LOWER COAL CREEK FLOOD HAZARD REDUCTION PROJECT - PRELIMINARY DESIGN FOR CULVERT REPLACEMENT

Geotechnical Engineering Report

Prepared for: Tetra Tech

Project No. 140362 • October 4, 2016

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1 Introduction and Project Description

This geotechnical engineering report presents the results of a site reconnaissance, subsurface explorations, and geotechnical analyses and recommendations performed by Aspect Consulting, LLC (Aspect) in support of the Lower Coal Creek Flood Hazard Reduction Project—Preliminary Design and Permitting Services phase (Project).

Over the last two decades, the City of Bellevue (City) has received and responded to numerous flooding complaints in the Newport Shores neighborhood (Site) of the Coal Creek watershed associated with a range of causes, including backup of storm drains, culvert blockages, and channel overflows. The location of the Project is shown on Figure 1. The City is seeking flood protection measures that abate existing flooding problems and provide protection from the 100-year flood event.

In the long-term, we understand the flood protection measures include five culvert replacements, storm drain improvements, two stormwater siphons in Lower Coal Creek, and up to three new outfalls to Lake Washington. We understand the goal of this phase of the Project is to develop 30-percent planning and design recommendations for the culvert replacements and siphons. Outfall options will be studied and reported under a separate deliverable.

The five culverts planned for replacement exist along Lower Coal Creek and convey water beneath several streets in the Newport Shores neighborhood. The culverts to be replaced are named according to the street they undercross and their relative elevation in the neighborhood ("lower" indicating lowland near Lake Washington, and "upper" indicating more inland and upland). A map of the Newport Shores neighborhood and the culvert replacement locations are shown on Figure 2.

The existing culverts consist of either three-sided corrugated metal arch or concrete, four-sided box structures. The existing culvert structure type and dimensions are shown below in Table 1.

Table 1 – Existing Culvert Types and Dimensions

Culvert Replacement Identification	Type	Height (feet)	Span (feet)
Lower Skagit Key	Corrugated Metal Arch	6.7	13.5
Newport Key	Corrugated Metal Arch	6.7	13.5
Glacier Key	Concrete Four-sided Box	6	10
Upper Skagit Key	Concreted Four-sided Box	6	10
Cascade Key	Concrete Four-sided Box	6	10

Preliminary dimensions generated from the 15-percent design effort indicate the new box culverts will have span widths of about 24 feet and heights of about 6 to 8 feet.

Stormwater siphons are planned at the Newport Key Culvert and Glacier Key Culvert replacements. The new stormwater outfall locations have not yet been determined.

For the purposes of this study, we have been directed by the City to assume that design and construction of the improvements will be in accordance with City Transportation Code, and the American Association of State Highway and Transportation Officials Bridge Design Specifications (BDS) (AASHTO, 2014) and/or the Washington State Department of Transportation (WSDOT) Bridge Design Manual (BDM) (WSDOT, 2015).

2 Site Conditions

The Site lies near the eastern edge of Lake Washington and follows the route of lower Coal Creek, which flows from the foothills east of the lake, across the Lower Coal Creek alluvial fan and delta, and into Lake Washington. Deposits within the Site area reflect deposition within a number of different geologic environments, and these geologic deposits possess a wide range of engineering properties. This section presents the Site conditions including regional geologic and tectonic setting, and Site-area geology and subsurface conditions. This information provides context for the discussion of types and distribution of the geologic and engineering soil units, and a basis for anticipating the conditions that will be encountered during construction of the Project elements.

2.1 Topography

The southeastern end of the Site is located on the flank of a broad alluvial fan that begins where Coal Creek emerges from the foothills in the vicinity of Interstate 405 (Site topography is presented on Figure 2). The upper portion of the fan lies at about Elevation 50 feet. The ground surface of the alluvial fan dips gently toward the north and west where it merges in the vicinity of Upper Skagit Key with the Lower Coal Creek delta, at about Elevation 40 feet. The top of the delta dips very gently westward toward the lake. The northwestern end of the Site, near Lower Skagit Key, lies at about Elevation 25 feet. The shoreline of Lake Washington lies several hundred feet away at about Elevation 18 feet. The topography at each culvert replacement location is shown on Figures 4 through 8.

2.2 Surface Conditions

Surface conditions near the culvert replacements generally consist of relatively flat asphalt paved roadway over the existing culverts, residential landscape areas, or vegetation consisting of ivy, trees growing along the banks of Coal Creek, and some areas of bare soil and rip rap. Figures 3 through 7 show relevant surface features at each of the five culvert replacement sites.

2.3 Regional Geology

The Puget Lowland is located within an area of repeated glaciations in a complex tectonic environment with active seismicity. Starting about 25 million years ago, the geologic evolution of western Washington has been dominated by the subduction of the Juan de Fuca oceanic plate beneath the North American continental plate. This convergence of plates has created the Puget Trough, which is flanked by the Olympic Mountains to the west and the Cascade Range to the east. The Project will be constructed within the Puget Trough. The Tertiary and Quaternary deposits in the Puget Trough are estimated to be up to 4 miles thick.

Northward-directed compression of the Puget Trough has resulted in formation of a chain of sedimentary basins that extend from the Chehalis area of Washington northward past the Canadian border. These sedimentary basins are separated by fold-and-thrust belts that occur as broad zones of active thrust faults, strike-slip faults, folds, and uplifted and deformed bedrock and sediments.

The Site lies within the Seattle fault zone, the fold-and-thrust belt that divides the Seattle basin to the north from the Tacoma Basin to the south. The broad area of uplifted and deformed strata associated with the Seattle fault is called the Seattle uplift, and the Site lies within this uplifted zone. Bedrock is shallow in much of the Seattle Uplift, and bedrock crops out at ground surface about one mile east of the Site.

The present-day land surface in the Project area reflects deposition of postglacial sediments that lie above glacial and nonglacial sediments that were deposited during the Quaternary Period (within the last 2.6 million years). These sediments lie above Oligocene (22 to 36 million years before present) Blakeley Formation sedimentary bedrock. Only the late Quaternary and Holocene (within the last 10,000 years) deposits are exposed in the Project area at land surface or are present with the depths of deep foundations.

The Quaternary geologic history of the Puget Sound region is dominated by multiple continental glaciations and intervening interglacial periods. Many of the glacial and interglacial cycles appeared to have resulted from a similar sequences of events. Between periods of glaciation, depositional processes were similar to those of the predevelopment Puget Sound lowlands, with forested uplands separating broad river valleys with meandering low-energy rivers, floodplains, and wetlands. Deposits in the Site area associated with these interglacial climates are called nonglacial deposits and include sandy to gravelly river channel-bed deposits, silty to fine sandy floodplain deposits, silty to clayey lake deposits, and organic-rich wetland deposits.

During episodes of cooler mean global temperatures, continental ice sheets originating in Canada advanced southward covering much of the Puget Lowland with glacial ice over a mile thick in places, and up to about 3,000 feet thick in the Site area. Glacial ice and meltwater from the glaciers and glacially impounded Puget Lowland rivers deposited sequences of clayey and silty to sandy glaciolacustrine (glacial lake) deposits in glacially impounded areas, broad sheets of outwash sand and gravel, glacial tills and diamicts (poorly sorted deposits), and sandy to gravelly recessional outwash.

Much of the sculpting of the Site-area hills and carving of Puget Sound waterways, river valleys, and deeper lakes occurred during glaciations by subglacial meltwater flow that created deep channels cut into previously deposited soils. The deep channels and the hills between them were then smoothed by flowing ice to create the sculpted and fluted glacial drumlins that form the hills of Bellevue and the valleys between. Thus, the landscape of Bellevue and the Project area is a result of these repeated periods of deposition during interglacial periods, and glaciations. The hills contain accumulated sediments from multiple glacial and interglacial events, and the hills and valleys were scoured and sculpted by subglacial erosion into the elongate hills and ridges we see today.

Lake Washington is a product of this subglacial meltwater scour and erosion. The flanks of the hills above the lake, including those east of Lower Coal Creek, were then modified by normal slope erosion processes including landslides and incision by ravines and drainages from the uplands.

Since after the end of the most recent glaciation in the region (about 13,000 years ago), Coal Creek has flowed from its headwaters on Cougar Mountain, through hills of older glacial and nonglacial soils, and much older sedimentary rock (including coal), to Lake Washington. Coal Creek has deposited, and continues to deposit, the sediments collected from its course in a broad alluvial fan and delta, and then into the still water of Lake Washington.

The delta is nearly flat on the top, but below water, the front of the delta slopes gently toward the bottom of the lake. The Newport Shores neighborhood occupies most of the now above-water surface of the delta.

The last phase of geologic development is associated with regional development. Logging of the uplands and slopes was followed by mining of coal in the headwaters of Coal Creek, and other development as the surrounding area grew. This regional development triggered increased sedimentation into Coal Creek and the Site area.

Prior to construction of the Lake Washington Ship Canal and Government Locks, Lake Washington was about 9 feet higher than present. Much of the delta would have been a shallowly submerged bench that extended into Lake Washington. When the lake was lowered 9 feet (to a mean elevation of about 18 feet), the former shoreline and nearshore lake bench became a terrace that was then filled and later developed with an airfield and then residential housing. Site topography, existing features, and locations of the proposed culvert replacement sites are presented on Figures 2 and 4 through 8. Interpretive geologic cross sections are presented as Figures 3a through 3c.

2.4 Seismicity

The Project will be constructed within an area of active tectonic forces associated with the interaction of the offshore Juan de Fuca plate, the Pacific plate, and the onshore North American plate. These plate interactions result in seismic hazards to the Project. Significant hazards include regional ground shaking from subduction zone earthquakes, deep earthquakes, and shallow crustal earthquakes; liquefaction of soft ground; seismically triggered landslides and sublake slumps or lateral spreading; and the potential for surficial ground rupture. Potential hazards are described here.

The Project lies within the Seattle fault zone. This broad zone of compressional folding and faulting is known to be active, and has ruptured and triggered earthquakes several times during the last 10,000 years. The U. S. Geological Survey (USGS) estimates that it is capable of producing earthquakes of magnitude 7.3 or greater. The last large earthquake on this fault system was about 1,100 years ago, and resulted in up to 27 feet of uplift in parts of west Seattle, and surficial ground rupture at Vasa Park east of the Site. Faulting was likely associated with surficial ground rupture elsewhere in Bellevue, although most traces of the rupture have been obliterated by erosion and urban development.

The Site also lies within the zone of strong shaking from subduction zone earthquakes. The recurrence interval of these earthquakes is thought to be on the order of about 500 years. The most recent subduction zone earthquake occurred about 300 years ago. Deep intraslab earthquakes also occur in the region every decade or two, including the 2001

Nisqually earthquake. These earthquakes are generally less severe than the shallow crustal and subduction zone earthquakes, but have the potential to cause damage to older structures built before modern seismic codes were enacted, and those in areas susceptible to liquefaction.

2.5 Subsurface Exploration and Laboratory Testing

2.5.1 Soil Borings

A total of five soil borings, designated B-1 through B-5, were completed for this study; one at each culvert replacement location. Table 2 below shows the soil boring completed for each culvert replacement sites. The locations of the soil borings are shown on Figures 4 through 8.

Table 2 – Culvert Replacement Soil Borings

Culvert Replacement Identification	Soil Boring Completed	Total Depth Below Grade (feet)
Lower Skagit Key	B-1	66.5
Newport Key	B-2	60.5
Glacier Key	B-3	61.5
Upper Skagit Key	B-4	36.5
Cascade Key	B-5	30.0

The soil borings were completed by a subcontracted driller (Gregory Drilling, Inc.) using mud-rotary drilling methods. Soil samples were collected using Standard Penetration Test (SPT) and thin-wall “Shelby” tube methods. The drilling and sampling was observed full-time by an Aspect geologist who documented soil and groundwater conditions during drilling, and collected soil samples for review and laboratory testing. A 2-inch-diameter, groundwater level-monitoring piezometer (well) with 0.01-inch slotted screen was installed in each boring and completed with a flush-mount surface monument. Detailed descriptions of the drilling, sampling, and soil classification methods; well construction and materials; and the soil boring logs are presented in Appendix A.

2.5.2 Geotechnical Laboratory Testing

Selected soil samples were submitted to a subcontracted geotechnical testing laboratory (Hayre McElroy & Associates, LLC) to complete index testing consisting of moisture content, grain-size distribution, Atterberg Limits (plasticity), organic content, one-dimensional consolidation testing to determine consolidation parameters, and consolidated undrained (CU) triaxial shear strength testing. Further description of the soil samples submitted, test methods, and results are presented in Appendix B.

2.5.3 Hydraulic Conductivity (Slug) Testing

Slug tests were completed on all piezometers to develop estimates of hydraulic conductivity. Results of slug testing and a summary of methods used are presented in Appendix A.

2.6 Subsurface Conditions

Our interpretation of the subsurface conditions at the Site was developed based on the soil borings completed at each of the five culvert replacement sites (boring locations and culvert replacement sites are shown on Figure 2; boring logs completed for this Project are presented in Appendix A), review the logs of soil boings previously completed by others near the Sites (Appendix C), review of the geologic map of the area (Troost et al., 2012), and our experience with other projects in the Newport Shores neighborhood and similar settings.

Site soils include those that predate the development of Lake Washington, deposits from the Vashon glaciation, postglacial deposits, and man-placed or modified fills. These deposits have been subdivided into geologic units and engineering soil units. Geologic units consist of soils deposited in unique geologic depositional environments that are laterally traceable and generally predictable. Characterization by geologic unit aids in interpreting the geometry of the deposits beyond or between the borings. Engineering soil units consist of soils that may have been deposited within one or more geologic units and possess similar engineering behavior and characteristics. Engineering soil units are used to anticipate behavior of soils at specific tested locations under specific conditions.

2.6.1 Geologic Units

The primary geologic units include the following: all glacially overridden sediments that predate retreat of Vashon glacial ice; Vashon recessional glacial outwash; Holocene delta complex sediments consisting of lacustrine/floodplain overbank sediments, organic-rich lacustrine sediments, and channel deposits; and historic man-placed fill that caps the Site area. Figures 3a through 3c show the distributions of these units.

This alluvial fan-and-delta complex ranges from about 15 feet thick in the soil borings at the southeastern edge of the Site to about 50 feet thick in borings at the northwest end of the Site. Each of these geologic units contains soils with a range of engineering behaviors. The geologic characteristics and distribution of these units are described here, from generally younger (stratigraphically higher) to older (stratigraphically lower).

Fill

Fill consists of any man-placed or modified soils. It is composed primarily of loose, brown, gravelly, slightly silty to silty sand, and silt (SP-SM, SM, and ML[1]). Fill below road pavement also includes up to a foot of medium dense, silty gravel base course. Fill may include debris and rubble including boulders, concrete, wood or logs. Fill was observed below the ground surface in all of the soil borings to a depth of about 5 feet, except for B-3 where it was observed to a depth 9.5 feet.

Channel Deposits

Channel deposits include Holocene age sandy alluvial sediments deposited by Coal Creek on the alluvial fan and delta top (including a several-foot-thick layer of coal waste reportedly deposited after failure of a tailings pond dam). The unit also includes sands and gravels that were deposited on the delta front when channel deposits on the upper portion of the delta slumped and slid into deeper water on the delta front.

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[1] Soil Classification per the Unified Soil Classification System (USCS). Refer to ASTM D2488.

Channel deposits consist of very loose to medium dense sand and slightly silty to silty sand (SP, SW, SW-SM, and SM), with some interbeds of very soft silt (ML), and with variable gravel and trace to numerous organic fragments. Channel deposits may include some cobbles and wood or logs.

Lacustrine and Overbank Deposits

The lacustrine (lake) and floodplain overbank deposits unit includes Holocene-age fine-grained sediments deposited in slack-water lake or flooded delta top environments. This unit consists of very soft, nonplastic silt and elastic silt, and clay (ML, MH, and CL) locally interbedded with silty sand (SM) and with trace to numerous organic fragments. Wood and logs may be present in this unit.

This unit is present below fill within the body of the delta complex in generally westward dipping layers ranging from several feet to about 20 feet thick.

Organic-rich Lacustrine Deposits

This unit is composed of organic-rich sediments deposited in the lake and in bogs on the delta. It consists primarily of very soft fine-grained organic silt (OL), fibrous to fine-grained peat (PT), and nonplastic silt (ML). Wood and logs may be present in this unit.

The organic-rich lacustrine unit was observed in all Project borings at a depth of about 12 to 17 feet below ground surface (bgs), except boring B-5. This unit was observed to range from 3 to 15 feet thick. Although not observed at boring B-5, we estimate that organic-rich lacustrine deposits may be present throughout the entire Project area based on the depositional environment.

Recessional Glacial Outwash

Recessional outwash was deposited by glacial meltwaters in the bottom of the glacially eroded trough now occupied by Lake Washington. Most of the recessional deposits have not been fully glacially overridden although some deposits have experienced moderate ice loading. Recessional outwash consists of medium dense to very dense slightly silty sand, silty sand, sand, and silty gravel (SM-SP, SM, SP, and GM). Although not encountered in the borings, recessional outwash often contains cobbles and scattered boulders.

These sediments were encountered in the lower portions of all five boring Project borings at depths ranging from about 55 feet in B-1, shallowing to about 20 feet in B-5. The thickness of this unit is estimated to be over 10 feet in all borings, and at least 25 feet in some locations with deeper borings.

Glacially Overridden Deposits

Undifferentiated soils composed of Vashon glacial deposits and pre-Vashon soils are inferred to lie below recessional outwash deposits. These sediments were consolidated by the weight of thousands of feet of ice, and are typically very dense or hard. The glacially overridden deposits can contain any type of soils, and may contain cobbles and scattered boulders.

None of the Project borings encountered these deposits, but based on nearby borings by others, very dense glacially overridden deposits are present at depths of about 60 to 70 feet bgs in the vicinity of B-1, and at about 15 to 20 feet bgs in borings by others located about 400 feet east of B-5. The top of the glacially overridden deposits unit appears to have considerable relief and consequently, should not be assumed to extend uniformly between the locations where it was encountered.

2.6.2 Engineering Soil Units

The Site soils have been grouped into engineering soil units that are anticipated to exhibit similar engineering properties and strength parameters. The engineering soil units are described in detail below.

Fill

We encountered fill at the ground surface in all of the borings completed for this study. Fill at the culvert sites is interpreted to be about 5 to 9 feet thick and is composed primarily of loose, brown, gravelly, slightly silty to silty sand, and silt (SP-SM, SM, and ML). Fill below road pavement also includes up to a foot of medium dense, silty gravel base course. The presence of fine-grained soil (soil particles passing the No. 200 sieve) makes the fill susceptible to disturbance during construction as it is moisture sensitive.

The fill is anticipated to exhibit low to moderate shear strength, low to moderate compressibility under new loads, and low to moderate permeability.

Very Loose to Loose Sand

Very loose to loose sand, geologically interpreted to be channel and delta slump deposits, underlies the fill. The very loose to loose sand generally consists of very loose to loose, wet, gray or black, sand with variable silt, clay and gravel content (SW, SW-SM, SM, and SC). In some instances, the very loose to loose sand is interbedded with very soft, gray, low-plasticity to nonplastic silt (ML) and layers of sand-size coal fragments that are up to several-feet thick as observed in borings B-1, B-4, and B-5.

The very loose to loose sand is anticipated to exhibit low shear strength, moderate compressibility under new loads, low to moderate permeability, and is susceptible to liquefaction during the design-level earthquake.

Very Soft Silt, Organic Silt, and Peat

The 25 feet of the subsurface profile and beneath the fill is interpreted to be very soft silt, organic silt, and peat, comprised of lacustrine and overbank deposits, and organic-rich lacustrine deposits were typically observed within. In general, this soil unit consists of interlayered and/or interbedded very soft, wet, gray or brown, low-plasticity to nonplastic silt (ML) with variable sand content, organic low-plasticity to nonplastic silt (OL), and fibrous peat (PT).

The very soft silt, organic silt, and peat is anticipated to exhibit very low shear strength, high compressibility under new loads, low permeability, and is susceptible to liquefaction during the design-level earthquake. Because of the organic-rich nature of some zones of this engineering soil unit, long-term settlement occurring over many years is anticipated to occur over the Project area.

Very Soft Clay and Elastic Silt

Very soft clay and elastic silt, geologically interpreted to be lacustrine and overbank deposits, exists at depths greater than 20 feet in Project borings B-1, B-2, and B-3. In general, the soil unit consists of very soft, wet, gray clay (CL) with variable silt and sand content with interbedded soft silt (ML) and loose silty sand (SM), or very soft, wet, light gray elastic silt (MH).

The very soft clay and elastic silt is anticipated to behave as a fine-grained cohesive material that exhibits very low shear strength, high compressibility under new loads, and low permeability.

Medium Dense Sand

Medium dense sand, geologically interpreted to be glacial recessional outwash and channel/delta slump deposits, exists in all of the borings. This soil unit consist of medium dense, wet, gray slightly silty to silty sand (SP-SM, SM) with variable gravel content, and in some instances is interbedded with medium stiff nonplastic silt (ML).

The medium dense sand is anticipated to exhibit moderate shear strength, low compressibility under new loads, moderate to high permeability, and is generally not susceptible to liquefaction.

Dense Sand and Gravel

Dense sand and gravel, geologically interpreted to be recessional glacial outwash deposits, exists in each boring at the depth and elevation shown below in Table 3 below. This engineering soil unit consists of dense to very dense, wet, gray silty sand (SM) with variable gravel content, or silty gravel (GM) with variable sand content. Cobbles within this soil unit were also observed within boring B-5.

The dense sand and gravel is anticipated to exhibit high shear strength, low compressibility under new loads, moderate to high permeability. This material is not susceptible to liquefaction due to its high relative density. The dense sand and gravel soil unit is an excellent material in which to embed pile foundations because it provides relatively high end bearing resistances.

Table 3 – Depth to Dense Sand-and-Gravel Engineering Soil Unit

Soil Boring	Depth to Dense Sand and Gravel (feet bgs)	Elevation (feet)
B-1	60	-34
B-2	55	-27
B-3	54	-24
B-4	25	+16
B-5	25	+19

Notes: Corrected for documented field and sampling procedures.

2.6.3 Groundwater

Lake Washington forms a baseline for the lowest groundwater levels at the Site area. Lake Washington levels fluctuate between about Elevation 16.7 and 18.7. At the five culvert replacement sites, groundwater levels are generally controlled by the level of water in the nearby channel of Lower Coal Creek.

Static groundwater levels were measured in October 2015 when groundwater levels would be near the seasonal low, and again in late May 2016 when groundwater levels would be near the seasonal high. Groundwater level measurements are presented in Table 5

Table 4 – Groundwater Level Measurements

Well	Crossing	Well Casing Elevation	10/14/2015		03/30/2016	
			DTW feet BTOC	GW Elevation	DTW feet BTOC	GW Elevation
B-1	Lower Skagit Key	26.10	7.40	18.70	7.20	18.90
B-2	Newport Key	27.66	5.67	21.99	4.55	23.11
B-3	Glacier Key	30.89	5.96	24.93	5.26	25.63
B-4	Upper Skagit Key	40.20	10.76	29.44	10.42	29.78
B-5	Cascade Key	44.24	7.40	36.84	7.21	37.03

Notes: DTW – Depth to groundwater, BTOC – Below top of PVC casing, GW – Groundwater.

Groundwater was present at depths of about 5 to 7 feet bgs in all borings, roughly equal to the level of water in Coal Creek at the time of measuring; except boring B-4, where groundwater was measured at about 11 feet bgs. However, the groundwater level observed at time of drilling of boring B-4 was 7.0 feet bgs which is close to the level of water in the creek. The discrepancy in static groundwater level measurements of boring B-4 is due to the depth and geologic unit of the screened interval. This well is completed in the recessional glacial outwash unit, and is separated from shallower water-bearing units (the units screened by the other wells) by several beds of low permeability silt and clay. The anomalous depth of groundwater in B-4 indicates that there is a downward gradient of groundwater at the site, and that the deeper water bearing unit is in poor hydraulic continuity with the shallow water bearing units.

Groundwater levels are expected to vary seasonally by several feet with the highest levels occurring in late winter or early spring. Based on the data presented above, we assumed a static groundwater level of 6 feet bgs for our preliminary analyses.

2.7 Engineering Properties

The engineering properties of the subsurface soils were generalized for engineering analyses purposes. The generalized subsurface conditions in the project area and engineering properties used in the analyses are based on the limited subsurface information obtained from the completed explorations, geotechnical laboratory testing and our experience with similar materials.

The generalized engineering soil unit properties and strength parameters used in the geotechnical analyses are shown below in Table 5.

Table 5 – Generalized Engineering Soil Unit Properties and Strength Parameters

Engineering Soil Unit	USCS Classification	Total Unit Weight (pcf)	Effective Friction Angle (degrees)	Cohesion (psf)	Undrained Strength (psf)
Fill	SM	120	30	0	NA
Very Loose to Loose Sand	SW, SW-SM, SM, includes Coal	110	27	0	NA
Very Soft Silt, Organic Silt and Peat	ML (non-plastic), OL, PT	105	14	150	300
Very Soft Clay and Elastic Silt	CL, MH	105	N/A	250	250
Medium Dense Sand	SP-SM, SM	125	34	0	NA
Dense Sand and Gravel	SP	130	36	0	NA

Notes: pcf = pounds per cubic foot; psf = pounds per square foot.

2.8 Seismic Hazards and Design Parameters

We consider earthquake-induced hazards that are relevant to the Project Site to include fault rupture, soil liquefaction, and associated vertical and lateral deformation. The following sections discuss these hazards and the seismic design parameters used to evaluate hazards and recommended for design of the buried structure culverts.

2.8.1 Ground Motion

The AASHTO BDS response spectra for design are based on local seismicity and Site soil conditions. The seismicity is represented by the peak bedrock acceleration (PBA) based on established seismic risk models. The 7-percent probability of exceedance in 75-year design event (approximately 1,000-year recurrence interval) is being considered for this project.

Based on our characterization of the subsurface conditions, and the assumption that the new culvert structures will have a fundamental period of vibration less than 0.5 seconds, Site Class E should be assigned for the culvert replacement sites. The recommended seismic design parameters are shown below in Table 6.

Table 6 – Ground Motion Parameters

Design Parameter	Recommended Value
Site Class	E
Peak Ground Acceleration (PGA)	0.44g (Site Class B)
Short Period Spectral Acceleration (S_s)	0.98g (Site Class B)
1-Second Period Spectral Acceleration (S_1)	0.33g (Site Class B)
Site Coefficient F_{pga}	0.90 (Site Class E)
Site Coefficient F_a	0.93 (Site Class E)
Site Coefficient F_v	2.70 (Site Class E)
Acceleration Coefficient (A_s)	0.40g (Site Class E)
Design Short Period Spectral Acceleration (SD_s)	0.91g (Site Class D)
Design 1-Second Period Spectral Acceleration (SD_1)	0.89g (Site Class D)

Surficial Fault Rupture

No areas of known surficial ground rupture have been identified in the Site area.

Liquefaction and Related Effects

Liquefaction occurs when loose, saturated, and relatively cohesionless soil deposits temporarily lose strength as a result of earthquake shaking. Primary factors controlling the development of liquefaction include intensity and duration of strong ground motion, characteristics of subsurface soil, *in-situ* stress conditions and the depth to groundwater. Potential effects of soil liquefaction include temporary loss of shear strength, liquefaction-induced settlement, and sand boils, any of which could result in significant structural damage and/or distortion of the roadway approaches and creek channel.

Liquefaction evaluations were conducted with the aid of WSLiq, a liquefaction analysis software program that was created as part of an extended research project supported by WSDOT and authored by Steve Kramer (2008). The evaluations are based on the data collect from soil borings B-1 through B-5 for this Project.

We evaluated liquefaction potential based on the design event as summarized in Table 7. The design level event is based on the USGS National Seismic Hazard Map data to obtain the PBA and earthquake magnitude. The Peak Ground Acceleration (PGA) was determined by adjust the PBA using the methods recommended in AASHTO LRFD, and assuming Site Class E.

Table 7 – Design Level Earthquake Parameters

Seismic Event Return Period (years)	As, Site Adjusted Peak Ground Acceleration (g)	Earthquake Magnitude(1)	Mean Source-to-Site Distance (km)(1)
1,000	0.40	6.99	37.3

Notes:1) Based on USGS Probabilistic Seismic Hazard Deaggregation.

The analyses performed indicate that liquefaction of the saturated fill, very loose to loose sand, very soft silt, organic silt, and peat, engineering soil units, located below the groundwater level is anticipated to occur beneath all five culvert locations during the design seismic event.

Table 8 below presents the depths below ground surface and elevations over which liquefaction is anticipated to occur, and the estimate ground surface liquefaction-induced settlement.

Table 8 – Liquefaction Susceptibility Summary

Culvert Replacement Identification	Estimated Depth Ranges of Liquefaction (bgs feet)	Estimated Liquefaction Total Settlement (inches)
Lower Skagit Key	6-22 40-55	12 to 13
Newport Key	6-21 25-35 45-50	6 to 12
Glacier Key	6-35 50-55	9 to 12
Upper Skagit Key	6-22	3 to 8
Cascade Key	6-20	3 to 8

Liquefaction-induced ground settlement will cause drag loads on pile foundation shafts (discussed more in Section 3.4 and 3.5), will distort the roadway surface potentially to the extent that it is not drivable, and may cause movement and sloughing of the creek banks upstream and downstream of the culvert, and fill the creek channel with material.

Seismically induced lateral spreading and flow failures characterized as vertical and horizontal ground deformations on the order of inches to feet towards Lake Washington (the west) and Coal Creek is anticipated to occur throughout the Newport Shores neighborhood. We anticipate the deformations will result in significant damage to utilities, roadways, existing structures and residences, and will exert additional loads on the culvert structures and foundations that will need to be further analyzed and quantified during final design.

3 Conclusions and Recommendations

3.1 General

In our opinion, the proposed project is feasible from a geotechnical perspective. The following sections present the results of our engineering analyses and recommendations. Applicable sections of the AASHTO LRFD BDS (AASHTO, 2012) and WSDOT BDM (WSDOT, 2015) were utilized in our evaluations and analyses.

The following recommendations are for earthwork, bridge foundation support, and other pertinent geotechnical design issues.

3.2 Culvert Foundations

Foundation design and selection for the proposed culverts must consider the design loads, subsurface conditions, constructability, construction impacts (nearby structures, infrastructure, and habitat), settlement performance, and cost.

As part of the Tetra Tech team, Aspect provided preliminary geotechnical design recommendations to inform preferred culvert foundation design and construction concept selection. In general, the foundation concepts considered included grade-supported mat and spread foundations constructed in the wet (with no excavation dewatering) or in the dry (with dewatering as needed, or excavation above the groundwater table), considering both open-cut and shored excavations, and pile-supported options. Details, schematics, advantages, and disadvantages of the top-four alternative concepts identified by the Tetra Tech team are presented in the memorandum authored by Tetra Tech (2015) with input from Aspect titled, *Lower Coal Creek Culvert Replacement Alternative Concepts*, which is included as an attachment in the main Tetra Tech pre-design report.

In general, grade-supported mat and spread foundation options were determined by the design team and the City to provide inadequate settlement performance due to placement of new foundations loads over very soft and highly compressible soil, and liquefaction of saturated soils underlying the foundations. Construction of some of the grade-supported options were also proposed to include robust and expensive sheet pile shoring and dewatering. Options to complete significant excavation dewatering during culvert construction was determined too risky by the design team and the City because it could result in drawdown of the groundwater level and settlement of the compressible soils around the Site resulting in damage to nearby utilities and structures.

The alternative concept recommended by the Tetra Tech team is to support the culverts using pile foundations embedded into the dense sand and gravel (bearing layer) beneath the weak compressible and liquefiable soils. Pile foundations will provide suitable vertical and lateral support, and they can be constructed from a working surface above groundwater, which will significantly reduce impacts on the neighborhood related to excavations, dewatering, and related drawdown settlement. We initially considered a number of alternative pile foundation types. Presented below are details of two preferred alternatives identified by the project design team during preliminary design for the purpose of conceptualizing design and cost estimating: driven steel closed-end pipe piles and helical piles. Detailed design may include these alternatives, as well as drilled shaft foundations.

3.3 Driven Piles

Driven steel closed-end pipe piles consist of a steel pipe with a closed bottom that is driven through the subsurface and into the bearing layer with an impact or vibratory hammer. The pipe is then filled with a reinforcing cage and structural concrete. The pipe pile develops its total axial resistance from end bearing resistance in the bearing layer and side friction along the pile surface. Typically, pipe piles range in diameter from 12 to 24 inches with a 0.375- to 0.500-inch wall thickness, but can be larger.

Vibration from pile driving could result in perceived damage (such as settlement) to nearby residential structures or utilities that are founded on the very soft, sensitive Site soils. Means to mitigate vibrations during pipe pile installation will include initially setting the piles with a high-frequency/low-amplitude vibratory hammer as deep as practical into soft/loose ground, and then advancing the piles to final tip elevation with an impact hammer. During pile driving, vibration monitoring devices can be employed to measure and record the peak particle velocities at key locations. Because pile driving vibrations attenuate rapidly with distance, it is our opinion that the risk of vibration-induced settlement damage to adjacent private properties, is relatively low. Such risk can be effectively managed by implementing preconstruction-condition surveys of selected structures and properties. The preconstruction survey will document baseline conditions (such as preexisting cracks in pavements, foundations, and drywall; any tight doorway/window openings; and surveyed ground elevations at key locations.). Post construction surveys can be completed as needed if claims or damage are made. We recommend 18-inch-diameter closed-end steel pipe piles filled with structural concrete to support these culverts.

3.3.1 Driven Pile Axial Resistance

Axial pile resistance analyses were completed for driven, closed-end 18-inch-diameter, steel pipe piles in accordance with AASHTO BDS guidelines.

We recommend the piles be driven/installed at least 5 feet into the dense sand-and-gravel soil engineering unit. The depth and elevation of the dense sand-and-gravel engineering soil unit is shown in Table 3. Depending on the structural design and resistance requirements, piles may need to be driven/installed deeper than the minimum pile-tip depth to develop the required geotechnical resistance. Actual pile depths will need to be evaluated in the field through a combination of installation observation and dynamic or static load testing, as appropriate.

The results of our axial resistance analyses are presented as nominal (ultimate) resistances for both bearing (compression) and uplift (tension) for a single driven pile. The estimated nominal resistances are shown on Figures D-1 through D-5 in Appendix D for the five culvert replacement sites. The computed nominal axial resistances are applicable to piles with a minimum spacing of 2.5-pile diameters, we should be consulted to consider group effects if pile spacing is less than 2.5-pile diameters.

The recommended Resistance Factors are shown in Table 9 and can be used in conjunction with Figures D-1 through D-5 to determine estimated strength, service, and extreme limit state geotechnical resistances at various driven pile embedment depths. Estimating the strength, service and extreme limit state resistances should take into account the effects of the predicted liquefaction and downdrag (DD) loads shown in the notes of Figures D-1 through D-5 and described below in Section 3.3.2 – *Driven Pile Downdrag*.

It is important to understand that the nominal resistances shown on Figures D-1 through D-5 are *estimates* based on static analysis methods, and pile resistance should be confirmed by field observations made during driving.

Table 9 – Recommended Resistance Factors for Driven Pile Design

	Resistance Factor, ϕ		
Limit State	Bearing Resistance, ϕ_{stat}[1]	Bearing Resistance, ϕ_{dyn}[2],	Uplift, ϕ_{up}
Strength	0.45	0.50(3)/ 0.55(4)	0.35
Service	1.0	1.0	1.0
Extreme	1.0	1.0	0.8

Notes:

1) Applies to nominal resistance as determined by static analysis methods (see Figures D-1 through D-5).
2) Applies to nominal resistance as determined by dynamic analysis methods during pile driving.
3) Assumes wave equation analysis without pile dynamic measurements or load test but with field confirmation of hammer performance.
4) Assumes the WSDOT driving formula will be used as the basis for the dynamic analysis and pile driving construction control.

3.3.2 Driven Pile Downdrag (DD)

Estimation of the service, strength and extreme limit states resistances should take into account the effects of the unfactored negative DD loading presented on Figure D-1 through D-5 along the pile shaft due to long-term compression and settlement of the organic-rich silt and peat for the Strength and Service limit states, and liquefaction induced-settlement for the Extreme limit state.

We recommend a load factor (γp_{DD}) of 1.05 be applied to the DD load. The recommended ultimate DD loads apply to the pile shaft, and assume piles are driven below the predicted zone of long-term compression or liquefaction-induced settlement.

3.4 Driven Pile Installation and Testing Considerations

Our borings and geologic interpretations indicate that impediments to pile driving, such as logs or other debris, and layers of medium dense sand and gravel soils may be present in the subsurface. It is possible that an obstruction may be encountered that will preclude a pile from being driven to tip elevation at its design location. However, this risk is relatively low in our opinion. In our experience, fitting the piles with externally-flush conical driving tips will improve the likelihood that a pile will deflect or break up an obstruction. We also recommend the foundation design allow flexibility to enable adjustment of pile locations, if needed.

To reduce the risk of vibration damage to nearby utilities and structures, piles should be initially set as deep as practical with a vibratory hammer, before switching to an impact hammer to drive them to bearing capacity and minimum tip elevation.

Selection of the appropriate impact hammer will depend on the pile size and sections selected for use on the project, the contractor’s methods, and other factors. Prior to driving any piles, the contractor should submit details of the proposed pile driving system and driving criteria that can conservatively meet the required ultimate bearing capacities while preventing pile damage and minimizing vibration. The proposed pile driving system and driving criteria should meet the minimum requirements as presented in Section 6-05 of the WSDOT Standard Specifications (WSDOT, 2016).

A wave equation analysis of piles (WEAP) should be generated to guide the selection of properly sized driving equipment to ensure the selected pile section can be driven to the required resistance without damaging the pile. A WEAP analysis will also provide for a minimum penetration rate required for the pile to sufficiently develop the required resistance.

We recommend that one production pile per culvert replacement site be driven as a test pile in accordance with WSDOT Standard Specifications Section 6-05.3(10), so that field conditions, dynamic testing, and pile-driving acceptance criteria can be developed. The owner’s geotechnical engineer (not the contractor) should monitor and evaluate test pile driving, and develop acceptance criteria for the remaining production piles (WSDOT, 2016).

We recommend a detailed topographic and photographic survey of the utilities and structures (including residences) around the culvert site be completed prior to commencing pile driving, and after pile driving is completed. Pile driving should be monitored on a real-time basis using vibration detection equipment to observe and assess vibrations being transmitted off-site and toward existing utilities and structures.

3.5 Helical Piles

Helical piles consist of a large-diameter steel helical tip (typically 12 to 24 inches in diameter) structurally connected to a small-diameter, high-strength steel shaft (typically 5 to 8 inches in diameter). A wide variety of sizes and configurations of helical piles are available. The large-diameter helical-tip section is screwed into the ground with a hydraulic drill mounted to a large excavator by applying torque and downward force to the pile shaft. The helical tip is embedded beneath the settlement-prone and liquefiable Site soils and generates large end-bearing resistance in the underlying dense sand-and-gravel engineering soil unit (depth to dense sand and gravel shown in Table 3).

Compared to driven steel pipe piles with a uniform shaft and tip diameter, relatively lower DD forces from long-term settlement of organic-rich soil and liquefaction induced-settlement are realized along the relatively narrow helical pile shafts. In ideal conditions, helical pile installation results in minimal vibration compared to driven steel pipe piles. However, potential obstructions such as logs and medium-dense granular layers, will be difficult to penetrate with helical piles, and may require down-hole percussion-hammer tooling to aid in advancing the pile.

Helical pile design methodology is not currently described in the AASHTO BDS (AASHTO, 2014). In that regard, helical piles are a less-conventional pile-supported alternative than concrete-filled steel pipe piles. We based on our preliminary approach to helical pile analysis and recommendations based on Section 10.6 of the AASHTO BDS with guidance and technical reports provided by local helical pile vendor American Pile Driving Equipment (APE). If helical piles are utilized, we recommend that the contractor be responsible for detailed pile design, based on proprietary knowledge of equipment and products.

3.5.1 Helical Pile Axial Resistance

We recommend helical pile tips be embedded about 5 feet in to the dense sand-and-gravel engineering soil unit. The depth and elevation of the dense sand-and-gravel engineering soil unit is shown in Table 3. Axial pile resistance analyses were completed for two common helical pile configurations:

- 5.5- x 16-inch: a 5.5-inch-diameter pile shaft with a 0.4 inch wall thickness and a single 16-inch-diameter helical tip.
- 7.6- x 18-inch: a 7.6-inch-diameter pile shaft with a 0.5 inch wall thickness and a single 18-inch-diameter helical tip.

We calculated the estimated helical pile nominal bearing resistance using the Nordlund/Thurman Method (Hannigan et al., 2005). The calculated nominal bearing resistances were reduced by 20 percent based on design guidance provided by APE. Positive side-friction resistance along the pile shaft was conservatively ignored. The results of our axial resistance analyses are presented as estimated nominal (ultimate) bearing resistances for both bearing for a single helical pile for all five culvert replacements sites are shown below in Table 10.

Table 10 – Estimated Nominal Bearing Resistances

Helical Pile Configuration	Nominal Bearing Resistance (kips)
5.5” X 16”	170
7.6” X 18”	215

Based on our discussions with APE, estimated nominal uplift resistances can be estimated to be about 75 percent of the nominal bearing resistances shown in Table 10.

It is important to understand that the nominal resistances shown in Table 10 are *estimates* based on static analysis methods with input and experience from helical pile vendor and designer American Pile Driving Equipment (APE). Pile resistance should be confirmed by field observations made during installation and subsequent load testing.

