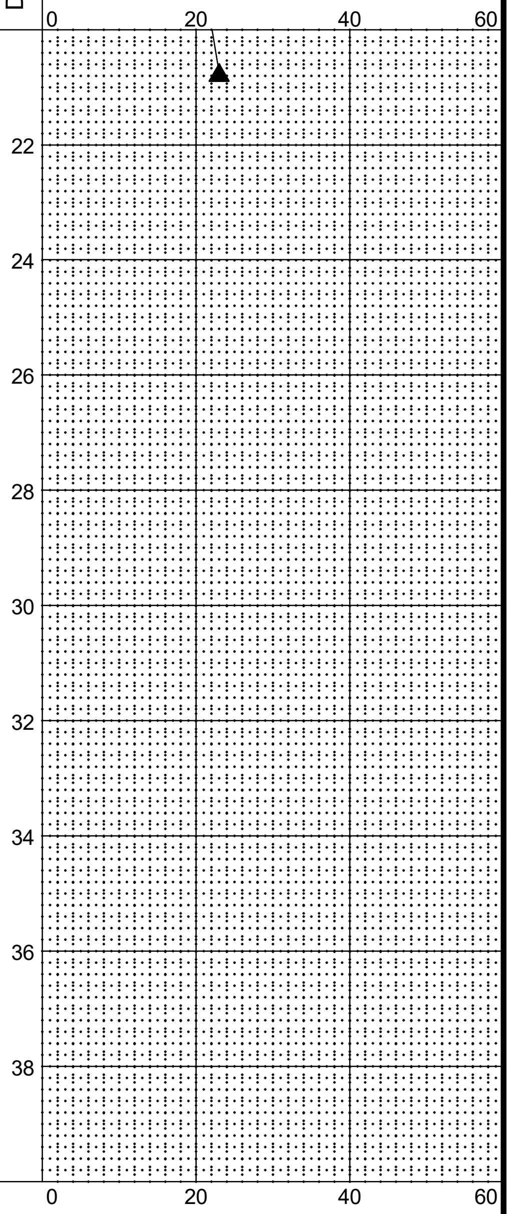
REV 3 - Approved for Submittal

Total Depth:	21.5 ft.	Northing:	241,138 ft.	Drilling Method:	Hollow Stem Auger	Hole Diam.:	9 in.
Top Elevation:	15.3 ft.	Easting:	1,181,523 ft.	Drilling Company:	Boart Longyear	Rod Diam.:	2-5/8"
Vert. Datum:	NAVD88	Station:	18+12.2A ft.	Drill Rig Equipment:	Mobile B-59	Hammer Type:	Automatic
Horiz. Datum:	NAD 83	Offset:	15.1R	Other Comments:			

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.	Symbol	Samples	Ground Water
Very stiff, gray, silty CLAY; wet; CL.	20.0	▨	8	
Medium dense, gray, silty, fine to medium SAND; wet; SM.	21.0 21.5			
BOTTOM OF BORING COMPLETED 4/11/2013				

PENETRATION RESISTANCE (blows/foot)

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



◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ├──●──┤ Liquid Limit

Natural Water Content

LEGEND

- * Sample Not Recovered
- G Grab Sample
- ⌶ 2.0" O.D. Split Spoon Sample

NOTES

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

Bay Shore and Washington
Improvements Project
Silverdale, Washington

LOG OF BORING B-3
(Revised 2019)

January 2020 21-1-21829-010

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-4
Sheet 2 of 2

REV 3 - Approved for Submittal

MASTER_LOG_E 21-21829.GPJ SHAN_WIL.GDT 11/13/19 Log: AXT Rev: CIJ Typ: LKN

Shannon & Wilson, Inc. (S&W), uses a soil identification system modified from the Unified Soil Classification System (USCS). Elements of the USCS and other definitions are provided on this and the following pages. Soil descriptions are based on visual-manual procedures (ASTM D2488) and laboratory testing procedures (ASTM D2487), if performed.

S&W INORGANIC SOIL CONSTITUENT DEFINITIONS

CONSTITUENT[2]	**FINE-GRAINED SOILS (50% or more fines)**[1]	**COARSE-GRAINED SOILS (less than 50% fines)**[1]
Major	***Silt, Lean Clay, Elastic Silt,*** or ***Fat Clay***[3]	***Sand*** or ***Gravel***[4]
Modifying (Secondary) Precedes major constituent	30% or more coarse-grained: ***Sandy*** or ***Gravelly***[4]	More than 12% fine-grained: ***Silty*** or ***Clayey***[3]
Minor Follows major constituent	15% to 30% coarse-grained: ***with Sand*** or ***with Gravel***[4]	5% to 12% fine-grained: ***with Silt*** or ***with Clay***[3]
	30% or more total coarse-grained *and* lesser coarse-grained constituent is 15% or more: ***with Sand*** or ***with Gravel***[5]	15% or more of a second coarse-grained constituent: ***with Sand*** or ***with Gravel***[5]

[1] All percentages are by weight of total specimen passing a 3-inch sieve.
[2] The order of terms is: *Modifying Major with Minor.*
[3] Determined based on behavior.
[4] Determined based on which constituent comprises a larger percentage.
[5] Whichever is the lesser constituent.

MOISTURE CONTENT TERMS

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

STANDARD PENETRATION TEST (SPT) SPECIFICATIONS

Hammer:	140 pounds with a 30-inch free fall. Rope on 6- to 10-inch-diam. cathead 2-1/4 rope turns, > 100 rpm NOTE: If automatic hammers are used, blow counts shown on boring logs should be adjusted to account for efficiency of hammer.
Sampler:	10 to 30 inches long Shoe I.D. = 1.375 inches Barrel I.D. = 1.5 inches Barrel O.D. = 2 inches
N-Value:	Sum blow counts for second and third 6-inch increments. Refusal: 50 blows for 6 inches or less; 10 blows for 0 inches.

NOTE: Penetration resistances (N-values) shown on boring logs are as recorded in the field and have not been corrected for hammer efficiency, overburden, or other factors.

PARTICLE SIZE DEFINITIONS

DESCRIPTION	**SIEVE NUMBER AND/OR APPROXIMATE SIZE**
FINES	< #200 (0.075 mm = 0.003 in.)
SAND	
Fine	#200 to #40 (0.075 to 0.4 mm; 0.003 to 0.02 in.)
Medium	#40 to #10 (0.4 to 2 mm; 0.02 to 0.08 in.)
Coarse	#10 to #4 (2 to 4.75 mm; 0.08 to 0.187 in.)
GRAVEL	
Fine	#4 to 3/4 in. (4.75 to 19 mm; 0.187 to 0.75 in.)
Coarse	3/4 to 3 in. (19 to 76 mm)
COBBLES	3 to 12 in. (76 to 305 mm)
BOULDERS	> 12 in. (305 mm)

RELATIVE DENSITY / CONSISTENCY

COHESIONLESS SOILS		**COHESIVE SOILS**	
N, SPT, BLOWS/FT.	RELATIVE DENSITY	N, SPT, BLOWS/FT.	RELATIVE CONSISTENCY
< 4	Very loose	< 2	Very soft
4 - 10	Loose	2 - 4	Soft
10 - 30	Medium dense	4 - 8	Medium stiff
30 - 50	Dense	8 - 15	Stiff
> 50	Very dense	15 - 30	Very stiff
		> 30	Hard

WELL AND BACKFILL SYMBOLS

▧	Bentonite Cement Grout	▒	Surface Cement Seal
▨	Bentonite Grout	■	Asphalt or Cap
▩	Bentonite Chips	▨	Slough
░	Silica Sand	◫	Inclinometer or Non-perforated Casing
▤	Perforated or Screened Casing	◨	Vibrating Wire Piezometer

PERCENTAGES TERMS[1, 2]

Trace	< 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

[1] Gravel, sand, and fines estimated by mass. Other constituents, such as organics, cobbles, and boulders, estimated by volume.

[2] Reprinted, with permission, from ASTM D2488 - 09a Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. A copy of the complete standard may be obtained from ASTM International, www.astm.org.

Bay Shore and Washington
Improvements Project
Silverdale, Washington

SOIL DESCRIPTION AND LOG KEY

January 2020 21-1-21829-010

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-9
Sheet 1 of 3

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)
(Modified From USACE Tech Memo 3-357, ASTM D2487, and ASTM D2488)

MAJOR DIVISIONS			GROUP/GRAPHIC SYMBOL	TYPICAL IDENTIFICATIONS
COARSE-GRAINED SOILS *(more than 50% retained on No. 200 sieve)*	Gravels *(more than 50% of coarse fraction retained on No. 4 sieve)*	Gravel *(less than 5% fines)*	GW	Well-Graded Gravel; Well-Graded Gravel with Sand
			GP	Poorly Graded Gravel; Poorly Graded Gravel with Sand
		Silty or Clayey Gravel *(more than 12% fines)*	GM	Silty Gravel; Silty Gravel with Sand
			GC	Clayey Gravel; Clayey Gravel with Sand
	Sands *(50% or more of coarse fraction passes the No. 4 sieve)*	Sand *(less than 5% fines)*	SW	Well-Graded Sand; Well-Graded Sand with Gravel
			SP	Poorly Graded Sand; Poorly Graded Sand with Gravel
		Silty or Clayey Sand *(more than 12% fines)*	SM	Silty Sand; Silty Sand with Gravel
			SC	Clayey Sand; Clayey Sand with Gravel
FINE-GRAINED SOILS *(50% or more passes the No. 200 sieve)*	Silts and Clays *(liquid limit less than 50)*	Inorganic	ML	Silt; Silt with Sand or Gravel; Sandy or Gravelly Silt
			CL	Lean Clay; Lean Clay with Sand or Gravel; Sandy or Gravelly Lean Clay
		Organic	OL	Organic Silt or Clay; Organic Silt or Clay with Sand or Gravel; Sandy or Gravelly Organic Silt or Clay
	Silts and Clays *(liquid limit 50 or more)*	Inorganic	MH	Elastic Silt; Elastic Silt with Sand or Gravel; Sandy or Gravelly Elastic Silt
			CH	Fat Clay; Fat Clay with Sand or Gravel; Sandy or Gravelly Fat Clay
		Organic	OH	Organic Silt or Clay; Organic Silt or Clay with Sand or Gravel; Sandy or Gravelly Organic Silt or Clay
HIGHLY-ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor		PT	Peat or other highly organic soils (see ASTM D4427)

NOTE: No. 4 size = 4.75 mm = 0.187 in.; No. 200 size = 0.075 mm = 0.003 in.

NOTES

1. Dual symbols *(symbols separated by a hyphen, i.e., SP-SM, Sand with Silt)* are used for soils with between 5% and 12% fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart. Graphics shown on the logs for these soil types are a combination of the two graphic symbols (e.g., SP and SM).

2. Borderline symbols *(symbols separated by a slash, i.e., CL/ML, Lean Clay to Silt; SP-SM/SM, Sand with Silt to Silty Sand)* indicate that the soil properties are close to the defining boundary between two groups.

Bay Shore and Washington
Improvements Project
Silverdale, Washington

SOIL DESCRIPTION AND LOG KEY

January 2020 21-1-21829-010

SHANNON & WILSON, INC.
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FIG. A-9
Sheet 2 of 3

SOIL_CLASS_KEY_PG2 21-21829.GPJ SHAN_WIL.GDT 11/11/19

GRADATION TERMS

Poorly Graded	Narrow range of grain sizes present or, within the range of grain sizes present, one or more sizes are missing (Gap Graded). Meets criteria in ASTM D2487, if tested.
Well-Graded	Full range and even distribution of grain sizes present. Meets criteria in ASTM D2487, if tested.