The estimated nominal axial resistances are applicable to piles with a minimum spacing of 2.5-helical-tip diameters. Aspect should be consulted to consider group effects if pile spacing is less than this.

The recommended preliminary Resistance Factors are shown in Table 10 and can be used in conjunction with Table 11, below, to determine estimated strength, service, and extreme limit state geotechnical resistances.

Table 11 – Preliminary Resistance Factors for Helical Pile Design

Limit State	Resistance Factor, ϕ		
	Bearing Resistance, $\phi_{stat}^{(1)}$	Bearing Resistance, ϕ_{dyn}	Uplift, ϕ_{up}
Strength	0.45	$0.50^{(2)}$	$0.35^{(1)}/0.50^{(2)}$
Service	1.0	1.0	1.0
Extreme	1.0	1.0	0.8

Notes:

1) Applies to nominal resistance as determined by static analysis methods presented in Table 10.
2) Applies to ultimate resistance as determined successful static load test (ϕ_{dyn} = 0.65) of at least one pile per culvert replacement site and soil condition at the pile tip.

3.5.2 *Helical Pile Downdrag (DD)*

Estimation of the service and strength limit states resistances should take into account the effects of the unfactored negative DD loading presented in Table 12, along the helical pile shaft due to long-term compression and settlement of the organic-rich silt and peat.

Estimation of the extreme limit state resistances should take into account the effects of the unfactored DD loading present in Table 13 along the pile shaft due to liquefaction-induced settlement.

DD load calculations were completed utilizing the Beta Method detailed in the AASHTO BDS (AASHTO, 2014).

Table 12 – Service and Strength Limit States Downdrag Loads

Culvert Replacement Identification	Downdrag Load (DD) Resulting from Long-Term Settlement (kips)	
	5.5” X 16” Helical Pile	7.6” X 18” Helical Pile
Lower Skagit Key	9	13
Newport Key	7	9
Glacier Key	11	16
Upper Skagit Key	7	10
Cascade Key	7	10

Table 13 – Extreme Limit State Downdrag Loads

Culvert Replacement Identification	Downdrag Load (DD) Resulting from Liquefaction-Induced Settlement (kip)	
	5.5” X 16” Pile	7.6” X 18" Pile
Lower Skagit Key	15	21
Newport Key	19	26
Glacier Key	20	27
Upper Skagit Key	3	4
Cascade Key	3	4

3.5.3 Helical Pile Installation and Testing

Helical pile installation and resistance verification testing should be monitored on a full-time basis is to verify the piles are installed in accordance with our recommendations, and to provide recommendations for design changes should conditions revealed during construction differ from those anticipated.

All pile installation operations should be observed by the Project geotechnical engineer, or his representative, experienced in the design and observation of deep foundation installations.

The subsurface conditions contain potential obstructions to helical pile advancement, such as logs and layers of medium-dense sand and gravel soils. Such conditions are risky for successful helical pile installation. We understand from our discussion with APE that downhole tools, such as percussion hammers, can be utilized downhole through the helical piles shaft to obliterate or advance past obstructions. However, the deployment of such equipment will be expensive, time-consuming, and will cause minor vibrations.

A minimum of one test helical pile per culvert replacement site should be installed, and have the axial resistance verified by completing a full-scale load test of a test pile in general accordance with American Society for Testing and Materials (ASTM) Standard D1143 using the Quick Load Test Procedure.

3.6 Lateral Pile Resistance

The very soft and loose consistency/density of the upper portion of the subsurface profile is anticipated to contribute relatively low levels of lateral pile resistance. Lateral soil resistance will be greater in the deeper, medium dense to dense sand and gravel soil units.

For preliminary planning and cost estimating for the Glacier Key culvert location, we recommend the lateral soil parameter shown below in Table 14 and Table 15 (attached at end of text) be used in lateral pile analysis for the static/inertial and post-inertial/liquefied scenarios, respectively. Detailed lateral soil parameters should be developed for each culvert location during culvert design.

Group interaction effects should be taken into account where piles are installed with a center-to-center spacing of five pile diameters in accordance with Table 10.7.2.4-1 of the AASHTO BDS (AASHTO, 2014).

External lateral loading from liquefaction-induced lateral spreading and/or flow failure (both modes of lateral soil displacement) on abutment walls and pile shaft are function of many factors including soil type, depth, and pile diameter and can be detailed further for each culvert location during final design.

3.7 Scour Protection

We understand the design team is planning to resist scour by installing shallow sheet piles beneath and structurally connected to the pile cap.

3.8 Corrosion Protection

The Site presents a moderately to aggressively corrosive environment. Steel exposed above grade will be subject to corrosion and degradation over time. We recommend that all steel foundation and wall elements be appropriately protected from corrosion (epoxy coating or equivalent) to a minimum of 5 feet below the finish grades. Alternatively, the foundation and wall elements can be oversized to accommodate future corrosion.

3.9 Culvert Abutment and Wing Walls Considerations

We understand the culvert abutment walls may be up to 6 feet tall (exposed) and will be constructed above the groundwater level. We assume lateral loads that occur parallel to the roadway and culvert will be transmitted through the culvert lid or girders and utilize the passive earth pressure support against the opposite abutment wall for resistance. Under the configurations described above, the lateral earth pressures acting behind the culvert abutments should be considered to be restrained, at-rest earth pressures. The lateral earth pressures for preliminary design of culvert abutment walls, including seismic and surcharge pressures, are presented in Table 16.

Imported abutment backfill materials should consist of material meeting the requirements of Gravel Backfill for Walls (Section 9-03.12(2) of the WSDOT Standard Specifications) within about 12 to 18 inches of the wall. A suitable culvert abutment drainage system should be incorporated into the design to prevent buildup of hydrostatic pressure.

We understand that grade transitions at the culvert ends may be accomplished using slopes with robust scour protection or relatively short wing walls. Wing walls may be pile supported and/or structurally connected to the culvert structure. Aspect is available to assist Tetra Tech during final design by providing lateral earth pressures and lateral pile resistances based on the configuration of the wing walls as needed.

3.9.1 Lateral Earth Pressures

The recommended lateral earth pressures for use in design of the culvert abutments and wing walls assume some granular structural fill will be imported and placed as a horizontal backfill between the walls and the onsite fill and the loose sand soils located within the upper 6 to 7 feet of the subsurface profile.

Table 16 – Culvert Abutment Wall Lateral Earth Pressure Parameters

Earth Pressure Condition	Earth Pressure Coefficient	Equivalent Fluid Weight$^{(1)}$ (pcf)	Earth Pressure$^{(2)}$ (psf)	Surcharge Pressure (psf)
Active (K_a)$^{(3)}$	0.33	40	40H	0.33S$^{(8)}$
At-Rest (K_o)	0.50	60	60H	0.50S$^{(8)}$
Passive (K_p)$^{(4)}$	3.00	250$^{(5)}$ 125 (submerged)	330D$^{(5),(6),(7)}$	-
Active Seismic (K_{ae})$^{(9)}$	0.47	-	9H	-
At-Rest Seismic (K_{ae})$^{(10)}$	0.70	-	22H	-

Notes:

1) Assumes granular backfill placed as structural fill with a unit weight of about 125 pcf is assumed.
2) Static earth pressures result in a triangular pressure distribution along the height of the abutment wall. Seismic earth pressures result in a uniform pressure distribution along the height of the abutment wall.
3) To invoke the active conditions, the wall must rotate about the base with a lateral movement at the top of the abutment wall of approximately 0.002H, where H is the height of the abutment wall. Active conditions will not develop against the box culvert walls, but could potentially develop along un-restrained wing walls.
4) To invoke the passive conditions, the wall must move into the backfill with a lateral movement of approximately 0.01H.
5) Nominal passive pressures are presented; a strength limit state resistance factor (ϕ_{ep}) of 0.50 should be applied for design.
6) Where D is the depth of embedment of wall below finish grade.
7) Passive pressure should be ignored within 18 inches below finish grade.
8) Resulting uniform surcharge acting along the height of the wall, where S is the surcharge pressure.
9) The seismic pressures were calculated in accordance with Chapter 11 and Appendix A11.1.1.1 of the AASHTO LRFD Bridge Specifications using the design earthquake parameters shown in Table 6 and 7, and multiplying the horizontal acceleration coefficient by 0.5 as recommended by Section 11.6.5.2 of the AASHTO BDS.
10) The at-rest seismic pressure was calculated by multiplying the horizontal acceleration coefficient by 1.0 as recommended by Section 11.6.5.4 of the AASHTO BDS.

Seismic and surcharge pressures are typically not considered concurrently in design, unless specific conditions dictate otherwise.

Live load surcharge (LS) from vehicular loading should be taken as a uniform load of 140 pounds per square foot (psf) acting against the culvert abutments walls.

Lateral forces that may be induced on the pile caps due to unique surcharge loads, such as heavy construction equipment, should be considered on a case-by-case basis by the structural engineer.

Over-compaction of the backfill behind walls should be avoided. We recommend compacting backfill behind walls to approximately 90 percent of maximum dry density

(MDD) as determined by ASTM D1557 (Modified Proctor). Heavy compactors and large pieces of construction equipment should not operate within 5 feet of any embedded wall to avoid the buildup of excessive lateral pressures. Compaction close to the walls should be accomplished using hand-operated vibratory plate compactors.

3.10 Culvert Roadway Approaches

We understand that the culvert roadway approaches are not planned to be raised significantly above their current elevation. Due to the compressible nature of portions of the subsurface profile, we anticipate some settlement will occur along the culvert roadway approaches due to incidental grading and backfilling (replacing excavated site soils with heavier compacted structural fill) around the culvert structure and long-term (over many years) settlement due to the organic-rich nature of some of the subsurface soils throughout the Newport Shores neighborhood.

We anticipate some differential settlement, on the order of a few inches, may occur at the interface between the pile-supported culvert structure and the roadway approaches. Some of this will be attributable to incidental grading and backfill, and will occur within a few weeks after culvert structure construction and grading is complete. Delaying paving, to the extent possible after culvert construction and earthwork, will mitigate this to some degree. However, differential settlements resulting from long-term compression of organic-rich soils will continue long after construction. One method to mitigate long term settlement, is to utilize articulating approach slabs at the culvert structure and roadway approach interface.

3.11 Siphons and Manhole Structures

Stormwater siphons are planned at Newport Key and Glacier Key. These structures will essentially consist of precast concrete structures on either side of the stream and interconnected by 12- to 24-inch-diameter drain pipes, which will be buried below the stream. We understand the pipe invert depths will be around 12 to 15 feet below grade; manhole structures will be about 2 feet deeper. With groundwater at a design depth of 6 feet below the existing roadway grade, these excavations will extend significantly below groundwater.

It is understood that the City prefers to avoid construction dewatering if possible on this project. In our opinion, these siphon structures can be constructed in the wet (without dewatering); preliminary conclusions and recommendations are provided in this regard.

In our opinion, it will be possible to construct a rectangular-shaped cofferdam using interlocking steel sheet piles. The cofferdam would be located/sized so as to include the two manhole structures and the connecting siphon. Sheet piles would be vibrated down to tip elevation below manhole bottom elevations. Then a few feet of existing soil within the rectangular enclosure would be removed (but still above groundwater), and an internal perimeter bracing system (using back-to-back channel sections or I-beams) would be welded to the inside faces of the sheet piles. Excavations would then continue in the wet down to pipe invert and manhole bottom elevation.

Because organic silt and peat exists at the manhole bottom and pipe invert elevation, it will be necessary to subexcavate some of this material and replace it using quarry spalls.

We suggest a 2-foot-minimum thickness of 2- to 4-inch spalls be placed below the precast concrete manhole structures; and a chocking/leveling course of finer 2-inch clear crushed rock should be placed over the spalls. The manhole structure would then be placed onto this prepared foundation.

After the two structures have been placed, the siphon pipe would be placed onto a prepared foundation/bedding layer. We believe it would be possible to place the siphon pipe in a single, approximately 25-foot, length.

A challenge we perceive to constructing these structures in the wet will be the pipe-to-structure connections. We recommend consultation with a specialty contractor to explore this in greater detail.

Because the soft organic-rich soil underlying both of the siphon structures is susceptible to long-term secondary compression and biodegradation settlement, the siphon system will need to be designed and constructed to be tolerant of differential and total settlements. Ductile iron or HDPE pipe material should be considered.

Also, the manhole structures will need to be designed to counteract upward buoyancy forces. Use of an expanded base is one common method for such structures.

3.12 Earthwork

Based on the explorations performed on-Site and our understanding of the proposed Project, it is our opinion that basic excavation and grading can generally be completed with standard construction equipment. Shallow groundwater conditions and very soft/loose soils will require planning, careful excavation strategies, and reduced excavation side-slope inclinations.

Appropriate erosion control measures should be implemented prior to beginning earthwork activities in accordance with the City’s Best Management Practices (BMPs).

3.12.1 Temporary Excavation Slopes

Maintenance of safe working conditions, including temporary excavation stability, is the responsibility of the Contractor. All temporary cuts in excess of 4 feet in height that are not protected by trench boxes or otherwise shored, should be sloped in accordance with Part N of Washington Administrative Code (WAC) 296-155 (WAC, 2009).

In general, the material soils across the Site classify as Occupational Safety and Health Administration (OSHA) Soil Classification Type C. Temporary excavation side slopes are anticipated to stand no steeper than 1½H:1V (Horizontal:Vertical). The cut-slope inclinations should be considered preliminary estimates at this stage and may require additional shallowing of side-slope angle based on field observations during construction.

With time and the presence of seepage and/or precipitation, the stability of temporary unsupported cut slopes can be significantly reduced. Therefore, all temporary slopes should be protected from erosion by installing a surface water diversion ditch or berm at the top of the slope. In addition, the contractor should monitor the stability of the temporary cut slopes, and adjust the construction schedule and slope inclination accordingly. Vibrations created by traffic and construction equipment may cause caving and raveling of the temporary slopes. In such an event, lateral support for the temporary slopes should be provided by the contractor to prevent loss of ground support.

3.13 Structural Fill

In general, suitable structural fill material for the Project is fill placed within 3 percent of its optimum moisture content per the ASTM D1557 (modified Proctor test) and does not contain deleterious materials, greater than 5 percent organics, or particles larger than 3 inches in diameter. Structural fill should be placed and compacted to at least 95 percent MDD as determined by test method ASTM D1557.

In general, the on-Site soils generally have a high fines content that cause them to be very moisture sensitive and difficult to compact and maintain stability in wet conditions. We also observed the on-Site soils contain variable amounts of coal fragments and organic material that is not suitable for structural fill. In our opinion, the on-Site soils should not be considered for reuse as structural fill for these reasons, and import of structural fill should be assumed.

We recommend using import material meeting the criteria for Gravel Borrow as specified in Section 9-03.14(1) of the WSDOT Standard Specifications. Class A Gravel Backfill for Foundations as specified in Section 9-03.12(1)A of the WSDOT Standard Specifications should be used for base rock underneath structures. Crushed Surfacing Base Course as specified in Section 9-03.9(3) of the WSDOT Standard Specifications should be used as base rock for reestablishing the gravel roadway.

The procedure to achieve the specified minimum relative compaction depends on the size and type of compacting equipment, the number of passes, the thickness of the layer being compacted, and certain soil properties. When size of the excavation restricts the use of heavy equipment, smaller equipment can be used, but the soil must be placed in thin enough lifts to achieve the required compaction. A sufficient number of in-place density tests should be performed as the fill is placed to verify the required relative compaction is being achieved. The frequency of the in-place density testing can be determined at the time of final design when more details of the Project grading and backfilling plans are available.

3.13.1 Structural Fill Around Utilities

Structural fill materials placed directly below (bedding), around, and above (cover) utility pipes should consist of Gravel Backfill for Pipe Zone Bedding as described in Section 9.03.12(3) of the WSDOT Standard Specifications (WSDOT, 2016). The pipe bedding materials should be placed and compacted to a relatively firm condition in accordance with the pipe manufacturer’s specifications. Utility pipe bedding and cover should be at least 6 and 12 inches thick, respectively. We recommend Bank Run Gravel for Trench Backfill Section 9.03.19 of the WSDOT Standard Specifications (WSDOT, 2016) be used above the utility cover materials to backfill the utility trench excavations.

Structural fill above the pipe cover materials up to the ground surface should be compacted to at least 95 percent MDD as determined by ASTM D1557. Within a lateral distance of 3 feet of any wall, smaller, possibly hand-operated equipment should be used in conjunction with thinner soil lifts to achieve the required compaction so as not to damage the structure.

Care should be taken not to damage the utility during placement and compaction of structural fill including limiting use of large, dynamic compaction equipment until at least 2 feet of structural fill has been placed over the top of the utility.

4 Closing

This investigation and report was completed for preliminary design. The engineering analyses completed for this study were done so with careful consideration of the existing and available Site data while making reasonable assumptions about Site conditions not fully detailed or addressed by existing data. Depending upon the selected final design and methods of construction, it may be necessary to complete additional data collection for final design. Aspect is available to provide additional data collection that may be required, and provide final design and construction observation services.

5 References

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6 Limitations

Work for this project was performed for Tetra Tech and the City of Bellevue (Client), and this report was prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. This report does not represent a legal opinion. No other warranty, expressed or implied, is made.

This report is issued with the understanding that it is the responsibility of Tetra Tech to ensure that the information and recommendations contained herein are brought to the attention of the appropriate design team personnel and ultimately incorporated into the Project final design, plans, and specifications.

All reports prepared by Aspect Consulting for the Client apply only to the services described in the Agreement(s) with the Client. Any use or reuse by any party other than the Client is at the sole risk of that party, and without liability to Aspect Consulting. Aspect Consulting’s original files/reports shall govern in the event of any dispute regarding the content of electronic documents furnished to others.

TABLES

Table 14 - Recommended Soil Parameters for Use in LPILE Software: Static and Inertial Loading Cases

Project No. 140362 - Lower Coal Creek Flood Hazard Reduction Project, Bellevue, WA

Soil Layer	**Elevation Range (ft)**	**Depth Range (ft)** below pile head	**LPile Soil Type (p-y model)**	**Effective Unit Weight, γ' (pcf)**	**Cohesion, c (psf)**	**Friction Angle, φ (deg)**	**p-y Modulus, k (pci)**	**Strain Factor, ε_{50}**	**Soil resistance, p (lbs/in)**
Very Loose to Loose Sand	25 – 19	0 – 5	Sand (Reese)	47.6	-	28	10	-	-
Very Soft Silt, Organic Silt and Peat	19 – 12	5 – 12	Sand (Reese)	42.6	-	20	5	-	-
Very Loose to Loose Sand	12 – 9	12 – 15	Sand (Reese)	47.6	-	28	10	-	-
Very Soft Silt, Organic Silt and Peat	9 – 5	15 – 19	Sand (Reese)	42.6	-	20	5	-	-
Very Loose to Loose Sand	5 – -3	19 – 26	Sand (Reese)	47.6	-	28	10	-	-
Very Soft Clay and Elastic Silt	-3 – -8	26 – 31	Soft Clay (Matlock)	42.6	250	-	-	0.02	-
Medium Dense Sand	-8 – -13	31 – 36	Sand (Reese)	62.6	-	34	60	-	-
Very Soft Clay and Elastic Silt	-13 – -18	36 – 41	Soft Clay (Matlock)	42.6	250	-	-	0.02	-
Very Loose to Loose Sand	-18 – -23	41 – 46	Sand (Reese)	47.6	-	28	10	-	-
Dense Sand and Gravel	-23 – -33	46 – 76	Sand (Reese)	67.6	-	38	125	-	-

Table 15 - Recommended Soil Parameters for Use in LPILE Software: Post-inertial Liquefaction Case

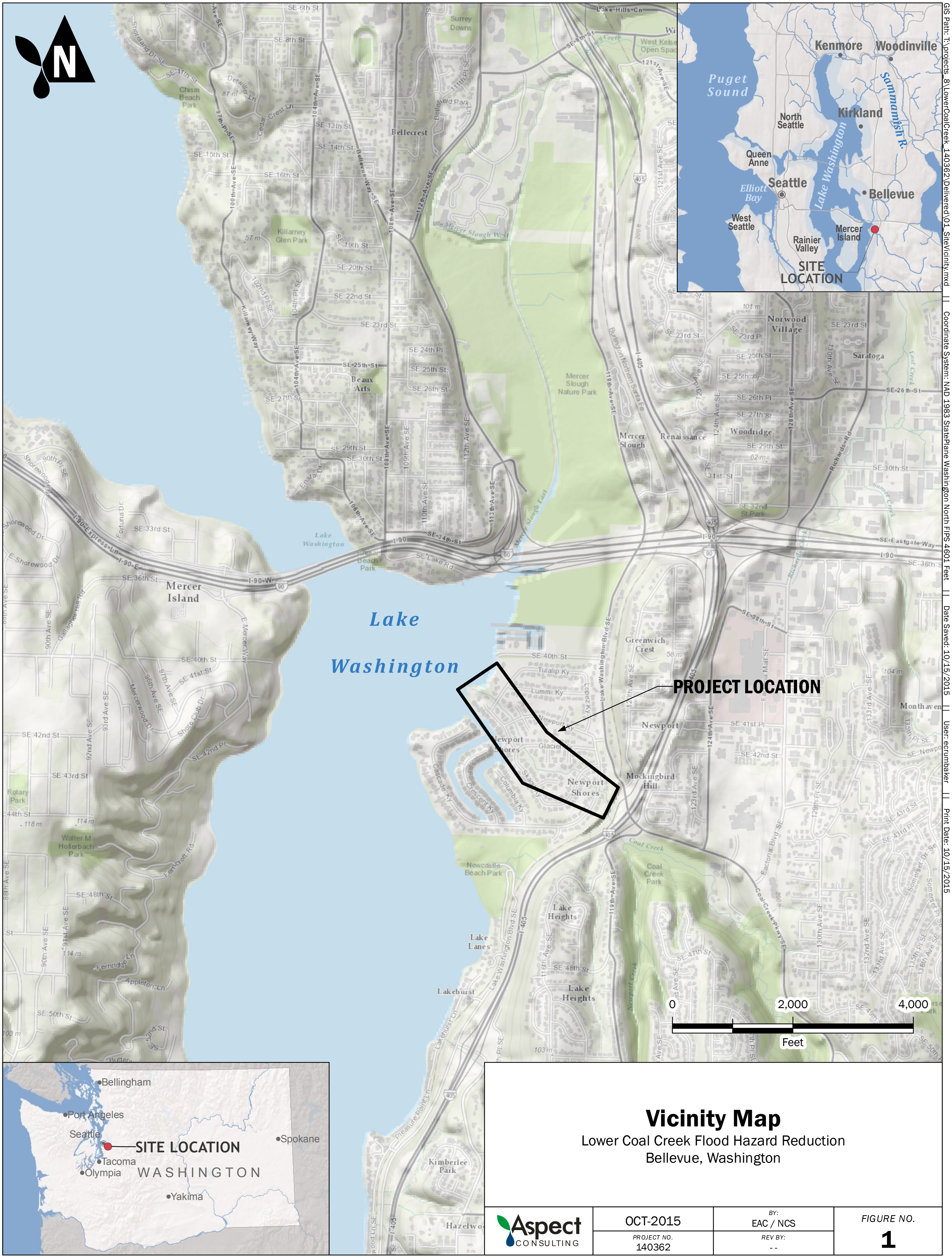
Project No. 140362 - Lower Coal Creek Flood Hazard Reduction Project, Bellevue, WA

Soil Layer	**Elevation Range (ft)**	**Depth Range (ft)** from top of pile	**LPile Soil Type (p-y model)**	**Effective Unit Weight, γ' (pcf)**	**Cohesion, c (psf)**	**Friction Angle, φ (deg)**	**p-y Modulus, k (pci)**	**Strain Factor, ε_{50}**	**Soil resistance, p (lbs/in)**
Very Loose to Loose Sand[2]	25 – 19	0 – 5	User Input p-y Curves	47.6	-	-	-	-	0.1
Very Soft Silt, Organic Silt and Peat[2]	19 – 12	5 – 12	User Input p-y Curves	42.6	-	-	-	-	0.1
Very Loose to Loose Sand[2]	12 – 9	12 – 15	User Input p-y Curves	47.6	-	-	-	-	0.1
Very Soft Silt, Organic Silt and Peat[1]	9 – 5	15 – 19	Liquefied Sand (Rollins)	42.6	-	-	-	-	-
Very Loose to Loose Sand[1]	5 – -3	19 – 26	Liquefied Sand (Rollins)	47.6	-	-	-	-	-
Very Soft Clay and Elastic Silt	-3 – -8	26 – 31	Soft Clay (Matlock)	42.6	250	-	-	0.02	-
Medium Dense Sand	-8 – -13	31 – 36	Sand (Reese)	62.6	-	34	60	-	-
Very Soft Clay and Elastic Silt	-13 – -18	36 – 41	Soft Clay (Matlock)	42.6	250	-	-	0.02	-
Very Loose to Loose Sand[1]	-18 – -23	41 – 46	Liquefied Sand (Rollins)	47.6	-	-	-	-	-
Dense Sand and Gravel	-23 – -33	46 – 76	Sand (Reese)	67.6	-	38	125	-	-

[1] - Liquefied without lateral flow toward creek channel

[2] - Liquefied with lateral flow toward the creek channel

FIGURES



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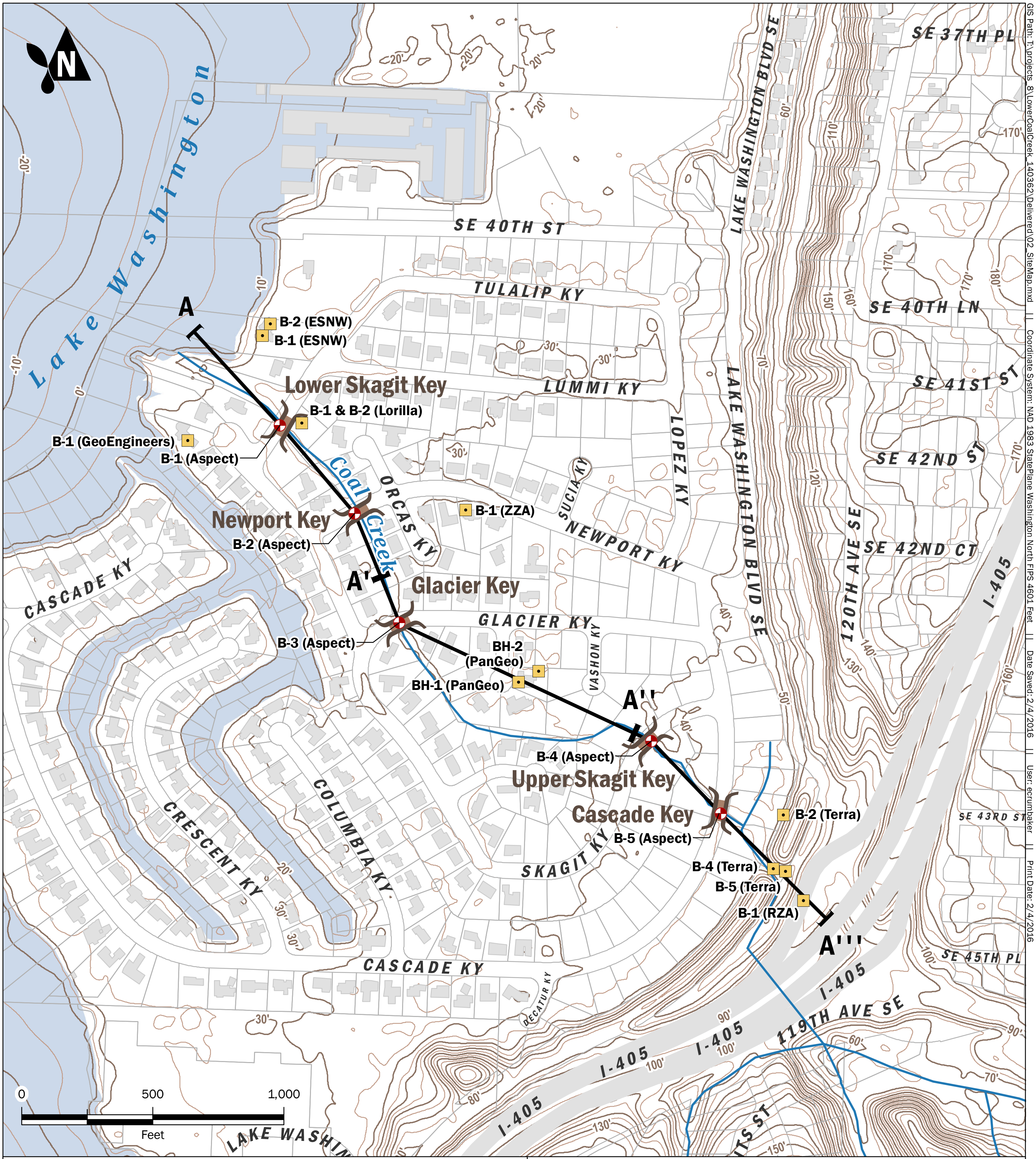
Vicinity Map

Lower Coal Creek Flood Hazard Reduction
Bellevue, Washington

Aspect CONSULTING

OCT-2015	BY: EAC / NCS	FIGURE NO.	
PROJECT NO. 140362	REV BY: - -	1	



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Culvert Replacement

Soil Boring by Aspect Consulting

Soil Boring by Others (Company Name)

Subsurface Cross Sections

10-ft LiDAR Contour

5-ft LiDAR Contour

Parcels

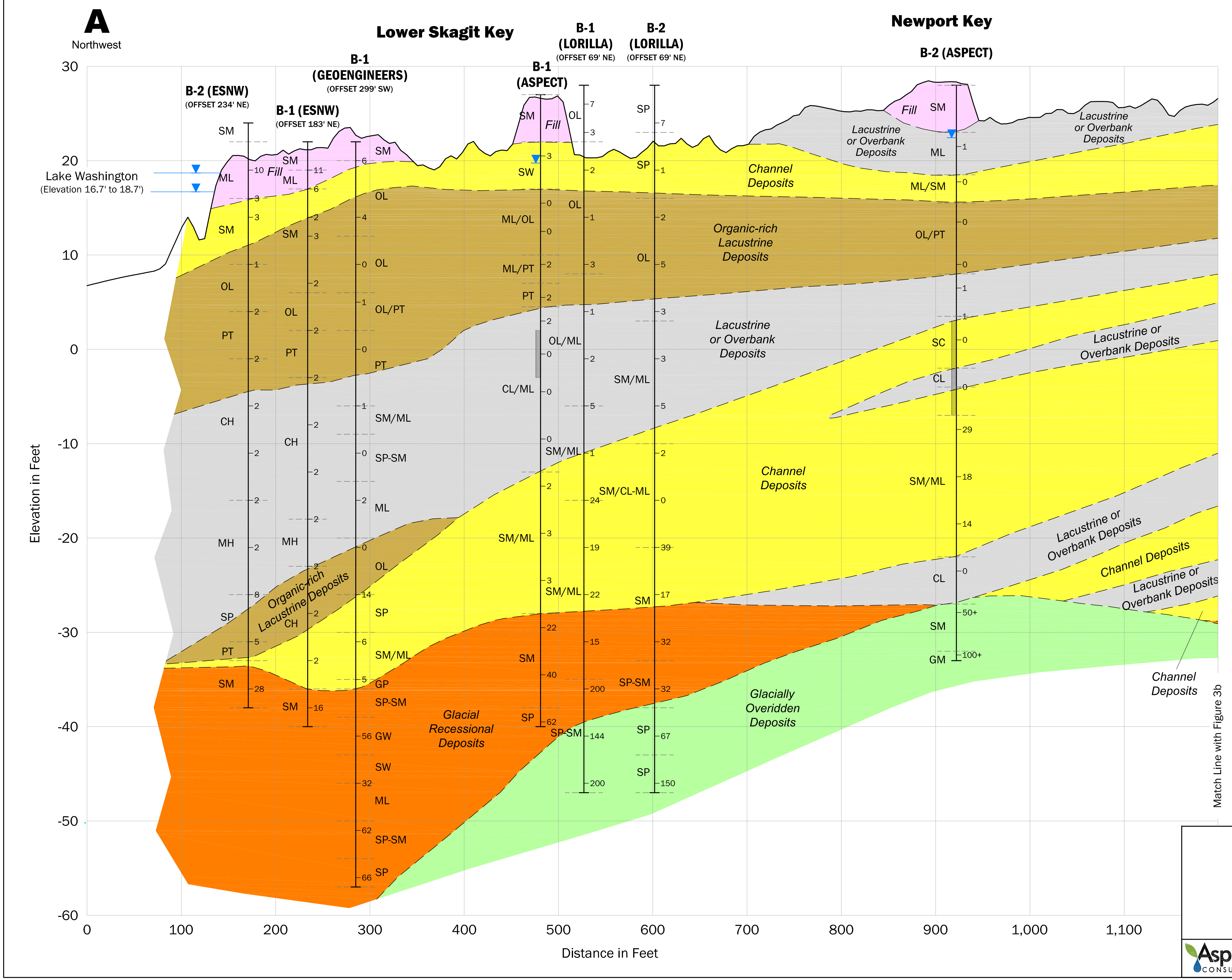
Building

Site and Exploration Map

Lower Coal Creek Flood Hazard Reduction
Bellevue, Washington

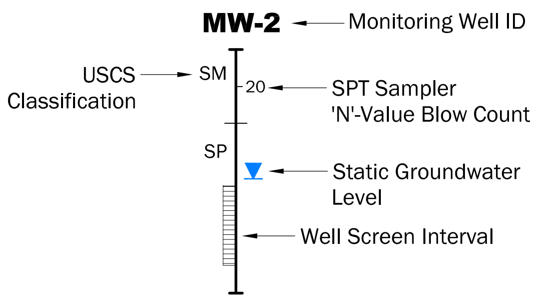
Aspect CONSULTING

FEB-2016	BY: EAC / NCS	FIGURE NO. 2
PROJECT NO. 140362	REVISED BY: ---	



Engineering Geologic Units

🟪	Fill - Man-placed or modified soils; primarily loose silty sand and silt.
🟨	Channel Deposits - Holocene alluvial fan and deltaic deposits; very loose to medium dense sand to silty sand, and coal waste.
🟫	Organic-Rich Lacustrine Deposits - Holocene lake and bog sediments; very soft organic silt and peat.
⬜	Lacustrine or Overbank Deposits - Holocene lake and low energy floodplain sediments; very soft silt and clay.
🟧	Glacial Recessional Deposits - Latest Pleistocene recessional glacial deposits; medium dense to very dense sand to silty sand, and silty gravel.
🟩	Glacially Overridden Deposits - Pleistocene glacially consolidated soils, undifferentiated; very dense/hard.



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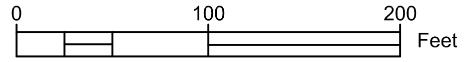
Vertical Scale: 1" = 10'
Vertical Exaggeration 10x



Geologic Cross-Section A-A'

Lower Coal Creek Flood Hazard Reduction
Bellevue, Washington

Aspect CONSULTING

Oct-2016	BY: NCS/SCC	FIGURE NO. 3a
PROJECT NO. 140362	REVISED BY: -	

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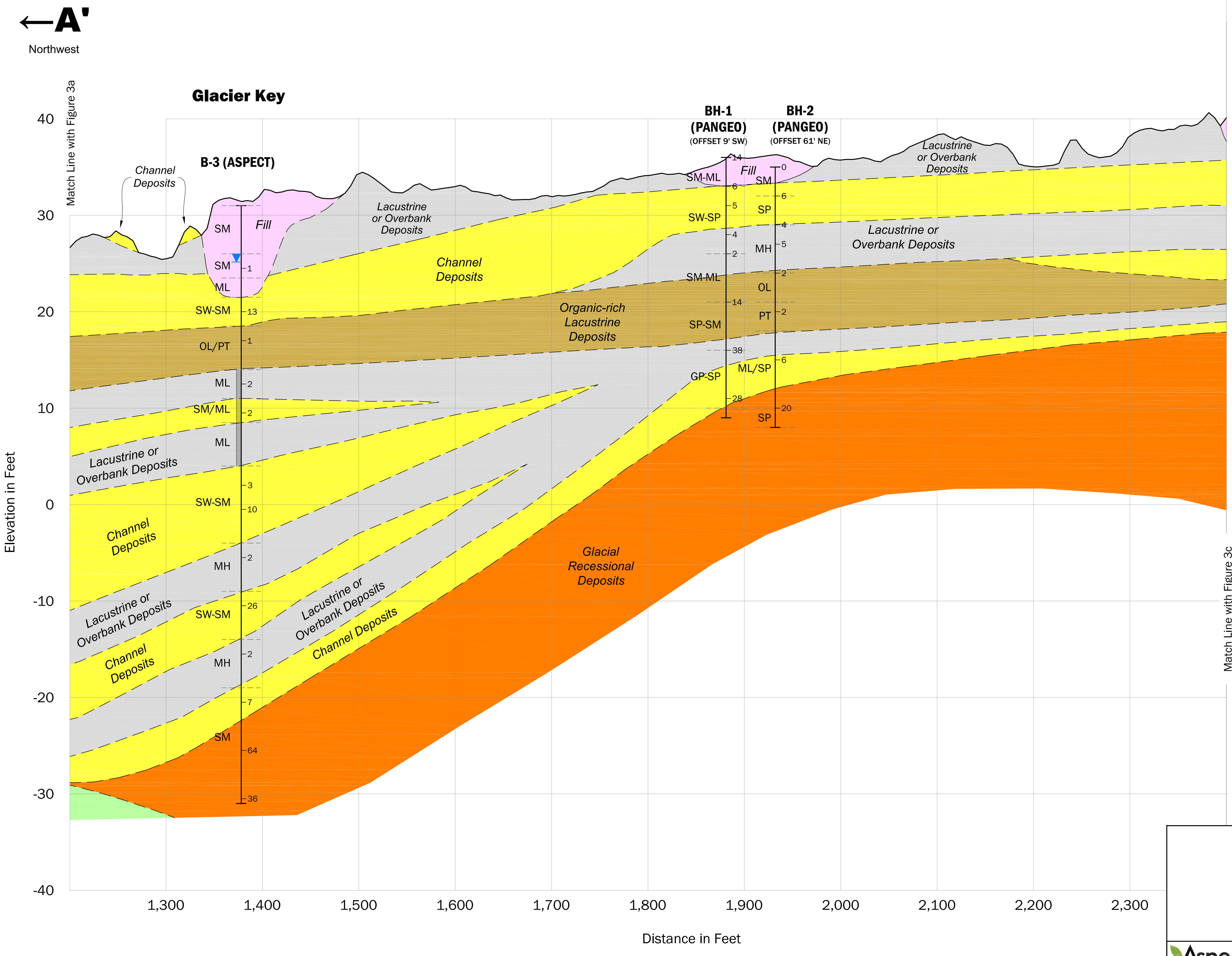
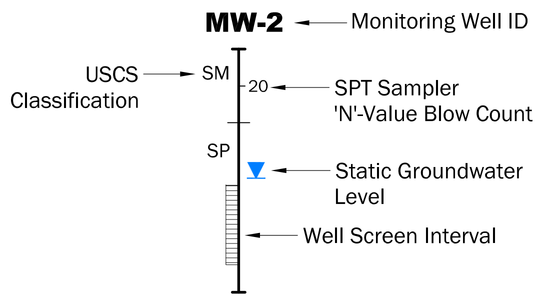


Engineering Geologic Units

🟪	Fill - Man-placed or modified soils; primarily loose silty sand and silt.
🟨	Channel Deposits - Holocene alluvial fan and deltaic deposits; very loose to medium dense sand to silty sand, and coal waste.
🟫	Organic-Rich Lacustrine Deposits - Holocene lake and bog sediments; very soft organic silt and peat.
⬜	Lacustrine or Overbank Deposits - Holocene lake and low energy floodplain sediments; very soft silt and clay.
🟧	Glacial Recessional Deposits - Latest Pleistocene recessional glacial deposits; medium dense to very dense sand to silty sand, and silty gravel.
🟩	Glacially Overridden Deposits - Pleistocene glacially consolidated soils, undifferentiated; very dense/hard.



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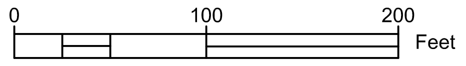

Geologic Cross-Section A'-A"

Lower Coal Creek Flood Hazard Reduction
Bellevue, Washington

Aspect CONSULTING

Oct-2016	BY: NCS/SCC	FIGURE NO. 3b
PROJECT NO. 140362	REVISED BY: -	

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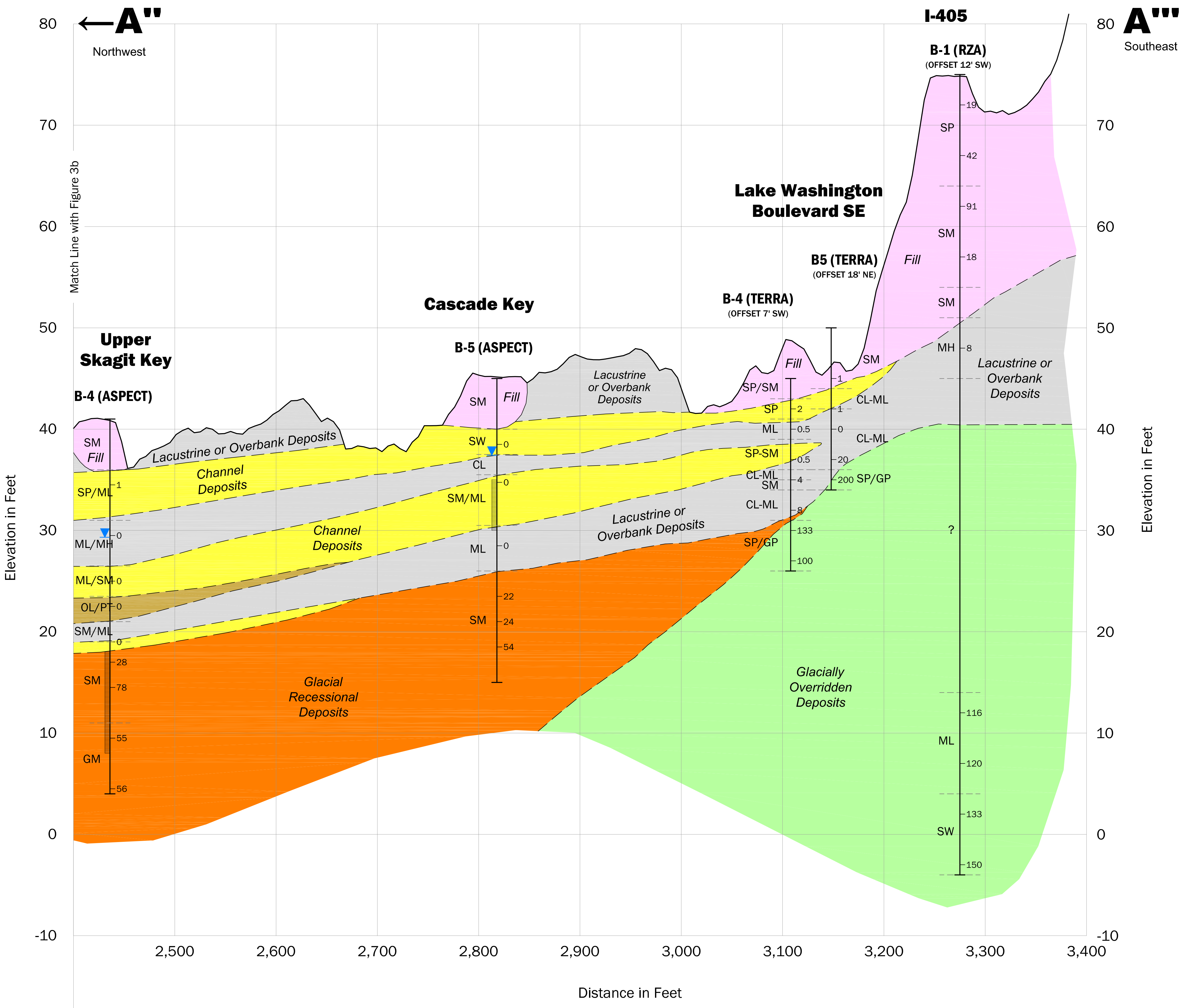
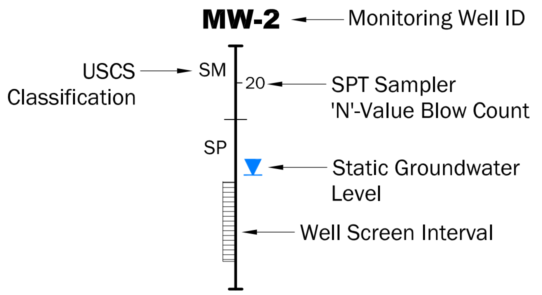


Engineering Geologic Units

🟪	Fill - Man-placed or modified soils; primarily loose silty sand and silt.
🟨	Channel Deposits - Holocene alluvial fan and deltaic deposits; very loose to medium dense sand to silty sand, and coal waste.
🟫	Organic-Rich Lacustrine Deposits - Holocene lake and bog sediments; very soft organic silt and peat.
⬜	Lacustrine or Overbank Deposits - Holocene lake and low energy floodplain sediments; very soft silt and clay.
🟧	Glacial Recessional Deposits - Latest Pleistocene recessional glacial deposits; medium dense to very dense sand to silty sand, and silty gravel.
🟩	Glacially Overridden Deposits - Pleistocene glacially consolidated soils, undifferentiated; very dense/hard.



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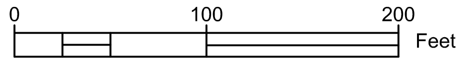
Vertical Exaggeration 10x



Geologic Cross-Section A"-A"'

Lower Coal Creek Flood Hazard Reduction
Bellevue, Washington

Aspect CONSULTING

Oct-2016	BY: NCS/SCC	FIGURE NO.
PROJECT NO. 140362	REVISED BY: -	3c

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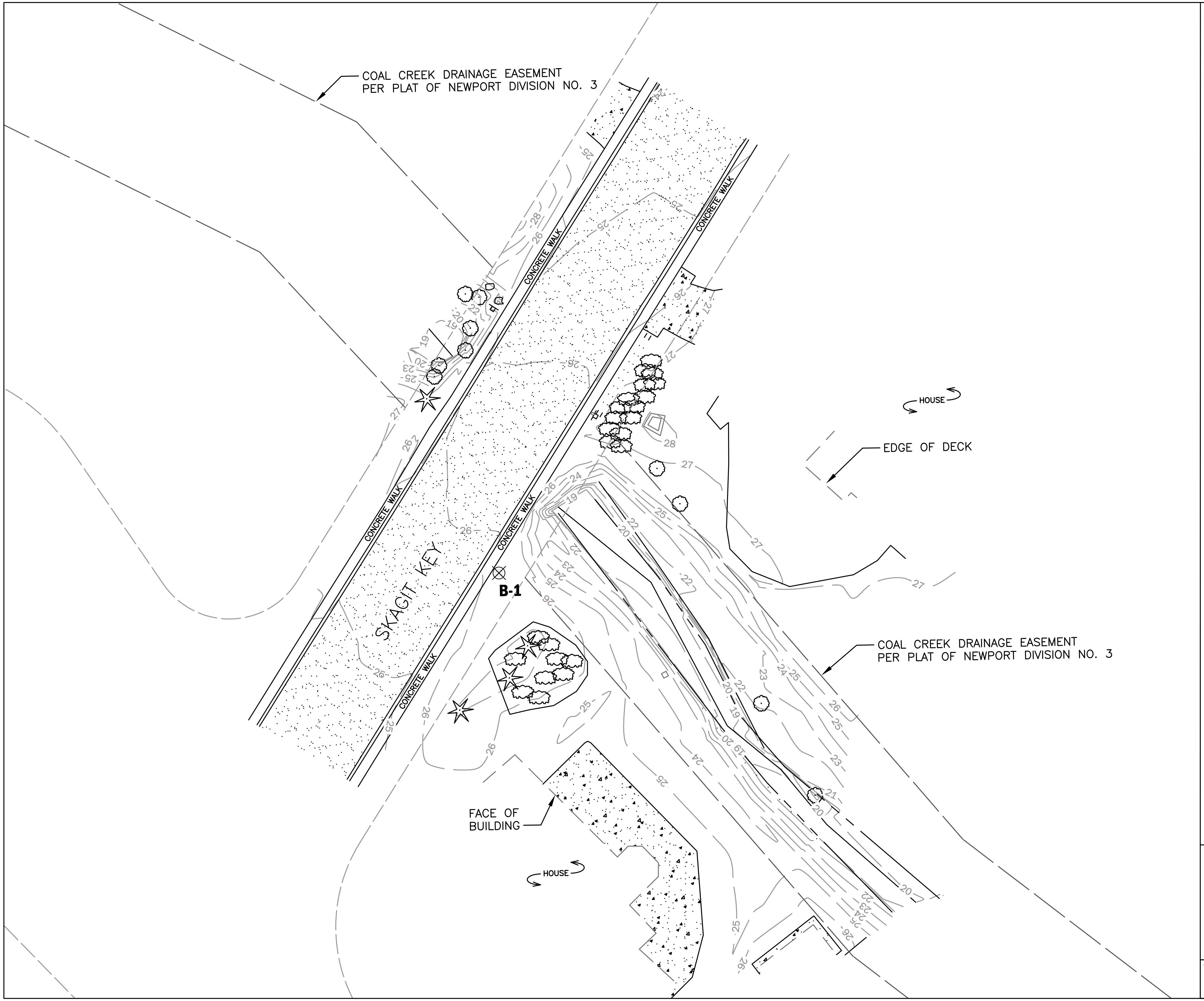


⊠ SOIL BORING BY ASPECT CONSULTING

0 30 60 Feet

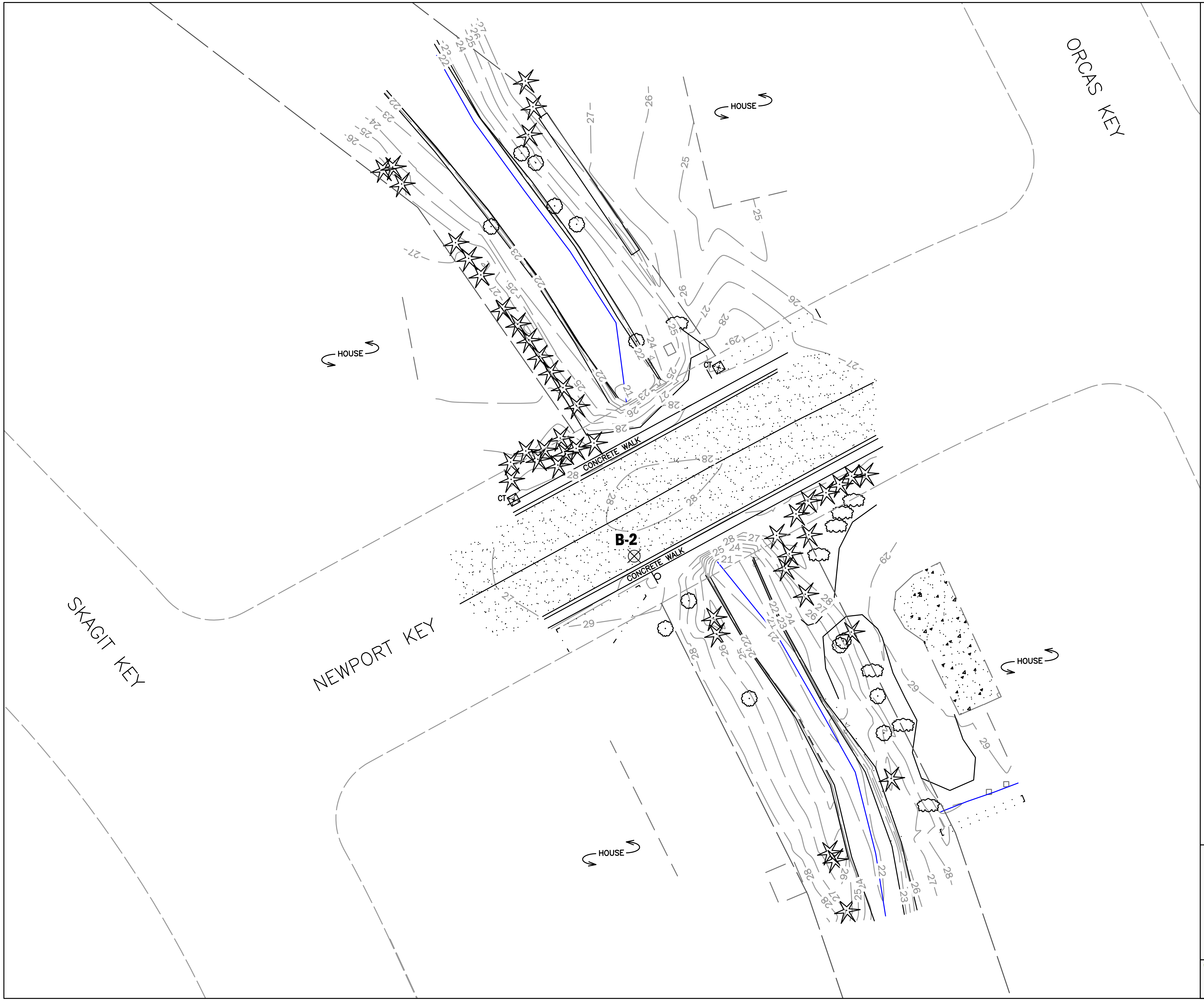
BASE MAP PROVIDED BY TETRA TECH.

Site Exploration Plan
Lower Skagit Key

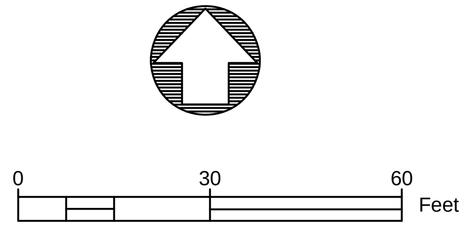
Lower Coal Creek Flood Hazard Reduction
Bellevue, Washington

Aspect CONSULTING	JUN-2016	BY: NCS/SCC	FIGURE NO.
	PROJECT NO. 140362	REVISED BY: -	4

CAD Path: Q:\Lower Coal Creek\140362 LCC Flood Hazard Reduction\2015-12 Site Exploration Maps\140362-03 Site Exploration Plans.dwg Lower Skagit Key || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Jun 07, 2016 11:26am || User: scudd



⊠ SOIL BORING BY ASPECT CONSULTING



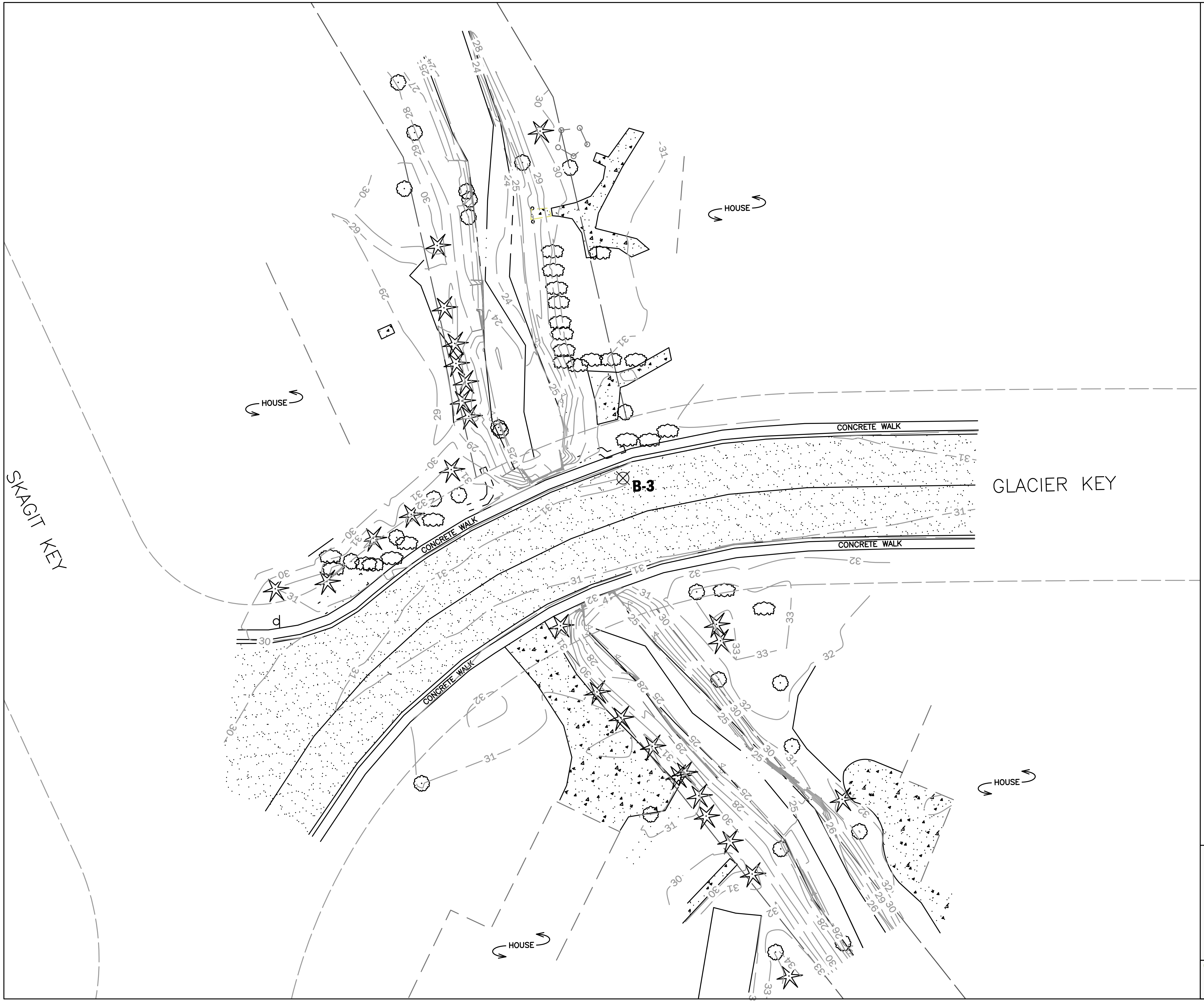
BASE MAP PROVIDED BY TETRA TECH.

Site Exploration Plan
Newport Key

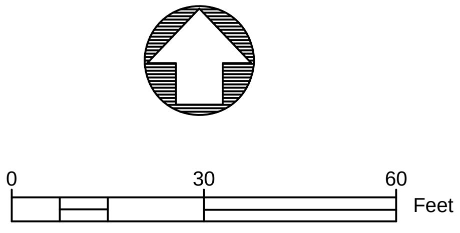
Lower Coal Creek Flood Hazard Reduction
Bellevue, Washington

Aspect CONSULTING	JUN-2016	BY: NCS/SCC	FIGURE NO.
	PROJECT NO. 140362	REVISED BY: -	5

CAD Path: Q:\Lower Coal Creek\140362 LCC Flood Hazard Reduction\2015-12 Site Exploration Maps\140362-03 Site Exploration Plans.dwg Newport Key || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Jun 07, 2016 11:26am || User: scudd



⊗ SOIL BORING BY ASPECT CONSULTING



BASE MAP PROVIDED BY TETRA TECH.

Site Exploration Plan
Glacier Key

Lower Coal Creek Flood Hazard Reduction
Bellevue, Washington

Aspect CONSULTING

JUN-2016	BY: NCS/SCC	FIGURE NO.	
PROJECT NO. 140362	REVISED BY: -	6	

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⊠ SOIL BORING BY ASPECT CONSULTING

0 30 60 Feet

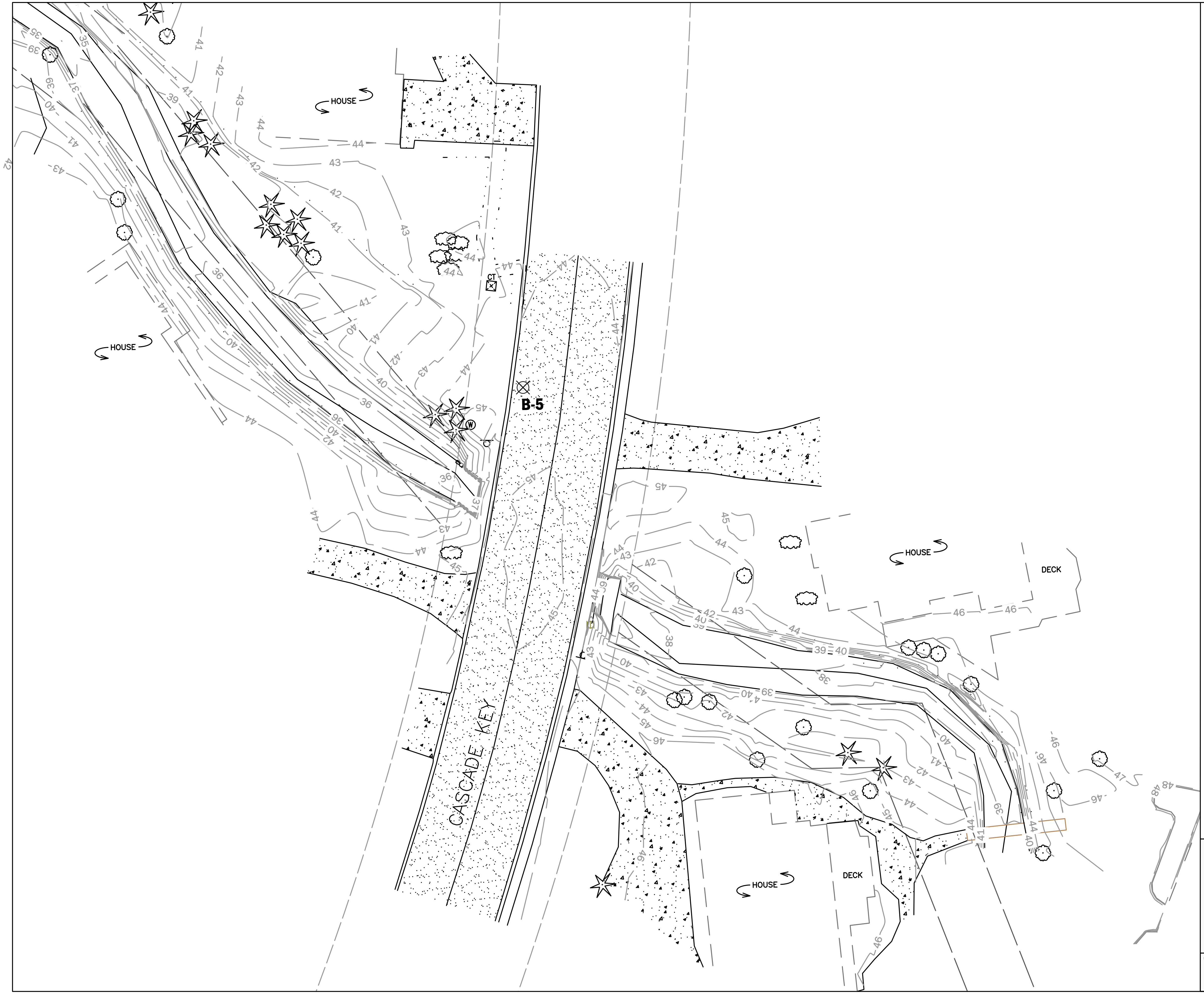
BASE MAP PROVIDED BY TETRA TECH.

Site Exploration Plan
Upper Skagit Key

Lower Coal Creek Flood Hazard Reduction
Bellevue, Washington

Aspect CONSULTING	JUN-2016	BY: NCS/SCC	FIGURE NO.
	PROJECT NO. 140362	REVISED BY: -	7

CAD Path: Q:\Lower Coal Creek\140362 LCC Flood Hazard Reduction\2015-12 Site Exploration Maps\140362-03 Site Exploration Plans.dwg Upper Skagit Key || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Jun 07, 2016 11:29am || User: scudd



⊠ SOIL BORING BY ASPECT CONSULTING

BASE MAP PROVIDED BY TETRA TECH.

Site Exploration Plan
Cascade Key

Lower Coal Creek Flood Hazard Reduction
Bellevue, Washington

Aspect CONSULTING	JUN-2016 PROJECT NO. 140362	BY: NCS/SCC REVISED BY: -	FIGURE NO. 8

CAD Path: Q:\Lower Coal Creek\140362 LCC Flood Hazard Reduction\2015-12 Site Exploration Maps\140362-03 Site Exploration Plans.dwg Cascade Key || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Jun 07, 2016 11:30am || User: scudd

APPENDIX A

Soil Boring Logs

A. Soil Borings

A.1 General

Under subcontract to Aspect Consulting, Gregory Drilling advanced five soil borings (B-1 through B-5) using a truck-mounted CME 85 drill rig. The soil borings were completed to depths ranging from 30.0 to 66.5 feet below existing ground surface. The soil borings were completed between October 5 and October 8, 2015. The locations of the soil borings are shown on Figure 2, *Site and Exploration Map.*

A.2 Soil Borings

All soil borings were drilled with mud-rotary drilling techniques. The mud-rotary method consists of advancing a tri-cone bit with drilling mud (a bentonite slurry). The drill rig rotates the tri-cone bit and applies downward pressure to advance the borehole; the mud is used to cool the bit, to wash the soil cuttings from the borehole, and to maintain borehole stability. The drilling mud is pumped down the interior of the drill rods and out through the bit at the bottom of the hole. The drilling mud carries soil cuttings up the annular space between the drill rods and the borehole wall to the mud tub at the surface. Cuttings carried by the drilling mud are screened out or allowed to settle out in the mud tub and the drilling mud is recirculated back down the borehole.

The borings were continuously monitored by an Aspect geologist who classified the soils encountered, collected representative soil samples, observed groundwater conditions, and generated a detailed exploration log for each soil boring. The logs of the soil borings are presented on Figures A-2 to A-6.

A.2.1 Soil Sampling Procedures

Disturbed and relatively undisturbed soil samples were collected from the boreholes. The soil descriptions used in the boring logs use the Unified Soil Classification System (USCS), as defined in American Society for Testing and Materials (ASTM) D2488, for identification of soil types. Description of soils was performed in general accordance with the ASTM method. Terminology used in soil descriptions is presented on Figure A-1.

Disturbed Samples

Soil samples were generally collected from each borehole at 2.5-foot and 5-foot intervals using the Standard Penetration Test (SPT) method in general accordance with ASTM D1586. The samples were collected by driving a 2-inch-outside-diameter, split-barrel sampler 18 inches, or to a maximum SPT blowcount of 50 per 6 inches of driving, into the soil with a 140-pound automatic hammer falling 30 inches. The number of blows of the hammer required to drive the sampler each 6 inches was recorded. After performing the SPT, the sampler was retrieved to the surface and opened, and the soil was observed and described. The soil sample was then removed from the sampler, placed in a labelled, water-tight jar or bag, and submitted for analysis.

Relatively Undisturbed Samples

Relatively undisturbed soil samples were collected in general accordance with ASTM D1587 method, at selected depths where fine-grained, cohesive soils were encountered in the borings. Samples were collected by slowly, steadily pushing a 3-inch-diameter by 24-inch-long, thin-walled steel tube (Shelby Tube) into the ground using the drill rig sampling rods and hydraulics. After several minutes, the sampler was retrieved to the surface, immediately capped with plastic end caps and sealed with tape, then labelled and submitted for analysis.

A.3 Monitoring Wells

A geologist from Aspect observed the installation of monitoring wells in soil borings B-1 through B-5. The monitoring wells were constructed using 2-inch-diameter polyvinyl chloride (PVC) casing. The depth to which the well casing and screen was installed was based on our understanding of the subsurface conditions at the time of drilling and the Project objectives. The screened length of the well consists of 0.01-inch slotted PVC pipe surround by a 10x20 sand pack. The borehole above the well screen was backfilled with bentonite chips and a flush mount monument set into concrete at the ground surface. The well construction is shown on the boring logs Figures A-2 through A-6.

A.4 Groundwater Measurements

The depth to groundwater was recorded and the time of drilling (ATD) and was measured in monitoring wells using a water sounding tape. The ATD and monitoring well groundwater measurements are shown on Figures A-2 through A-6.

A.5 Monitoring Well Slug Testing

Single-well aquifer (“slug”) tests were performed in each of the five wells installed by Aspect. The protocol for the tests was as follows:

1. The static water level in the well was measured and recorded, and a data-logging pressure transducer was installed in the well.
2. A “slug” (solid CPVC rod 1.25 inches diameter by 60 inches long) was quickly lowered into the well until it was completely submerged. At the same time, the data logger was started.
3. The water level in the well was monitored and when it had returned to within 0.05 feet of the level before the slug was introduced, the data logger was stopped.
4. The slug was quickly removed from the well and the data logger was restarted. When the water level returned to within 0.05 feet, the data logger was stopped.
5. This process was repeated at least once at each of the five wells.

The water level data collected from the slug tests were analyzed using Bouwer & Rice methods (Bouwer & Rice, 1976) to estimate the hydraulic conductivity of the formation at each well. Aspect used the geometric mean of these results to infer the hydraulic conductivity of the overall formation at the Site.

Coarse-Grained Soils - More than 50% (1) Retained on No. 200 Sieve	Gravels - More than 50% (1) of Coarse Fraction Retained on No. 4 Sieve	≤5% Fines (5)	GW	Well-graded gravel and gravel with sand, little to no fines
			GP	Poorly-graded gravel and gravel with sand, little to no fines
		≥15% Fines (5)	GM	Silty gravel and silty gravel with sand
			GC	Clayey gravel and clayey gravel with sand
	Sands - 50% (1) or More of Coarse Fraction Passes No. 4 Sieve	≤5% Fines (5)	SW	Well-graded sand and sand with gravel, little to no fines
			SP	Poorly-graded sand and sand with gravel, little to no fines
		≥15% Fines (5)	SM	Silty sand and silty sand with gravel
			SC	Clayey sand and clayey sand with gravel
Fine-Grained Soils - 50% (1) or More Passes No. 200 Sieve	Silts and Clays Liquid Limit Less than 50		ML	Silt, sandy silt, gravelly silt, silt with sand or gravel
			CL	Clay of low to medium plasticity; silty, sandy, or gravelly clay, lean clay
			OL	Organic clay or silt of low plasticity
	Silts and Clays Liquid Limit 50 or More		MH	Elastic silt, clayey silt, silt with micaceous or diatomaceous fine sand or silt
			CH	Clay of high plasticity, sandy or gravelly clay, fat clay with sand or gravel
			OH	Organic clay or silt of medium to high plasticity
Highly Organic Soils			PT	Peat, muck and other highly organic soils

Terms Describing Relative Density and Consistency

	Density	SPT (2) blows/foot
Coarse-Grained Soils	Very Loose	0 to 4
	Loose	4 to 10
	Medium Dense	10 to 30
	Dense	30 to 50
	Very Dense	>50
	Consistency	**SPT (2) blows/foot**
Fine-Grained Soils	Very Soft	0 to 2
	Soft	2 to 4
	Medium Stiff	4 to 8
	Stiff	8 to 15
	Very Stiff	15 to 30
	Hard	>30

Test Symbols

FC = Fines Content
G = Grain Size
M = Moisture Content
A = Atterberg Limits
C = Consolidation
DD = Dry Density
K = Permeability
Str = Shear Strength
Env = Environmental
PiD = Photoionization Detector

Component Definitions

Descriptive Term	Size Range and Sieve Number
Boulders	Larger than 12"
Cobbles	3" to 12"
Gravel	3" to No. 4 (4.75 mm)
Coarse Gravel	3" to 3/4"
Fine Gravel	3/4" to No. 4 (4.75 mm)
Sand	No. 4 (4.75 mm) to No. 200 (0.075 mm)
Coarse Sand	No. 4 (4.75 mm) to No. 10 (2.00 mm)
Medium Sand	No. 10 (2.00 mm) to No. 40 (0.425 mm)
Fine Sand	No. 40 (0.425 mm) to No. 200 (0.075 mm)
Silt and Clay	Smaller than No. 200 (0.075 mm)

(3) Estimated Percentage

Percentage by Weight	Modifier
<5	Trace
5 to 15	Slightly (sandy, silty, clayey, gravelly)
15 to 30	Sandy, silty, clayey, gravelly)
30 to 49	Very (sandy, silty, clayey, gravelly)

Moisture Content

Dry - Absence of moisture, dusty, dry to the touch

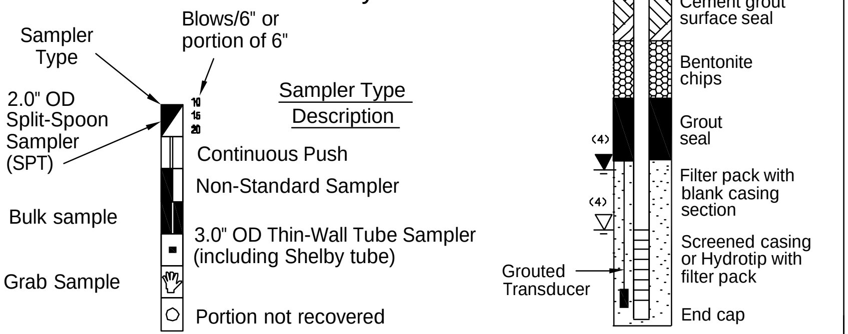
Slightly Moist - Perceptible moisture

Moist - Damp but no visible water

Very Moist - Water visible but not free draining

Wet - Visible free water, usually from below water table

Symbols



(1) Percentage by dry weight

(2) (SPT) Standard Penetration Test (ASTM D-1586)

(3) In General Accordance with Standard Practice for Description and Identification of Soils (ASTM D-2488)

(4) Depth of groundwater

▽ ATD = At time of drilling

▼ Static water level (date)

(5) Combined USCS symbols used for fines between 5% and 15% as estimated in General Accordance with Standard Practice for Description and Identification of Soils (ASTM D-2488)

BGS = below ground surface

Classifications of soils in this report are based on visual field and/or laboratory observations, which include density/consistency, moisture condition, grain size, and plasticity estimates and should not be construed to imply field or laboratory testing unless presented herein. Visual-manual and/or laboratory classification methods of ASTM D-2487 and D-2488 were used as an identification guide for the Unified Soil Classification System.

Aspect CONSULTING

Exploration Log Key

DATE:
DESIGNED BY:
DRAWN BY:
REVISED BY:

PROJECT NO.

FIGURE NO.
A-1

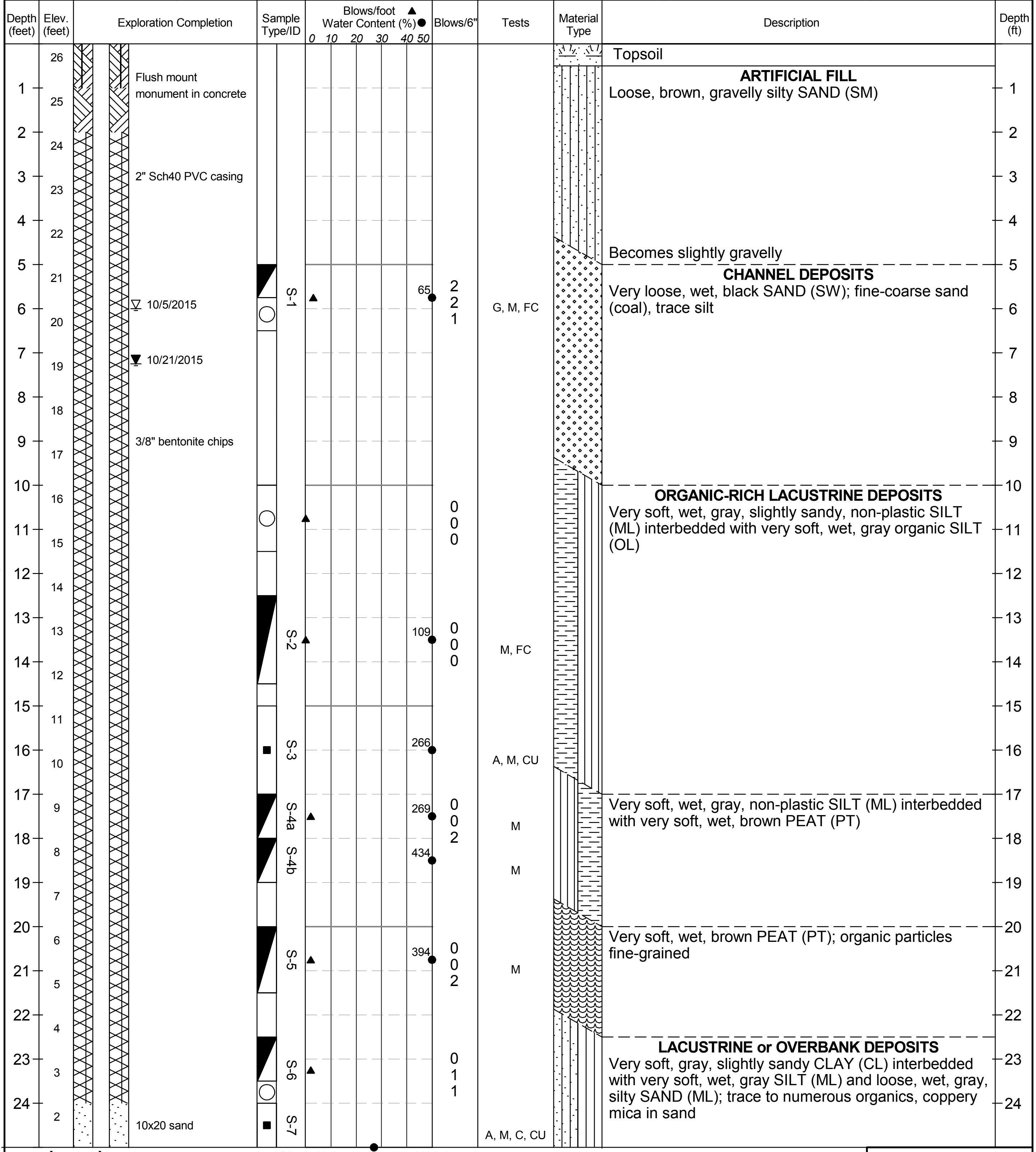
Q:_ACAD Standards\Standard Details\Exploration Log Key A1.dwg

Aspect CONSULTING

140362 - Lower Coal Creek Flood Reduction

Geotechnical Exploration Log

Project Address & Site Specific Location			*Coordinates (SPN NAD83 ft)*	*Exploration Number*
Bellevue, WA, Lower Skagit Key			E:1305827.454 N:211860.363	**B-1**
Contractor	*Equipment*	*Sampling Method*	*Ground Surface (GS) Elev. (NAVD88)*	Ecology Well Tag No. BJK822
Gregory Drilling	Rotary drill rig	Autohammer; 140 lb hammer; 30" drop	26.302'	
Operator	*Exploration Method(s)*	*Work Start/Completion Dates*	*Top of Casing Elev. (NAVD88)*	*Depth to Water (Below GS)*
Cory James	Mud rotary	10/5/2015	26.101'	6' (ATD) 7.25' (Static)



Exploration Completion:

Depth (ft)	
0–2	Flush mount monument in concrete
3	2" Sch40 PVC casing
6	∇ 10/5/2015
7	▼ 10/21/2015
9	3/8" bentonite chips
24.5	10x20 sand

Depth (ft)	Sample Type/ID	Water Content (%)	Blows/6"	Tests
5–6.5	S-1 (SPT), ○	65	2 2 1	G, M, FC
10–11.5	○		0 0 0	
12.5–14	S-2 (SPT)	109	0 0 0	M, FC
16	S-3 (■)	266		A, M, CU
17–18	S-4a (SPT)	269	0 0 2	M
18–19	S-4b (SPT)	434		M
20–21.5	S-5 (SPT)	394	0 0 2	M
22.5–24	S-6 (SPT), ○		0 1 1	
24.5–25	S-7 (■)			A, M, C, CU

Depth (ft)	Description
0	Topsoil
0.5	**ARTIFICIAL FILL** Loose, brown, gravelly silty SAND (SM)
4.5	Becomes slightly gravelly
5	**CHANNEL DEPOSITS** Very loose, wet, black SAND (SW); fine-coarse sand (coal), trace silt
10	**ORGANIC-RICH LACUSTRINE DEPOSITS** Very soft, wet, gray, slightly sandy, non-plastic SILT (ML) interbedded with very soft, wet, gray organic SILT (OL)
17	Very soft, wet, gray, non-plastic SILT (ML) interbedded with very soft, wet, brown PEAT (PT)
20	Very soft, wet, brown PEAT (PT); organic particles fine-grained
22.5	**LACUSTRINE or OVERBANK DEPOSITS** Very soft, gray, slightly sandy CLAY (CL) interbedded with very soft, wet, gray SILT (ML) and loose, wet, gray, silty SAND (ML); trace to numerous organics, coppery mica in sand

Plastic Limit ⊢●⊣ Liquid Limit

Legend

Sample Method
- ○ No Soil Sample Recovery
- ◩ SPT (ASTM 1586)
- ▣ Thin wall 3" (Shelby)

Water Level
- ▼ Static Water Level
- ∇ Water Level (ATD)

For detailed Soil Graphic Descriptions, see Figure 1.