CEMENTATION TERMS[1]

Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

PLASTICITY[2]

DESCRIPTION	VISUAL-MANUAL CRITERIA	APPROX. PLASITICITY INDEX RANGE
Nonplastic	A 1/8-in. thread cannot be rolled at any water content.	< 4
Low	A thread can barely be rolled and a lump cannot be formed when drier than the plastic limit.	4 to 10
Medium	A thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. A lump crumbles when drier than the plastic limit.	10 to 20
High	It takes considerable time rolling and kneading to reach the plastic limit. A thread can be rerolled several times after reaching the plastic limit. A lump can be formed without crumbling when drier than the plastic limit.	> 20

ADDITIONAL TERMS

Mottled	Irregular patches of different colors.
Bioturbated	Soil disturbance or mixing by plants or animals.
Diamict	Nonsorted sediment; sand and gravel in silt and/or clay matrix.
Cuttings	Material brought to surface by drilling.
Slough	Material that caved from sides of borehole.
Sheared	Disturbed texture, mix of strengths.

PARTICLE ANGULARITY AND SHAPE TERMS[1]

Angular	Sharp edges and unpolished planar surfaces.
Subangular	Similar to angular, but with rounded edges.
Subrounded	Nearly planar sides with well-rounded edges.
Rounded	Smoothly curved sides with no edges.
Flat	Width/thickness ratio > 3.
Elongated	Length/width ratio > 3.

ACRONYMS AND ABBREVIATIONS

ATD	At Time of Drilling
Diam.	Diameter
Elev.	Elevation
ft.	Feet
FeO	Iron Oxide
gal.	Gallons
Horiz.	Horizontal
HSA	Hollow Stem Auger
I.D.	Inside Diameter
in.	Inches
lbs.	Pounds
MgO	Magnesium Oxide
mm	Millimeter
MnO	Manganese Oxide
NA	Not Applicable or Not Available
NP	Nonplastic
O.D.	Outside Diameter
OW	Observation Well
pcf	Pounds per Cubic Foot
PID	Photo-Ionization Detector
PMT	Pressuremeter Test
ppm	Parts per Million
psi	Pounds per Square Inch
PVC	Polyvinyl Chloride
rpm	Rotations per Minute
SPT	Standard Penetration Test
USCS	Unified Soil Classification System
q_u	Unconfined Compressive Strength
VWP	Vibrating Wire Piezometer
Vert.	Vertical
WOH	Weight of Hammer
WOR	Weight of Rods
Wt.	Weight

STRUCTURE TERMS[1]

Interbedded	Alternating layers of varying material or color with layers at least 1/4-inch thick; singular: bed.
Laminated	Alternating layers of varying material or color with layers less than 1/4-inch thick; singular: lamination.
Fissured	Breaks along definite planes or fractures with little resistance.
Slickensided	Fracture planes appear polished or glossy; sometimes striated.
Blocky	Cohesive soil that can be broken down into small angular lumps that resist further breakdown.
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay.
Homogeneous	Same color and appearance throughout.

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[1] Reprinted, with permission, from ASTM D2488 - 09a Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. A copy of the complete standard may be obtained from ASTM International, www.astm.org.

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Bay Shore and Washington
Improvements Project
Silverdale, Washington

SOIL DESCRIPTION AND LOG KEY

January 2020 21-1-21829-010

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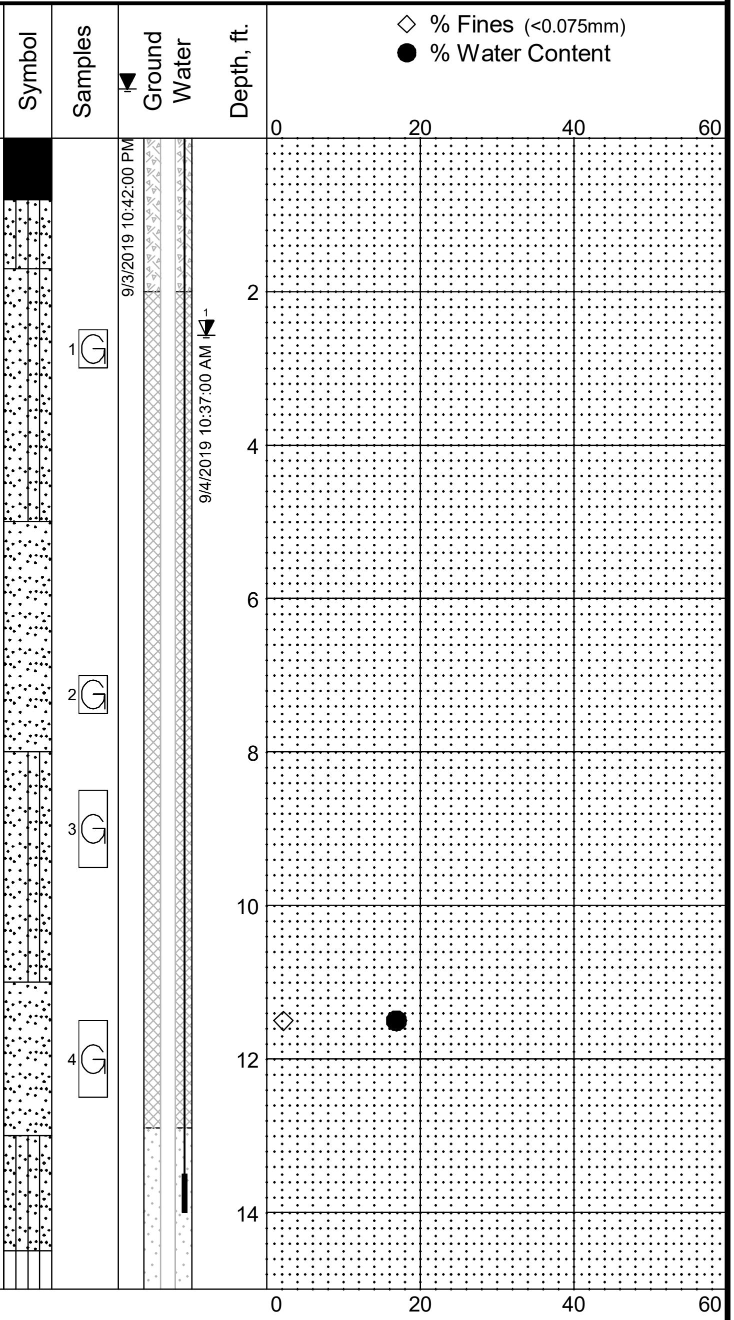
FIG. A-9
Sheet 3 of 3

Total Depth:	40 ft.	Northing:	241,147 ft.	Drilling Method:	Sonic Core	Hole Diam.:	6 in.
Top Elevation:	15.4 ft.	Easting:	1,181,494 ft.	Drilling Company:	Holt Services	Rod Diam.:	
Vert. Datum:	NAVD88	Station:	18+20.2A ft.	Drill Rig Equipment:	Terra Sonic TSi 150CC	Hammer Type:	
Horiz. Datum:	NAD 83	Offset:	13.4L	Other Comments:			

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.
Asphalt.	0.8
Brown, *Silty Sand with Gravel (SM)* to *Silty Gravel with Sand (GM)*; moist; angular to subrounded gravel; fine to coarse sand; nonplastic; trace debris. (Hf)	1.7
Light gray-brown, *Poorly Graded Sand with Silt (SP-SM)*; moist; fine to medium sand; nonplastic. (Ha) - Wet below 4.7 feet.	5.0
Brown, *Poorly Graded Sand with Gravel (SP)*; wet; subangular to subrounded gravel; fine to coarse sand; nonplastic. (Ha) -6-inch layer at 6 feet of *Poorly Graded Sand with Silt (SP-SM).*	8.0
Brown, interbedded *Poorly Graded Sand with Silt (SP-SM)* and *Silty Sand (SM)*; wet; trace subrounded gravel; fine to medium sand; nonplastic. (Qvro) - Iron oxide-stained from 8 to 9.5 feet.	11.0
Brown and orange-brown, *Poorly Graded Sand (SP)*; wet; trace fine, subrounded gravel; fine to coarse sand; nonplastic; iron oxide-stained. (Qvro)	13.0
Brown and orange-brown, *Silty Sand (SM)*; wet; fine to medium sand; nonplastic; iron oxide-stained. (Qvro)	14.5



CONTINUED NEXT SHEET

LEGEND

*	Sample Not Recovered
G	Grab Sample
▦	Well Screen and Sand Filter
▧	Bentonite-Cement Grout
▩	Bentonite Chips/Pellets
▨	Bentonite Grout
▼	Ground Water Level in Well
▼	Ground Water Level in VWP

NOTES

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

Bay Shore and Washington
Improvements Project
Silverdale, Washington

LOG OF BORING B-8WV-19

January 2020 21-1-21829-010

SHANNON & WILSON, INC.
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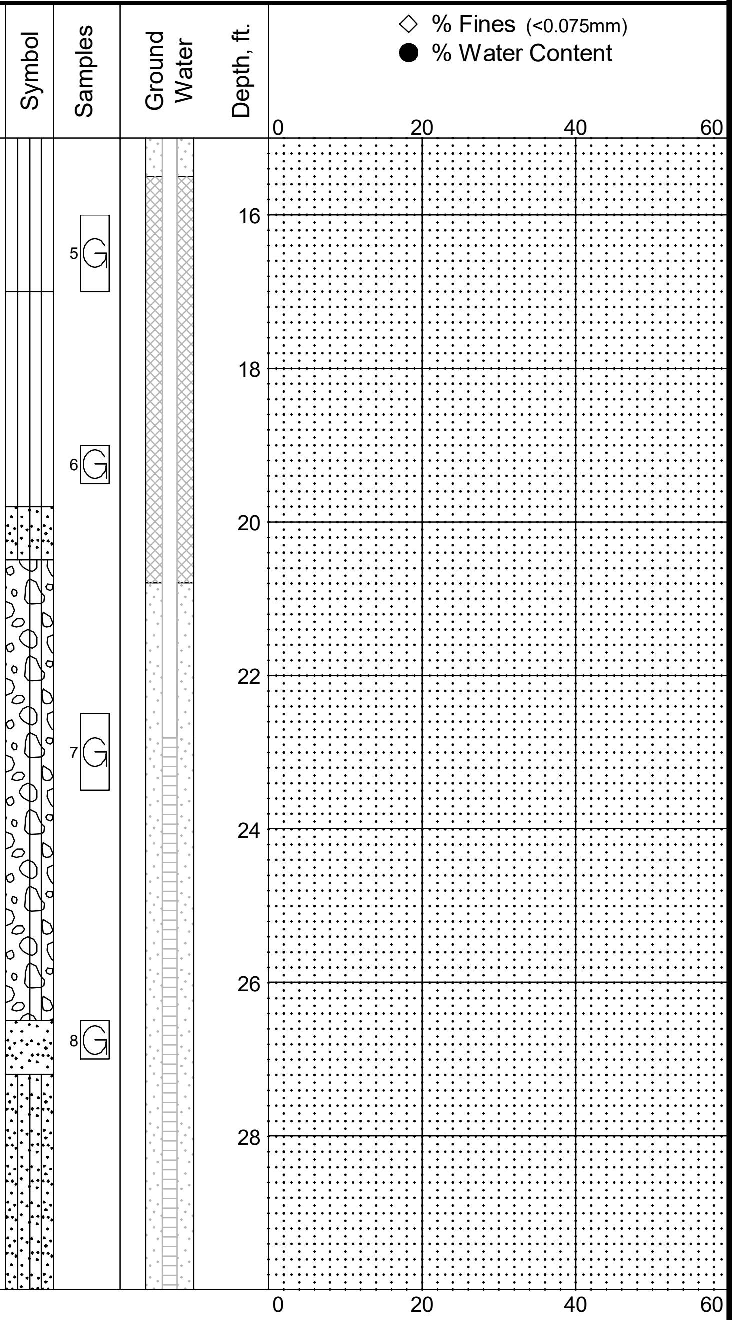
FIG. A-10
Sheet 1 of 4