Logged by: Mv
Approved by: NS

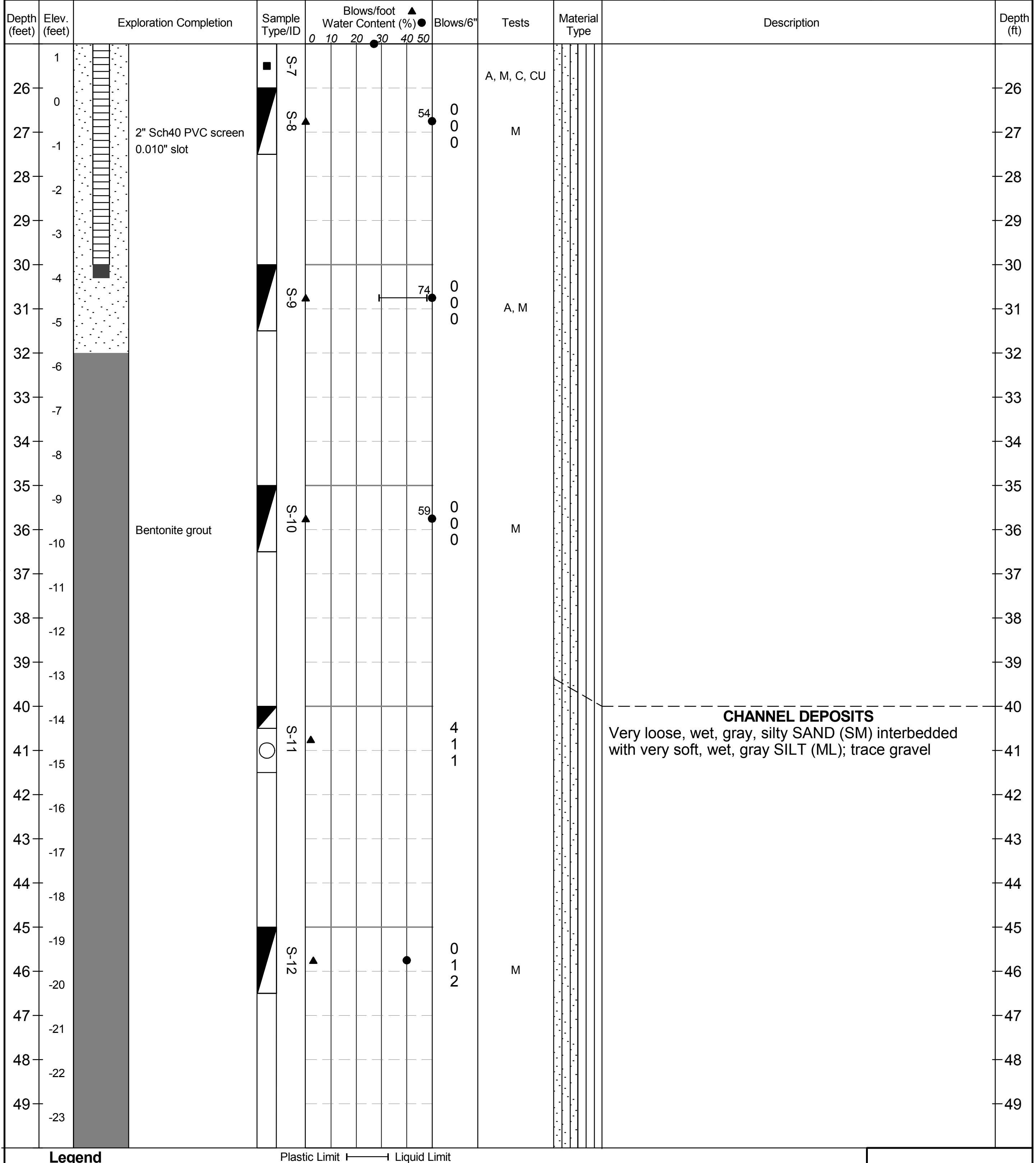
Figure No.

A-2

Sheet 1 of 3

Aspect CONSULTING

140362 - Lower Coal Creek Flood Reduction			**Geotechnical Exploration Log**	
Project Address & Site Specific Location			*Coordinates (SPN NAD83 ft)*	*Exploration Number*
Bellevue, WA, Lower Skagit Key			E:1305827.454 N:211860.363	**B-1**
Contractor	*Equipment*	*Sampling Method*	*Ground Surface (GS) Elev. (NAVD88)*	Ecology Well Tag No. BJK822
Gregory Drilling	Rotary drill rig	Autohammer; 140 lb hammer; 30" drop	26.302'	
Operator	*Exploration Method(s)*	*Work Start/Completion Dates*	*Top of Casing Elev. (NAVD88)*	*Depth to Water (Below GS)*
Cory James	Mud rotary	10/5/2015	26.101'	6' (ATD) 7.25' (Static)



CHANNEL DEPOSITS

Very loose, wet, gray, silty SAND (SM) interbedded with very soft, wet, gray SILT (ML); trace gravel

Plastic Limit ├──┤ Liquid Limit

Legend

Sample Method
- ◻ No Soil Sample Recovery
- ◪ SPT (ASTM 1586)
- ▣ Thin wall 3" (Shelby)

Water Level
- ▼ Static Water Level
- ▽ Water Level (ATD)

For detailed Soil Graphic Descriptions, see Figure 1.

Logged by: Mv
Approved by: NS

Figure No.

A-2

Sheet 2 of 3

Aspect CONSULTING

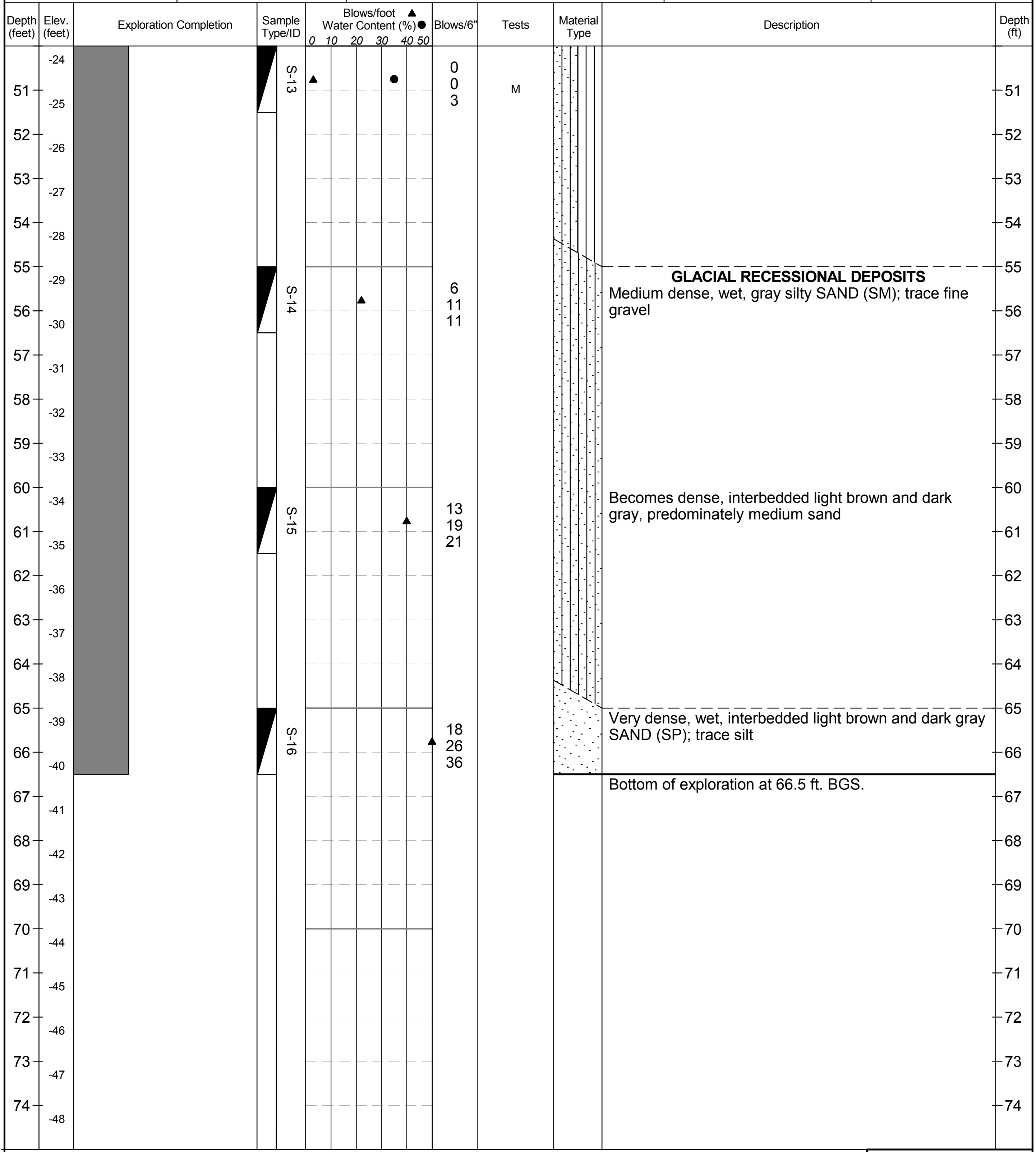
140362 - Lower Coal Creek Flood Reduction

Geotechnical Exploration Log

Project Address & Site Specific Location	Coordinates (SPN NAD83 ft)	Exploration Number
Bellevue, WA, Lower Skagit Key	E:1305827.454 N:211860.363	B-1

Contractor	Equipment	Sampling Method	Ground Surface (GS) Elev. (NAVD88)	Ecology Well Tag No.
Gregory Drilling	Rotary drill rig	Autohammer; 140 lb hammer; 30" drop	26.302'	BJK822

Operator	Exploration Method(s)	Work Start/Completion Dates	Top of Casing Elev. (NAVD88)	Depth to Water (Below GS)
Cory James	Mud rotary	10/5/2015	26.101'	6' (ATD) 7.25' (Static)



Depth (feet)	Elev. (feet)	Sample Type/ID	Blows/6"	Tests	Description
50–51.5	-24 to -25.5	S-13	0 0 3	M	
55	-29	S-14	6 11 11		**GLACIAL RECESSIONAL DEPOSITS** Medium dense, wet, gray silty SAND (SM); trace fine gravel
60	-34	S-15	13 19 21		Becomes dense, interbedded light brown and dark gray, predominately medium sand
65	-39	S-16	18 26 36		Very dense, wet, interbedded light brown and dark gray SAND (SP); trace silt
66.5	-40.5				Bottom of exploration at 66.5 ft. BGS.

Legend

Plastic Limit ├──┤ Liquid Limit

Sample Method
- ◎ No Soil Sample Recovery
- ◩ SPT (ASTM 1586)
- ▣ Thin wall 3" (Shelby)

Water Level
- ▼ Static Water Level
- ▽ Water Level (ATD)

For detailed Soil Graphic Descriptions, see Figure 1.

Logged by: Mv
Approved by: NS

Figure No.

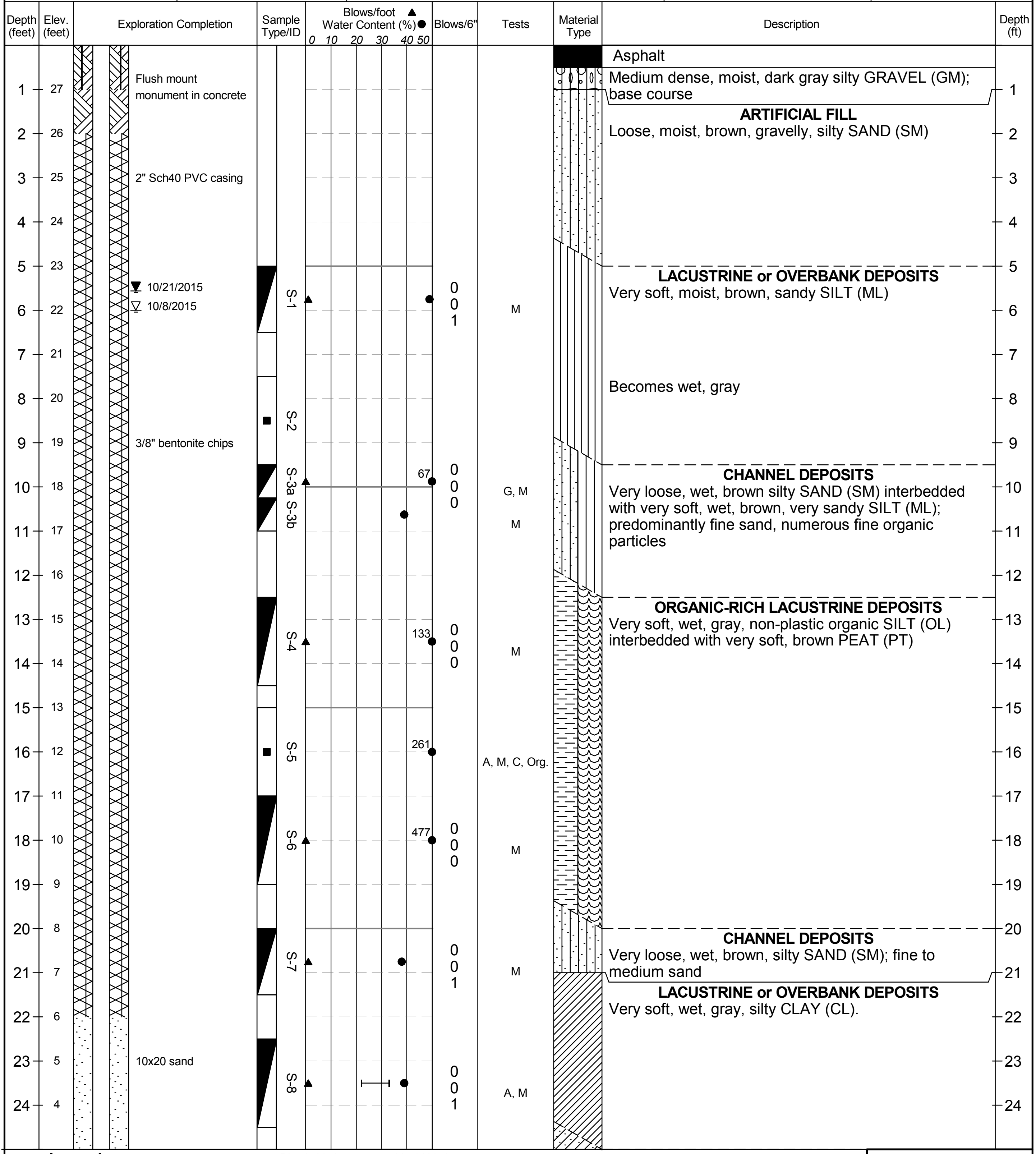
A-2

Sheet 3 of 3

140362 - Lower Coal Creek Flood Reduction

Geotechnical Exploration Log

Project Address & Site Specific Location	Bellevue, WA, Newport Key	*Coordinates (SPN NAD83 ft)*	E:1306097.399 N:211552.546
Exploration Number	**B-2**	Ecology Well Tag No.	BJK826
Contractor	Gregory Drilling	*Equipment*	Rotary drill rig
Sampling Method	Autohammer; 140 lb hammer; 30" drop	*Ground Surface (GS) Elev. (NAVD88)*	27.976'
Operator	Cory James	*Exploration Method(s)*	Mud Rotary
Work Start/Completion Dates	10/8/2015	*Top of Casing Elev. (NAVD88)*	27.657'
Depth to Water (Below GS)	5.56' (Static) 6' (ATD)		



Depth (feet)	Elev. (feet)	Exploration Completion	Sample Type/ID	Blows/foot ▲ Water Content (%) ●	Blows/6"	Tests	Description
							Asphalt
1	27	Flush mount monument in concrete					Medium dense, moist, dark gray silty GRAVEL (GM); base course
2	26						**ARTIFICIAL FILL** Loose, moist, brown, gravelly, silty SAND (SM)
3	25	2" Sch40 PVC casing					
4	24						
5	23						**LACUSTRINE or OVERBANK DEPOSITS** Very soft, moist, brown, sandy SILT (ML)
6	22	▼ 10/21/2015 ▽ 10/8/2015	S-1		0 0 1	M	
7	21						
8	20		S-2				Becomes wet, gray
9	19	3/8" bentonite chips					
10	18		S-3a	67	0 0 0	G, M	**CHANNEL DEPOSITS** Very loose, wet, brown silty SAND (SM) interbedded with very soft, wet, brown, very sandy SILT (ML); predominantly fine sand, numerous fine organic particles
11	17		S-3b			M	
12	16						
13	15						**ORGANIC-RICH LACUSTRINE DEPOSITS** Very soft, wet, gray, non-plastic organic SILT (OL) interbedded with very soft, brown PEAT (PT)
14	14		S-4	133	0 0 0	M	
15	13						
16	12		S-5	261		A, M, C, Org.	
17	11						
18	10		S-6	477	0 0 0	M	
19	9						
20	8						**CHANNEL DEPOSITS** Very loose, wet, brown, silty SAND (SM); fine to medium sand
21	7		S-7		0 0 1	M	**LACUSTRINE or OVERBANK DEPOSITS** Very soft, wet, gray, silty CLAY (CL).
22	6						
23	5	10x20 sand					
24	4		S-8		0 0 1	A, M	

Legend

Sample Method
- ◎ No Soil Sample Recovery
- ◩ SPT (ASTM 1586)
- ▣ Thin wall 3" (Shelby)
- ▮ Split barrel 3" X 2.375"

Water Level
- ▼ Static Water Level
- ▽ Water Level (ATD)

For detailed Soil Graphic Descriptions, see Figure 1.

Logged by: Mv
Approved by: NS

Figure No.

A-3

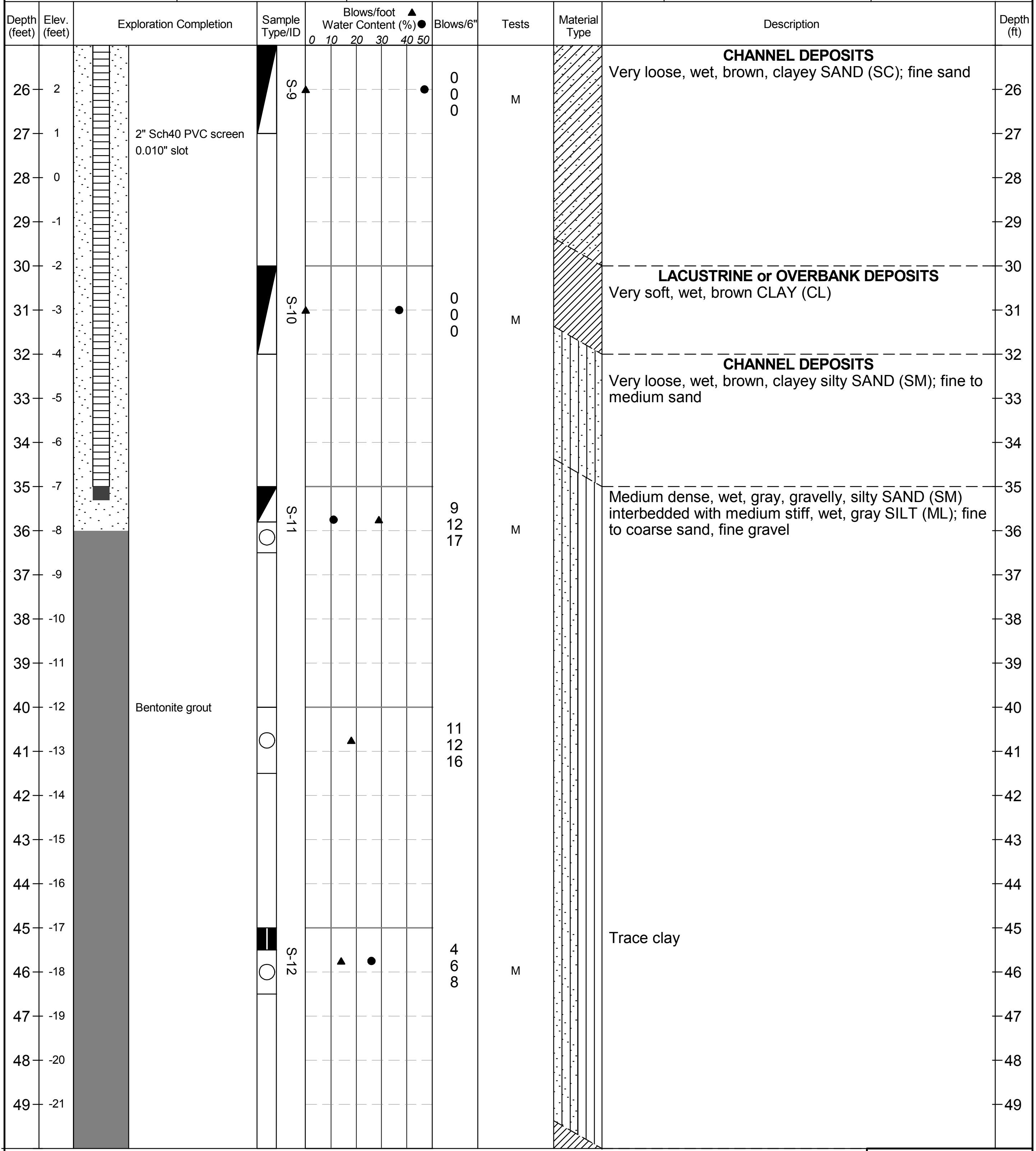
Sheet 1 of 3

Aspect CONSULTING

140362 - Lower Coal Creek Flood Reduction

Geotechnical Exploration Log

Project Address & Site Specific Location		*Coordinates (SPN NAD83 ft)*	*Exploration Number*	
Bellevue, WA, Newport Key		E:1306097.399 N:211552.546	**B-2**	
Contractor	*Equipment*	*Sampling Method*	*Ground Surface (GS) Elev. (NAVD88)*	Ecology Well Tag No. BJK826
Gregory Drilling	Rotary drill rig	Autohammer; 140 lb hammer; 30" drop	27.976'	
Operator	*Exploration Method(s)*	*Work Start/Completion Dates*	*Top of Casing Elev. (NAVD88)*	*Depth to Water (Below GS)*
Cory James	Mud Rotary	10/8/2015	27.657'	5.56' (Static) 6' (ATD)



Depth (feet)	Elev. (feet)	Exploration Completion	Sample Type/ID	Blows/6"	Tests	Description	Depth (ft)
						CHANNEL DEPOSITS Very loose, wet, brown, clayey SAND (SC); fine sand	
26	2		S-9	0 0 0	M		26
27	1	2" Sch40 PVC screen 0.010" slot					27
28	0						28
29	-1						29
30	-2					**LACUSTRINE or OVERBANK DEPOSITS** Very soft, wet, brown CLAY (CL)	30
31	-3		S-10	0 0 0	M		31
32	-4					**CHANNEL DEPOSITS** Very loose, wet, brown, clayey silty SAND (SM); fine to medium sand	32
33	-5						33
34	-6						34
35	-7					Medium dense, wet, gray, gravelly, silty SAND (SM) interbedded with medium stiff, wet, gray SILT (ML); fine to coarse sand, fine gravel	35
36	-8		S-11	9 12 17	M		36
37	-9						37
38	-10						38
39	-11						39
40	-12	Bentonite grout					40
41	-13			11 12 16			41
42	-14						42
43	-15						43
44	-16						44
45	-17					Trace clay	45
46	-18		S-12	4 6 8	M		46
47	-19						47
48	-20						48
49	-21						49

Legend

Sample Method
- ◎ No Soil Sample Recovery
- ◩ SPT (ASTM 1586)
- ▣ Thin wall 3" (Shelby)
- ▮ Split barrel 3" X 2.375"

Plastic Limit ⊢—⊣ Liquid Limit

Water Level
- ▼ Static Water Level
- ▽ Water Level (ATD)

For detailed Soil Graphic Descriptions, see Figure 1.

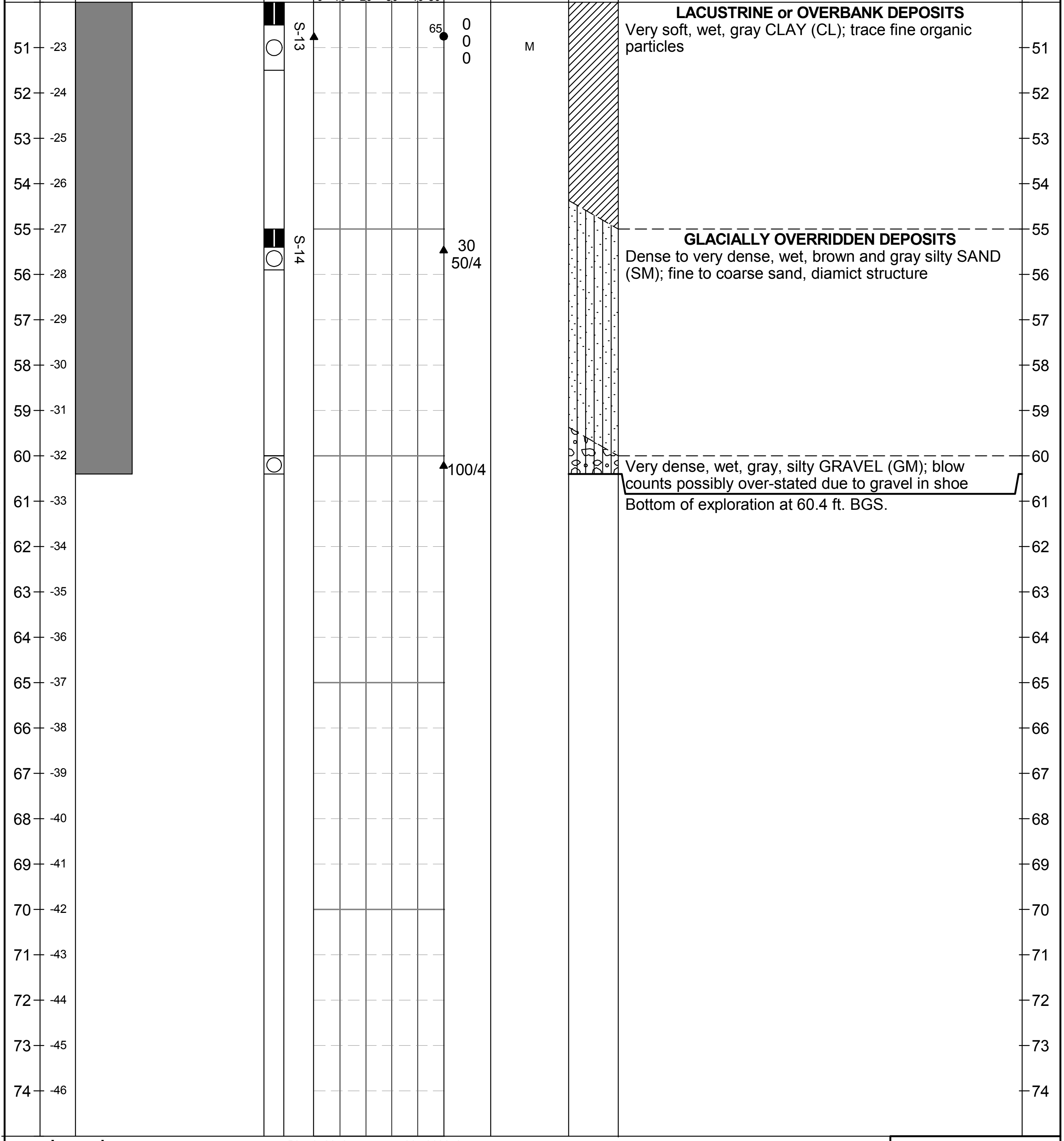
Logged by: Mv
Approved by: NS

Figure No.

A-3

Sheet 2 of 3

Aspect CONSULTING	140362 - Lower Coal Creek Flood Reduction		Geotechnical Exploration Log	
	Project Address & Site Specific Location		*Coordinates (SPN NAD83 ft)*	*Exploration Number*
	Bellevue, WA, Newport Key		E:1306097.399 N:211552.546	**B-2**
Contractor	*Equipment*	*Sampling Method*	*Ground Surface (GS) Elev. (NAVD88)*	Ecology Well Tag No.
Gregory Drilling	Rotary drill rig	Autohammer; 140 lb hammer; 30" drop	27.976'	BJK826
Operator	*Exploration Method(s)*	*Work Start/Completion Dates*	*Top of Casing Elev. (NAVD88)*	*Depth to Water (Below GS)*
Cory James	Mud Rotary	10/8/2015	27.657'	5.56' (Static) 6' (ATD)



Depth (feet)	Elev. (feet)	Exploration Completion	Sample Type/ID	Blows/foot ▲ Water Content (%) ●	Blows/6"	Tests	Material Type	Description	Depth (ft)
51	-23		S-13	65	0 0 0	M		**LACUSTRINE or OVERBANK DEPOSITS** Very soft, wet, gray CLAY (CL); trace fine organic particles	51
52	-24								52
53	-25								53
54	-26								54
55	-27		S-14		30 50/4			**GLACIALLY OVERRIDDEN DEPOSITS** Dense to very dense, wet, brown and gray silty SAND (SM); fine to coarse sand, diamict structure	55
56	-28								56
57	-29								57
58	-30								58
59	-31								59
60	-32				100/4			Very dense, wet, gray, silty GRAVEL (GM); blow counts possibly over-stated due to gravel in shoe	60
61	-33							Bottom of exploration at 60.4 ft. BGS.	61
62	-34								62
63	-35								63
64	-36								64
65	-37								65
66	-38								66
67	-39								67
68	-40								68
69	-41								69
70	-42								70
71	-43								71
72	-44								72
73	-45								73
74	-46								74

Legend

Plastic Limit ├──┤ Liquid Limit

Sample Method
- ◎ No Soil Sample Recovery
- ◩ SPT (ASTM 1586)
- ▣ Thin wall 3" (Shelby)
- ▮ Split barrel 3" X 2.375"

Water Level
- ▼ Static Water Level
- ▽ Water Level (ATD)

For detailed Soil Graphic Descriptions, see Figure 1.

Logged by: Mv
Approved by: NS

Figure No.

A-3

Sheet 3 of 3

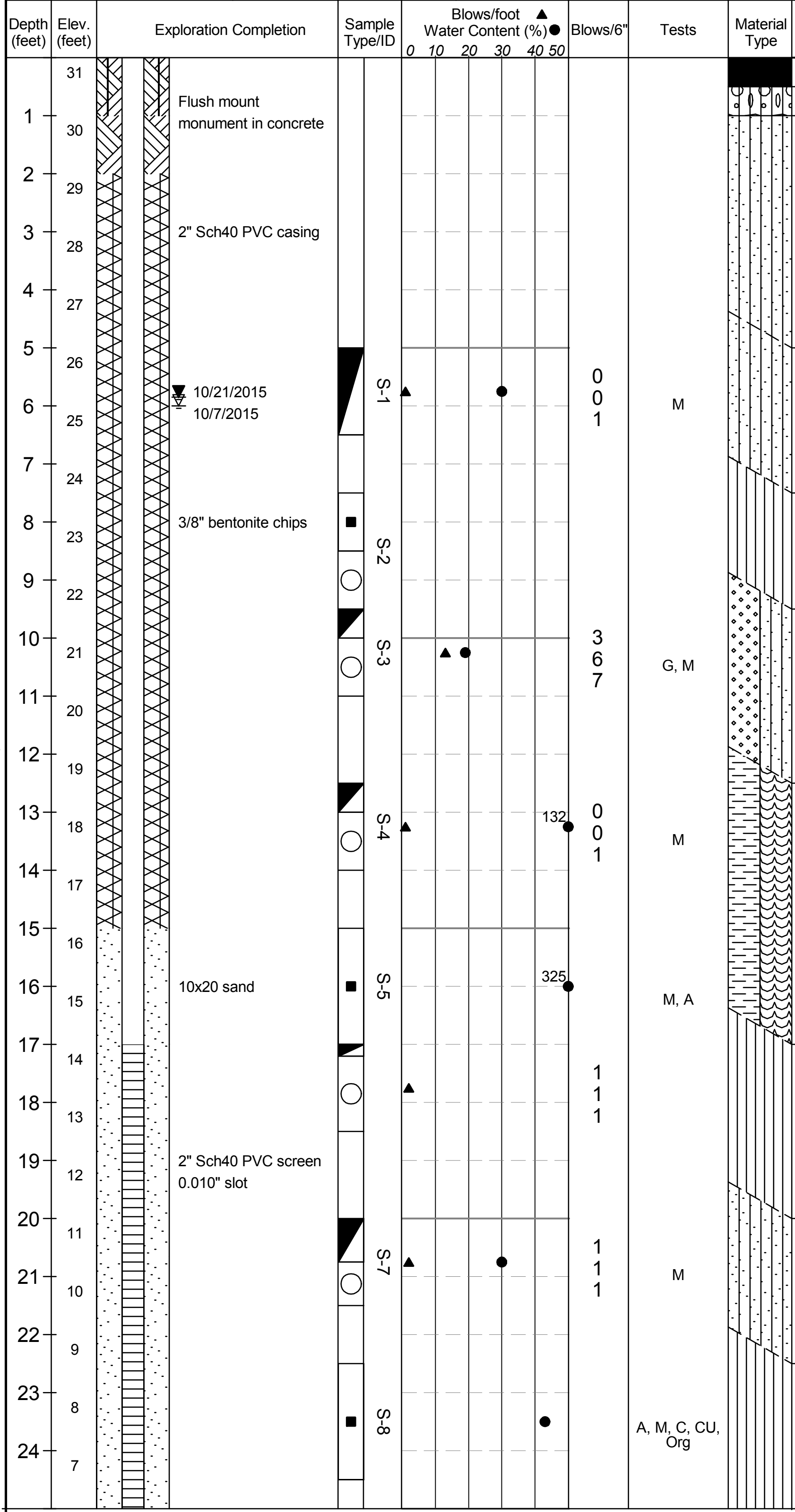
Aspect CONSULTING

140362 - Lower Coal Creek Flood Reduction

Geotechnical Exploration Log

Project Address & Site Specific Location	*Coordinates (SPN NAD83 ft)*	*Exploration Number*
Bellevue, WA, Glacier Key	E:1306292.235 N:211172.593	**B-3**

Contractor	*Equipment*	*Sampling Method*	*Ground Surface (GS) Elev. (NAVD88)*	
Gregory Drilling	Rotary drill rig	Autohammer; 140 lb hammer; 30" drop	31.247'	Ecology Well Tag No. BJK825
Operator	*Exploration Method(s)*	*Work Start/Completion Dates*	*Top of Casing Elev. (NAVD88)*	*Depth to Water (Below GS)*
Cory James	Mud Rotary	10/7/2015	30.89'	5.85' (Static) 6' (ATD)



Depth (ft)	Description
0	Asphalt
	Medium dense, moist, gray, sandy, silty GRAVEL (GM); base course
1	**ARTIFICIAL FILL** Loose, moist, brown, gravelly, silty SAND (SM)
5	Very loose, moist to wet, gray silty SAND (SM); fine sand, trace medium sand
7.5	Very soft, wet, sandy SILT (ML); fine sand
9.5	**CHANNEL DEPOSITS** Medium dense, wet, gray, slightly silty SAND (SW-SM); fine to coarse sand, trace fine gravel
12.5	**ORGANIC-RICH LACUSTRINE DEPOSITS** Very soft, wet, brown, non-plastic, organic SILT (OL) interbedded with very soft, brown PEAT (PT); woody particles
17	**LACUSTRINE or OVERBANK DEPOSITS** Very soft, wet gray SILT (ML); rapid dilatancy, trace fine organics
20	**CHANNEL DEPOSITS** Very loose, wet, gray, silty SAND (SM); fine to coarse sand
22.5	**LACUSTRINE or OVERBANK DEPOSITS** Very soft, wet, gray, slightly sandy, non-plastic SILT (ML); fine sand, trace medium sand, rapid dilatancy Organic content 5.7%

Legend

Plastic Limit ├──┤ Liquid Limit

Sample Method
- ▢ No Soil Sample Recovery
- ◩ SPT (ASTM 1586)
- ▣ Thin wall 3" (Shelby)

Water Level
- ▼ Static Water Level
- ▽ Water Level (ATD)

For detailed Soil Graphic Descriptions, see Figure 1.

Logged by: Mv
Approved by: NS

Figure No. A-4

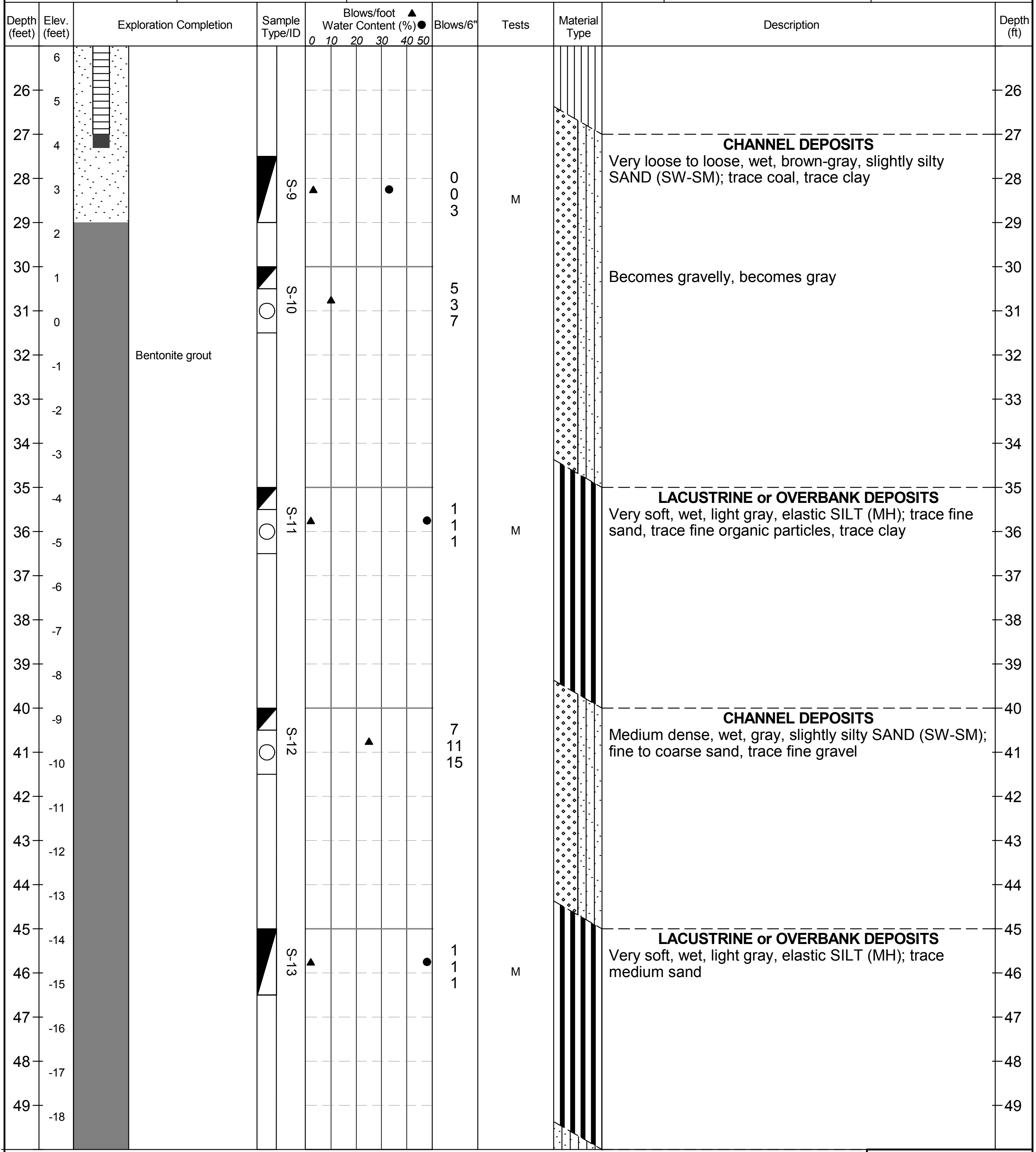
Sheet 1 of 3

Aspect CONSULTING

140362 - Lower Coal Creek Flood Reduction

Geotechnical Exploration Log

Project Address & Site Specific Location	Bellevue, WA, Glacier Key	*Coordinates (SPN NAD83 ft)*	E:1306292.235 N:211172.593	*Exploration Number* **B-3**
Contractor	Gregory Drilling	*Ground Surface (GS) Elev. (NAVD88)*	31.247'	Ecology Well Tag No. BJK825
Equipment	Rotary drill rig	*Sampling Method*	Autohammer; 140 lb hammer; 30" drop	
Operator	Cory James	*Top of Casing Elev. (NAVD88)*	30.89'	*Depth to Water (Below GS)* 5.85' (Static) 6' (ATD)
Exploration Method(s)	Mud Rotary	*Work Start/Completion Dates*	10/7/2015	



Sample	Blows/6"	Tests
S-9	0 0 3	M
S-10	5 3 7	
S-11	1 1 1	M
S-12	7 11 15	
S-13	1 1 1	M

CHANNEL DEPOSITS

Very loose to loose, wet, brown-gray, slightly silty SAND (SW-SM); trace coal, trace clay

Becomes gravelly, becomes gray

LACUSTRINE or OVERBANK DEPOSITS

Very soft, wet, light gray, elastic SILT (MH); trace fine sand, trace fine organic particles, trace clay

CHANNEL DEPOSITS

Medium dense, wet, gray, slightly silty SAND (SW-SM); fine to coarse sand, trace fine gravel

LACUSTRINE or OVERBANK DEPOSITS

Very soft, wet, light gray, elastic SILT (MH); trace medium sand

Legend

Sample Method
- ◎ No Soil Sample Recovery
- ◩ SPT (ASTM 1586)
- ▣ Thin wall 3" (Shelby)

Plastic Limit ├──┤ Liquid Limit

Water Level
- ▼ Static Water Level
- ▽ Water Level (ATD)

For detailed Soil Graphic Descriptions, see Figure 1.

Logged by: Mv
Approved by: NS

Figure No.