REV 3 - Approved for Submittal

Total Depth:	*40 ft.*	Northing:	*241,147 ft.*	Drilling Method:	*Sonic Core*	Hole Diam.:	*6 in.*
Top Elevation:	*15.4 ft.*	Easting:	*1,181,494 ft.*	Drilling Company:	*Holt Services*	Rod Diam.:	
Vert. Datum:	*NAVD88*	Station:	*18+20.2A ft.*	Drill Rig Equipment:	*Terra Sonic TSi 150CC*	Hammer Type:	
Horiz. Datum:	*NAD 83*	Offset:	*13.4L*	Other Comments:			

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.
Gray, *Sandy Silt (ML)* to *Silty Sand (SM)*; wet; fine sand; nonplastic with seams of low plasticity fines; rapid dilatancy; trace organics. (Qvrl)	17.0
Gray *Silt (ML)* and *Lean Clay (CL)*; wet; few fine sand; low to medium plasticity; laminated; few silty sand seams. (Qpnl)	19.8
Gray, *Silty Sand (SM)*; wet; fine to medium sand; nonplastic. (Qpnf)	20.5
Gray, *Poorly Graded Gravel with Silt and Sand (GP-GM)* to *Silty Gravel with Sand (GM)*; wet; subrounded gravel; fine to coarse sand; nonplastic; few diamict pockets. (Qpgo)	26.5
Gray, *Poorly Graded Sand (SP)*; wet; trace fine, subrounded gravel; fine to coarse sand; nonplastic. (Qpgo)	27.2
Gray, *Silty Sand (SM)* to *Poorly Graded Sand with Silt and Gravel (SP-SM)*; wet; subrounded to rounded gravel; fine to coarse sand; nonplastic.	



CONTINUED NEXT SHEET

LEGEND

- * Sample Not Recovered
- G Grab Sample
- ▦ Well Screen and Sand Filter
- ▧ Bentonite-Cement Grout
- ⊠ Bentonite Chips/Pellets
- ▨ Bentonite Grout
- ▼ Ground Water Level in Well
- ▼ Ground Water Level in VWP

NOTES

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

Bay Shore and Washington
Improvements Project
Silverdale, Washington

LOG OF BORING B-8WV-19

January 2020 21-1-21829-010

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-10
Sheet 2 of 4

Total Depth:	*40 ft.*	Northing:	*241,147 ft.*	Drilling Method:	*Sonic Core*	Hole Diam.:	*6 in.*
Top Elevation:	*15.4 ft.*	Easting:	*1,181,494 ft.*	Drilling Company:	*Holt Services*	Rod Diam.:	
Vert. Datum:	*NAVD88*	Station:	*18+20.2A ft.*	Drill Rig Equipment:	*Terra Sonic TSi 150CC*	Hammer Type:	
Horiz. Datum:	*NAD 83*	Offset:	*13.4L*	Other Comments:			

SOIL DESCRIPTION

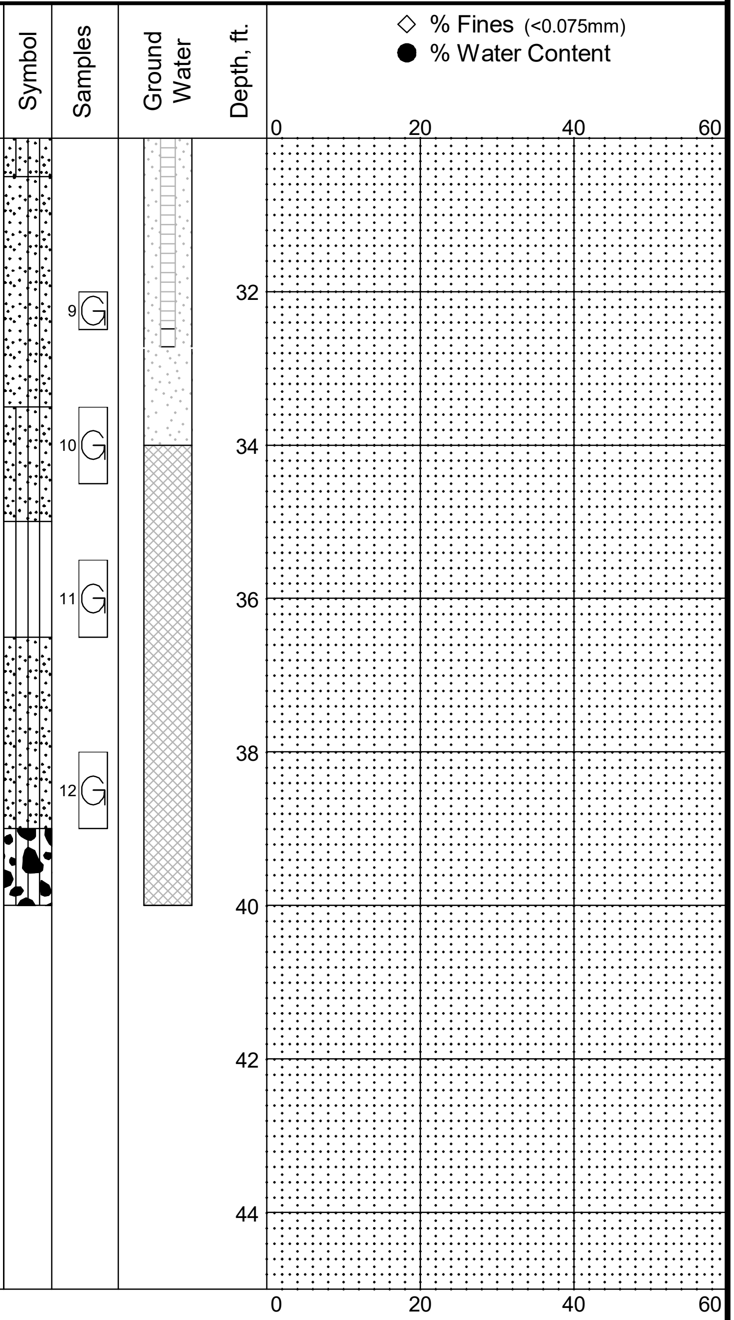
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

SOIL DESCRIPTION	Depth, ft.
(Qpgo) - Stiffer drilling from 30 to 40 feet.	30.5
Gray, *Poorly Graded Sand with Silt (SP-SM)*; wet; trace subrounded gravel; fine to medium sand; nonplastic. (Qpgo)	33.5
Dark gray, *Silty Sand with Gravel (SM)*; moist; diamict; subangular to subrounded gravel; fine to coarse sand; nonplastic to low plasticity; diamict. (Qpgd)	35.0
Dark gray, *Sandy Silt (ML)*; moist; few fine, subangular to subrounded gravel; fine to medium sand; low plasticity; trace organics. (Qpnl)	36.5
Dark gray, interbedded *Silty Sand with Gravel (SM)* and *Poorly Graded Sand (SP)*; wet; subangular to subrounded gravel; fine to coarse sand; nonplastic to low plasticity. (Qpnf)	39.0
Dark gray, *Silty Gravel with Sand (GM)*; moist; subangular to subrounded gravel; fine to coarse sand; low plasticity; diamict. (Qpgd)	40.0

BOTTOM OF BORING
COMPLETED 8/27/2019

Notes:
1. Potholed to 5 feet on 8/26/2019.
2. During well installation, heaved to 25 feet when casing was pulled from 34 to 33 feet.
3. VWP is Geokon Model 4500S-350kPa, S/N 1927039.
4. Well is constructed of 2-inch ID PVC casing

CONTINUED NEXT SHEET



LEGEND

* Sample Not Recovered
🄶 Grab Sample
⊡ Well Screen and Sand Filter
▧ Bentonite-Cement Grout
⊠ Bentonite Chips/Pellets
▨ Bentonite Grout
▼ Ground Water Level in Well
▼ Ground Water Level in VWP

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

Bay Shore and Washington
Improvements Project
Silverdale, Washington

LOG OF BORING B-8WV-19

January 2020 21-1-21829-010

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-10
Sheet 3 of 4

REV 3 - Approved for Submittal

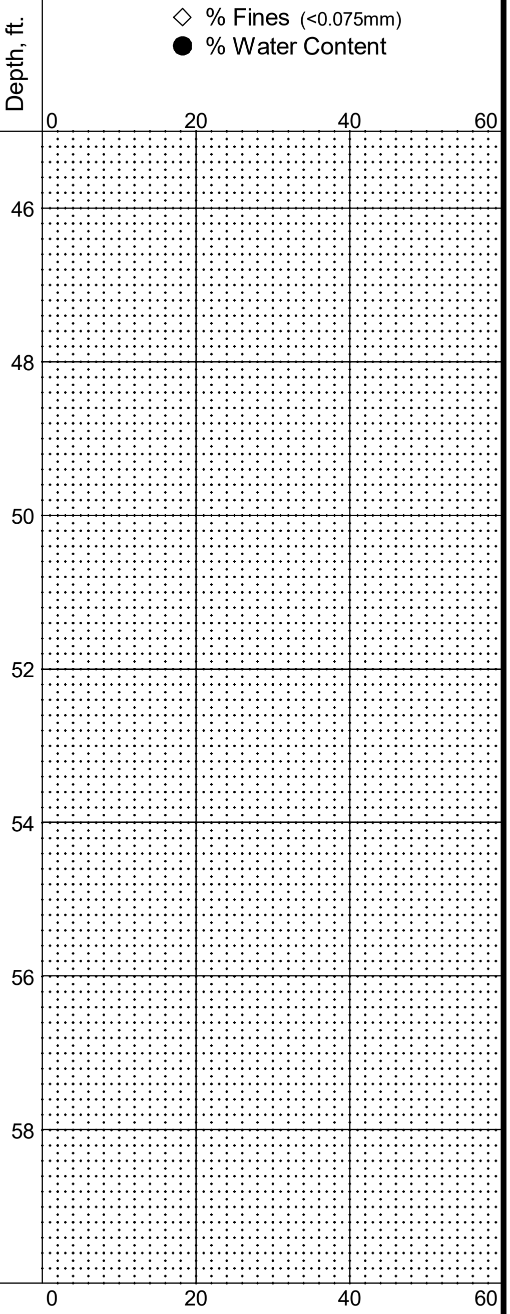
Total Depth: 40 ft.
Top Elevation: 15.4 ft.
Vert. Datum: NAVD88
Horiz. Datum: NAD 83
Northing: 241,147 ft.
Easting: 1,181,494 ft.
Station: 18+20.2A ft.
Offset: 13.4L
Drilling Method: Sonic Core
Drilling Company: Holt Services
Drill Rig Equipment: Terra Sonic TSi 150CC
Other Comments:
Hole Diam.: 6 in.
Rod Diam.:
Hammer Type:

SOIL DESCRIPTION

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

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

and 30-slot screen, with #12/20 filter pack sand.
5. Shallowest VWP groundwater reading measured on 9/3-9/6/2019 was 2.6 feet deep (9/4/2019).
6. Shallowest well groundwater reading measured on 9/3-9/6/2019 and 9/9-9/10/2019 was -0.6 feet deep (artesian, 9/3/2019).