A-4

Sheet 2 of 3

Aspect CONSULTING

Lower Coal Creek Flood Reduction - 140362

Geotechnical Exploration Log

Project Address & Site Specific Location			*Coordinates (SPN NAD83 ft)*	*Exploration Number*
Bellevue, WA, Glacier Key			E:1306292 N:211173	**B-3**
Contractor	*Equipment*	*Sampling Method*	*Ground Surface (GS) Elev. (NAVD88)*	Ecology Well Tag No.
Gregory Drilling	Rotary drill rig	Autohammer; 140 lb hammer; 30" drop	31.247'	BJK825
Operator	*Exploration Method(s)*	*Work Start/Completion Dates*	*Top of Casing Elev. (NAVD88)*	*Depth to Water (Below GS)*
Cory James	Mud Rotary	10/7/2015	30.89'	5.85' (Static) 6' (ATD)

Depth (feet)	Elev. (feet)	Exploration Completion and Notes	Sample Type/ID	Blows/foot ▲ Water Content (%) ●	Blows/6"	Tests	Material Type	Description	Depth (ft)
	-19		S-14	51	4 2 5	M		**CHANNEL DEPOSITS** Loose, wet, gray silty SAND (SM)	
51	-20								51
52	-21								52
53	-22								53
54	-23							**GLACIAL RECESSIONAL OUTWASH DEPOSITS** Loose, wet, gray, silty SAND (SM); fine to coarse sand	54
55	-24		S-15					Becomes very dense	55
56	-25		○		25 29 35				56
57	-26								57
58	-27								58
59	-28								59
60	-29		S-16						60
61	-30		○		17 16 20			Becomes dense, fine to medium sand. Bottom of exploration at 61.5 ft. BGS.	61
62	-31								62
63	-32								63
64	-33								64
65	-34								65
66	-35								66
67	-36								67
68	-37								68
69	-38								69
70	-39								70
71	-40								71
72	-41								72
73	-42								73
74	-43								74

0 10 20 30 40 50

Legend

Sample Method
- ◙ No Soil Sample Recovery
- ▣ Thin wall 3" (Shelby)

Plastic Limit ├──┤ Liquid Limit

Water Level
- ▼ Static Water Level
- ▽ Water Level (ATD)

See Exploration Log Key for explanation of symbols

Logged by: Mv
Approved by: NS

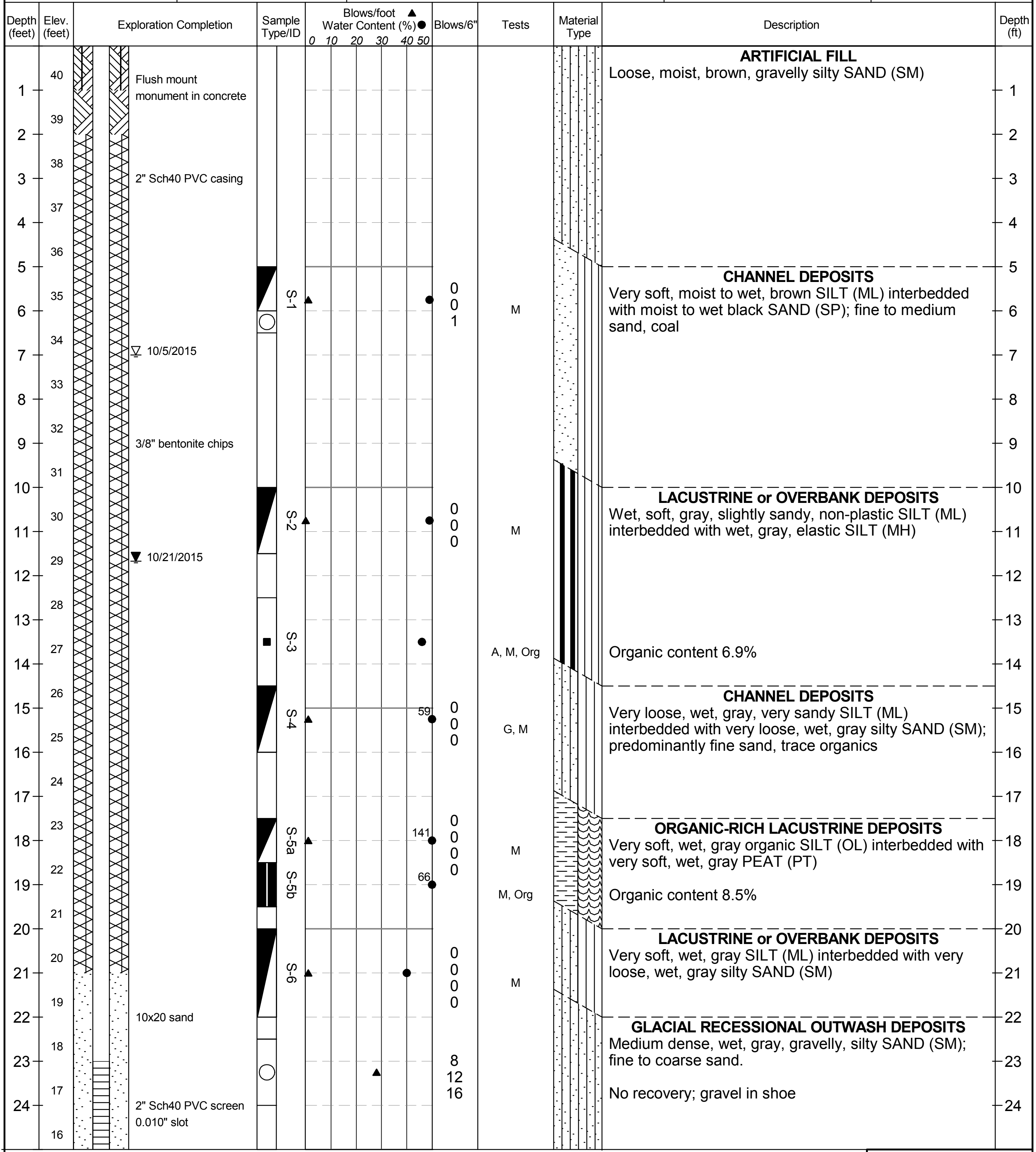
Exploration log
A-4
Sheet 3 of 3

Aspect CONSULTING

140362 - Lower Coal Creek Flood Reduction

Geotechnical Exploration Log

Project Address & Site Specific Location			*Coordinates (SPN NAD83 ft)*	*Exploration Number*
Bellevue, WA, Upper Skagit Key			E:1307236.172 N:210679.851	**B-4**
Contractor	*Equipment*	*Sampling Method*	*Ground Surface (GS) Elev. (NAVD88)*	Ecology Well Tag No.
Gregory Drilling	Rotary drill rig	Autohammer; 140 lb hammer; 30" drop	40.653'	BJK823
Operator	*Exploration Method(s)*	*Work Start/Completion Dates*	*Top of Casing Elev. (NAVD88)*	*Depth to Water (Below GS)*
Cory James	Mud Rotary	10/6/2015	40.201'	7' (ATD) 11.67' (Static)



Depth (feet)	Elev. (feet)	Exploration Completion	Sample Type/ID	Water Content (%)	Blows/6"	Tests	Description
0–2	40–39	Flush mount monument in concrete					**ARTIFICIAL FILL** Loose, moist, brown, gravelly silty SAND (SM)
3	38	2" Sch40 PVC casing					
5–6.5	36–35		S-1		0 0 1	M	**CHANNEL DEPOSITS** Very soft, moist to wet, brown SILT (ML) interbedded with moist to wet black SAND (SP); fine to medium sand, coal
7	34	▽ 10/5/2015					
9	32	3/8" bentonite chips					
10–11.5	31–30		S-2		0 0 0	M	**LACUSTRINE or OVERBANK DEPOSITS** Wet, soft, gray, slightly sandy, non-plastic SILT (ML) interbedded with wet, gray, elastic SILT (MH)
11.67	29	▼ 10/21/2015					
13–14	28–27		S-3			A, M, Org	Organic content 6.9%
14.5–16	26–25		S-4	59	0 0 0	G, M	**CHANNEL DEPOSITS** Very loose, wet, gray, very sandy SILT (ML) interbedded with very loose, wet, gray silty SAND (SM); predominantly fine sand, trace organics
17.5–18.5	23–22		S-5a	141	0 0 0 0	M	**ORGANIC-RICH LACUSTRINE DEPOSITS** Very soft, wet, gray organic SILT (OL) interbedded with very soft, wet, gray PEAT (PT)
18.5–19.5	22–21		S-5b	66		M, Org	Organic content 8.5%
20–22	20–19		S-6		0 0 0 0	M	**LACUSTRINE or OVERBANK DEPOSITS** Very soft, wet, gray SILT (ML) interbedded with very loose, wet, gray silty SAND (SM)
22	19	10x20 sand					**GLACIAL RECESSIONAL OUTWASH DEPOSITS** Medium dense, wet, gray, gravelly, silty SAND (SM); fine to coarse sand.
23–24	18–17	2" Sch40 PVC screen 0.010" slot			8 12 16		No recovery; gravel in shoe

Plastic Limit ├──┤ Liquid Limit

Legend

Sample Method
- ○ No Soil Sample Recovery
- ◩ SPT (ASTM 1586)
- ▣ Thin wall 3" (Shelby)
- ▮ Split barrel 3" X 2.375"

Water Level
- ▼ Static Water Level
- ▽ Water Level (ATD)

For detailed Soil Graphic Descriptions, see Figure 1.

Logged by: Mv
Approved by: NS

Figure No.

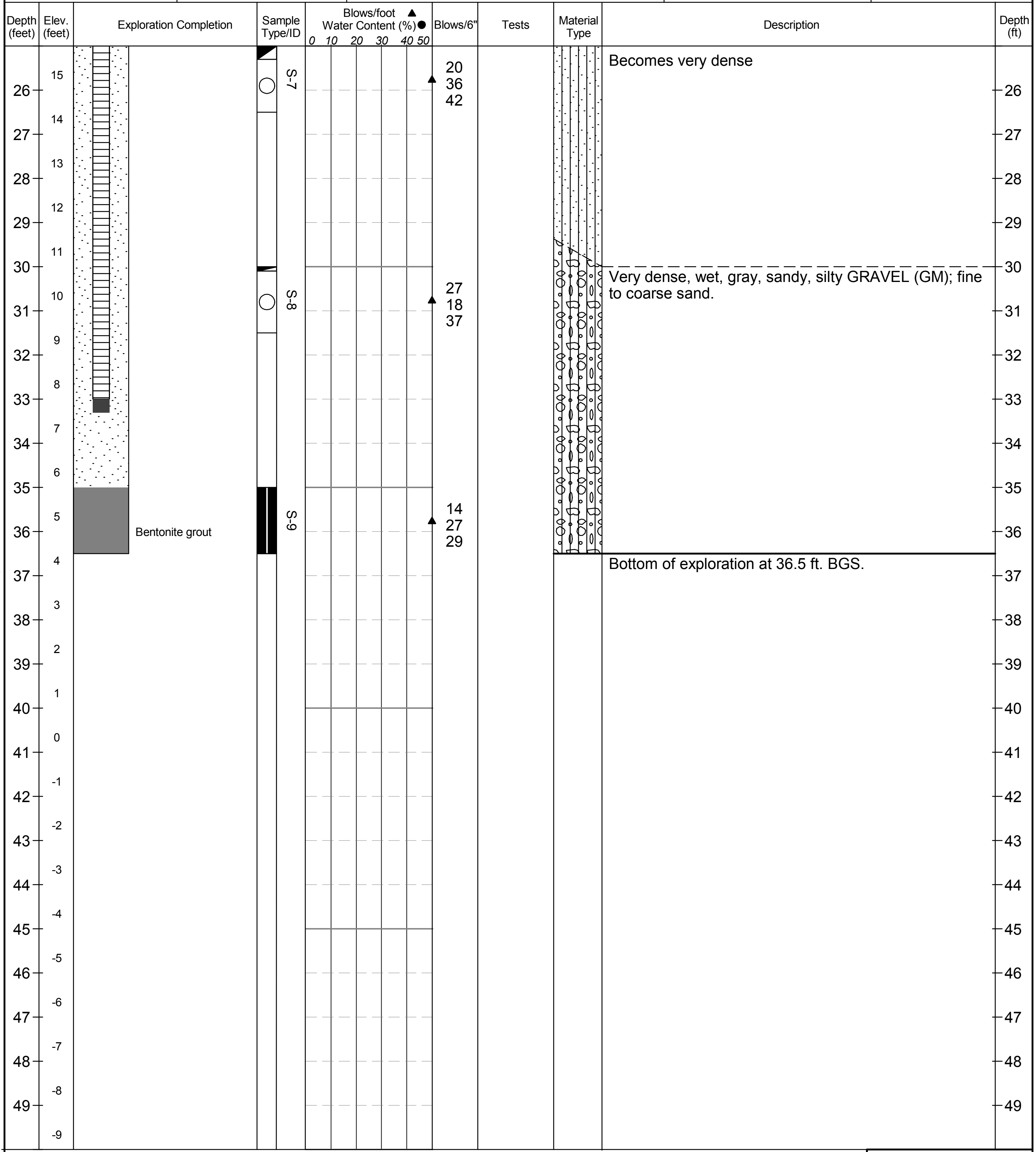
A-5

Sheet 1 of 2

140362 - Lower Coal Creek Flood Reduction

Geotechnical Exploration Log

Project Address & Site Specific Location			*Coordinates (SPN NAD83 ft)*	*Exploration Number*
Bellevue, WA, Upper Skagit Key			E:1307236.172 N:210679.851	**B-4**
Contractor	*Equipment*	*Sampling Method*	*Ground Surface (GS) Elev. (NAVD88)*	Ecology Well Tag No.
Gregory Drilling	Rotary drill rig	Autohammer; 140 lb hammer; 30" drop	40.653'	BJK823
Operator	*Exploration Method(s)*	*Work Start/Completion Dates*	*Top of Casing Elev. (NAVD88)*	*Depth to Water (Below GS)*
Cory James	Mud Rotary	10/6/2015	40.201'	7' (ATD) 11.67' (Static)



Becomes very dense

Very dense, wet, gray, sandy, silty GRAVEL (GM); fine to coarse sand.

Bottom of exploration at 36.5 ft. BGS.

Legend

Sample Method

- ▢ No Soil Sample Recovery
- ◩ SPT (ASTM 1586)
- ▣ Thin wall 3" (Shelby)
- ▮ Split barrel 3" X 2.375"

Plastic Limit ├──┤ Liquid Limit

Water Level

- ▼ Static Water Level
- ▽ Water Level (ATD)

For detailed Soil Graphic Descriptions, see Figure 1.

Logged by: Mv
Approved by: NS

Figure No.

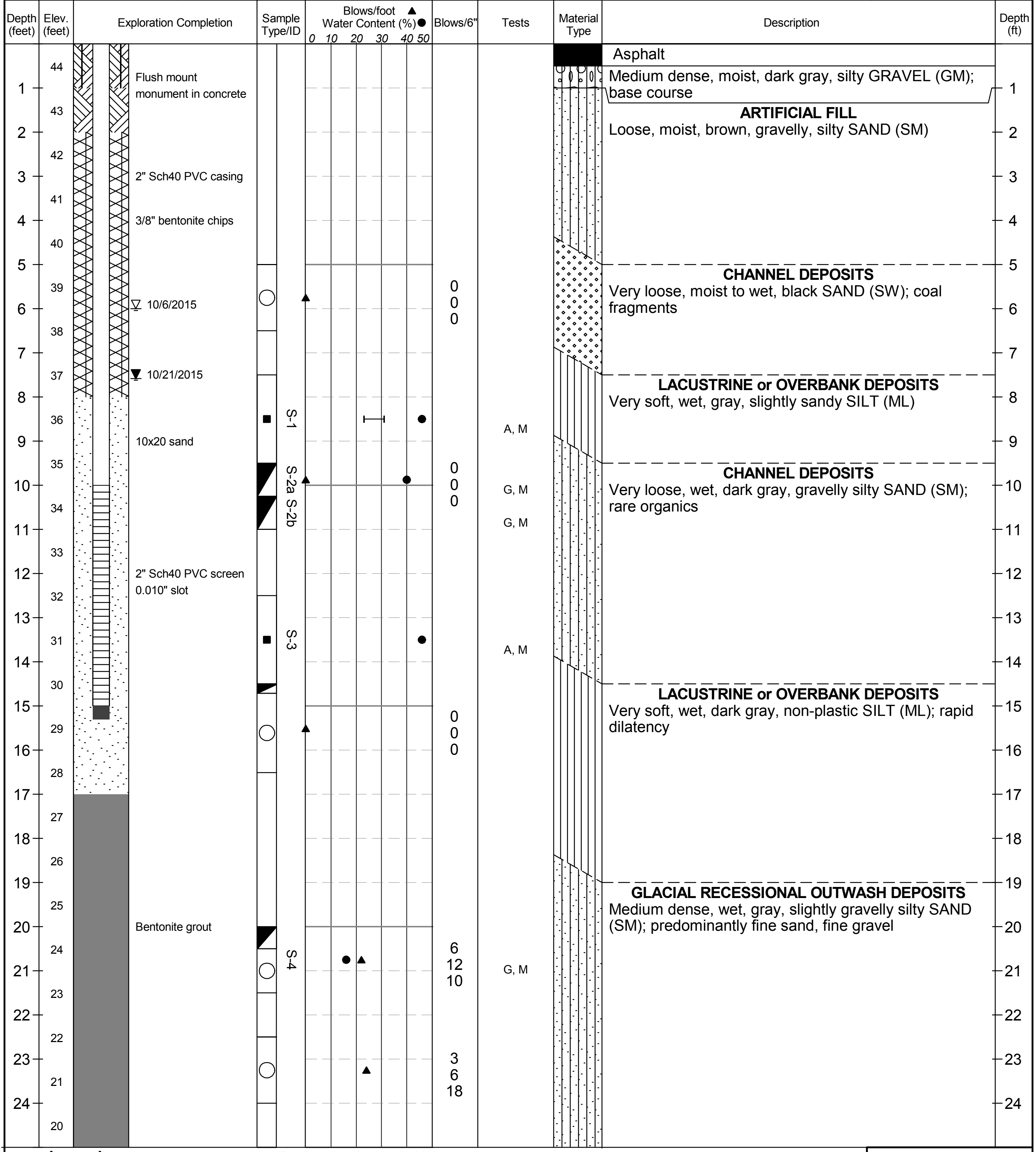
A-5

Sheet 2 of 2

140362 - Lower Coal Creek Flood Reduction

Geotechnical Exploration Log

Project Address & Site Specific Location			Coordinates (SPN NAD83 ft)	Exploration Number
Bellevue, WA, Cascade Key			E:1307514.214 N:210491.696	**B-5**
Contractor	Equipment	Sampling Method	Ground Surface (GS) Elev. (NAVD88)	Ecology Well Tag No.
Gregory Drilling	Rotary drill rig	Autohammer; 140 lb hammer; 30" drop	44.513'	BJK824
Operator	Exploration Method(s)	Work Start/Completion Dates	Top of Casing Elev. (NAVD88)	Depth to Water (Below GS)
Cory James	Mud rotary	10/7/2015	44.242'	6' (ATD) 7.58' (Static)



Asphalt

Medium dense, moist, dark gray, silty GRAVEL (GM); base course

ARTIFICIAL FILL
Loose, moist, brown, gravelly, silty SAND (SM)

CHANNEL DEPOSITS
Very loose, moist to wet, black SAND (SW); coal fragments

LACUSTRINE or OVERBANK DEPOSITS
Very soft, wet, gray, slightly sandy SILT (ML)

CHANNEL DEPOSITS
Very loose, wet, dark gray, gravelly silty SAND (SM); rare organics

LACUSTRINE or OVERBANK DEPOSITS
Very soft, wet, dark gray, non-plastic SILT (ML); rapid dilatency

GLACIAL RECESSIONAL OUTWASH DEPOSITS
Medium dense, wet, gray, slightly gravelly silty SAND (SM); predominantly fine sand, fine gravel

Plastic Limit ⊢⊣ Liquid Limit

Legend

Sample Method
- ○ No Soil Sample Recovery
- ▣ Thin wall 3" (Shelby)
- ◩ SPT (ASTM 1586)

Water Level
- ▼ Static Water Level
- ∇ Water Level (ATD)

For detailed Soil Graphic Descriptions, see Figure 1.

Logged by: Mv
Approved by: NS

Figure No.

A-6

Sheet 1 of 2

Aspect CONSULTING

140362 - Lower Coal Creek Flood Reduction

Geotechnical Exploration Log

Project Address & Site Specific Location	*Coordinates (SPN NAD83 ft)*	*Exploration Number*
Bellevue, WA, Cascade Key	E:1307514.214 N:210491.696	**B-5**

Contractor	*Equipment*	*Sampling Method*	*Ground Surface (GS) Elev. (NAVD88)*	Ecology Well Tag No.
Gregory Drilling	Rotary drill rig	Autohammer; 140 lb hammer; 30" drop	44.513'	BJK824
Operator	*Exploration Method(s)*	*Work Start/Completion Dates*	*Top of Casing Elev. (NAVD88)*	*Depth to Water (Below GS)*
Cory James	Mud rotary	10/7/2015	44.242'	6' (ATD) 7.58' (Static)

Depth (feet)	Elev. (feet)	Exploration Completion	Sample Type/ID	Blows/foot ▲ Water Content (%) ● 0 10 20 30 40 50	Blows/6"	Tests	Material Type	Description	Depth (ft)
	19		○	▲	16 26 28			Becomes very dense, cobbly	
26	18								26
27	17								27
28	16								28
29	15							Cobbles, caving	29
30	14							Bottom of exploration at 30 ft. BGS.	30
31	13								31
32	12								32
33	11								33
34	10								34
35	9								35
36	8								36
37	7								37
38	6								38
39	5								39
40	4								40
41	3								41
42	2								42
43	1								43
44	0								44
45	-1								45
46	-2								46
47	-3								47
48	-4								48
49	-5								49

Legend

Plastic Limit ├──┤ Liquid Limit

Sample Method
- ▣ No Soil Sample Recovery
- ■ Thin wall 3" (Shelby)
- ◩ SPT (ASTM 1586)

Water Level
- ▼ Static Water Level
- ▽ Water Level (ATD)

For detailed Soil Graphic Descriptions, see Figure 1.

Logged by: Mv
Approved by: NS

Figure No.

A-6

Sheet 2 of 2

APPENDIX B

Geotechnical Laboratory Testing

B. Geotechnical Laboratory Testing

Laboratory testing to characterize geotechnical properties was performed on selected soil samples obtained from the boreholes. Laboratory testing was conducted by Hayre McElroy, & Associates, LLC. Table 1 summarizes the geotechnical laboratory testing that was performed. The results of the tests are presented in Appendix B. The following is a summary of geotechnical laboratory testing methods utilized for the Project.

Water Content Determination

Select subsurface soil samples retrieved from the boreholes were submitted for analysis of water content by the American Society for Testing and Materials (ASTM) D2216 test method. This test method allows for the laboratory determination of the water (moisture) content of a soil sample by measuring and recording the mass of a sample before and then after drying. Test results are illustrated graphically on the boring logs in Appendix A.

Organic Content Tests

Select subsurface soil samples from the boreholes were submitted for quantification of organic content by the ASTM D2974 test method. This test method allows for the laboratory determination of the percent of organic material (by weight) in a dried soil sample. Test results are compiled in Appendix B.

Grain-Size Analysis

Select subsurface soil samples from the boreholes were submitted for analysis of grain size by the ASTM C136 and D1140 test methods[2]. This test method allows for the laboratory determination of the percent of the size fractions (by weight) of coarse-grained soil and the percent of fines in a soil sample. Test results are compiled in Appendix B.

Plasticity Index (Atterberg Limits) Determination

Select subsurface soil samples from the boreholes were submitted for analysis of plasticity index by the ASTM D4318 test method. This test method allows for the laboratory determination of the liquid limit and the plastic limit of the fines in a soil sample. Test results are compiled in Appendix B.

Consolidation Tests

Select subsurface soil samples from the boreholes were submitted for analysis of one-dimensional consolidation by the ASTM D2435 test method. This test method allows for the laboratory determination of compressibility characteristics of a soil subjected to incremental loading. Test results are compiled in Appendix B.

Consolidated-Undrained Triaxial Compression Tests

Select subsurface soil samples from the boreholes were submitted for analysis of triaxial compression by the ASTM D4767 test method. This method allows for the laboratory

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[2] The Particle Size Distribution Reports in Appendix B have a typographical error, and the ASTM method is listed as D1440, not D1140.

determination of shear strength characteristics of consolidated, undrained soil samples. Test results are compiled in Appendix B.

Hayre McElroy & Associates, LLC

Moisture Contents

Moisture Content Test Results (ASTM D2216) - Lower Coal Creek Project# 140362/08-175

HMA Sample #	Sample #	Location	Date Received	Date of Test	Tare #	Wt of Tare	Tare+ Wet	Tare+ Dry	Moisture %
7810-1	B-1 S1	5'-6.5'	10/15/2015	10/16/2015	B-6	15.8	237.0	149.5	65.4
7810-2	B-1 S2	12'.5-14'	10/15/2015	10/16/2015	B-7	15.8	439.1	218.4	108.9
7810-3	B-1 S4a	17'-18.5'	10/15/2015	10/16/2015	B-8	15.8	225.7	72.7	268.9
7810-4	B-1 S4b	17'-18.5'	10/15/2015	10/16/2015	B-9	15.8	112.4	33.9	433.7
7810-5	B-1 S5	20'-21.5'	10/15/2015	10/16/2015	B-10	15.8	299.6	73.3	393.6
7810-6	B-1 S8	26'-27.5'	10/15/2015	10/16/2015	B-11	15.8	314.0	209.6	53.9
7810-7	B-1 S9	30'-31.5'	10/15/2015	10/16/2015	B-12	15.8	489.6	288.7	73.6
7810-8	B-1 S10	35'-36.5'	10/15/2015	10/16/2015	B-13	15.80	557.80	356.40	59.1
7810-9	B-1 S12a	45'-46.5'	10/15/2015	10/16/2015	B-14	15.80	479.30	346.4	40.2
7810-10	B-1 S13	50'-51.5'	10/15/2015	10/16/2015	B-15	15.8	489.20	367.60	34.6
7810-11	B-2 S1	5'-6.5'	10/15/2015	10/16/2015	B-16	15.8	496.4	339.1	48.7
7810-12	B-2 S3a	9.5'-11'	10/15/2015	10/16/2015	B-17	15.8	245.6	153.70	66.6
7810-13	B-2 S3b	9.5'-11'	10/15/2015	10/16/2015	B-18	15.8	491.8	357.8	39.2
7810-14	B-2 S4	12.5'-14.5	10/15/2015	10/16/2015	B-19	15.8	397.0	179.1	133.4
7810-16	B-2 S6	17'-19'	10/15/2015	10/16/2015	B-20	15.8	267.2	59.4	476.6
7810-17	B-2 S7	20'-21.5'	10/15/2015	10/16/2015	B-21	15.8	417.7	306.2	38.4
7810-18	B-2 S8	22.5'-26.5'	10/15/2015	10/16/2015	B-22	15.8	525.0	382.10	39.0
7810-19	B-2 S9	25'-26.5'	10/15/2015	10/16/2015	B-23	15.8	442.5	307.1	46.5
7810-20	B-2 S10	30'-31.5'	10/15/2015	10/16/2015	B-24	15.8	586.9	433.8	36.6
7810-21	B-2 S11	35'-36.5'	10/15/2015	10/16/2015	B-25	15.8	353.8	319.1	11.4
7810-22	B-2 S12	45'-46.5'	10/15/2015	10/16/2015	B-26	15.8	296.8	238.5	26.2
7810-23	B-2 S13	50'-51.5'	10/15/2015	10/16/2015	B-27	15.8	403.3	250.4	65.2
7810-24	B-3 S1	5'-6.5'	10/15/2015	10/16/2015	B-28	15.8	435.1	337.5	30.3
7810-25	B-3 S3	9.5'-11'	10/15/2015	10/16/2015	B-15	15.8	293.3	249.9	18.5
7810-26	B-3 S4	12.5'-14'	10/15/2015	10/16/2015	B-9	15.8	269.1	125.2	131.5
7810-27	B-3 S7	20'-21.5	10/15/2015	10/16/2015	B-14	15.8	477	371.6	29.6
7810-28	B-3 S9	27.5'-29'	10/15/2015	10/16/2015	B-13	15.8	456.8	348	32.8
7810-29	B-3 S11	35'-36.5'	10/15/2015	10/16/2015	B-8	15.8	252.5	175.8	47.9
7810-30	B-3 S13	45'-46.5'	10/15/2015	10/16/2015	B-10	15.8	576.2	394.3	48.1
7810-31	B-3 S14	50'-51.5'	10/15/2015	10/16/2015	B-11	15.8	489.8	328.8	51.4
7810-32	B-4 S1	5'-6.5'	10/15/2015	10/16/2015	A-11	15.9	393.9	269	49.3
7810-33	B-4 S2	10'-11.5'	10/15/2015	10/16/2015	A-9	15.9	525.5	357.4	49.2
7810-34	B-4 S4	14.5'-16'	10/15/2015	10/16/2015	A-4	15.9	450.4	288.7	59.3
7810-35	B-4 S5a	17.5'-19.5'	10/15/2015	10/16/2015	A-3	15.9	329.5	146.2	140.7
7810-36	B-4 S5b	17.5'-19.5'	10/15/2015	10/16/2015	A-2	15.9	553.3	399.9	39.9
7810-37	B-4 S6	20'-22'	10/15/2015	10/15/2015	A-16	15.9	658.1	475.6	39.7
7810-38	B-5 S2a	9.5'-11'	10/15/2015	10/16/2015	A-15	15.9	512.8	370	40.3
7810-39	B-5 S4	20'-21.5'	10/15/2015	10/16/2015	A-14	15.9	404.1	349.9	16.2

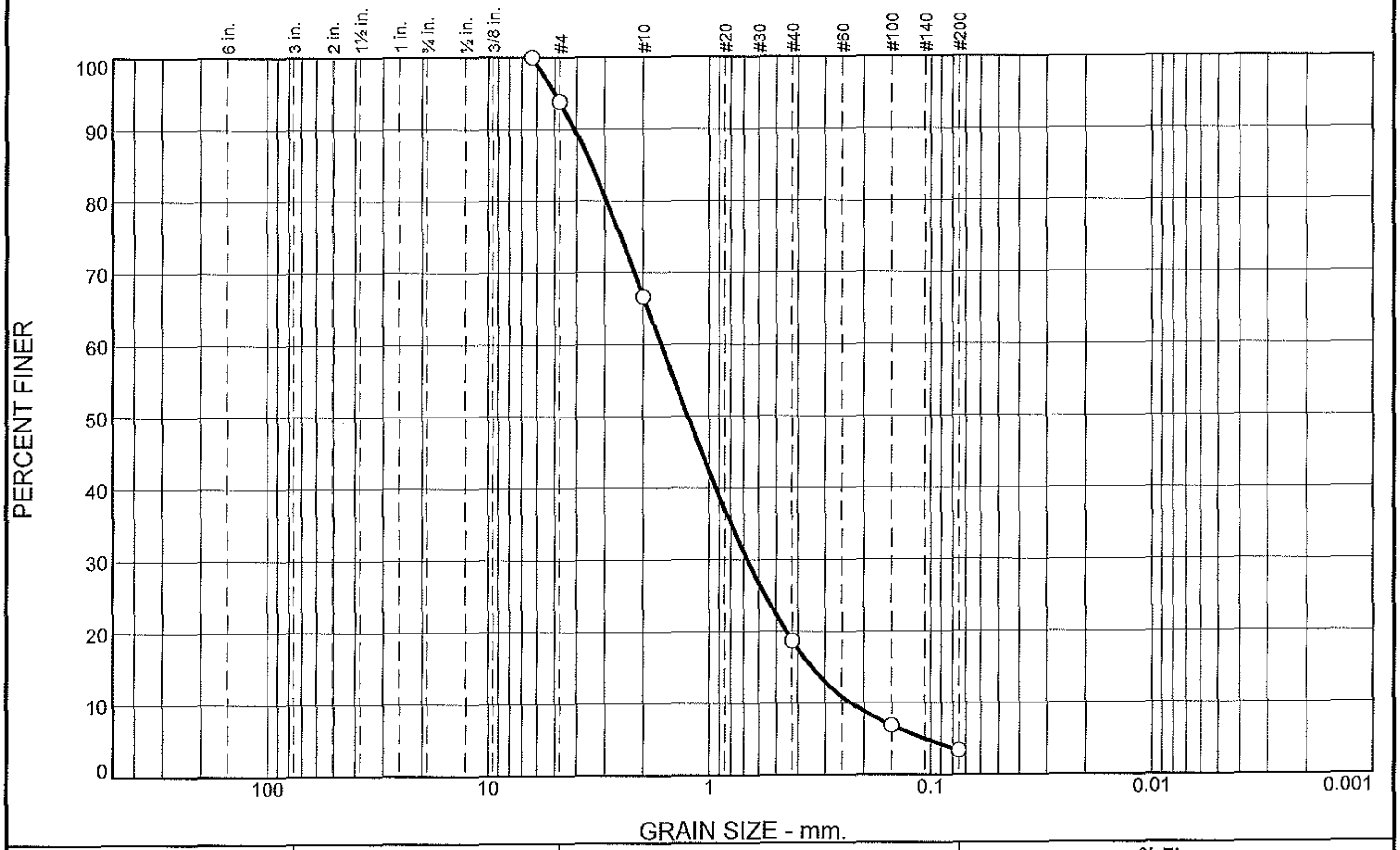
Hayre McElroy & Associates, LLC

Moisture Contents

Moisture Content Test Results (ASTM D2216) - Loower Coal Creek Project# 140362/08175

HMA Sample #	Sample #	Location	Date Received	Date of Test	Tare #	Wt of Tare	Tare+ Wet	Tare+ Dry	Moisture %
7810-41	B-1 S-3	15'-17'	10/15/2015	10/28/2015	A-6	16.0	269.8	85.4	265.7
7810-40	B-1 S-7	24'-26'	10/15/2015	10/28/2015	A-13	16.2	616.2	488.2	27.1
7810-42	B-2 S-5	15'-17'	10/15/2015	10/28/2015	A-7	15.9	639.8	188.9	260.6
7810-43	B-3 S-8	22.5'-24.5'	10/15/2015	10/28/2015	A-1	16.3	515.5	366.1	42.7
7810-46	B-4 S-3	12.5'-14.5'	10/15/2015	10/28/2015	A-12	15.9	372.2	260.4	45.7
7810-47	B-5 S-1	7.5'-9.5	10/15/2015	10/28/2015	A-10	15.80	345.30	242.00	45.7
7810-45	B-5 S-3	12.5'-14.5'	10/15/2015	10/28/2015	A-8	15.9	543.9	378.2	45.7
7810-44	B-3 S-5 15' to 17'		10/15/2015	10/28/2015	A-5	16.0	435.5	114.7	325.0

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	6.2	27.2	47.9	15.3	3.4	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1/4"	100.0		
#4	93.8		
#10	66.6		
#40	18.7		
#100	6.9		
#200	3.4		

* (no specification provided)

Soil Description

Sand

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 4.0957 D_{85}= 3.4462 D_{60}= 1.6610
D_{50}= 1.2527 D_{30}= 0.6739 D_{15}= 0.3447
D_{10}= 0.2286 C_u= 7.27 C_c= 1.20

Classification

USCS= SW AASHTO=

Remarks

B-1 S1 5'-6.5'

Location: B-1 S1
Sample Number: 7810-1 **Depth:** 5'-6.5' **Date:** 10/18/2015

Hayre McElroy & Associates, LLC

Redmond, WA

Client: Aspect Consulting
Project: Lower Coal Creek
Project No: 140362/08-175 **Figure**

Tested By: B.H **Checked By:** JAM

GRAIN SIZE DISTRIBUTION TEST DATA

10/26/2015

Client: Aspect Consulting
Project: Lower Coal Creek
Project Number: 140362/08-175
Location: B-1 S1
Depth: 5'-6.5' **Sample Number:** 7810-1
Material Description: Sand
Date: 10/18/2015
USCS Classification: SW
Testing Remarks: B-1 S1 5'-6.5'
Tested by: B.H **Checked by:** JAM

Sieve Test Data

Post #200 Wash Test Weights (grams): **Dry Sample and Tare =** 145.80
Tare Wt. = 15.80
Minus #200 from wash = 2.8%

Dry Sample and Tare (grams)	Tare (grams)	Sieve Opening Size	Weight Retained (grams)	Sieve Weight (grams)	Percent Finer
149.50	15.80	1/4"	0.00	0.00	100.0
		#4	8.30	0.00	93.8
		#10	36.30	0.00	66.6
		#40	64.10	0.00	18.7
		#100	15.80	0.00	6.9
		#200	4.70	0.00	3.4

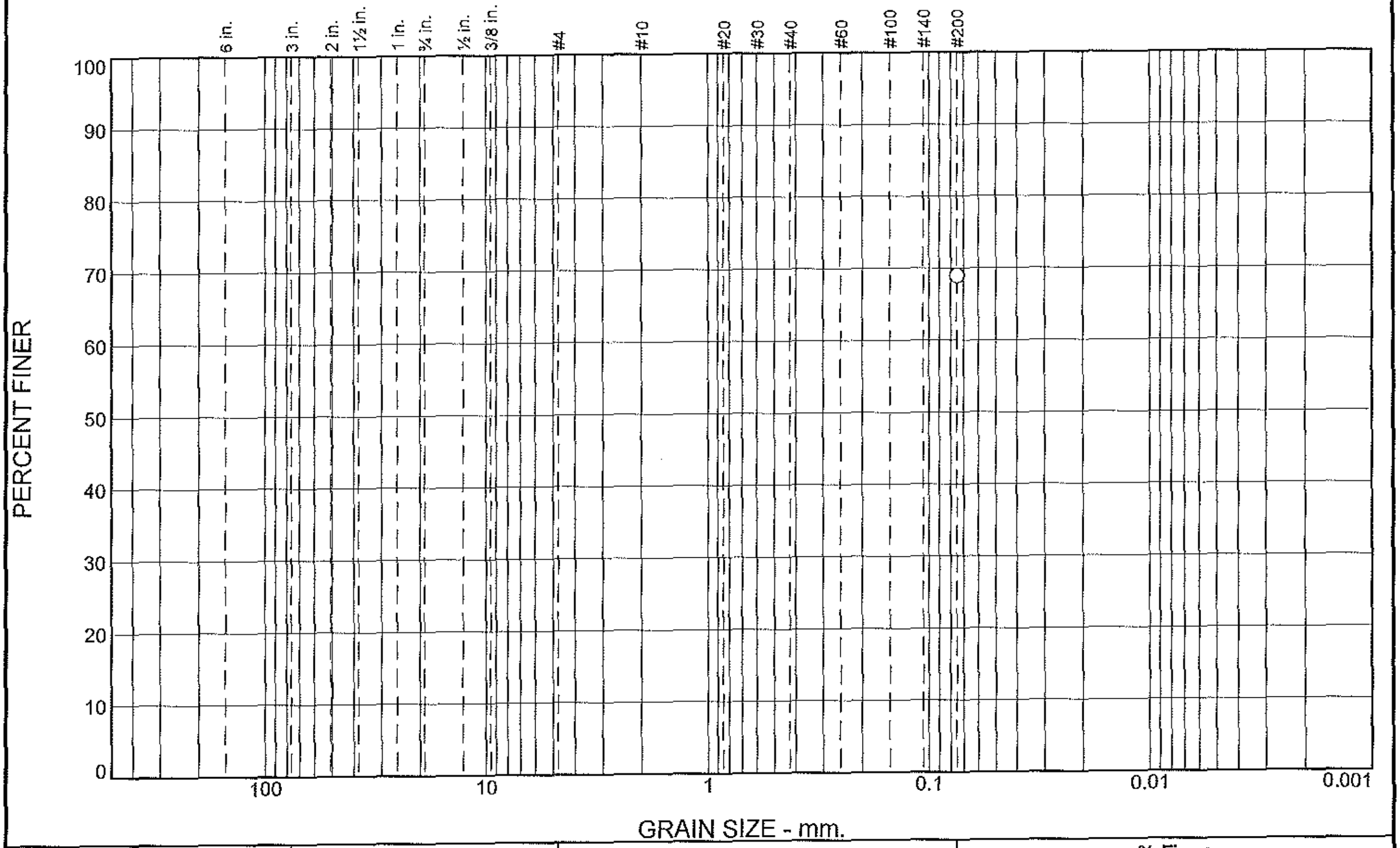
Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	6.2	6.2	27.2	47.9	15.3	90.4			3.4

D_{10}	D_{15}	D_{20}	D_{30}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
0.2286	0.3447	0.4527	0.6739	1.2527	1.6610	2.9437	3.4462	4.0957	5.0038

Fineness Modulus	C_u	C_c
3.39	7.27	1.20

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						69.0	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	69.0		

* (no specification provided)

Soil Description

B-1 S-2 12.5'-14'

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= AASHTO=

Remarks

B-1 S2 12.5'-14'

Location: B-1 S2
Sample Number: 7810-2 **Depth:** 12.5'-14' **Date:** 10/19/2015

Hayre McElroy & Associates, LLC

Redmond, WA

Client: Aspect Consulting
Project: Lower Coal Creek
Project No: 140362/08-175 **Figure**

Tested By: B.H **Checked By:** JAM

GRAIN SIZE DISTRIBUTION TEST DATA

10/26/2015

Client: Aspect Consulting
Project: Lower Coal Creek
Project Number: 140362/08-175
Location: B-1 S2
Depth: 12.5'-14' **Sample Number:** 7810-2
Material Description: B-1 S-2 12.5'-14'
Date: 10/19/2015
Testing Remarks: B-1 S2 12.5'-14'
Tested by: B.H **Checked by:** JAM

Sieve Test Data

Post #200 Wash Test Weights (grams): Dry Sample and Tare = 78.70
Tare Wt. = 15.80
Minus #200 from wash = 69.0%