LEGEND

- * Sample Not Recovered
- G Grab Sample
- ▦ Well Screen and Sand Filter
- ▧ Bentonite-Cement Grout
- ⊠ Bentonite Chips/Pellets
- ▨ Bentonite Grout
- ▼ Ground Water Level in Well
- ▼ Ground Water Level in VWP

NOTES

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

Bay Shore and Washington
Improvements Project
Silverdale, Washington

LOG OF BORING B-8WV-19

January 2020
21-1-21829-010

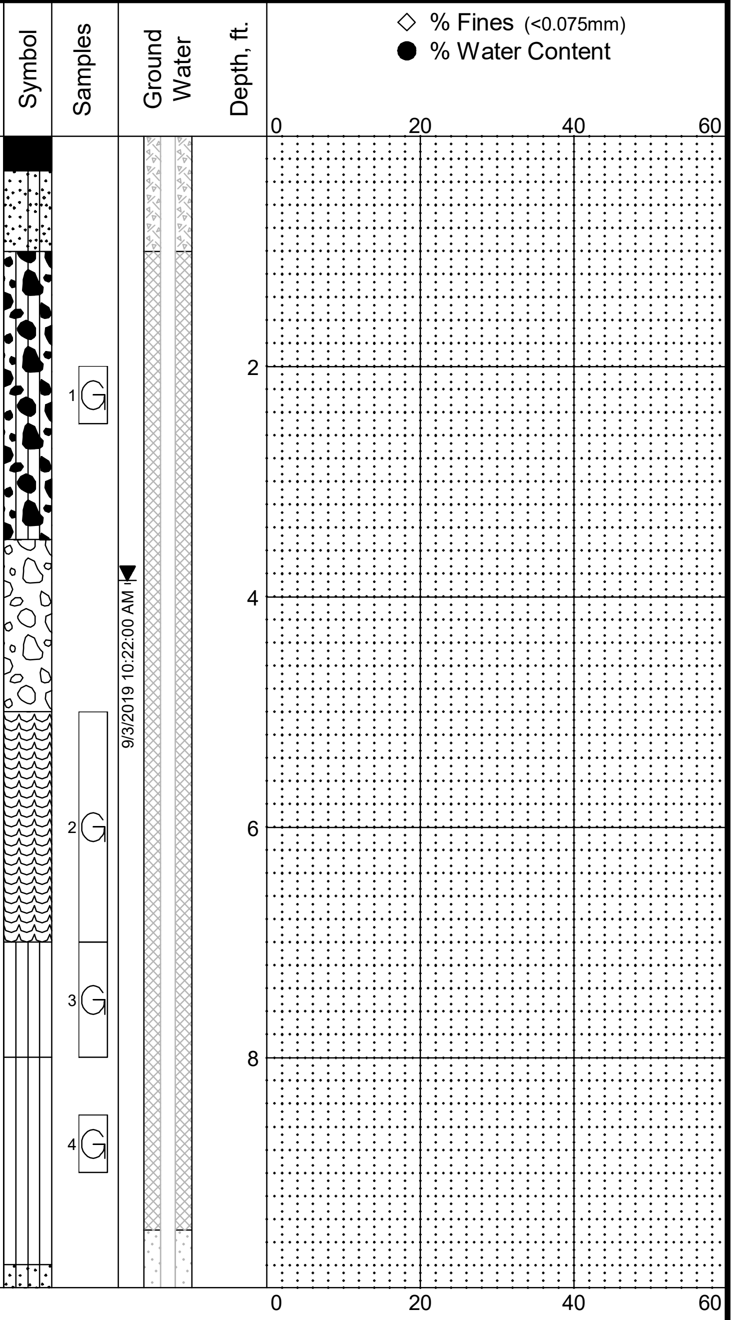
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-10
Sheet 4 of 4

REV 3 - Approved for Submittal

Total Depth:	15.1 ft.	Northing:	241,145 ft.	Drilling Method:	Sonic Core	Hole Diam.:	6 in.
Top Elevation:	15.3 ft.	Easting:	1,181,523 ft.	Drilling Company:	Holt Services	Rod Diam.:	
Vert. Datum:	NAVD88	Station:	18+19.1A ft.	Drill Rig Equipment:	Terra Sonic TSi 150CC	Hammer Type:	
Horiz. Datum:	NAD 83	Offset:	15.3R	Other Comments:			

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.
Asphalt.	0.3
Brown, *Poorly Graded Sand with Gravel (SP-SM)*; moist; subrounded gravel; fine to coarse sand; nonplastic; trace roots. (Hf)	1.0
Gray-brown, *Silty Gravel with Sand (GM)*; moist; angular to rounded gravel; fine to coarse sand; nonplastic; few asphalt chunks; trace fine roots; slight asphalt odor. (Hf)	3.5
Brown, *Poorly Graded Gravel with Sand and Cobbles (GP)*; moist; subrounded to rounded cobbles; subrounded to rounded gravel; fine to coarse sand; nonplastic. (Hf)	5.0
Dark brown *Peat (PT)*; moist to wet; trace subrounded gravel; few fine to medium sand; low plasticity; mostly organics. (Hp)	7.0
Gray-brown *Silt (ML)* to *Elastic Silt (MH)*; moist to wet; trace subrounded gravel; few sand; low to medium plasticity; little organics. (Hl)	8.0
Light gray *Silt (ML)* and *Sandy Silt (ML)*; wet; few to some fine sand; nonplastic; trace organics. (Hl) - Iron-oxidized at 9.5 feet.	9.8



CONTINUED NEXT SHEET

LEGEND

- * Sample Not Recovered
- G Grab Sample

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

NOTES

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

Bay Shore and Washington
Improvements Project
Silverdale, Washington

LOG OF BORING B-9W-19

January 2020 21-1-21829-010

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-11
Sheet 1 of 2

Log: PVH Rev: EAS Typ: LKN

Total Depth:	*15.1 ft.*	Northing:	*241,145 ft.*	Drilling Method:	*Sonic Core*	Hole Diam.:	*6 in.*
Top Elevation:	*15.3 ft.*	Easting:	*1,181,523 ft.*	Drilling Company:	*Holt Services*	Rod Diam.:	
Vert. Datum:	*NAVD88*	Station:	*18+19.1A ft.*	Drill Rig Equipment:	*Terra Sonic TSi 150CC*	Hammer Type:	
Horiz. Datum:	*NAD 83*	Offset:	*15.3R*	Other Comments:			

SOIL DESCRIPTION

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

Brown, *Silty Sand (SM)*; wet; few fine, subangular gravel; fine to medium sand; nonplastic fines; trace organics.
(Qvro)

Brown, *Poorly Graded Sand (SP)*; wet; few rounded gravel; fine to medium sand; nonplastic.
(Qvro)

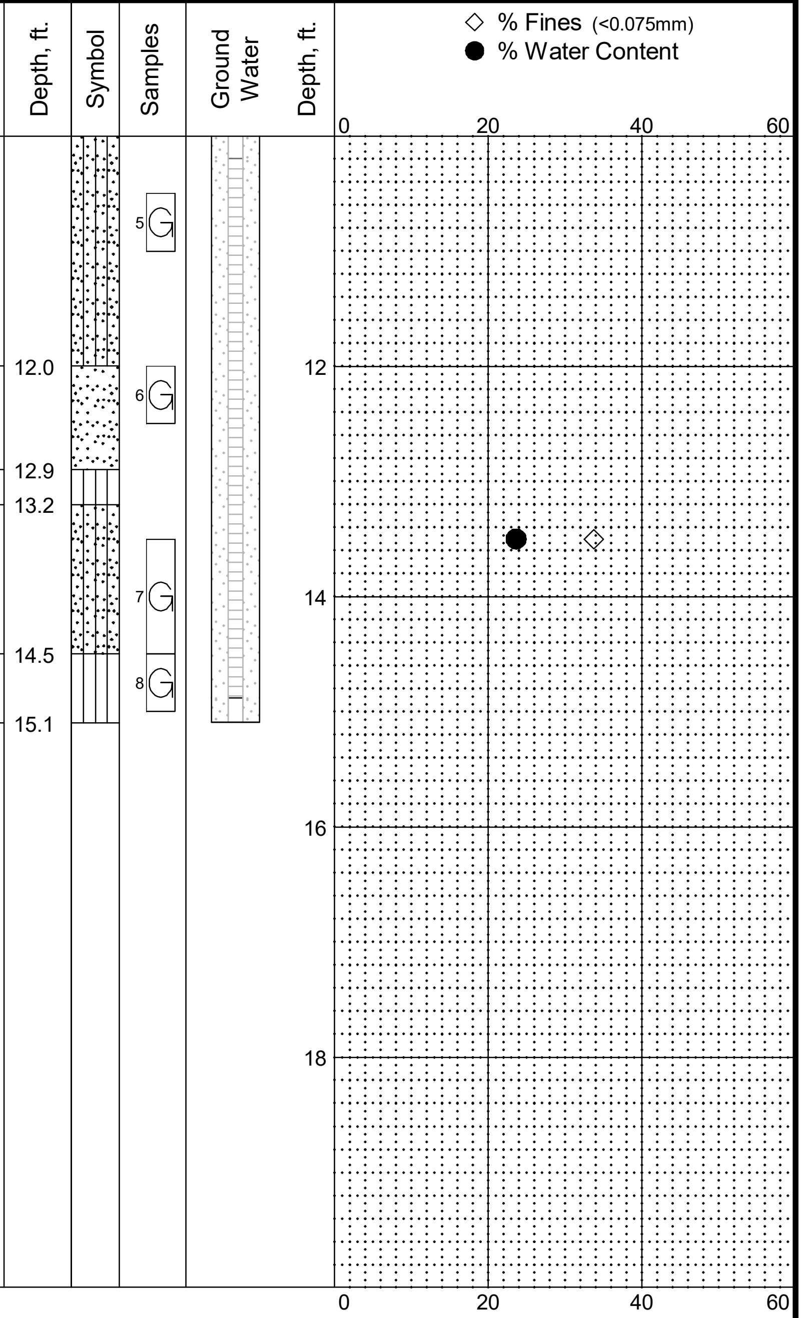
Mottled light gray and brown *Silt (ML)*; wet.
(Qvrl)

Yellow-brown, *Silty Sand (SM)*; wet; fine sand; nonplastic; iron oxide staining.
(Qvro)

Yellow-brown, *Sandy Silt (ML)*; wet; fine sand; nonplastic; iron oxide staining.
(Qvrl)

BOTTOM OF BORING
COMPLETED 8/27/2019

Notes:
1. Potholed to 5 feet on 8/26/2019.
2. Well is constructed of 2-inch ID PVC casing and 30-slot screen, with #12/20 filter pack sand.
3. Shallowest well groundwater reading measured on 9/3-9/6/2019 and 9/9-9/10/2019 was 3.9 feet deep (9/3/2019).



LEGEND

* Sample Not Recovered
G Grab Sample
⊡ Well Screen and Sand Filter
▧ Bentonite-Cement Grout
⊠ Bentonite Chips/Pellets
▨ Bentonite Grout
▼ Ground Water Level in Well

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

Bay Shore and Washington
Improvements Project
Silverdale, Washington

LOG OF BORING B-9W-19

January 2020 21-1-21829-010

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-11
Sheet 2 of 2

REV 3 - Approved for Submittal

Log: PVH Rev: EAS Typ: LKN

MASTER_LOG_E 21-21829.GPJ SHAN_WIL.GDT 11/12/19

Total Depth:	40 ft.	Northing:	241,155 ft.	Drilling Method:	Sonic Core	Hole Diam.:	12 in.
Top Elevation:	15.3 ft.	Easting:	1,181,523 ft.	Drilling Company:	Holt Services	Rod Diam.:	
Vert. Datum:	NAVD88	Station:	18+28.7A ft.	Drill Rig Equipment:	Terra Sonic TSi 150CC	Hammer Type:	
Horiz. Datum:	NAD 83	Offset:	14.7R	Other Comments:			

SOIL DESCRIPTION

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

Asphalt.

0.5

Brown, *Poorly Graded Sand with Silt and Gravel (SP-SM)* to *Silty Sand with Gravel (SM)*; moist; subangular to subrounded gravel; fine to coarse sand; nonplastic; trace roots and wood.
(Hf)

2.0

Brown, *Silty Gravel with Cobbles and Sand (GM)*; moist; some angular cobbles; subrounded to rounded gravel; fine to coarse sand; nonplastic; few bricks.
(Hf)

5.0

Dark brown, *Sandy, Organic Soil with Gravel (OL)*; moist to wet; subrounded to rounded gravel; fine to coarse sand; low plasticity; some organics.
(Hp)

7.0

Dark brown *Gravelly Peat with Sand (PT)*; wet; fine, subangular to rounded gravel; fine to medium sand; low plasticity; mostly organics.
(Hp)

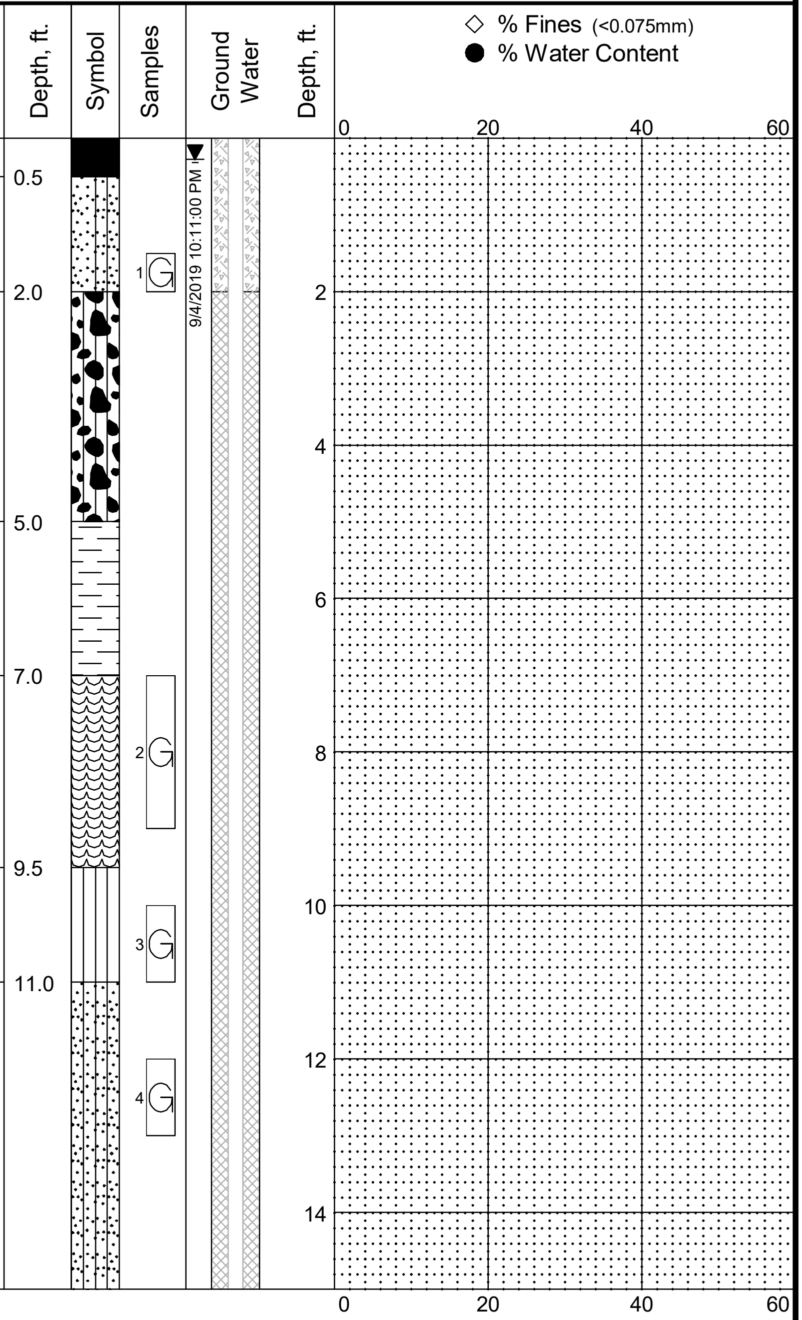
9.5

Gray *Silt with Sand (ML)*; wet; fine sand; nonplastic to low plasticity; rapid dilatency.
(Hl/Qvrl)
- Yellow-brown below 10 feet.

11.0

Yellow-brown, *Silty Sand (SM)*; wet; few subrounded gravel; fine to medium sand; nonplastic; slightly iron oxide-stained.
(Qvro)

- 2-inch layer of orange-brown, poorly graded sand at about 14 feet.



CONTINUED NEXT SHEET

LEGEND

- * Sample Not Recovered
- G Grab Sample
- ▦ Well Screen and Sand Filter
- ▧ Bentonite-Cement Grout
- ⊠ Bentonite Chips/Pellets
- ▨ Bentonite Grout
- ▼ Ground Water Level in Well

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

Bay Shore and Washington
Improvements Project
Silverdale, Washington

LOG OF BORING B-10PW-19

January 2020 21-1-21829-010

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-12
Sheet 1 of 4

REV 3 - Approved for Submittal

Log: PVH Rev: EAS Typ: LKN

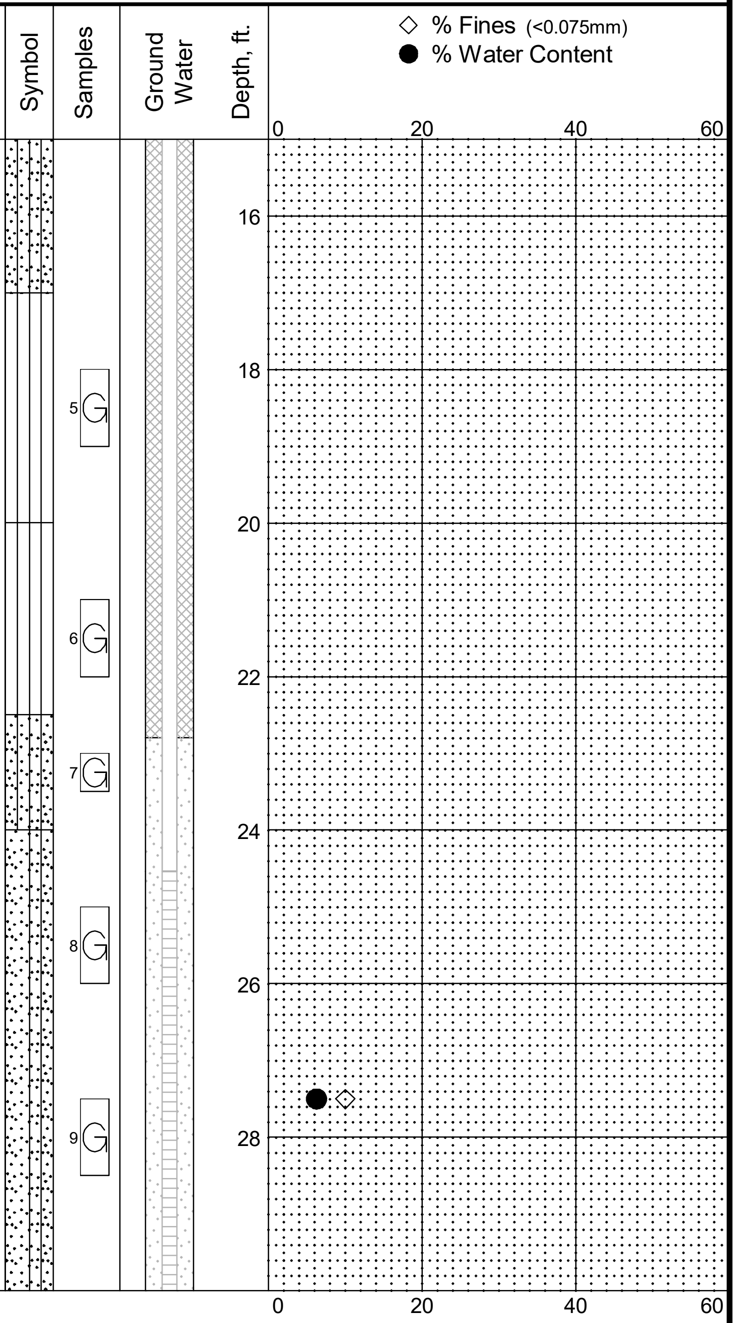
MASTER_LOG_E 21-21829.GPJ SHAN_WIL.GDT 11/12/19

Total Depth:	40 ft.	Northing:	241,155 ft.	Drilling Method:	Sonic Core	Hole Diam.:	12 in.
Top Elevation:	15.3 ft.	Easting:	1,181,523 ft.	Drilling Company:	Holt Services	Rod Diam.:	
Vert. Datum:	NAVD88	Station:	18+28.7A ft.	Drill Rig Equipment:	Terra Sonic TSi 150CC	Hammer Type:	
Horiz. Datum:	NAD 83	Offset:	14.7R	Other Comments:			

SOIL DESCRIPTION

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

Soil Description	Depth, ft.
Gray *Silt (ML)*; wet; few fine sand; nonplastic; rapid dilatency. (Qvrl) - Low plasticity below about 19.5 feet.	17.0
Gray, interbedded *Silt (ML)* and *Lean Clay (CL)*; moist; trace fine sand; low to medium plasticity. (Qpnl)	20.0
Gray, *Silty Sand (SM)*; wet; fine to medium sand; nonplastic. (Qpnf)	22.5
Gray, *Poorly Graded Sand with Silt and Gravel (SP-SM)* to *Poorly Graded Gravel with Silt, Sand, and Cobbles (GP-GM)*; wet; few cobbles; subangular to subrounded gravel; fine to coarse sand; nonplastic. (Qpgo)	24.0