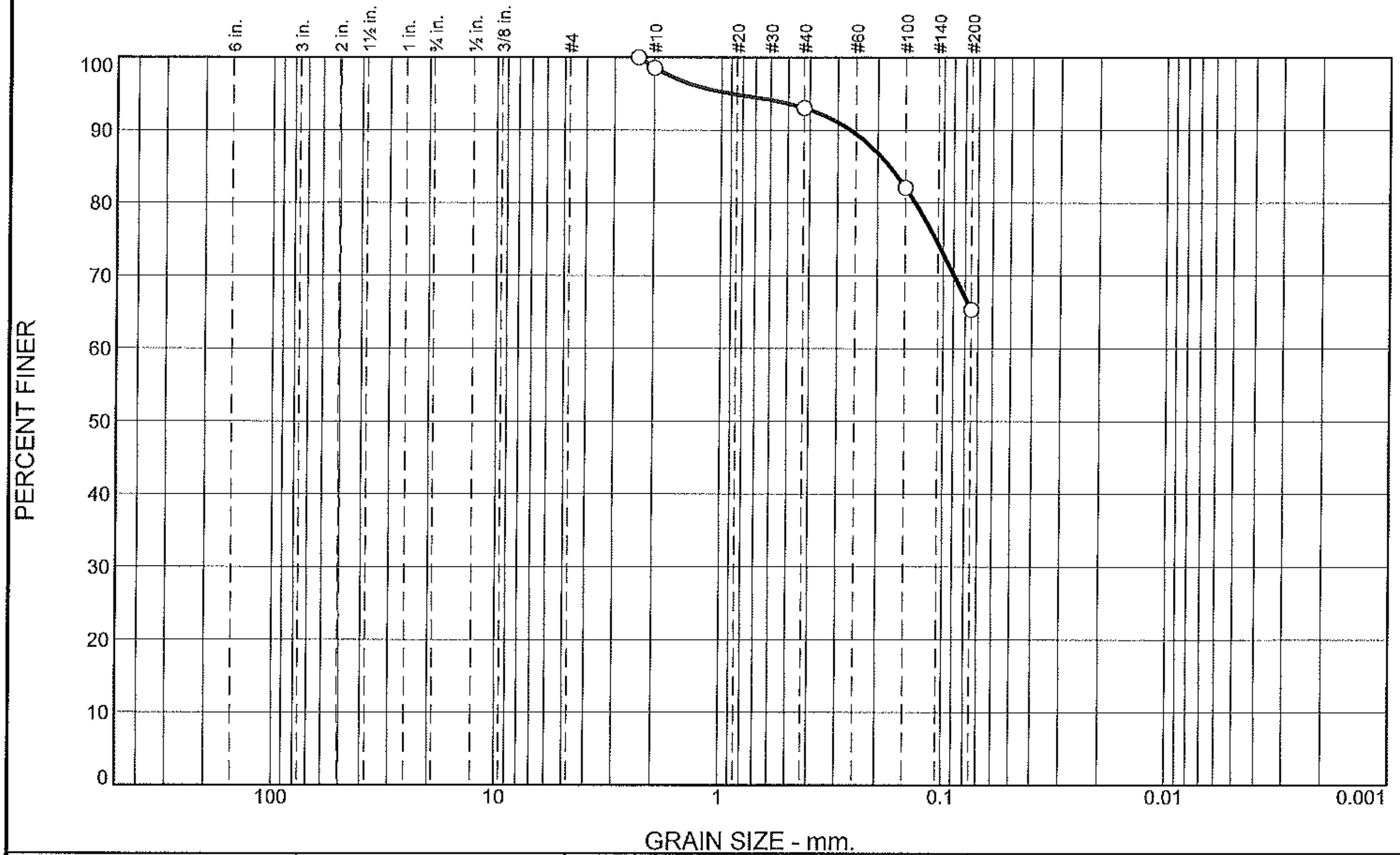
Dry Sample and Tare (grams)	Tare (grams)	Sieve Opening Size	Weight Retained (grams)	Sieve Weight (grams)	Percent Finer
218.40	15.80	#200			69.0

Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
										69.0

D_{10}	D_{15}	D_{20}	D_{30}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	1.5	5.5	27.7	65.3	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#8	100.0		
#10	98.5		
#40	93.0		
#100	82.1		
#200	65.3		

* (no specification provided)

Soil Description

Sandy Silt

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.2655 D_{85}= 0.1771 D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= ML AASHTO=

Remarks

B-2 S3a 9.5'-11'

Location: B-2 S3a
Sample Number: 7810-12 **Depth:** 9.5'-11' **Date:** 10/20/2015

Hayre McElroy & Associates, LLC

Redmond, WA

Client: Aspect Consulting
Project: Lower Coal Creek
Project No: 140362/08-175 **Figure**

Tested By: B.H **Checked By:** JAM

GRAIN SIZE DISTRIBUTION TEST DATA

10/27/2015

Client: Aspect Consulting
Project: Lower Coal Creek
Project Number: 140362/08-175
Location: B-2 S3a
Depth: 9.5'-11' **Sample Number:** 7810-12
Material Description: Sandy Silt
Date: 10/20/2015
USCS Classification: ML
Testing Remarks: B-2 S3a 9.5'-11'
Tested by: B.H **Checked by:** JAM

Sieve Test Data

Post #200 Wash Test Weights (grams): **Dry Sample and Tare =** 76.40
Tare Wt. = 15.80
Minus #200 from wash = 56.1%

Dry Sample and Tare (grams)	Tare (grams)	Sieve Opening Size	Weight Retained (grams)	Sieve Weight (grams)	Percent Finer
153.70	15.80	#8	0.00	0.00	100.0
		#10	2.00	0.00	98.5
		#40	7.60	0.00	93.0
		#100	15.10	0.00	82.1
		#200	23.10	0.00	65.3

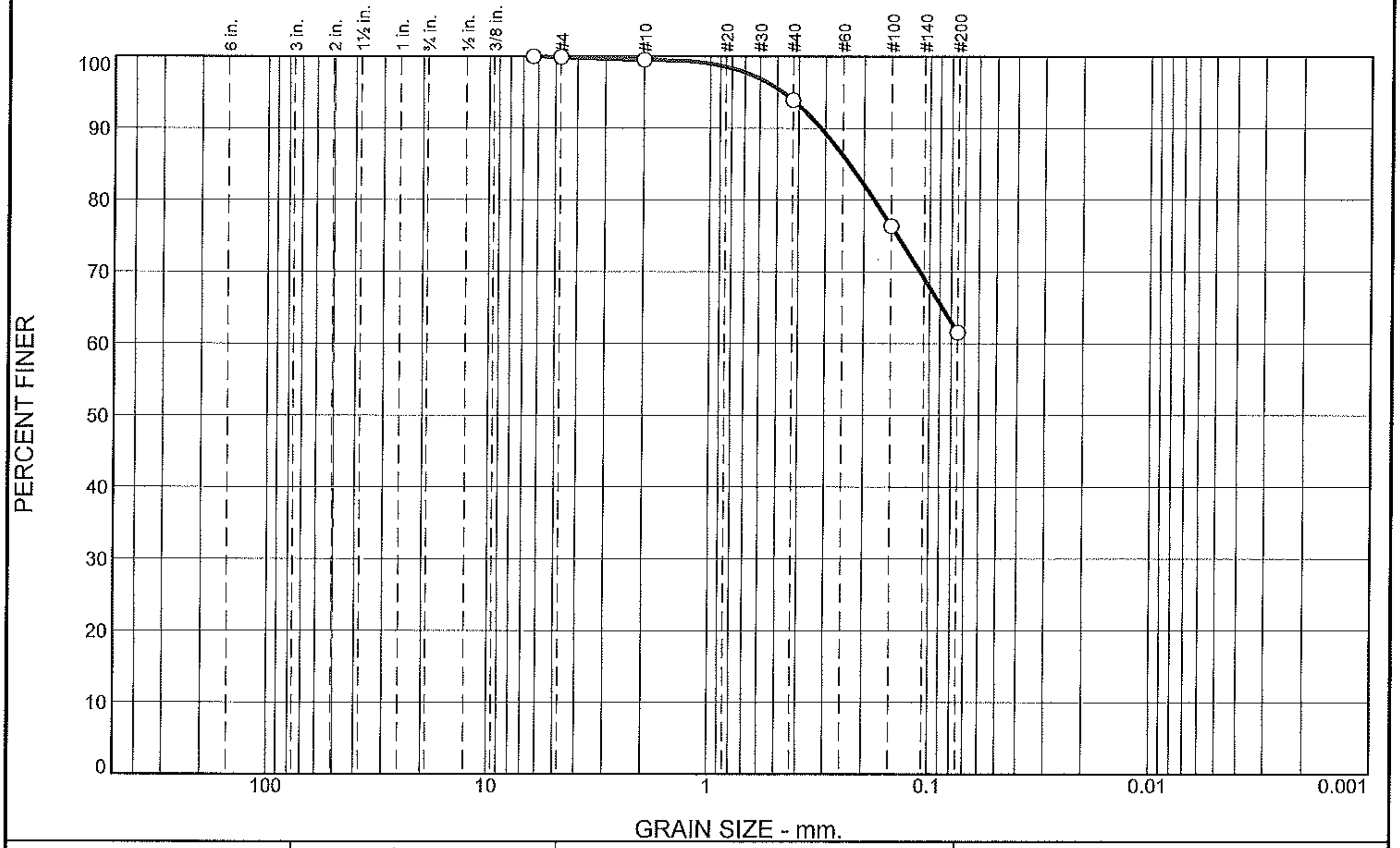
Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	0.0	0.0	1.5	5.5	27.7	34.7			65.3

D_{10}	D_{15}	D_{20}	D_{30}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
						0.1353	0.1771	0.2655	0.9037

Fineness Modulus
0.37

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.1	0.4	5.6	32.4	61.5	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1/4"	100.0		
#4	99.9		
#10	99.5		
#40	93.9		
#100	76.4		
#200	61.5		

* (no specification provided)

Soil Description

Sandy Silt

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.3162 D_{85}= 0.2339 D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= ML AASHTO=

Remarks

B-4 S4 14.5'-16'

Location: B-4 S4
Sample Number: 7810-34 **Depth:** 14.5'-16' **Date:** 10/29/2015

Hayre McElroy & Associates, LLC

Redmond, WA

Client: Aspect Consulting
Project: Lower Coal Creek
Project No: 140362/08-175 **Figure**

Tested By: B.H **Checked By:** JAM

GRAIN SIZE DISTRIBUTION TEST DATA

10/27/2015

Client: Aspect Consulting
Project: Lower Coal Creek
Project Number: 140362/08-175
Location: B-4 S4
Depth: 14.5'-16'
Sample Number: 7810-34
Material Description: Sandy Silt
Date: 10/29/2015
USCS Classification: ML
Testing Remarks: B-4 S4 14.5'-16'
Tested by: B.H
Checked by: JAM

Sieve Test Data

Post #200 Wash Test Weights (grams): **Dry Sample and Tare =** 135.10
Tare Wt. = 15.90
Minus #200 from wash = 56.3%

Dry Sample and Tare (grams)	Tare (grams)	Sieve Opening Size	Weight Retained (grams)	Sieve Weight (grams)	Percent Finer
288.70	15.90	1/4"	0.00	0.00	100.0
		#4	0.30	0.00	99.9
		#10	1.00	0.00	99.5
		#40	15.40	0.00	93.9
		#100	47.80	0.00	76.4
		#200	40.40	0.00	61.5

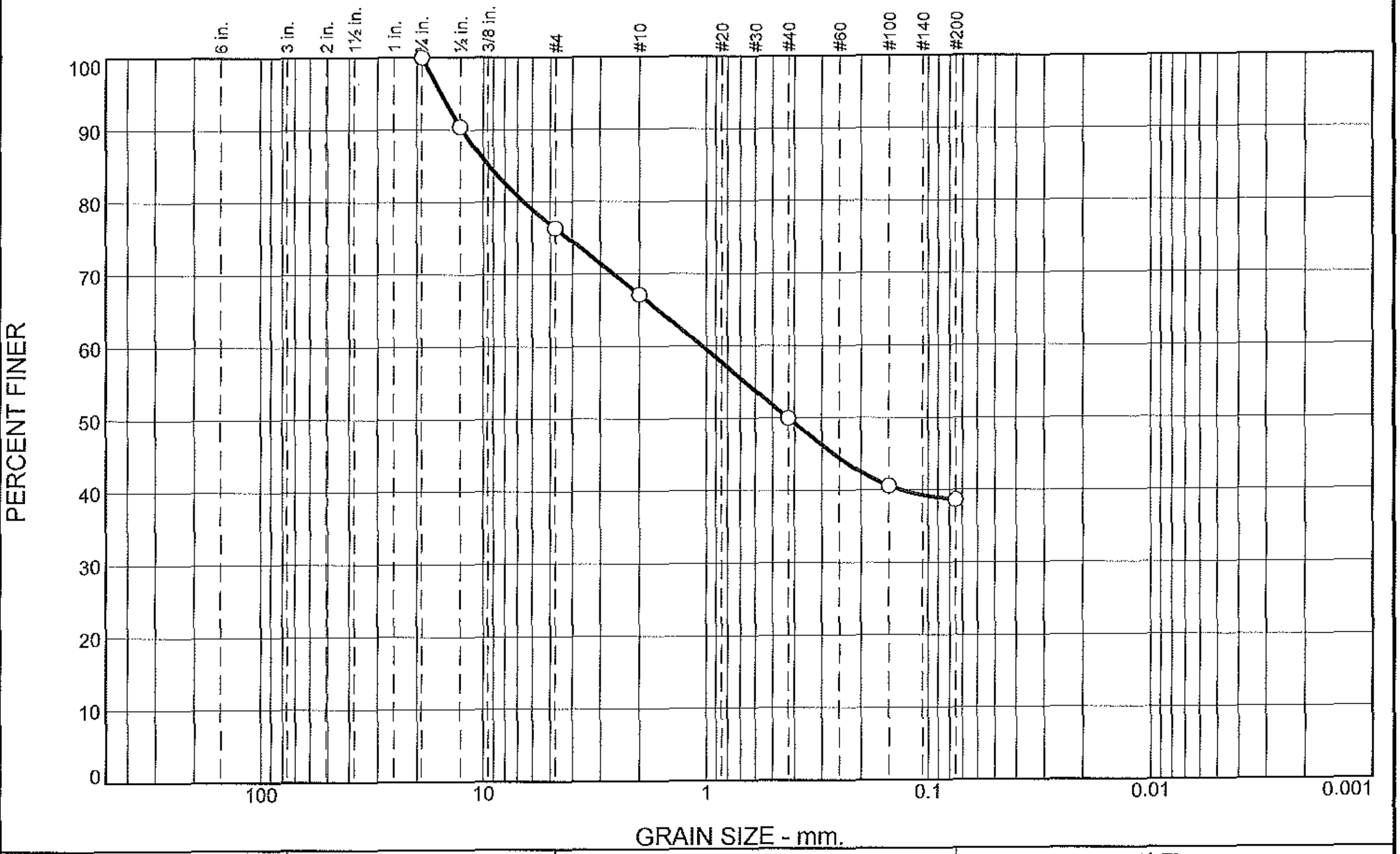
Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	0.1	0.1	0.4	5.6	32.4	38.4			61.5

D_{10}	D_{15}	D_{20}	D_{30}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
						0.1796	0.2339	0.3162	0.4739

Fineness Modulus
0.39

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	23.7	9.2	17.1	11.3	38.7	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/4"	100.0		
1/2"	90.4		
#4	76.3		
#10	67.1		
#40	50.0		
#100	40.6		
#200	38.7		

* (no specification provided)

Soil Description

Silty Sand with Gravel

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 12.4398 D_{85}= 9.4380 D_{60}= 1.0464
D_{50}= 0.4261 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= SM AASHTO=

Remarks

B-5 S2a 9.5'-11'

Location: B-5 S2a
Sample Number: 7810-38 **Depth:** 9.5'-11' **Date:** 10/20/2015

Hayre McElroy & Associates, LLC

Redmond, WA

Client: Aspect Consulting
Project: Lower Coal Creek
Project No: 140362/08-175 **Figure**

Tested By: B.H **Checked By:** JAM

GRAIN SIZE DISTRIBUTION TEST DATA

10/27/2015

Client: Aspect Consulting
Project: Lower Coal Creek
Project Number: 140362/08-175
Location: B-5 S2a
Depth: 9.5'-11'
Sample Number: 7810-38
Material Description: Silty Sand with Gravel
Date: 10/20/2015
USCS Classification: SM
Testing Remarks: B-5 S2a 9.5'-11'
Tested by: B.H
Checked by: JAM

Sieve Test Data

Post #200 Wash Test Weights (grams): **Dry Sample and Tare =** 233.70
Tare Wt. = 15.80
Minus #200 from wash = 38.5%

Dry Sample and Tare (grams)	Tare (grams)	Sieve Opening Size	Weight Retained (grams)	Sieve Weight (grams)	Percent Finer
370.00	15.80	3/4"	0.00	0.00	100.0
		1/2"	33.90	0.00	90.4
		#4	49.90	0.00	76.3
		#10	32.70	0.00	67.1
		#40	60.70	0.00	50.0
		#100	33.30	0.00	40.6
		#200	6.80	0.00	38.7

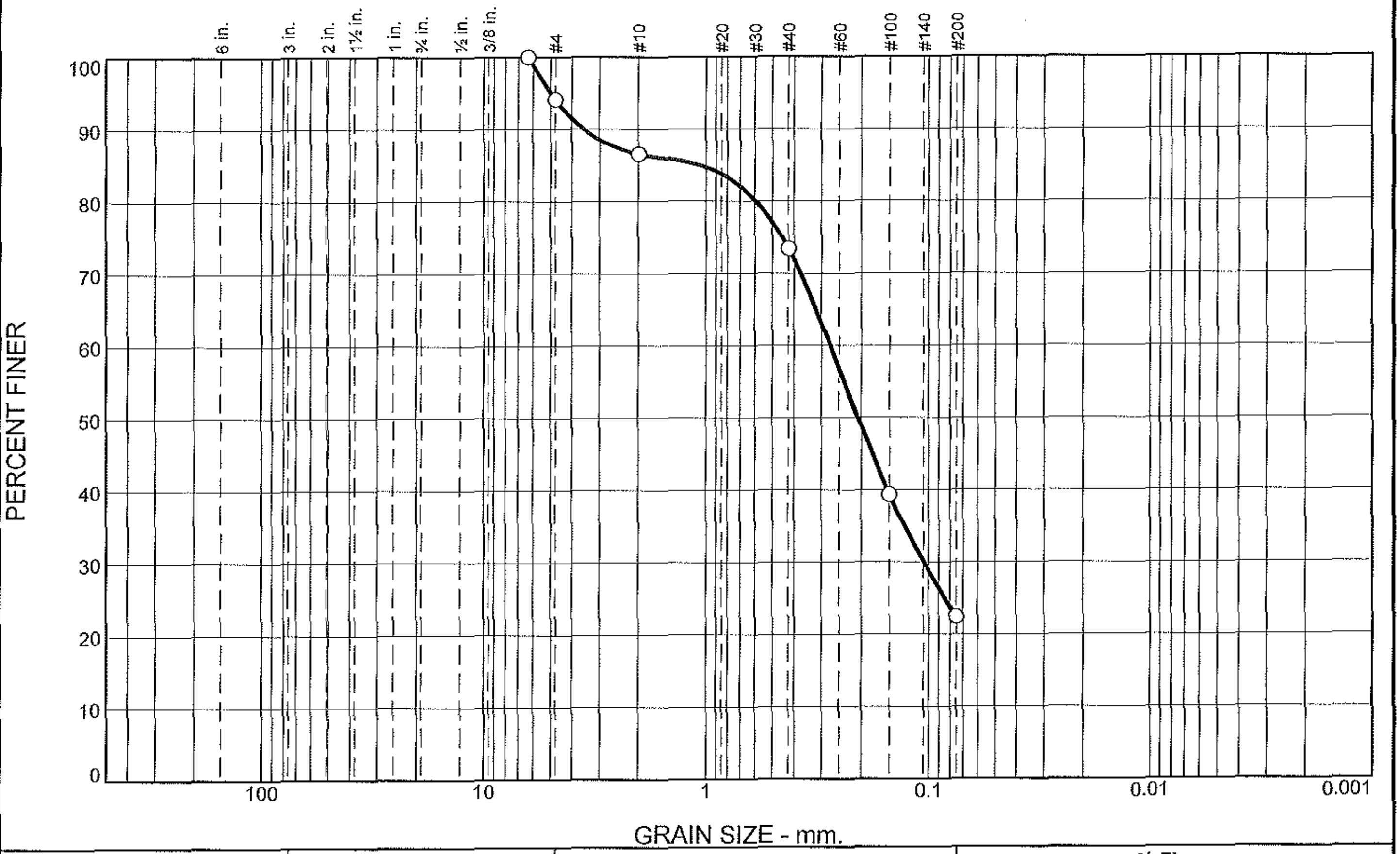
Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	23.7	23.7	9.2	17.1	11.3	37.6			38.7

D_{10}	D_{15}	D_{20}	D_{30}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
				0.4261	1.0464	6.5694	9.4380	12.4398	15.5466

Fineness Modulus
2.68

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	5.9	7.5	13.2	50.9	22.5	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1/4"	100.0		
#4	94.1		
#10	86.6		
#40	73.4		
#100	39.3		
#200	22.5		

* (no specification provided)

Soil Description

Sand with Silt

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 3.5271 D_{85}= 1.0755 D_{60}= 0.2745
D_{50}= 0.2070 D_{30}= 0.1055 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= SM AASHTO=

Remarks

B-5 S4 20'-21.5'

Location: B-5 S4
Sample Number: 7810-39 **Depth:** 7810-39 **Date:** 10/20/2015

Hayre McElroy & Associates, LLC

Redmond, WA

Client: Aspect Consulting
Project: Lower Coal Creek
Project No: 140362/08-175 **Figure**

Tested By: B.H **Checked By:** JAM

GRAIN SIZE DISTRIBUTION TEST DATA

10/27/2015

Client: Aspect Consulting
Project: Lower Coal Creek
Project Number: 140362/08-175
Location: B-5 S4
Depth: 7810-39 **Sample Number:** 7810-39
Material Description: Sand with Silt
Date: 10/20/2015
USCS Classification: SM
Testing Remarks: B-5 S4 20'-21.5'
Tested by: B.H **Checked by:** JAM

Sieve Test Data

Post #200 Wash Test Weights (grams): **Dry Sample and Tare =** 288.40
Tare Wt. = 15.90
Minus #200 from wash = 18.4%

Dry Sample and Tare (grams)	Tare (grams)	Sieve Opening Size	Weight Retained (grams)	Sieve Weight (grams)	Percent Finer
349.90	15.90	1/4"	0.00	0.00	100.0
		#4	19.60	0.00	94.1
		#10	25.30	0.00	86.6
		#40	43.80	0.00	73.4
		#100	114.00	0.00	39.3
		#200	56.30	0.00	22.5

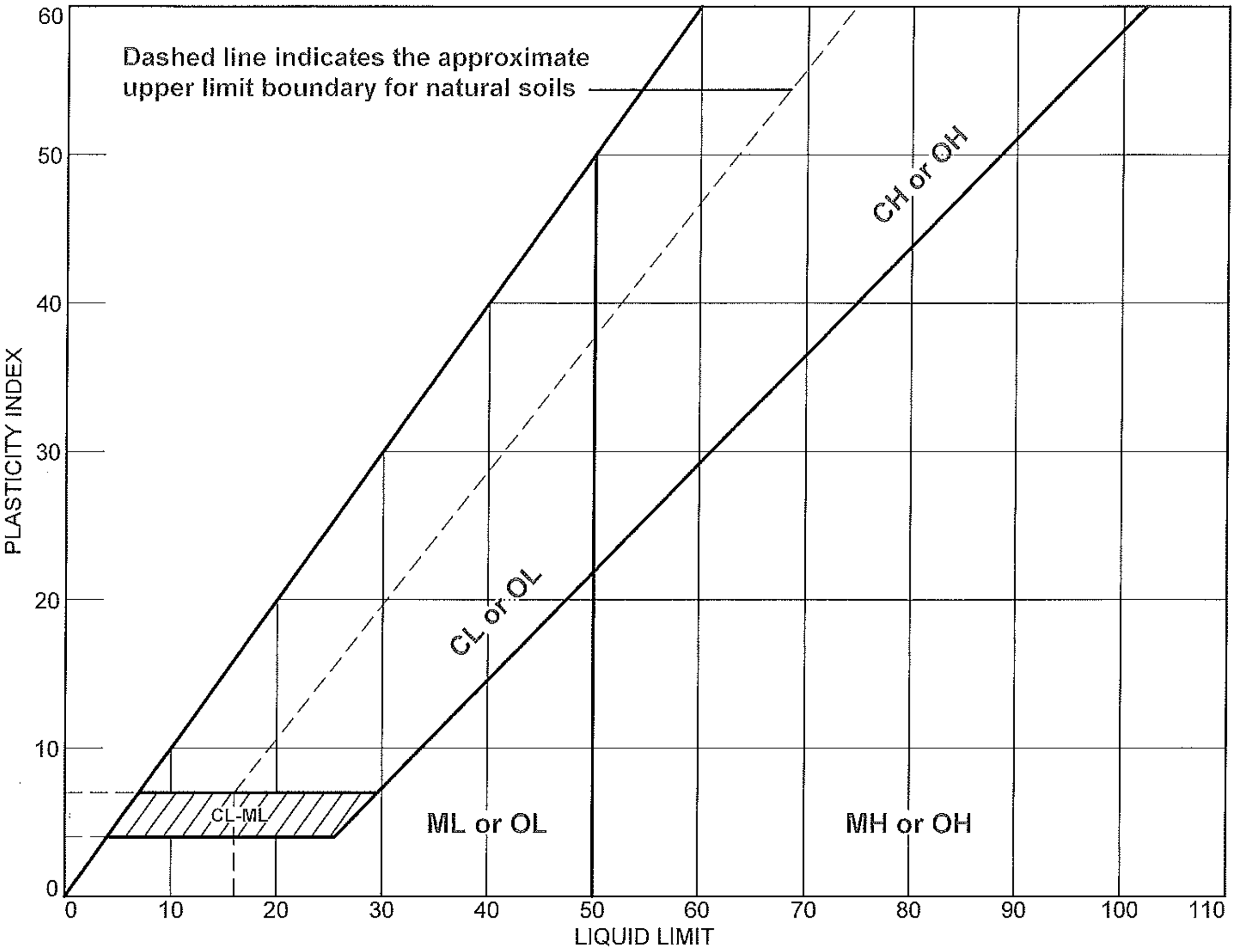
Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	5.9	5.9	7.5	13.2	50.9	71.6			22.5

D_{10}	D_{15}	D_{20}	D_{30}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
			0.1055	0.2070	0.2745	0.5949	1.0755	3.5271	4.9822

Fineness Modulus
1.51

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	B-1 S-3 15'-17'	7810-41	15'-17'	265.7	NP	NV	NP	OL

Hayre McElroy & Associates, LLC

Redmond, WA

Client: Aspect Consulting
Project: Lower Coal Creek

Project No.: 140362/08-175 **Figure**

Tested By: B.H **Checked By:** JAM

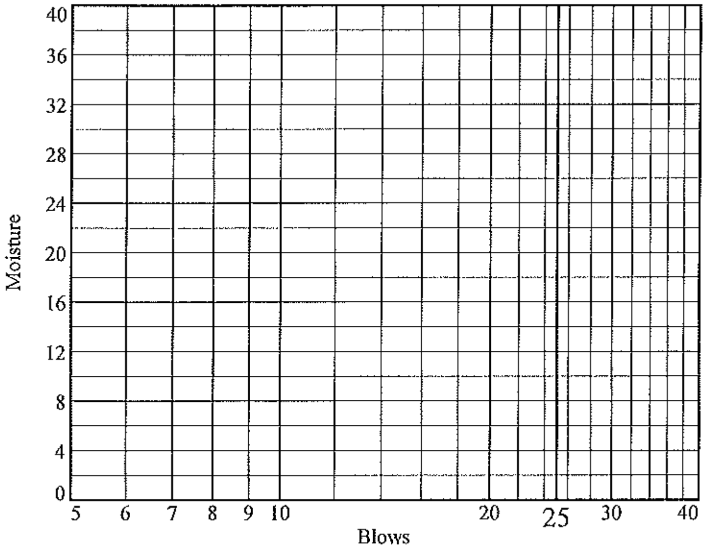
LIQUID AND PLASTIC LIMIT TEST DATA

11/2/2015

Client: Aspect Consulting
Project: Lower Coal Creek
Project Number: 140362/08-175
Location: B-1 S-3
Depth: 15'-17' **Sample Number:** 7810-41
Material Description: B-1 S-3 15'-17'
USCS: OL
Tested by: B.H **Checked by:** JAM

Liquid Limit Data

Run No.	1	2	3	4	5	6
Wet+Tare						
Dry+Tare						
Tare						
# Blows						
Moisture						



Liquid Limit= NV
Plastic Limit= NP
Plasticity Index= NP
Natural Moisture= 265.7

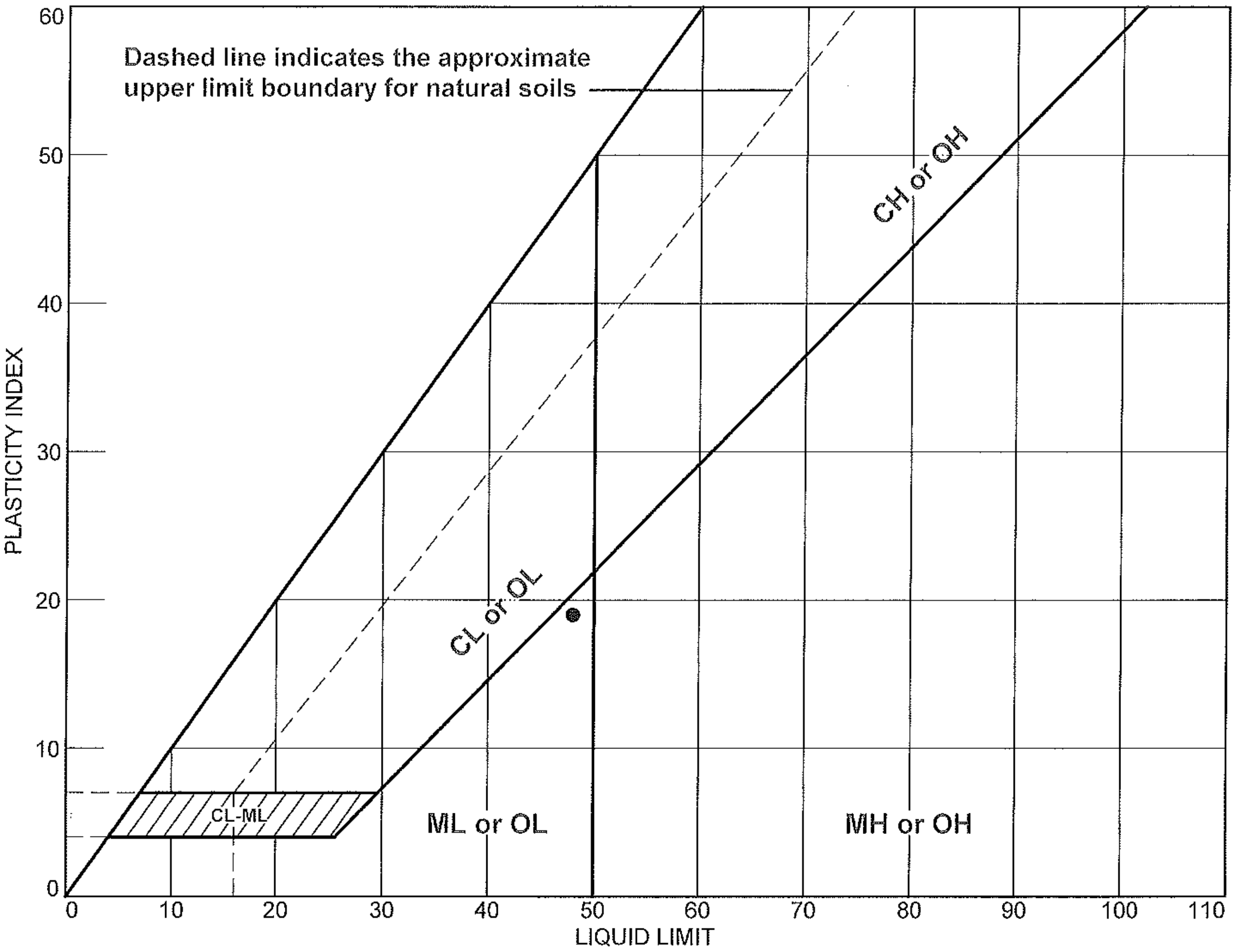
Plastic Limit Data

Run No.	1	2	3	4	
Wet+Tare					
Dry+Tare					
Tare					
Moisture					

Natural Moisture Data

Wet+Tare	Dry+Tare	Tare	Moisture
269.8	85.4	16.0	265.7

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	B-1 S9 30'-31.5	7810-7	30'-31.5'	73.6	29	48	19	

Hayre McElroy & Associates, LLC

Redmond, WA

Client: Aspect Consulting
Project: Lower Coal Creek
Project No.: 140362/08-175 **Figure**

Tested By: B.H **Checked By:** JAM

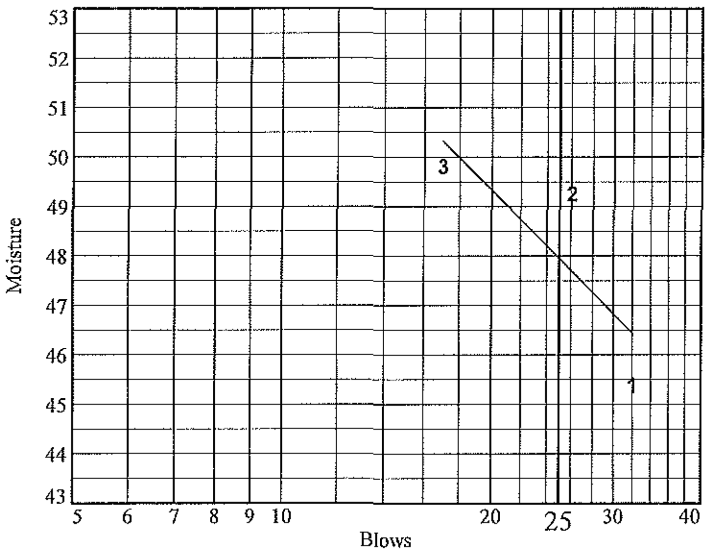
LIQUID AND PLASTIC LIMIT TEST DATA

10/27/2015

Client: Aspect Consulting
Project: Lower Coal Creek
Project Number: 140362/08-175
Location: B-1 S9
Depth: 30'-31.5'
Sample Number: 7810-7
Material Description: B-1 S9 30'-31.5
Tested by: B.H
Checked by: JAM

Liquid Limit Data

Run No.	1	2	3	4	5	6
Wet+Tare	30.35	31.96	30.21			
Dry+Tare	25.13	25.95	24.67			
Tare	13.63	13.75	13.55			
# Blows	32	26	17			
Moisture	45.4	49.3	49.8			



Liquid Limit= 48
Plastic Limit= 29
Plasticity Index= 19
Natural Moisture= 73.6
Liquidity Index= 2.3

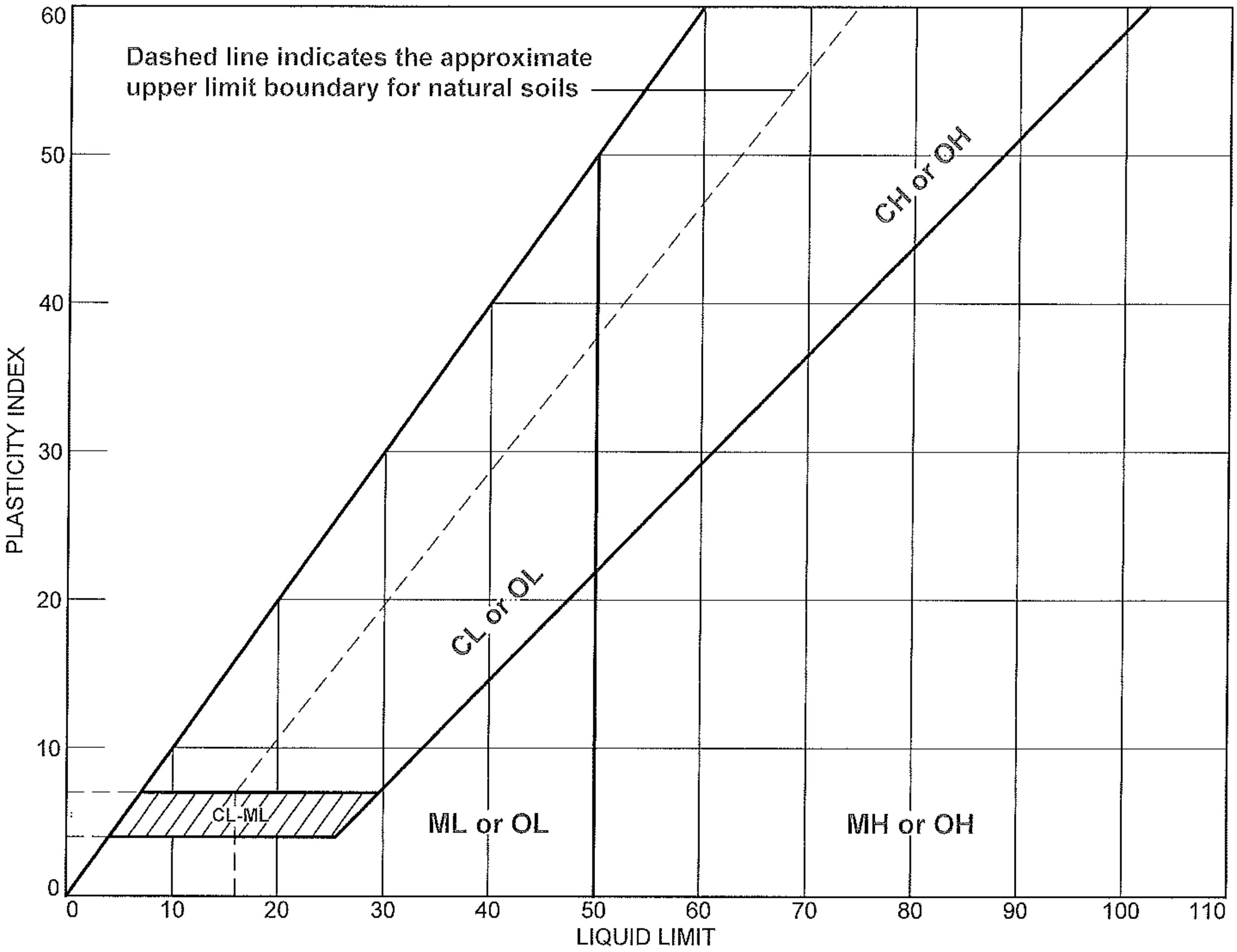
Plastic Limit Data

Run No.	1	2	3	4	
Wet+Tare	22.77	22.77	22.77		
Dry+Tare	20.71	20.71	20.71		
Tare	13.62	13.62	13.62		
Moisture	29.1	29.1	29.1		

Natural Moisture Data

Wet+Tare	Dry+Tare	Tare	Moisture
489.6	288.7	15.8	73.6

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	B-1 S-7 24'-26'	7810-40	24'-26'	27.1	NP	NV	NP	ML

Hayre McElroy & Associates, LLC

Redmond, WA

Client: Aspect Consulting
Project: Lower Coal Creek
Project No.: 140362/08-175 **Figure**

Tested By: B.H **Checked By:** JAM

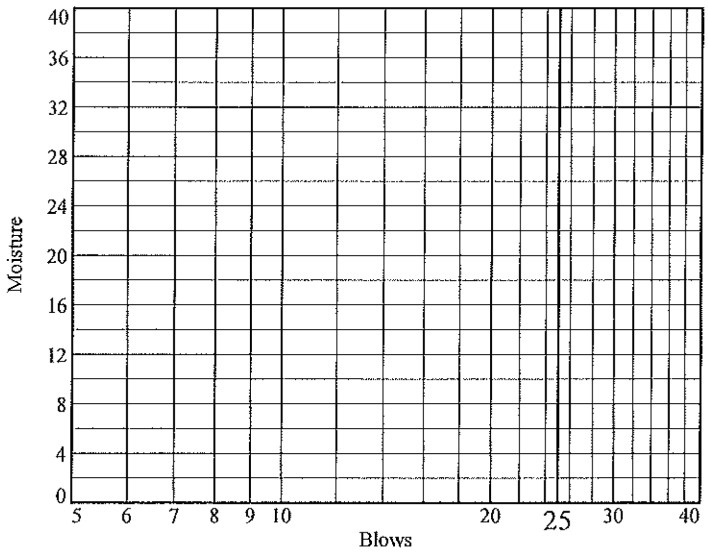
LIQUID AND PLASTIC LIMIT TEST DATA

11/2/2015

Client: Aspect Consulting
Project: Lower Coal Creek
Project Number: 140362/08-175
Location: B-1 S-7
Depth: 24'-26'
Sample Number: 7810-40
Material Description: B-1 S-7 24'-26'
USCS: ML
Tested by: B.H
Checked by: JAM

Liquid Limit Data

Run No.	1	2	3	4	5	6
Wet+Tare						
Dry+Tare						
Tare						
# Blows						
Moisture						