CONTINUED NEXT SHEET

LEGEND

*	Sample Not Recovered
G	Grab Sample

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

NOTES

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

Bay Shore and Washington
Improvements Project
Silverdale, Washington

LOG OF BORING B-10PW-19

January 2020 21-1-21829-010

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-12
Sheet 2 of 4

Log: PVH Rev: EAS Typ: LKN

MASTER LOG E 21-21829.GPJ SHAN WIL.GDT 11/12/19

REV 3 - Approved for Submittal

Total Depth:	*40 ft.*	Northing:	*241,155 ft.*	Drilling Method:	*Sonic Core*	Hole Diam.:	*12 in.*
Top Elevation:	*15.3 ft.*	Easting:	*1,181,523 ft.*	Drilling Company:	*Holt Services*	Rod Diam.:	
Vert. Datum:	*NAVD88*	Station:	*18+28.7A ft.*	Drill Rig Equipment:	*Terra Sonic TSi 150CC*	Hammer Type:	
Horiz. Datum:	*NAD 83*	Offset:	*14.7R*	Other Comments:			

SOIL DESCRIPTION

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

31.5 — Gray, *Silty Sand with Gravel (SM)*; moist to wet; subrounded to rounded gravel; fine to coarse sand; nonplastic to low plasticity; diamict. (Qpgt)

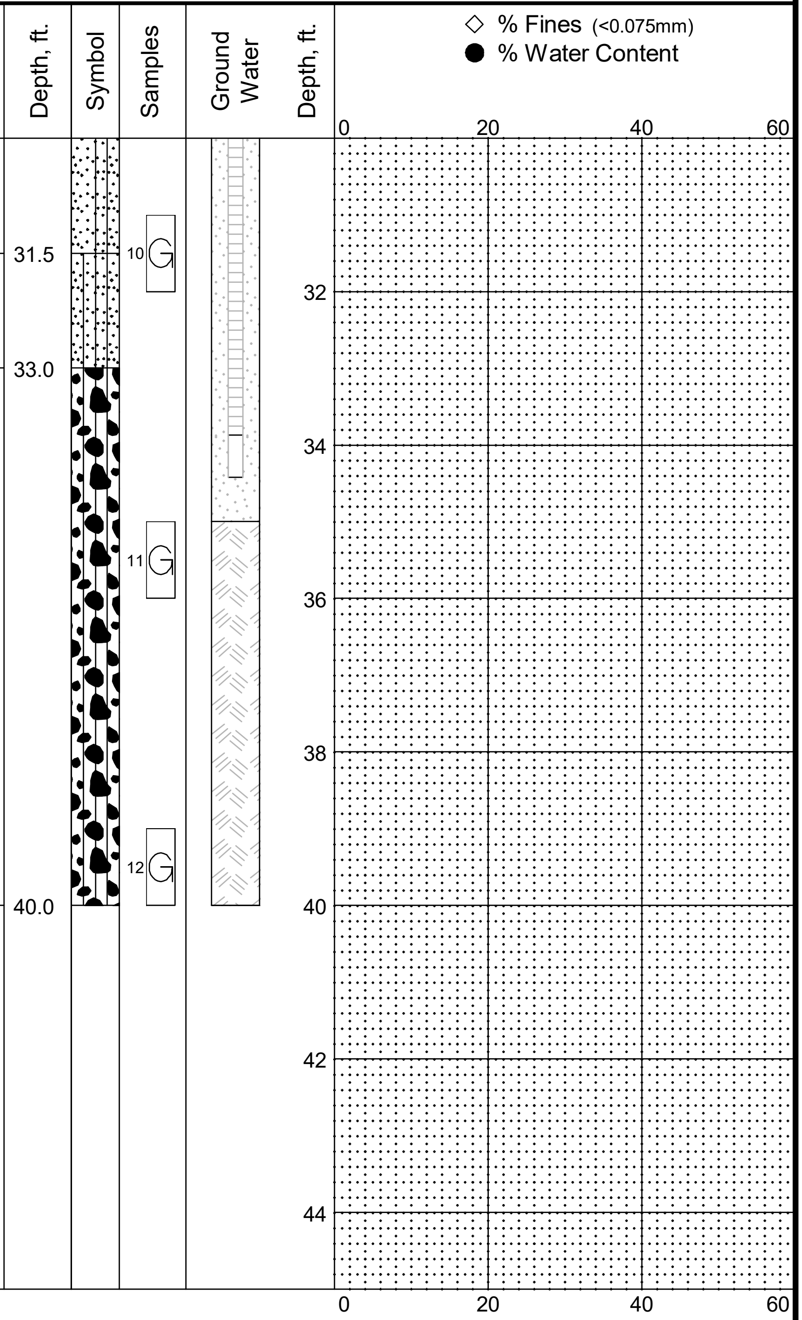
33.0 — Gray, *Silty Gravel with Sand (GM)*; moist to wet; subangular to subrounded gravel; fine to coarse sand; nonplastic to low plasticity; diamict.

- Hard drilling below 35 feet.
- More wet seams below about 39 feet.
- 1-inch layer of *Gray, Sandy Silt (ML)* at 39.5 feet; fine sand; low plasticity.

40.0

BOTTOM OF BORING
COMPLETED 8/29/2019

Notes:
1. Potholed to 5 feet on 8/26/2019.
2. Driller was unable to advance 12-inch temporary drill casing below 35 feet due to hard drilling.
3. Well is constructed of 8-inch ID PVC casing and 30-slot screen, with #12/20 filter pack sand.
4. Shallowest well groundwater reading



CONTINUED NEXT SHEET

LEGEND

- * Sample Not Recovered
- G Grab Sample
- ▦ Well Screen and Sand Filter
- ▧ Bentonite-Cement Grout
- ⊠ Bentonite Chips/Pellets
- ▨ Bentonite Grout
- ▼ Ground Water Level in Well

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

Bay Shore and Washington
Improvements Project
Silverdale, Washington

LOG OF BORING B-10PW-19

January 2020 21-1-21829-010

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-12
Sheet 3 of 4

Log: PVH Rev: EAS Typ: LKN

MASTER_LOG_E 21-21829.GPJ SHAN_WIL.GDT 11/12/19

REV 3 - Approved for Submittal

Total Depth: *40 ft.*
Top Elevation: *15.3 ft.*
Vert. Datum: *NAVD88*
Horiz. Datum: *NAD 83*

Northing: *241,155 ft.*
Easting: *1,181,523 ft.*
Station: *18+28.7A ft.*
Offset: *14.7R*

Drilling Method: *Sonic Core*
Drilling Company: *Holt Services*
Drill Rig Equipment: *Terra Sonic TSi 150CC*
Other Comments:

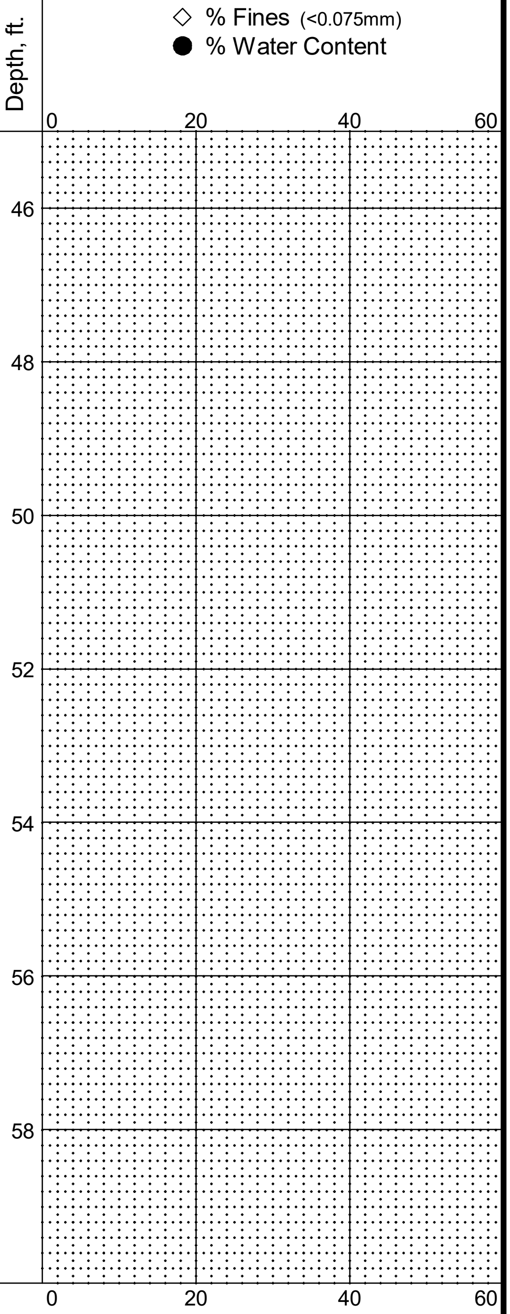
Hole Diam.: *12 in.*
Rod Diam.:
Hammer Type:

SOIL DESCRIPTION

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

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

measured on 9/3-9/6/2019 and 9/9/2019 was 0.3 feet deep (9/4/2019).



LEGEND

* Sample Not Recovered
G Grab Sample
▦ Well Screen and Sand Filter
▧ Bentonite-Cement Grout
⊠ Bentonite Chips/Pellets
▨ Bentonite Grout
▼ Ground Water Level in Well

NOTES

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

Bay Shore and Washington
Improvements Project
Silverdale, Washington

LOG OF BORING B-10PW-19

January 2020 21-1-21829-010

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-12
Sheet 4 of 4

REV 3 - Approved for Submittal

MASTER_LOG_E 21-21829.GPJ SHAN_WIL.GDT 11/12/19

Log: PVH Rev: EAS Typ: LKN

Total Depth:	*40 ft.*	Northing:	*241,170 ft.*	Drilling Method:	*Sonic Core*	Hole Diam.:	*6 in.*
Top Elevation:	*15.3 ft.*	Easting:	*1,181,524 ft.*	Drilling Company:	*Holt Services*	Rod Diam.:	
Vert. Datum:	*NAVD88*	Station:	*18+44.2A ft.*	Drill Rig Equipment:	*Terra Sonic TSi 150CC*	Hammer Type:	
Horiz. Datum:	*NAD 83*	Offset:	*15.7R*	Other Comments:			

SOIL DESCRIPTION

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

Asphalt.

Brown, *Silty Sand with Gravel (SM)* to *Poorly Graded Sand with Silt and Gravel (SP-SM)*; moist; subrounded to subangular gravel; fine to coarse sand; nonplastic.
(Hf)

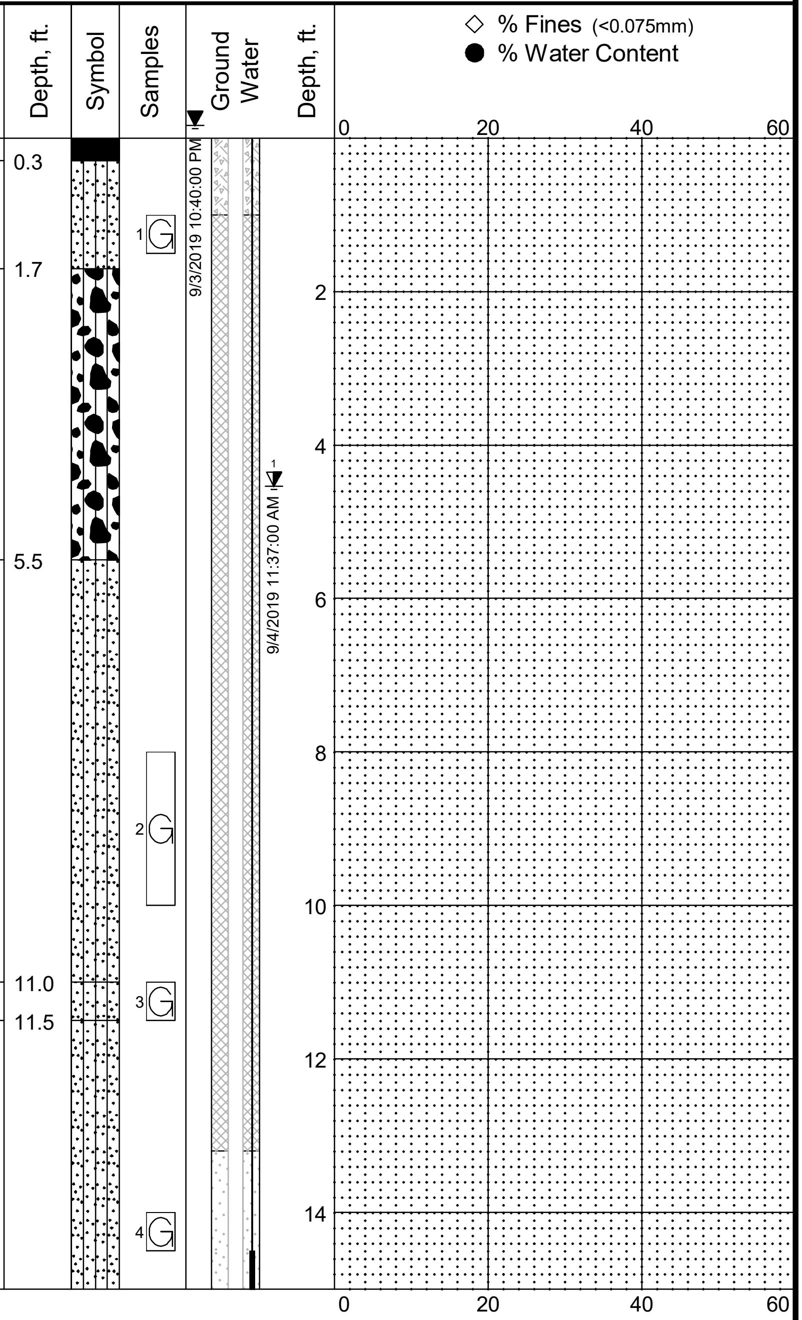
Brown, *Silty Gravel with Sand, Cobbles, and Boulders (GM)*; moist; angular to rounded cobbles; angular to rounded gravel; fine to coarse sand; nonplastic; trace debris (wire, metal U-bolt, and asphalt).
(Hf)
- Boulder from 2.5 to 3 feet.
- Cobble from 5 to 5.5 feet.
- Wet below 5 feet.

Dark brown, *Silty Sand with Gravel and Cobbles (SM)*; wet; little subrounded cobbles; subrounded gravel; fine to coarse sand; nonplastic; some wood fibers and chunks.
(Hf/Ha)

- No recovery from approximately 8.5 to 10 feet.

Yellow-brown, *Silty Sand (SM)*; wet; trace fine, subrounded gravel; fine to medium sand; nonplastic; trace wood fragments.
(Qvro)

Yellow-brown, *Silty Sand (SM)*; wet; fine to medium sand; nonplastic.
(Qvro)
- With layers of red-brown, *Poorly Graded Sand (SP)* from 13 to 13.5 feet; fine to medium sand; nonplastic; iron oxide-stained.



CONTINUED NEXT SHEET

LEGEND

- * Sample Not Recovered
- G Grab Sample
- ⊡ Well Screen and Sand Filter
- ▧ Bentonite-Cement Grout
- ⊠ Bentonite Chips/Pellets
- ▨ Bentonite Grout
- ▼ Ground Water Level in Well
- ▼ Ground Water Level in VWP

NOTES

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

Bay Shore and Washington
Improvements Project
Silverdale, Washington

LOG OF BORING B-11WV-19

January 2020
21-1-21829-010

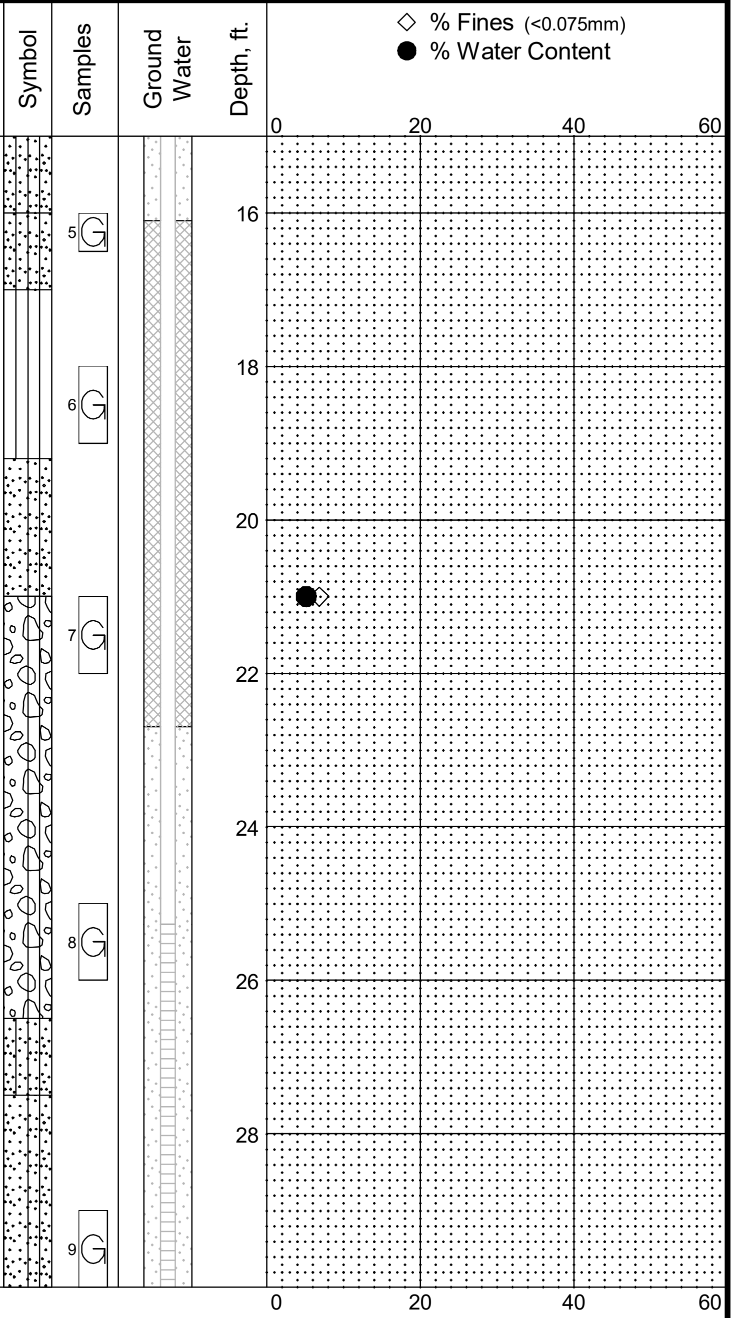
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-13
Sheet 1 of 4

REV 3 - Approved for Submittal

Total Depth:	40 ft.	Northing:	241,170 ft.	Drilling Method:	Sonic Core	Hole Diam.:	6 in.
Top Elevation:	15.3 ft.	Easting:	1,181,524 ft.	Drilling Company:	Holt Services	Rod Diam.:	
Vert. Datum:	NAVD88	Station:	18+44.2A ft.	Drill Rig Equipment:	Terra Sonic TSi 150CC	Hammer Type:	
Horiz. Datum:	NAD 83	Offset:	15.7R	Other Comments:			

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.
	16.0
Gray, *Silty Sand (SM)*; wet; fine sand; nonplastic. (Qvro)	17.0
Gray *Silt (ML)*; wet; few fine sand; nonplastic fines. (Qvrl) - Low plasticity fines below 17.5 feet.	19.2
Gray, *Poorly Graded Sand with Silt and Gravel (SP-SM)*; wet; subrounded to rounded gravel; fine to coarse sand; nonplastic. (Qpnf)	21.0
Gray, *Poorly Graded Gravel with Silt, Sand, and Cobbles (GP-GM)* to *Poorly Graded Sand with Silt and Gravel (SP-SM)*; wet; trace subrounded cobbles; subrounded to subangular gravel; fine to coarse sand; nonplastic. (Qpgo) - Few diamict pockets of *Silty Sand with Gravel (SM)* from 22 to 22.5 feet and 23.5 to 25 feet. - 1-foot layer at 25 feet of *Poorly Graded Sand with Silt (SP-SM)*; fine to medium sand; nonplastic.	26.5
Gray, *Silty Sand with Gravel (SM)*; wet; subrounded gravel; fine to coarse sand; nonplastic; diamict pockets. (Qpgo)	27.5
Gray, *Poorly Graded Sand with Silt (SP-SM)*; wet; few, subrounded gravel; fine to coarse sand; nonplastic; trace organics. (Qpgo)	



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered

G Grab Sample

⊡ Well Screen and Sand Filter

▧ Bentonite-Cement Grout

▩ Bentonite Chips/Pellets

▨ Bentonite Grout

▼ Ground Water Level in Well

▼ Ground Water Level in VWP

NOTES

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

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FIG. A-13
Sheet 2 of 4

REV 3 - Approved for Submittal

Total Depth:	*40 ft.*	Northing:	*241,170 ft.*	Drilling Method:	*Sonic Core*	Hole Diam.:	*6 in.*
Top Elevation:	*15.3 ft.*	Easting:	*1,181,524 ft.*	Drilling Company:	*Holt Services*	Rod Diam.:	
Vert. Datum:	*NAVD88*	Station:	*18+44.2A ft.*	Drill Rig Equipment:	*Terra Sonic TSi 150CC*	Hammer Type:	
Horiz. Datum:	*NAD 83*	Offset:	*15.7R*	Other Comments:			

SOIL DESCRIPTION

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

- Diamict interbed of *Silty Sand (SM)* from 28 to 28.5 feet.

Gray, *Silty Sand (SM)*; wet; fine sand; nonplastic; few seams of fine to medium sand. (Qpgo)

Gray, *Poorly Graded Sand with Silt and Gravel (SP-SM)* to *Silty Sand with Gravel (SM)*; wet; subangular to subrounded gravel; fine to coarse sand; nonplastic. (Qpgo).