Liquid Limit= NV
Plastic Limit= NP
Plasticity Index= NP
Natural Moisture= 27.1

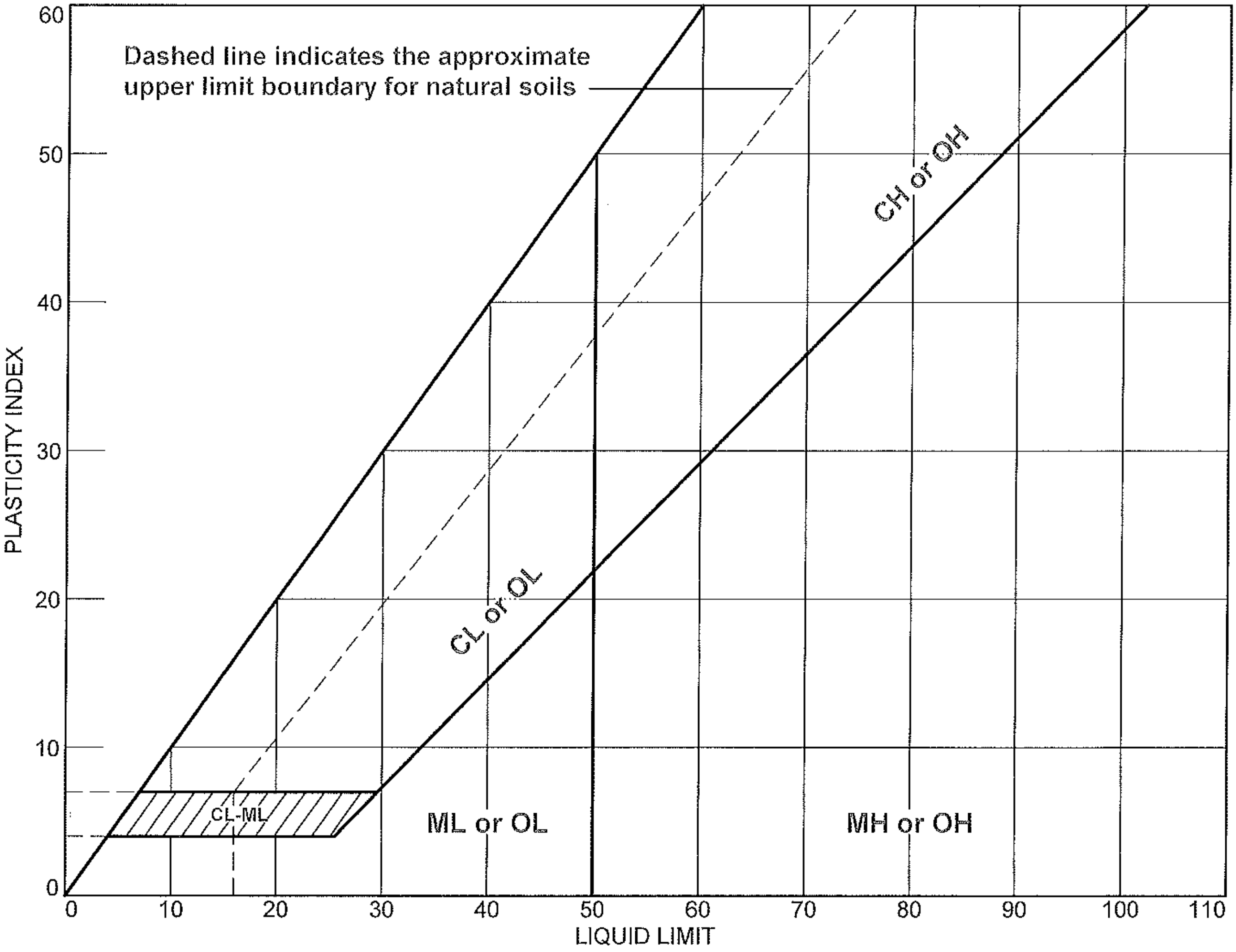
Plastic Limit Data

Run No.	1	2	3	4	
Wet+Tare					
Dry+Tare					
Tare					
Moisture					

Natural Moisture Data

Wet+Tare	Dry+Tare	Tare	Moisture
616.2	488.2	16.2	27.1

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	B-2 S-5 15'-17'	7810-42	15'-17'	260.6	NP	NV	NP	OL

Hayre McElroy & Associates, LLC

Redmond, WA

Client: Aspect Consulting
Project: Lower Coal Creek

Project No.: 140362/08-175 **Figure**

Tested By: B.H **Checked By:** JAM

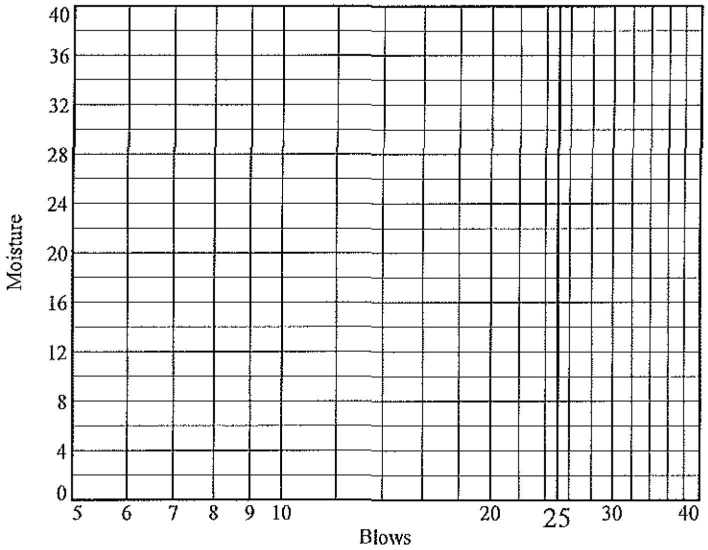
LIQUID AND PLASTIC LIMIT TEST DATA

11/2/2015

Client: Aspect Consulting
Project: Lower Coal Creek
Project Number: 140362/08-175
Location: B-2 S-5
Depth: 15'-17' **Sample Number:** 7810-42
Material Description: B-2 S-5 15'-17'
USCS: OL
Tested by: B.H **Checked by:** JAM

Liquid Limit Data

Run No.	1	2	3	4	5	6
Wet+Tare						
Dry+Tare						
Tare						
# Blows						
Moisture						



Liquid Limit= NV
Plastic Limit= NP
Plasticity Index= NP
Natural Moisture= 260.6

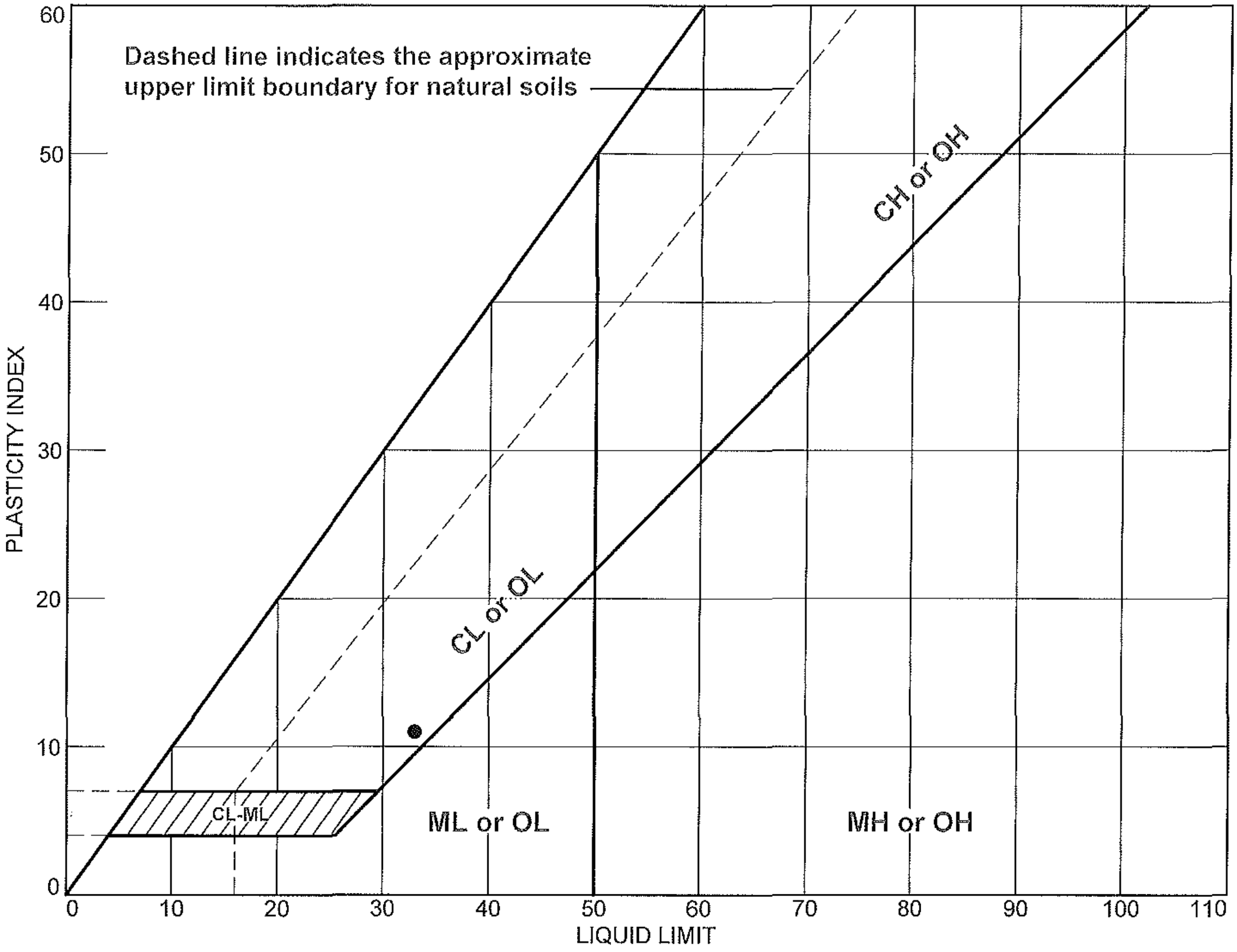
Plastic Limit Data

Run No.	1	2	3	4	
Wet+Tare					
Dry+Tare					
Tare					
Moisture					

Natural Moisture Data

Wet+Tare	Dry+Tare	Tare	Moisture
639.8	188.9	15.9	260.6

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	B-2 S8 22.5'-24.5'	7810-18	22.5'-24.5'	39.0	22	33	11	CL

Hayre McElroy & Associates, LLC

Redmond, WA

Client: Aspect Consulting
Project: Lower Coal Creek

Project No.: 140362/08-175 **Figure**

Tested By: B.H **Checked By:** JAM

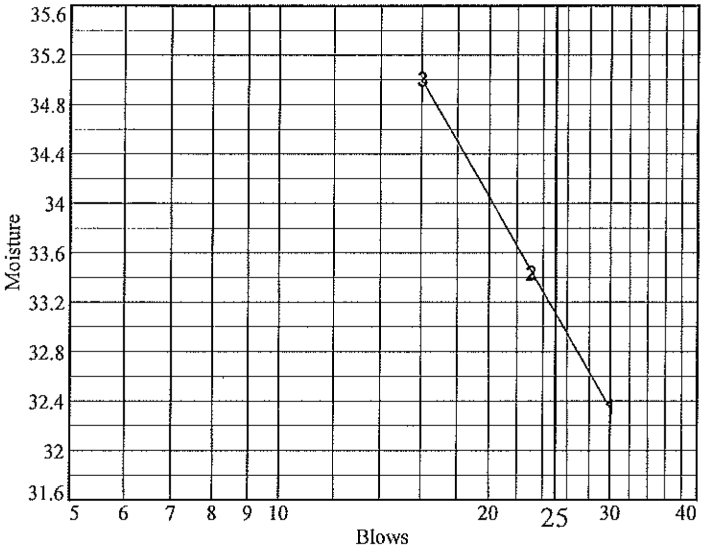
LIQUID AND PLASTIC LIMIT TEST DATA

10/27/2015

Client: Aspect Consulting
Project: Lower Coal Creek
Project Number: 140362/08-175
Location: B-2 S8
Depth: 22.5'-24.5' **Sample Number:** 7810-18
Material Description: B-2 S8 22.5'-24.5'
USCS: CL
Tested by: B.H **Checked by:** JAM

Liquid Limit Data

Run No.	1	2	3	4	5	6
Wet+Tare	31.94	30.58	29.29			
Dry+Tare	27.42	26.32	25.25			
Tare	13.45	13.58	13.71			
# Blows	30	23	16			
Moisture	32.4	33.4	35.0			



Liquid Limit= 33
Plastic Limit= 22
Plasticity Index= 11
Natural Moisture= 39.0
Liquidity Index= 1.5

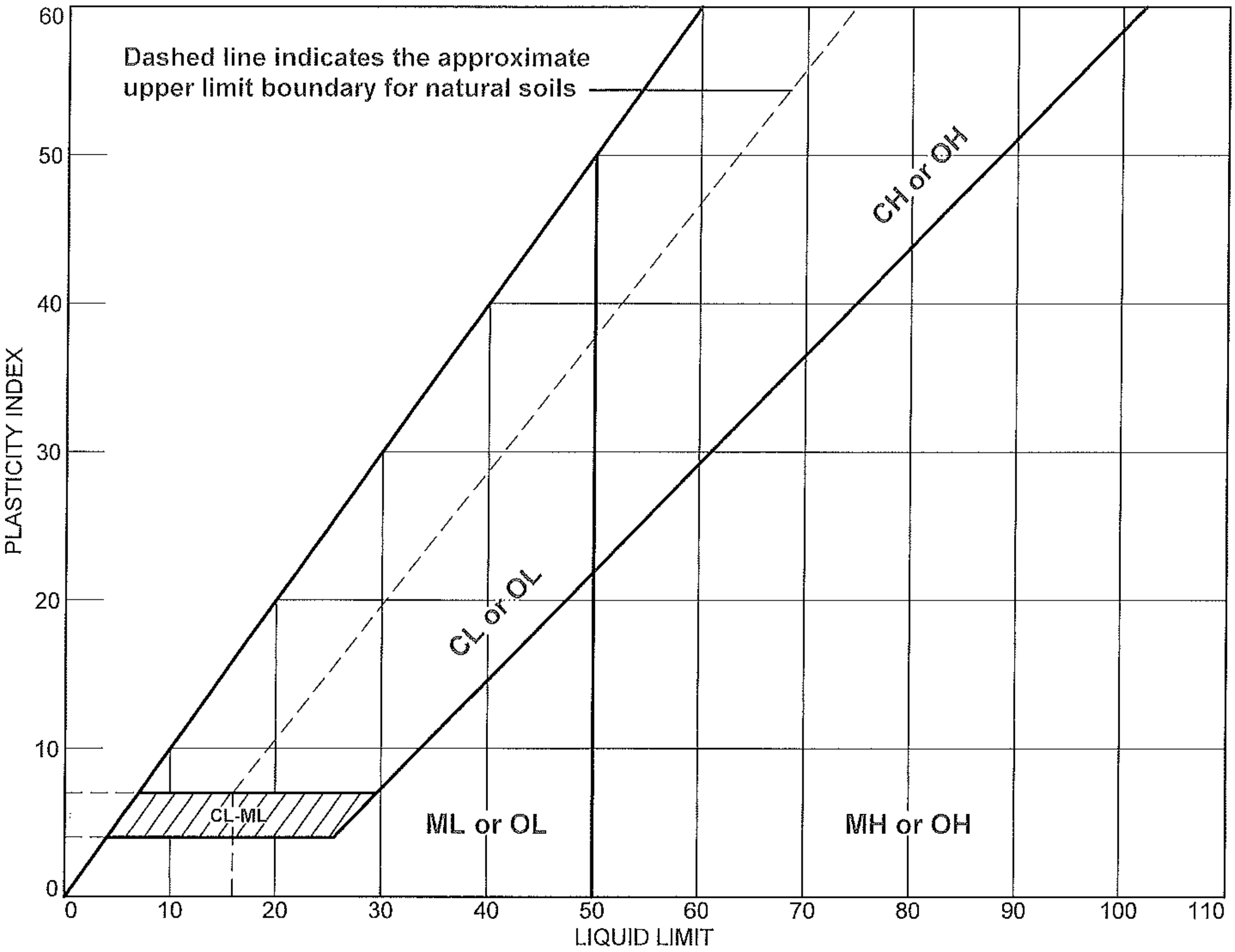
Plastic Limit Data

Run No.	1	2	3	4	
Wet+Tare	24.46	24.46	24.46		
Dry+Tare	22.49	22.49	22.49		
Tare	13.60	13.60	13.60		
Moisture	22.2	22.2	22.2		

Natural Moisture Data

Wet+Tare	Dry+Tare	Tare	Moisture
525.0	382.10	15.8	39.0

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	B-3 S3 9.5'-11'	7810-25	9.5'-11'	18.5	NP	NV	NP	

Hayre McElroy & Associates, LLC

Redmond, WA

Client: Aspect Consulting
Project: Lower Coal Creek
Project No.: 140362/08-175 **Figure**

Tested By: B.H **Checked By:** JAM

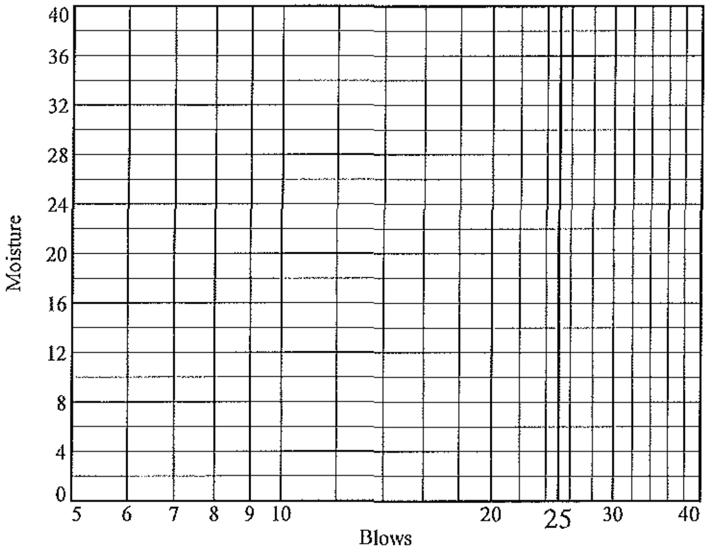
LIQUID AND PLASTIC LIMIT TEST DATA

10/27/2015

Client: Aspect Consulting
Project: Lower Coal Creek
Project Number: 140362/08-175
Location: B-3 S3
Depth: 9.5'-11'
Sample Number: 7810-25
Material Description: B-3 S3 9.5'-11'
Tested by: B.H
Checked by: JAM

Liquid Limit Data

Run No.	1	2	3	4	5	6
Wet+Tare						
Dry+Tare						
Tare						
# Blows						
Moisture						



Liquid Limit= NV
Plastic Limit= NP
Plasticity Index= NP
Natural Moisture= 18.5

Plastic Limit Data

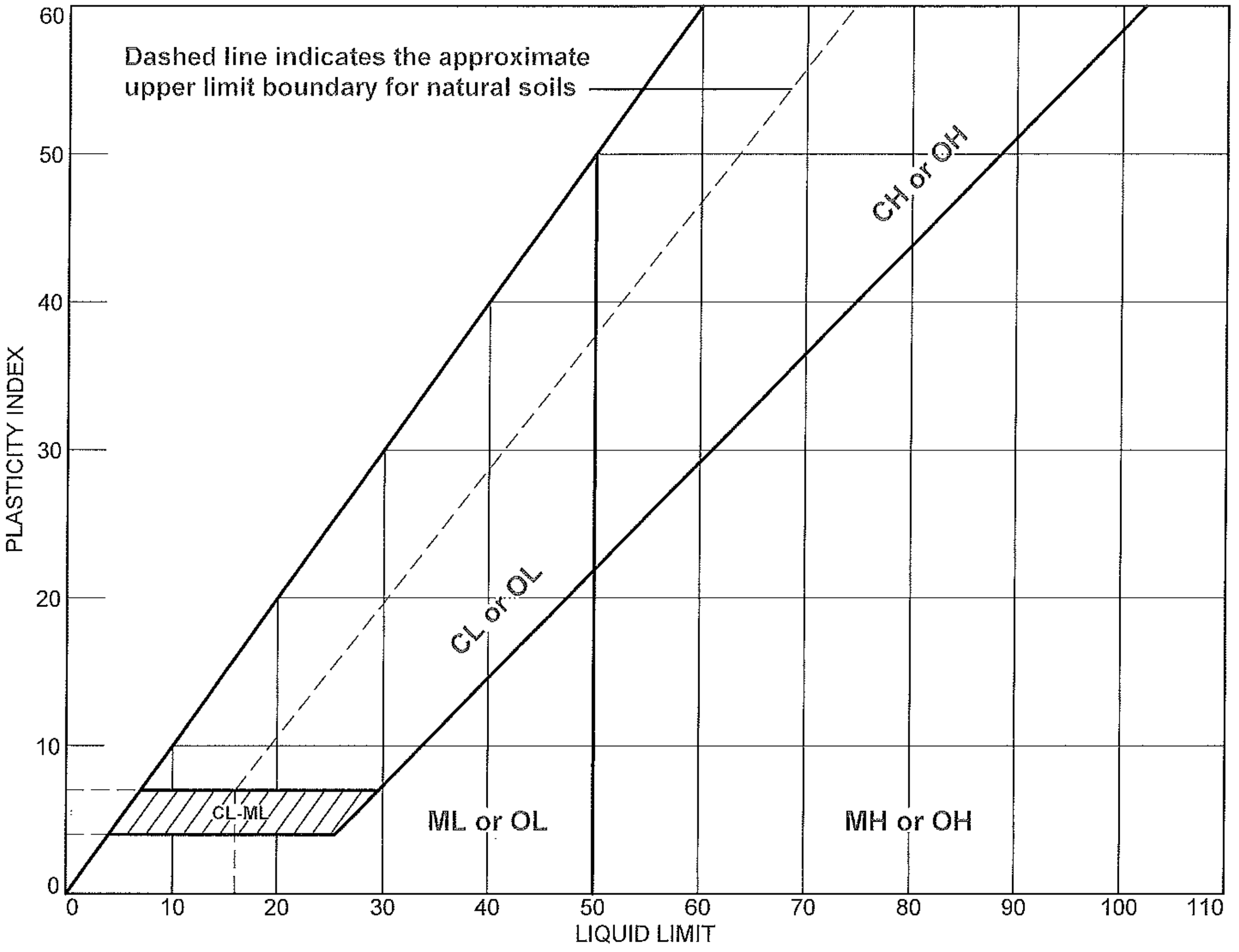
Run No.	1	2	3	4	
Wet+Tare					
Dry+Tare					
Tare					
Moisture					

Natural Moisture Data

Wet+Tare	Dry+Tare	Tare	Moisture
293.3	249.9	15.8	18.5

Hayre McElroy & Associates, LLC

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	~~B-5 S-5 15'-~~ 17' B-3, S-5, 15-17'	7810-44	15'-17'	325.0	NP	NV	NP	ML

Hayre McElroy & Associates, LLC

Redmond, WA

Client: Aspect Consulting

Project: Lower Coal Creek

Project No.: 140362/08-175 **Figure**

Tested By: B.H **Checked By:** JAM

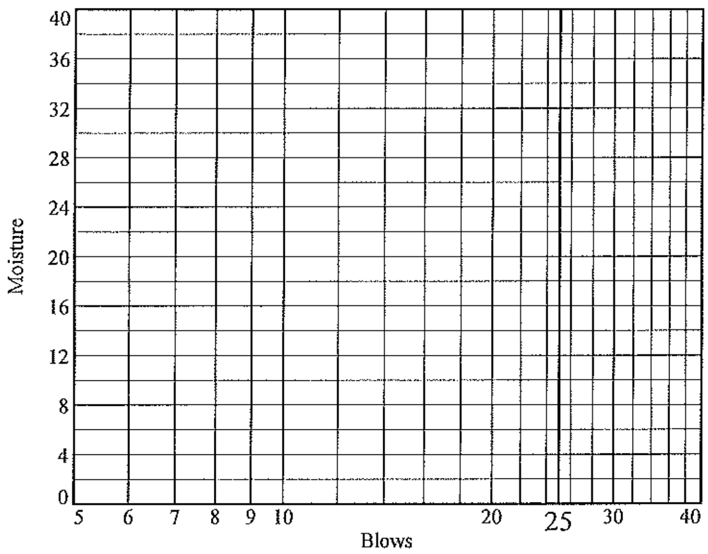
LIQUID AND PLASTIC LIMIT TEST DATA

11/2/2015

Client: Aspect Consulting
Project: Lower Coal Creek
Project Number: 140362/08-175
Location: B-5 S-5
Depth: 15'-1 B-3 S-5 15' to 17'
Sample Number: 7810-44
Material Description: B-5 S-5 15'-17'
USCS: ML
Tested by: B.H
Checked by: JAM

Liquid Limit Data

Run No.	1	2	3	4	5	6
Wet+Tare						
Dry+Tare						
Tare						
# Blows						
Moisture						



Liquid Limit= NV
Plastic Limit= NP
Plasticity Index= NP
Natural Moisture= 325.0

Plastic Limit Data

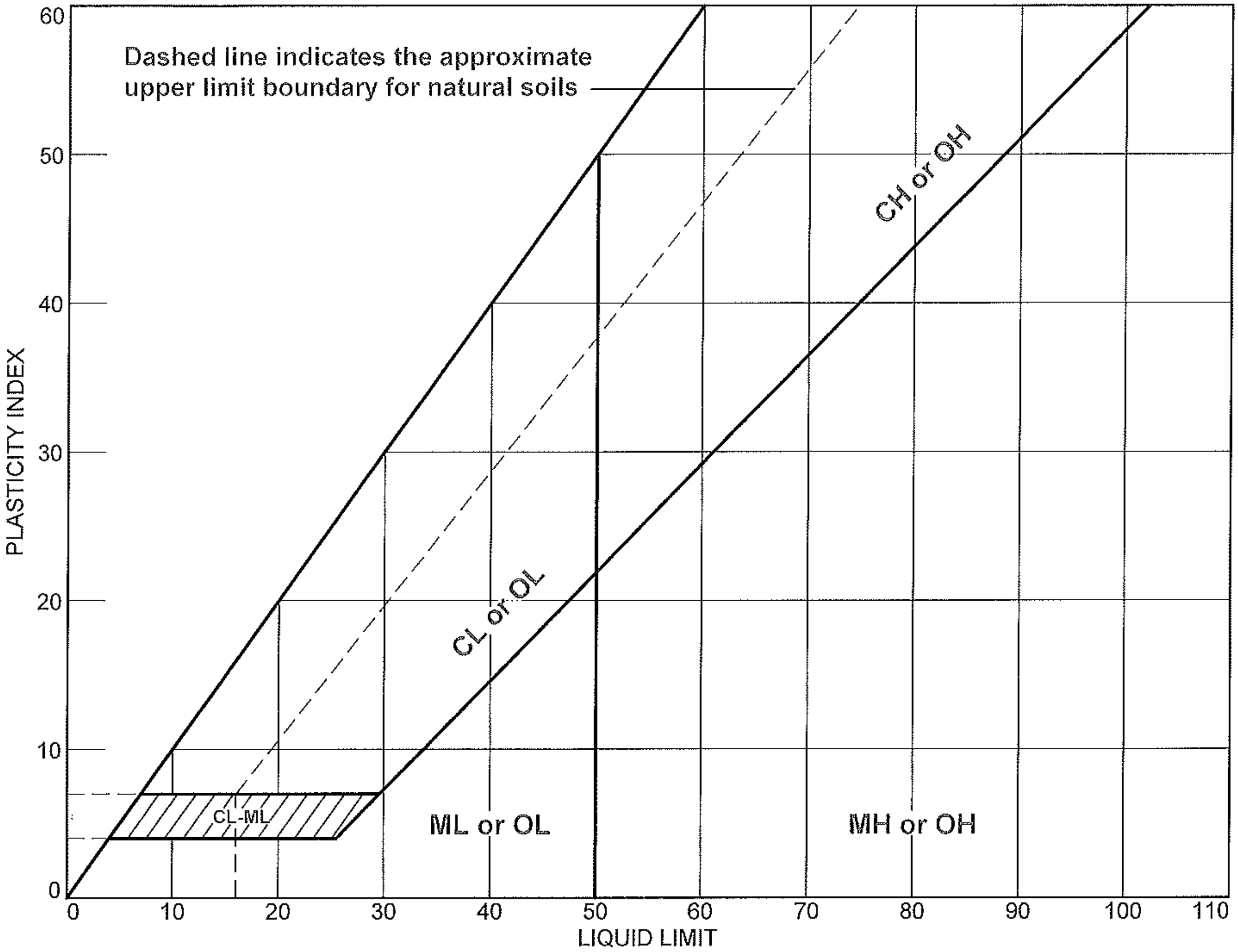
Run No.	1	2	3	4	
Wet+Tare					
Dry+Tare					
Tare					
Moisture					

Natural Moisture Data

Wet+Tare	Dry+Tare	Tare	Moisture
435.5	114.7	16.0	325.0

Hayre McElroy & Associates, LLC

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	B-3 S-8 22.5'-24.5'	7810-43	22.5'-24.5'	42.7	NP	NV	NP	ML

Hayre McElroy & Associates, LLC

Redmond, WA

Client: Aspect Consulting

Project: Lower Coal Creek

Project No.: 140362/08-175 **Figure**

Tested By: B.H **Checked By:** JAM

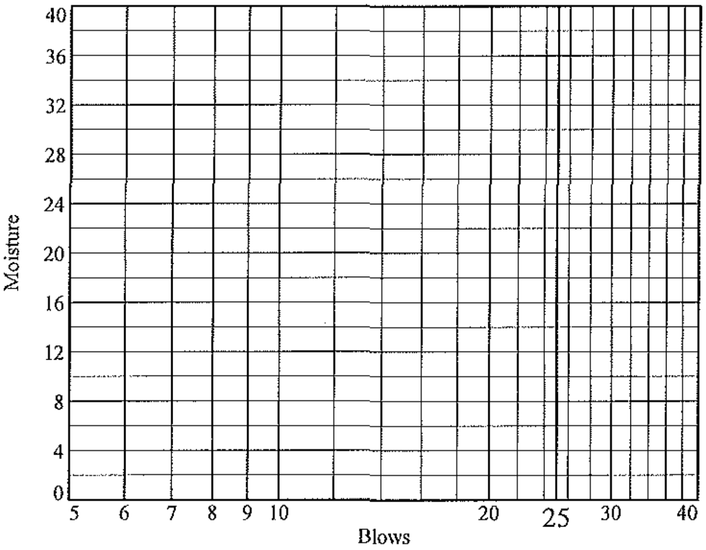
LIQUID AND PLASTIC LIMIT TEST DATA

11/2/2015

Client: Aspect Consulting
Project: Lower Coal Creek
Project Number: 140362/08-175
Location: B-3 S-8
Depth: 22.5'-24.5'
Sample Number: 7810-43
USCS: ML
Tested by: B.H
Checked by: JAM

Liquid Limit Data

Run No.	1	2	3	4	5	6
Wet+Tare						
Dry+Tare						
Tare						
# Blows						
Moisture						



Liquid Limit= NV
Plastic Limit= NP
Plasticity Index= NP
Natural Moisture= 42.7

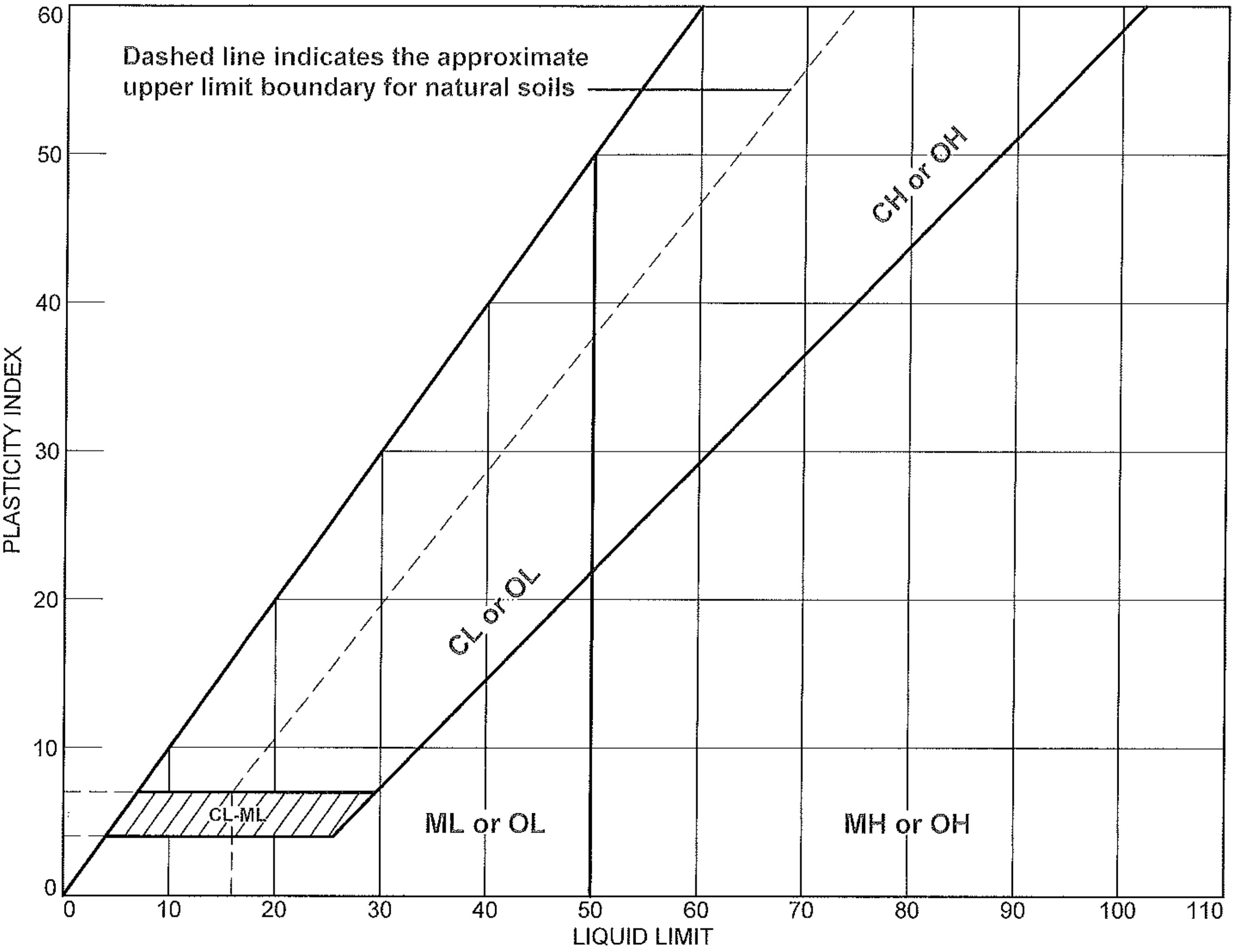
Plastic Limit Data

Run No.	1	2	3	4	
Wet+Tare					
Dry+Tare					
Tare					
Moisture					

Natural Moisture Data

Wet+Tare	Dry+Tare	Tare	Moisture
515.5	366.1	16.3	42.7

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	B-4 S-3 12.5'-14.5'	7810-46	12.5'-14.5'	45.7	NP	NV	NP	ML

Hayre McElroy & Associates, LLC **Redmond, WA**	**Client:** Aspect Consulting **Project:** Lower Coal Creek **Project No.:** 140362/08-175 **Figure**

Tested By: B.H **Checked By:** JAM

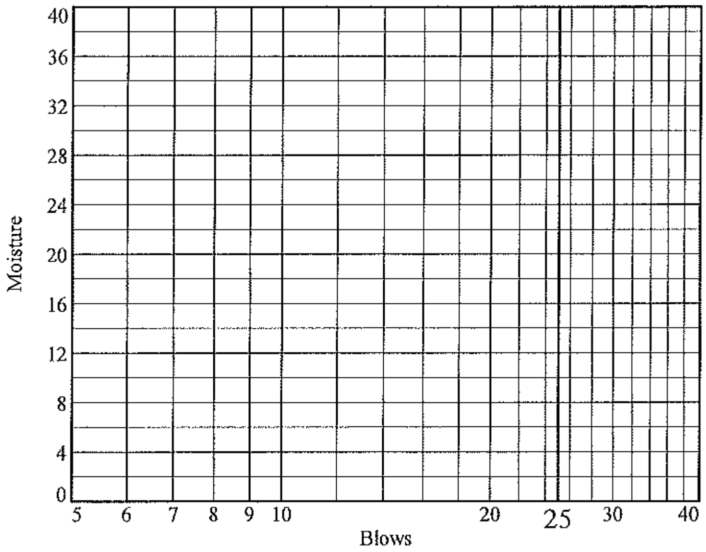
LIQUID AND PLASTIC LIMIT TEST DATA

11/2/2015

Client: Aspect Consulting
Project: Lower Coal Creek
Project Number: 140362/08-175
Location: B-4 S-3
Depth: 12.5'-14.5' **Sample Number:** 7810-46
Material Description: B-4 S-3 12.5-14.5'
USCS: ML
Tested by: B.H **Checked by:** JAM

Liquid Limit Data

Run No.	1	2	3	4	5	6
Wet+Tare						
Dry+Tare						
Tare						
# Blows						
Moisture						



Liquid Limit= NV
Plastic Limit= NP
Plasticity Index= NP
Natural Moisture= 45.7

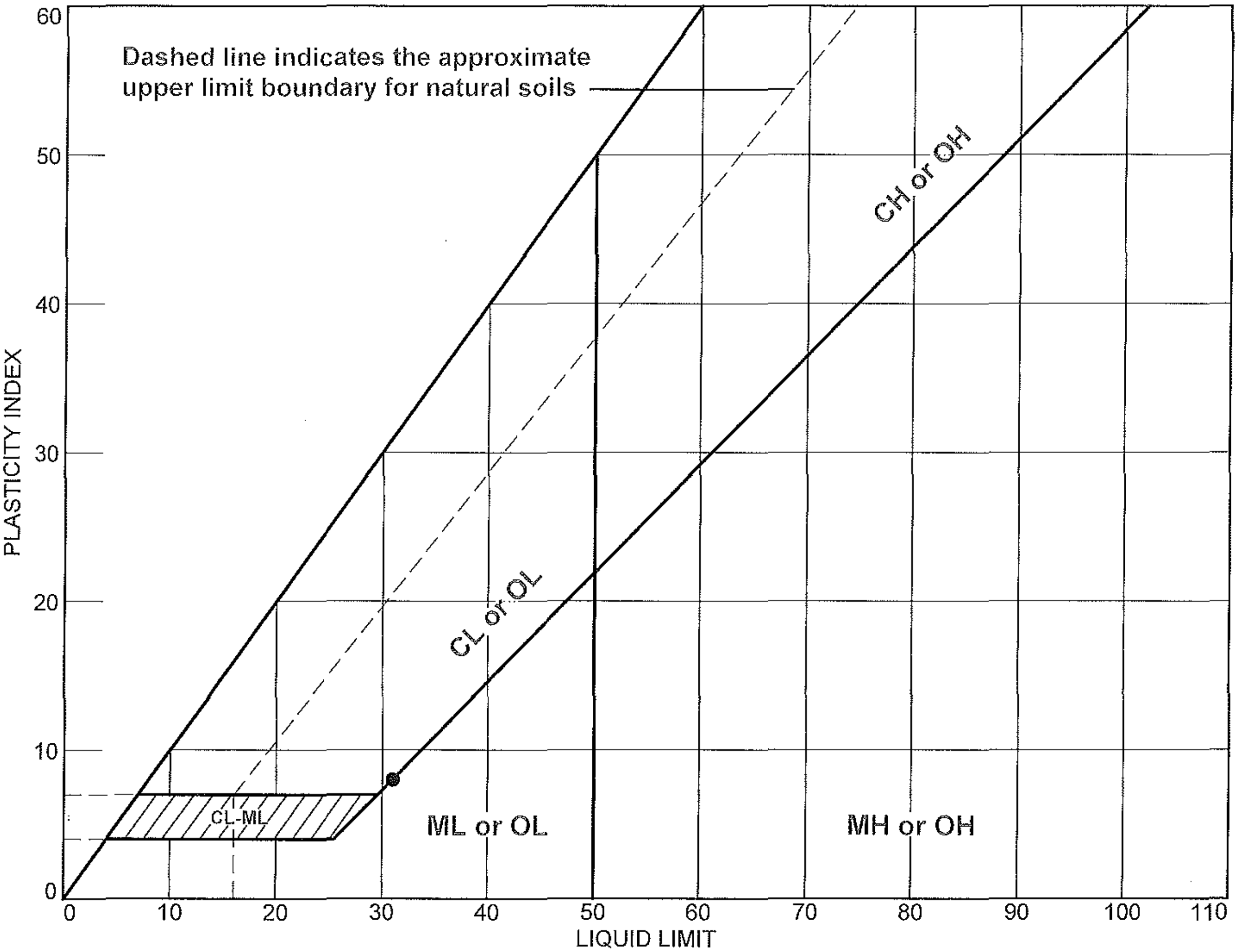
Plastic Limit Data

Run No.	1	2	3	4	
Wet+Tare					
Dry+Tare					
Tare					
Moisture					

Natural Moisture Data

Wet+Tare	Dry+Tare	Tare	Moisture
372.2	260.4	15.9	45.7

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	B-5 S-1 7.5'-9.5'	7810-47	7.5'-9.5'	45.7	23	31	8	CL