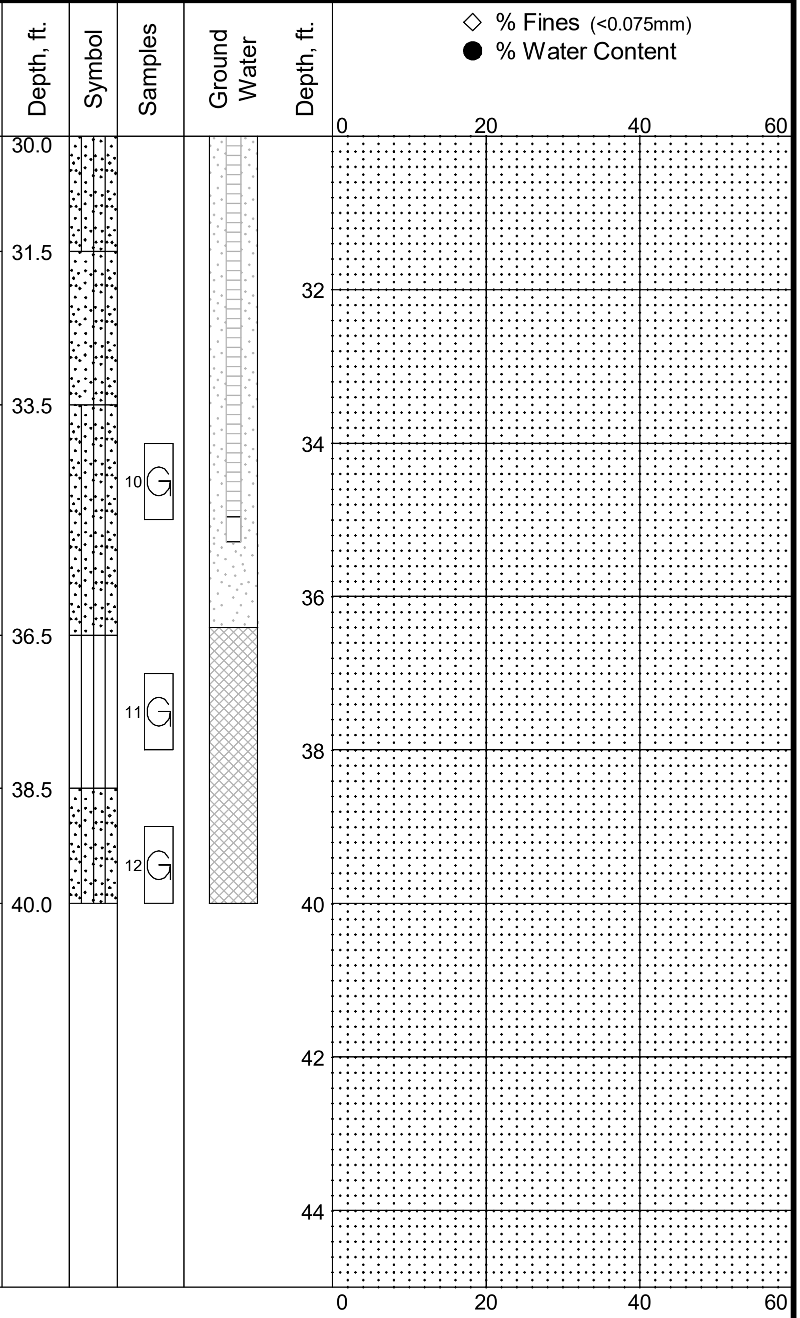
Gray, *Silty Sand with Gravel (SM)*; wet; fine, subangular to subrounded gravel; fine to coarse sand; nonplastic to low plasticity; diamict pockets. (Qpgo)

Dark gray *Silt with Sand (ML)*; moist to wet; trace fine, subrounded gravel; fine to coarse sand; nonplastic to low plasticity; trace wood; diamict. (Qpgm)

Gray, *Silty Sand with Gravel (SM)*; moist to wet; subangular to subrounded gravel; fine to coarse sand; nonplastic to low plasticity; few silt pockets with organics. (Qpnf)

BOTTOM OF BORING
COMPLETED 8/26/2019

Notes:
1. Potholed to 5 feet on 8/26/2019.
2. Heaved about 6 feet when lifted rods at 40 feet.
3. VWP is Geokon Model 4500S-350kPa, S/N 1927042.
4. Well is constructed of 2-inch ID PVC casing and 30-slot screen, with #12/20 filter pack sand.



CONTINUED NEXT SHEET

LEGEND

- * Sample Not Recovered
- G Grab Sample
- ▦ Well Screen and Sand Filter
- ▧ Bentonite-Cement Grout
- ▩ Bentonite Chips/Pellets
- ▨ Bentonite Grout
- ▼ Ground Water Level in Well
- ▼ Ground Water Level in VWP

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
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FIG. A-13
Sheet 3 of 4

REV 3 - Approved for Submittal

Total Depth: 40 ft.
Top Elevation: 15.3 ft.
Vert. Datum: NAVD88
Horiz. Datum: NAD 83

Northing: 241,170 ft.
Easting: 1,181,524 ft.
Station: 18+44.2A ft.
Offset: 15.7R

Drilling Method: Sonic Core
Drilling Company: Holt Services
Drill Rig Equipment: Terra Sonic TSi 150CC
Other Comments:

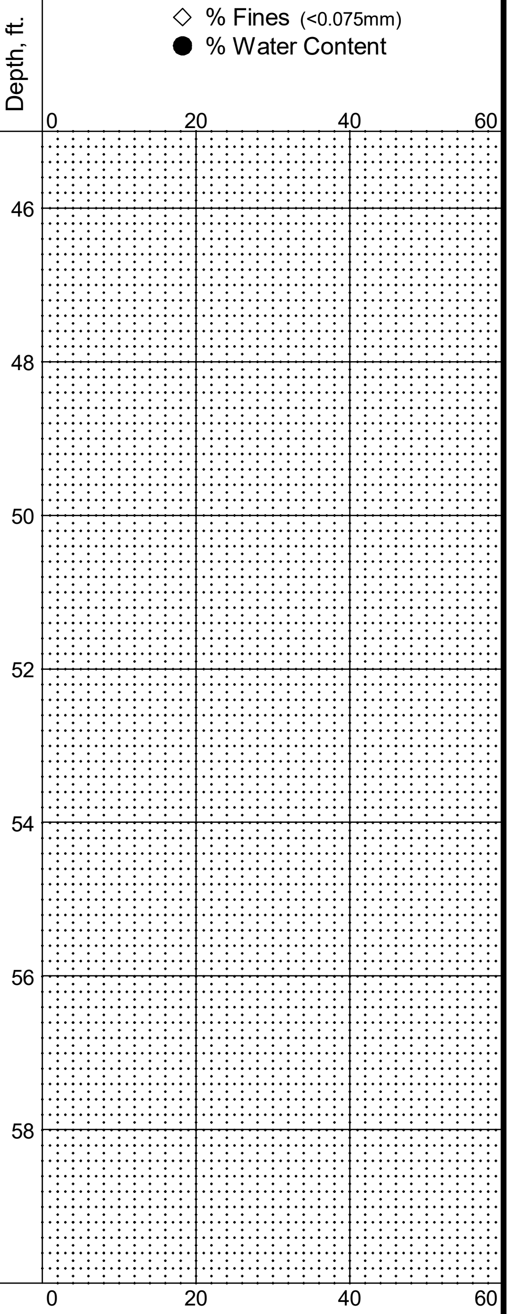
Hole Diam.: 6 in.
Rod Diam.:
Hammer Type:

SOIL DESCRIPTION

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

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

5. Shallowest VWP groundwater reading measured on 9/3-9/6/2019 was 4.5 feet deep (9/4/2019).
6. Shallowest well groundwater reading measured on 9/3-9/6/2019 and 9/9-9/10/2019 was -0.2 feet deep (artesian, 9/3/2019).



LEGEND

* Sample Not Recovered
G Grab Sample

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

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
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FIG. A-13
Sheet 4 of 4

MASTER_LOG_E 21-21829.GPJ SHAN_WIL.GDT 11/12/19
Log: PVH Rev: EAS Typ: LKN

REV 3 - Approved for Submittal

Boring Location: See GIMP Plan, Drawing M01, Sheet 2
Top Elevation: 13.07 Feet
Date Drilled: 9/8/2020

Drilling Company: Geologic Drill
Drilling Method: Hollow Stem Auger
Drill Rig: CAT Track

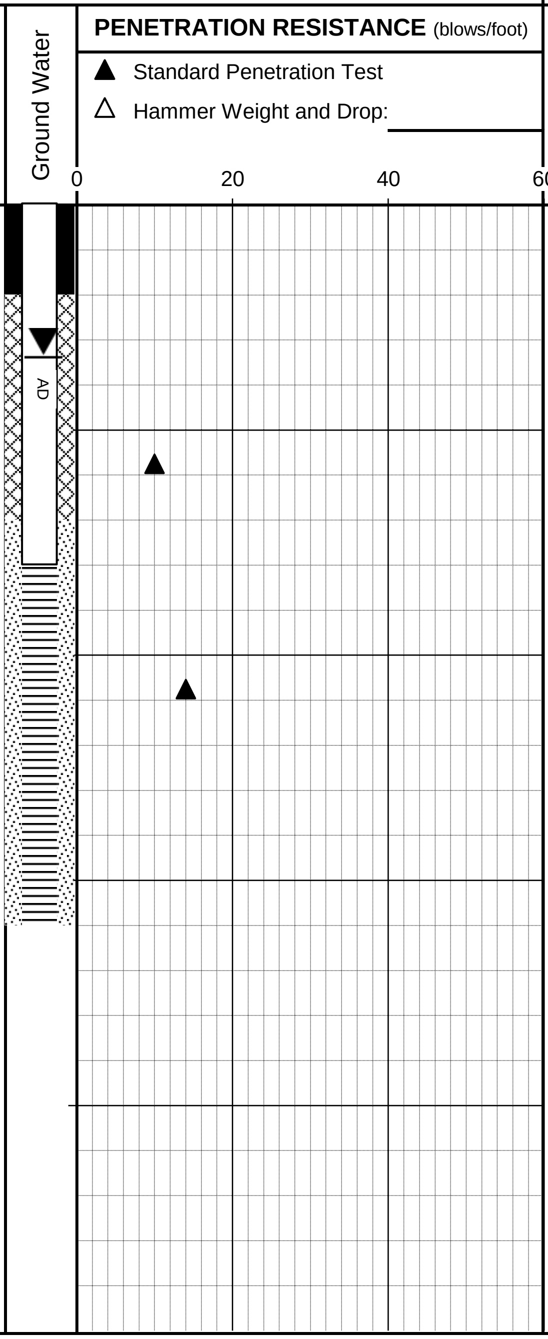
Bore Hole Dia.: 8-inch
Hammer Type: Cat Head
Logged by: BST

MW-2

SOIL DESCRIPTION

The stratification lines represent the approximate boundaries between soil types. The transition may be gradual. Refer to report text and appendices for additional information.

Depth (ft)	Soil Description	Sample Number	Recovery (In.)	Blow Counts	Testing
0	5-inches of asphalt over medium dense, moist, gray, silty SAND, some gravel scattered organics in upper 3 feet				
5	Medium dense, moist grading to saturated at about 3.4 feet, gray, gravelly SAND, trace silt.	S-1	16	10	
10	Medium dense, saturated, gray, gravelly SAND, trace silt.	S-2	8	14	
15	Boring terminated at approximately 16 feet below existing grade. Groundwater was encountered at approximately 3.4-feet after drilling (AD). Well tag #BLY008				
20					
25					



SAMPLE LEGEND

- I 2-inch O.D. split spoon sample
- II 3-inch I.D. Shelby tube sample

GROUNDWATER LEGEND

- ░ Clean Sand
- ▨ Bentonite
- ■ Grout/Concrete
- ☰ Screened Casing
- ☐ Blank Casing
- ▼ 11/2/12 Groundwater level at time of drilling (ATD) or on date of measurement.

TESTING KEY

GSA = Grain Size Analysis
200W = 200 Wash Analysis
Consol. = Consolidation Test
Att. = Atterberg Limits

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

Bay Shore Improvements
Bay Shore Dr. & Washington Ave.
Silverdale, Washington

Date: September 2020
Project No.: 2158.10

ZipperGeo
Geoprofessional Consultants
19019 36th Ave. W, Suite E
Lynnwood, WA

BORING LOG: MW-2