Hayre McElroy & Associates, LLC

Redmond, WA

Client: Aspect Consulting
Project: Lower Coal Creek

Project No.: 140362/08-175 **Figure**

Tested By: B.H **Checked By:** JAM

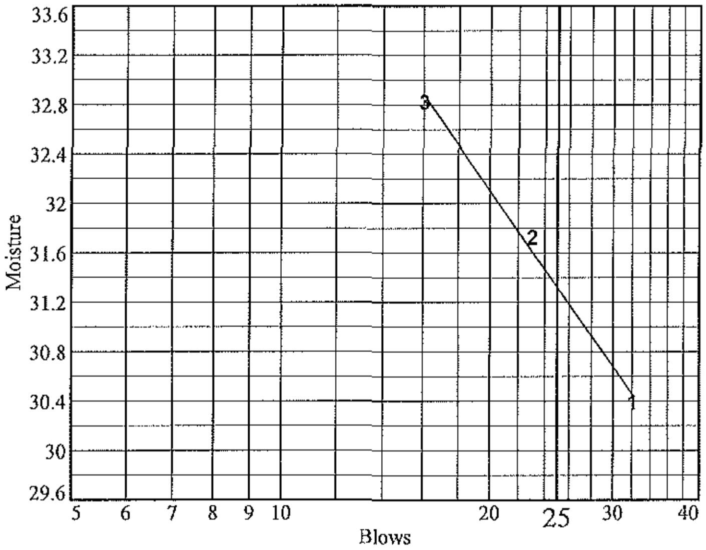
LIQUID AND PLASTIC LIMIT TEST DATA

11/2/2015

Client: Aspect Consulting
Project: Lower Coal Creek
Project Number: 140362/08-175
Location: B-5 S-1
Depth: 7.5'-9.5' **Sample Number:** 7810-47
Material Description: B-5 S-1 7.5'-9.5
USCS: CL
Tested by: B.H **Checked by:** JAM

Liquid Limit Data

Run No.	1	2	3	4	5	6
Wet+Tare	39.78	39.39	33.81			
Dry+Tare	33.71	33.19	28.83			
Tare	13.74	13.65	13.66			
# Blows	32	23	16			
Moisture	30.4	31.7	32.8			



Liquid Limit= 31
Plastic Limit= 23
Plasticity Index= 8
Natural Moisture= 45.7
Liquidity Index= 2.8

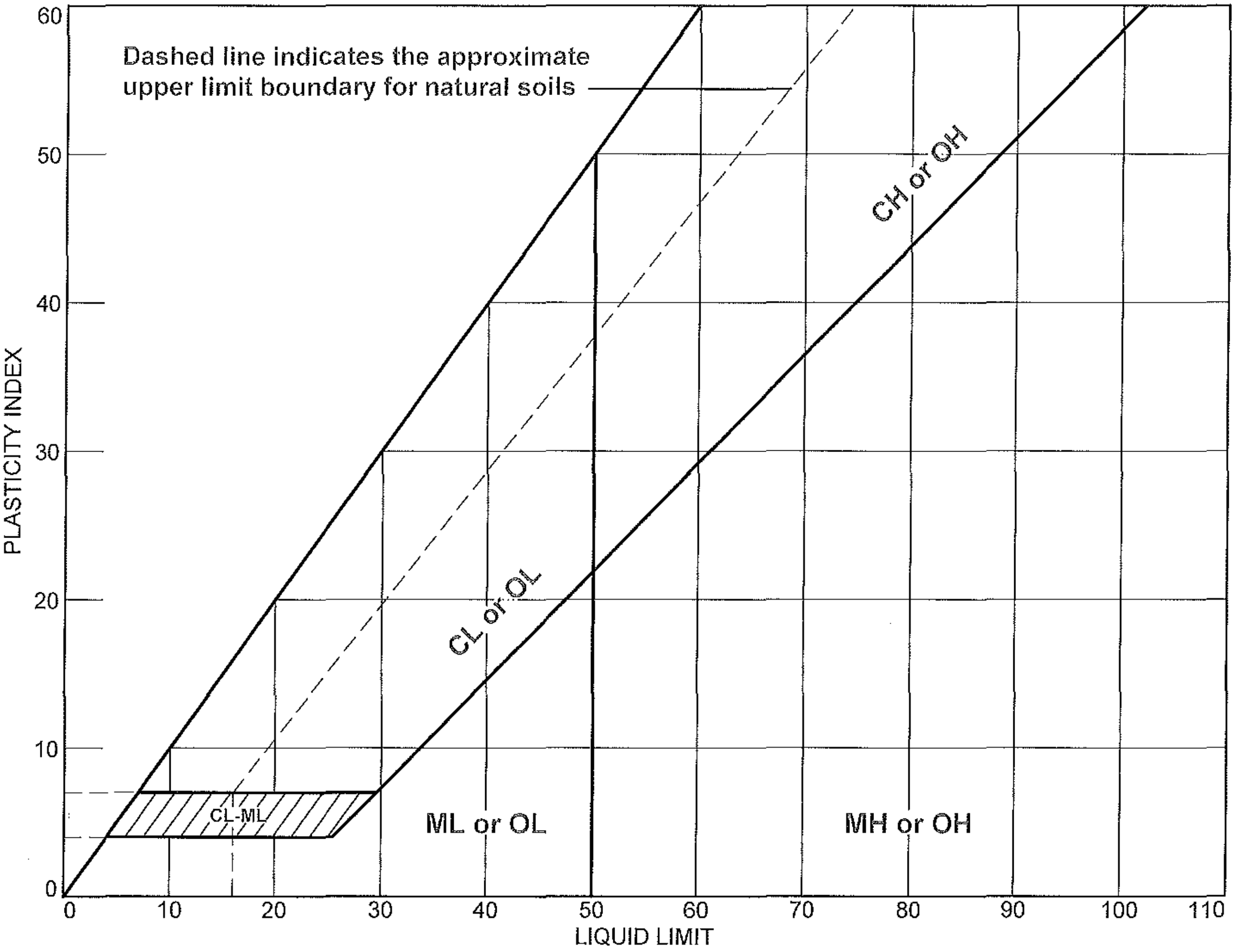
Plastic Limit Data

Run No.	1	2	3	4	
Wet+Tare	25.36	25.36	25.36		
Dry+Tare	23.10	23.10	23.10		
Tare	13.47	13.47	13.47		
Moisture	23.5	23.5	23.5		

Natural Moisture Data

Wet+Tare	Dry+Tare	Tare	Moisture
345.3	242.0	15.8	45.7

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	B-5 S-3 12.5'-14.5'	7810-45	12.5'-14.5'	45.7	NP	NV	NP	ML

Hayre McElroy & Associates, LLC

Redmond, WA

Client: Aspect Consulting

Project: Lower Coal Creek

Project No.: 140362/08-175

Figure

Tested By: B.H **Checked By:** JAM

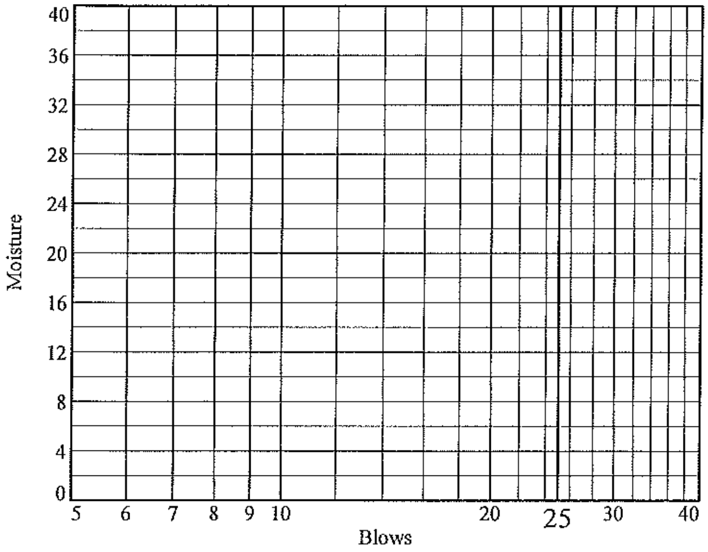
LIQUID AND PLASTIC LIMIT TEST DATA

11/2/2015

Client: Aspect Consulting
Project: Lower Coal Creek
Project Number: 140362/08-175
Location: B-5 S-3
Depth: 12.5'-14.5' **Sample Number:** 7810-45
Material Description: B-5 S-3 12.5'-14.5'
USCS: ML
Tested by: B.H **Checked by:** JAM

Liquid Limit Data

Run No.	1	2	3	4	5	6
Wet+Tare						
Dry+Tare						
Tare						
# Blows						
Moisture						



Liquid Limit= NV
Plastic Limit= NP
Plasticity Index= NP
Natural Moisture= 45.7

Plastic Limit Data

Run No.	1	2	3	4	
Wet+Tare					
Dry+Tare					
Tare					
Moisture					

Natural Moisture Data

Wet+Tare	Dry+Tare	Tare	Moisture
543.9	378.2	15.9	45.7

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Moisture, Ash, and Organic Matter
(ASTM D 2974-00)

Project Name:	Lower Coal Creek	HMA Project No:	140362/08/175
Client:	Aspect Consultants	HMA Lab No:	7810-42
Sample ID:	B-2 S-5 15'-17'	Date Tested:	10/29/2015
Tested by:	B.H	Equipment ID #:	
Checked by:	JAM	Data Entry by:	B.H

Total Wet Wt + Tare	428.0	grams
Total Oven Dried Wt + Tare	167.4	grams
Wt of Tare	121.0	grams
Moisture Loss	260.6	grams
Moisture Content	561.6	%
Initial Oven Dried Wt	46.4	grams

Burn attempt	Sample wt + tare (g)	Sample weight (g)	Ash (g)
1	167.4	46.4	0.0
2	160.0	39.0	7.4
3	153.2	32.2	14.2
4	149.2	28.2	18.2
5	148.2	27.2	19.2
6	147.2	26.2	20.2
7	147.1	26.1	20.3
8	147.0	26.0	20.4
9			
10			
11			
12			

Ash = initial sample wt - sample wt after final burn attempt

Ash Content, % = (Ash x 100)/B = 41.4 %

Moisture, Ash, and Organic Matter
(ASTM D 2974-00)

Project Name:	Lower Coal Creek	HMA Project No:	140362/08/175
Client:	Aspect Consultants	HMA Lab No:	7810-43
Sample ID:	B-3 S-8 22.5'-24.5'	Date Tested:	11/5/2015
Tested by:	B.H	Equipment ID #:	
Checked by:	JAM	Data Entry by:	B.H

Total Wet Wt + Tare	178.2	grams
Total Oven Dried Wt + Tare	175.5	grams
Wt of Tare	121.0	grams
Moisture Loss	2.7	grams
Moisture Content	5.0	%
Initial Oven Dried Wt	54.5	grams

Burn attempt	Sample wt + tare (g)	Sample weight (g)	Ash (g)
1	173.4	52.4	2.1
2	173.1	52.1	2.4
3	172.7	51.7	2.8
4	172.4	51.4	3.1
5	172.4	51.4	3.1
6			
7			
8			
9			
10			
11			
12			

Ash = initial sample wt - sample wt after final burn attempt

Ash Content, % = (Ash x 100)/B = 5.7 %

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Moisture, Ash, and Organic Matter
(ASTM D 2974-00)

Project Name:	Lower Coal Creek	HMA Project No:	140362/08/175
Client:	Aspect Consultants	HMA Lab No:	7810-46
Sample ID:	B-4 S-3 12.5'-14.5'	Date Tested:	11/5/2015
Tested by:	B.H	Equipment ID #:	
Checked by:	JAM	Data Entry by:	B.H

Total Wet Wt + Tare	195.6	grams
Total Oven Dried Wt + Tare	190.3	grams
Wt of Tare	136.3	grams
Moisture Loss	5.3	grams
Moisture Content	9.8	%
Initial Oven Dried Wt	54.0	grams

Burn attempt	Sample wt + tare (g)	Sample weight (g)	Ash (g)
1	188.3	52.0	2.0
2	187.5	51.2	2.8
3	187.1	50.8	3.2
4	186.6	50.3	3.7
5	186.6	50.3	3.7
6			
7			
8			
9			
10			
11			
12			

Ash = initial sample wt - sample wt after final burn attempt

Ash Content, % = (Ash x 100)/B = 6.9 %

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Moisture, Ash, and Organic Matter
(ASTM D 2974-00)

Project Name:	Lower Coal Creek	HMA Project No:	140362/08/175
Client:	Aspect Consultants	HMA Lab No:	7810-36
Sample ID:	B-4 S5b 17.5'-19.5'	Date Tested:	10/23/2015
Tested by:	B.H	Equipment ID #:	
Checked by:	JAM	Data Entry by:	B.H

Total Wet Wt + Tare	221.0	grams
Total Oven Dried Wt + Tare	181.1	grams
Wt of Tare	121.0	grams
Moisture Loss	39.9	grams
Moisture Content	66.4	%
Initial Oven Dried Wt	60.1	grams

Burn attempt	Sample wt + tare (g)	Sample weight (g)	Ash (g)
1	178.6	57.6	2.5
2	177.6	56.6	3.5
3	176.8	55.8	4.3
4	176.1	55.1	5.0
5	176.0	55.0	5.1
6			
7			
8			
9			
10			
11			
12			

Ash = initial sample wt - sample wt after final burn attempt

Ash Content, % = (Ash x 100)/B = 8.5 %

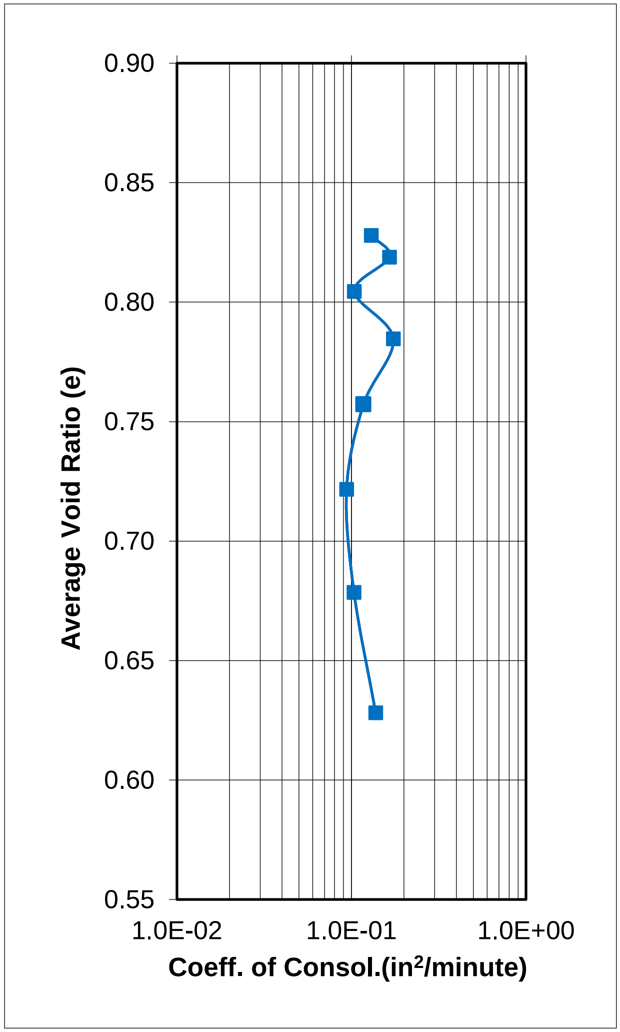
HWA GEOSCIENCES INC.

ONE DIMENSIONAL CONSOLIDATION
ASTM D 2435

Project Name: McElroy - Lower Coal Creek
Project Number: 2010-021 T5
Borehole Number: B-1

Sample Number: S-7
Sample Depth: 24-26 feet
Soil Description: Olive gray, silty SAND (SM)

	Start	Finish	
Moisture Content	29.4	23.0	%
Saturation	100.6	101.5	%
Dry Density	93.0	104.6	pcf



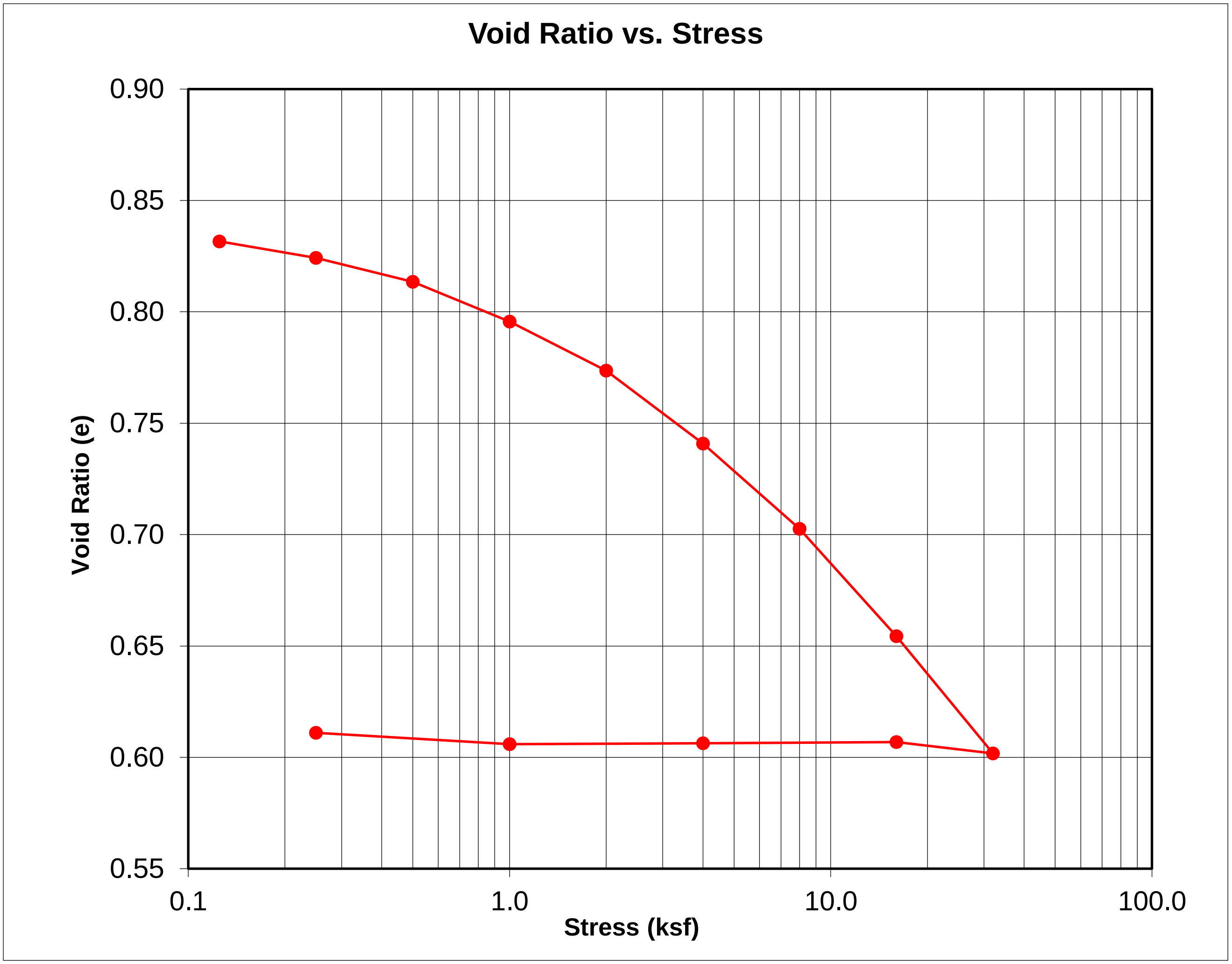


FIGURE 1

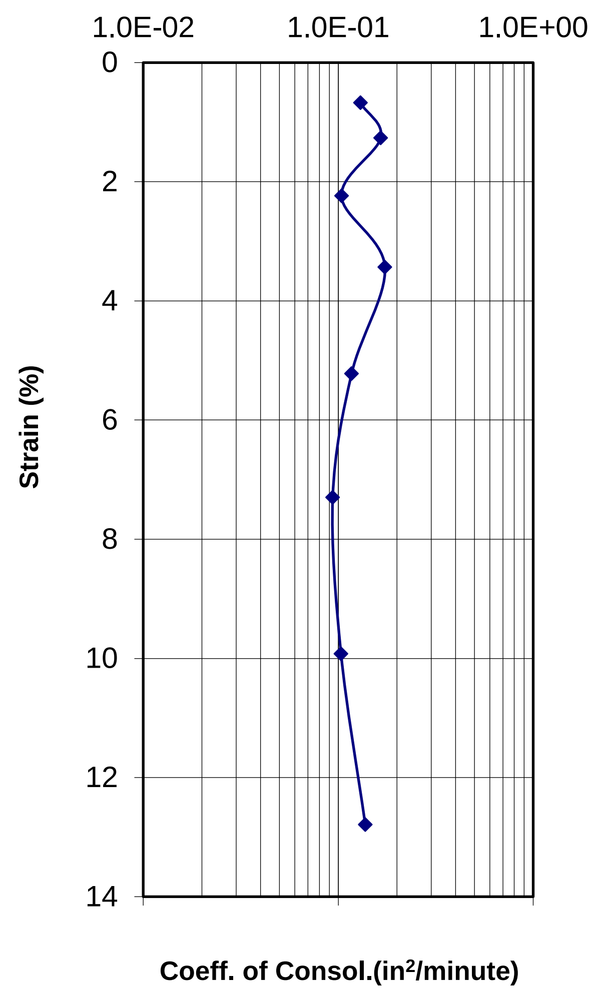
HWA GEOSCIENCES INC.

ONE DIMENSIONAL CONSOLIDATION
ASTM D 2435

Project Name: McElroy - Lower Coal Creek
Project Number: 2010-021 T5
Borehole Number: B-1

Sample Number: S-7
Sample Depth: 24-26 feet
Soil Description: Olive gray, silty SAND (SM)

	Start	Finish	
Moisture Content	29.4	23.0	%
Saturation	100.6	101.5	%
Dry Density	93.0	104.6	pcf



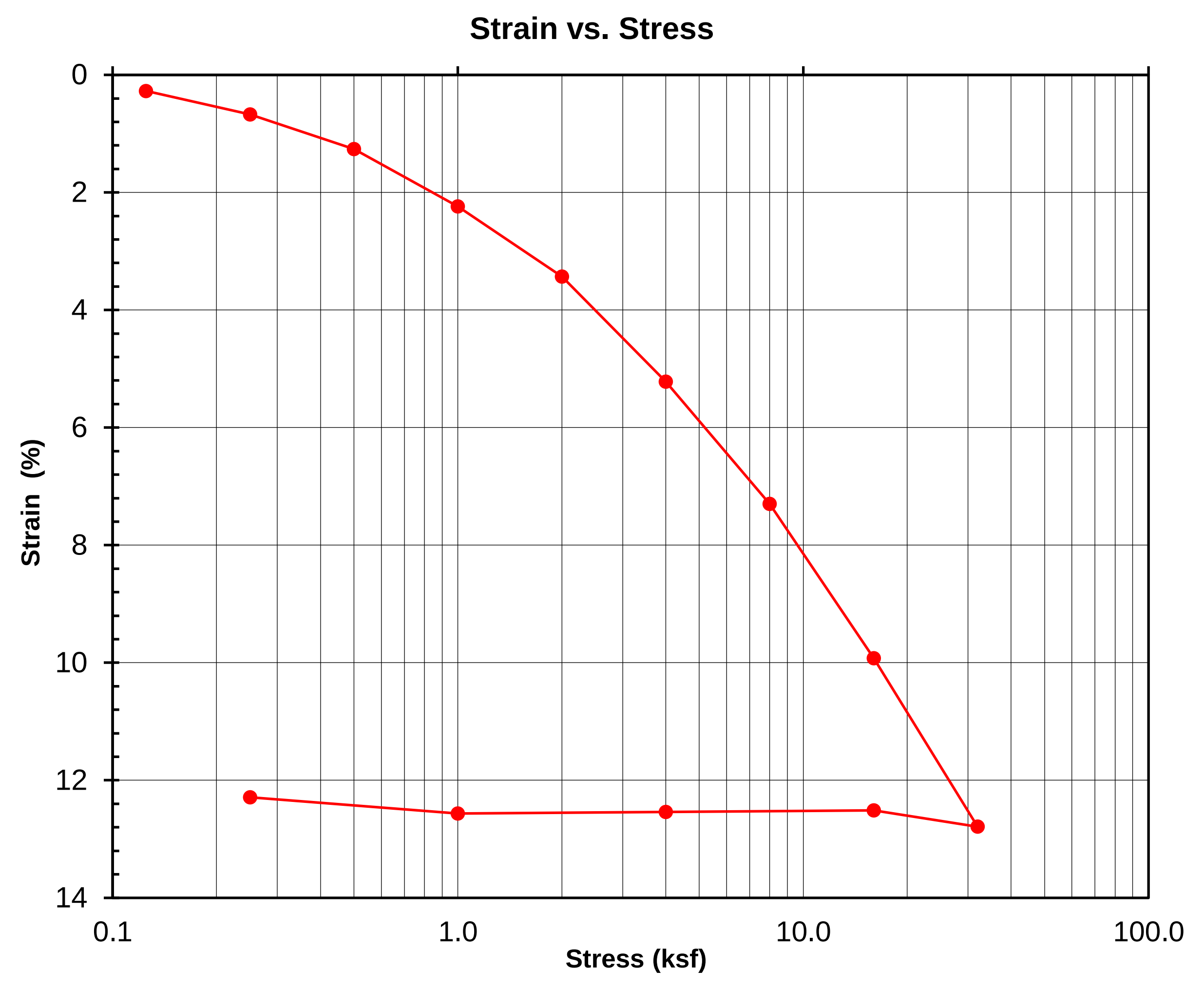


FIGURE 2

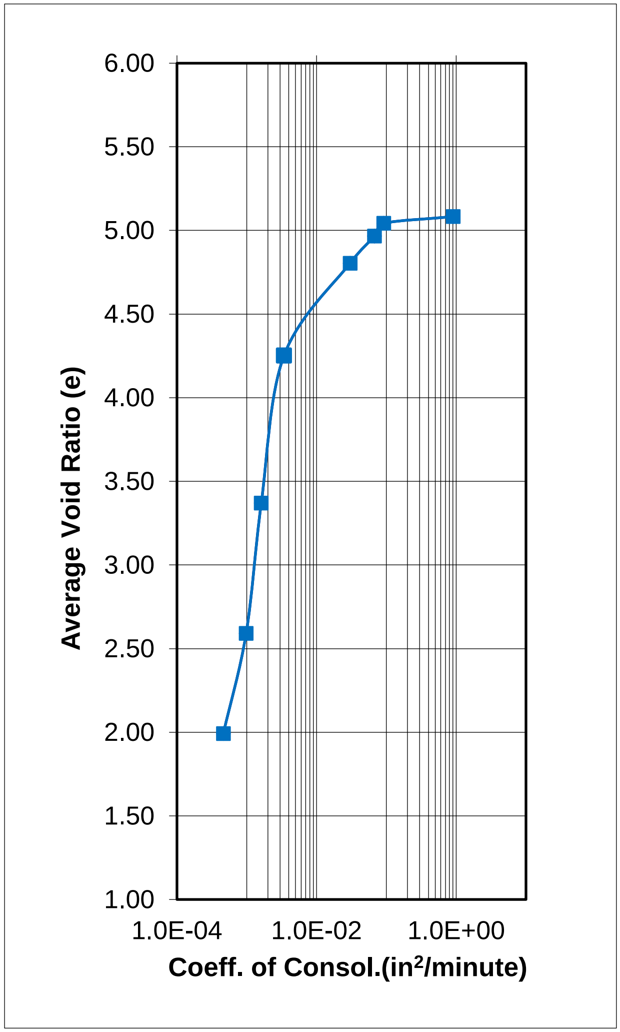
HWA GEOSCIENCES INC.

ONE DIMENSIONAL
CONSOLIDATION
ASTM D 2435

Project Name: McElroy - Lower Coal Creek
Project Number: 2010-021 T5
Borehole Number: B-2

Sample Number: S-5
Sample Depth: 15-17 feet
Soil Description: Dark brown, PEAT (PT)

	Start	Finish	
Moisture Content	215.6	100.5	%
Saturation	97.1	99.1	%
Dry Density	23.7	43.4	pcf



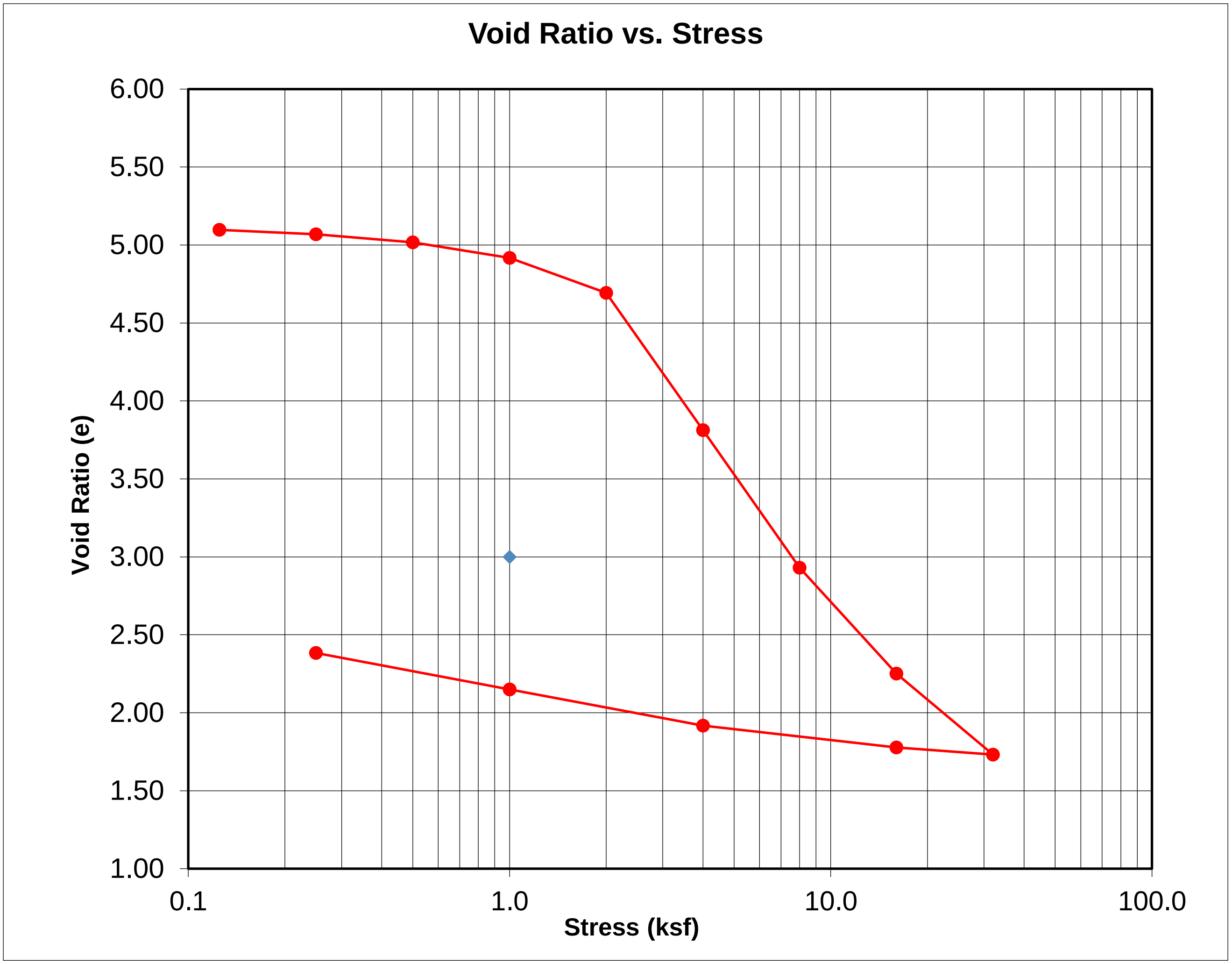


FIGURE 3

HWA GEOSCIENCES INC.

ONE DIMENSIONAL CONSOLIDATION
ASTM D 2435

Project Name: McElroy - Lower Coal Creek
Project Number: 2010-021 T5
Borehole Number: B-2

Sample Number: S-5
Sample Depth: 15-17 feet
Soil Description: Dark brown, PEAT (PT)

	Start	Finish	
Moisture Content	215.6	100.5	%
Saturation	97.1	99.1	%
Dry Density	23.7	43.4	pcf

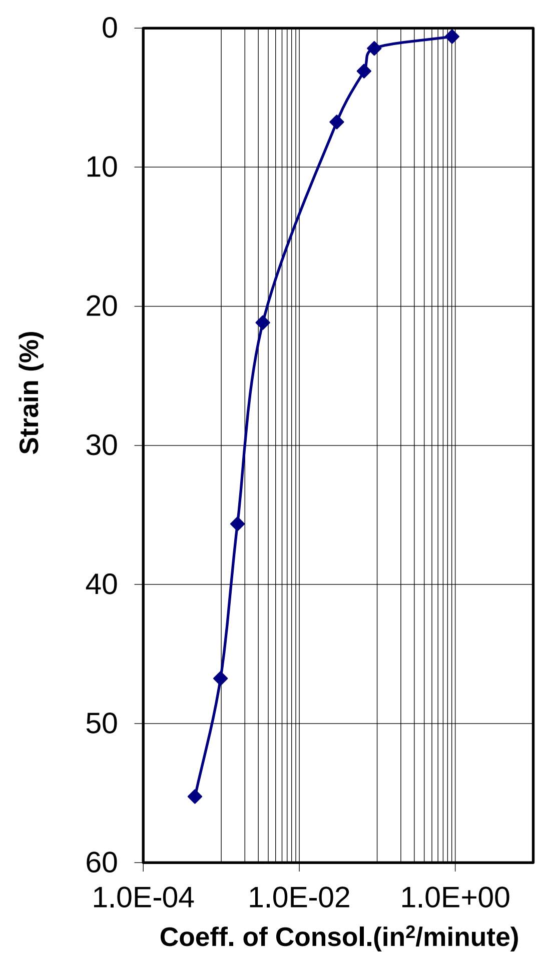


FIGURE 4

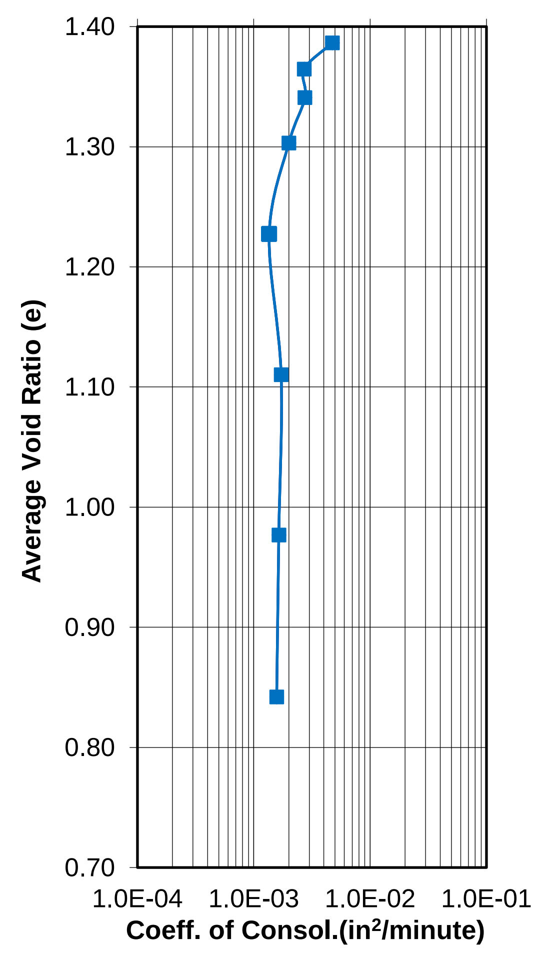
HWA GEOSCIENCES INC.

ONE DIMENSIONAL CONSOLIDATION
ASTM D 2435

Project Name: McElroy - Lower Coal Creek
Project Number: 2010-021 T5
Borehole Number: B-3

Sample Number: S-8
Sample Depth: 22.5-24.5
Soil Description: Dark grayish brown, SILT (ML)

	Start	Finish	
Moisture Content	51.4	34.0	%
Saturation	99.8	102.8	%
Dry Density	70.2	89.1	pcf



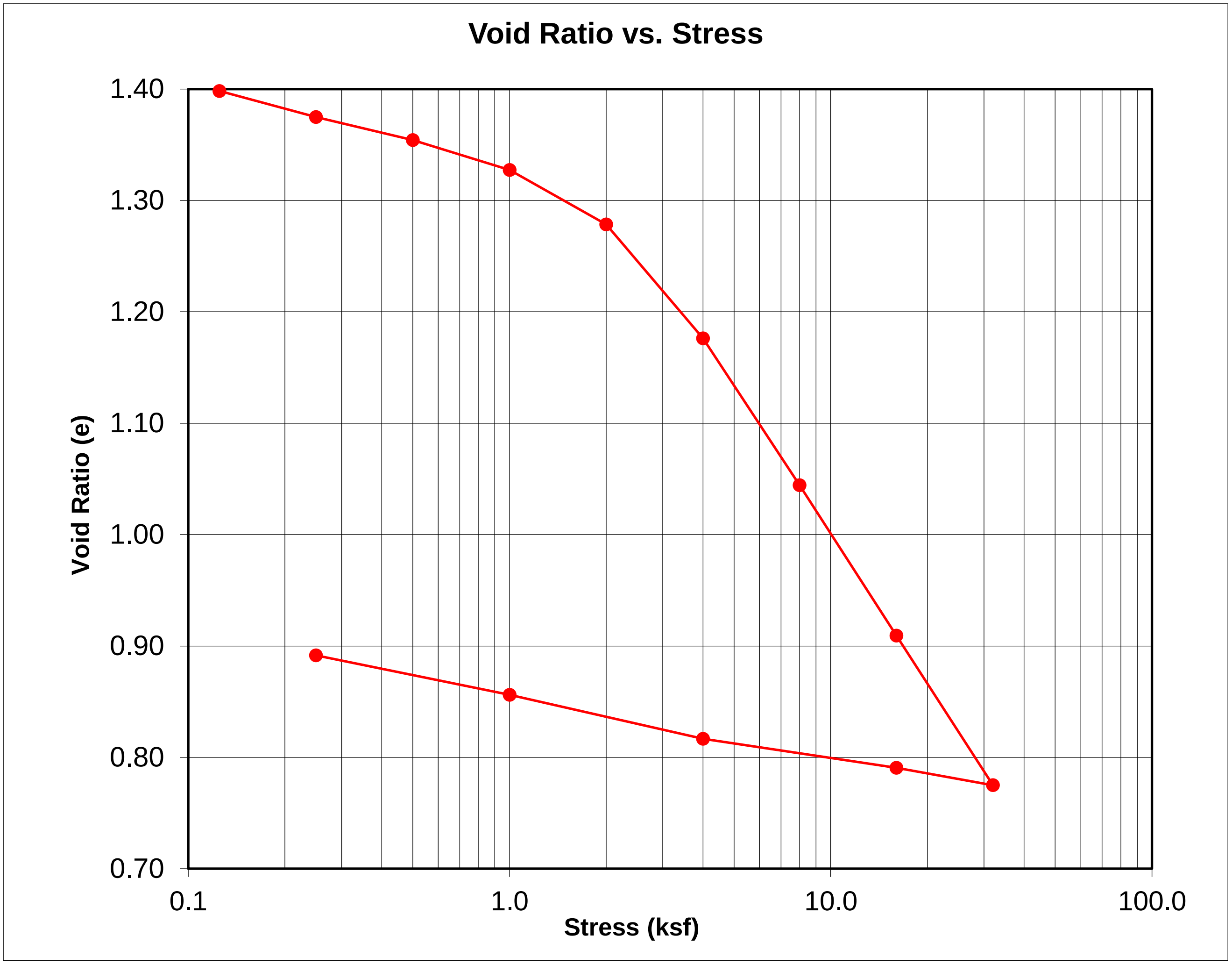


FIGURE 5

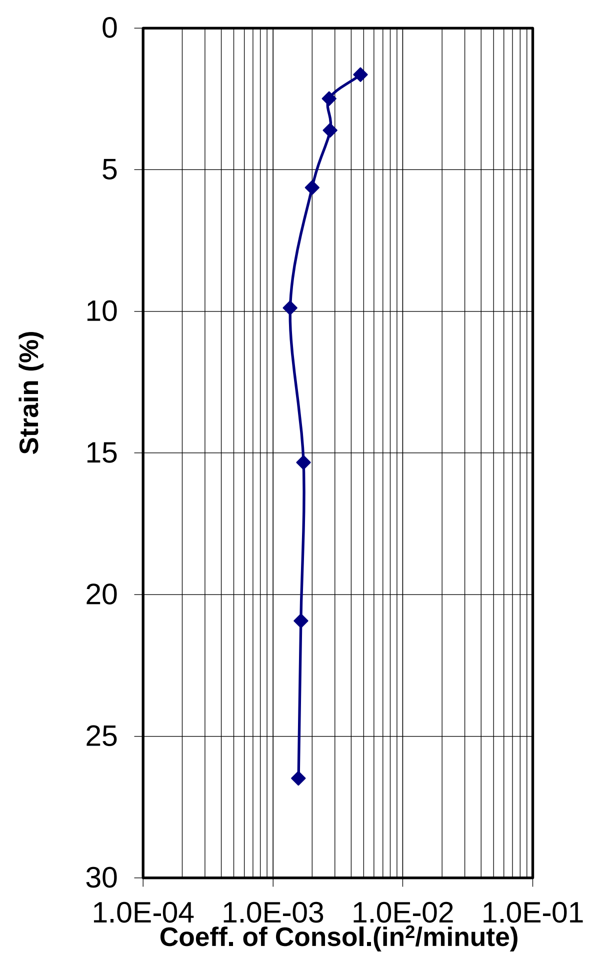
HWA GEOSCIENCES INC.

ONE DIMENSIONAL CONSOLIDATION
ASTM D 2435

Project Name: McElroy - Lower Coal Creek
Project Number: 2010-021 T5
Borehole Number: B-3

Sample Number: S-8
Sample Depth: 22.5-24.5
Soil Description: Dark grayish brown, SILT (ML)

	Start	Finish	
Moisture Content	51.4	34.0	%
Saturation	99.8	102.8	%
Dry Density	70.2	89.1	pcf



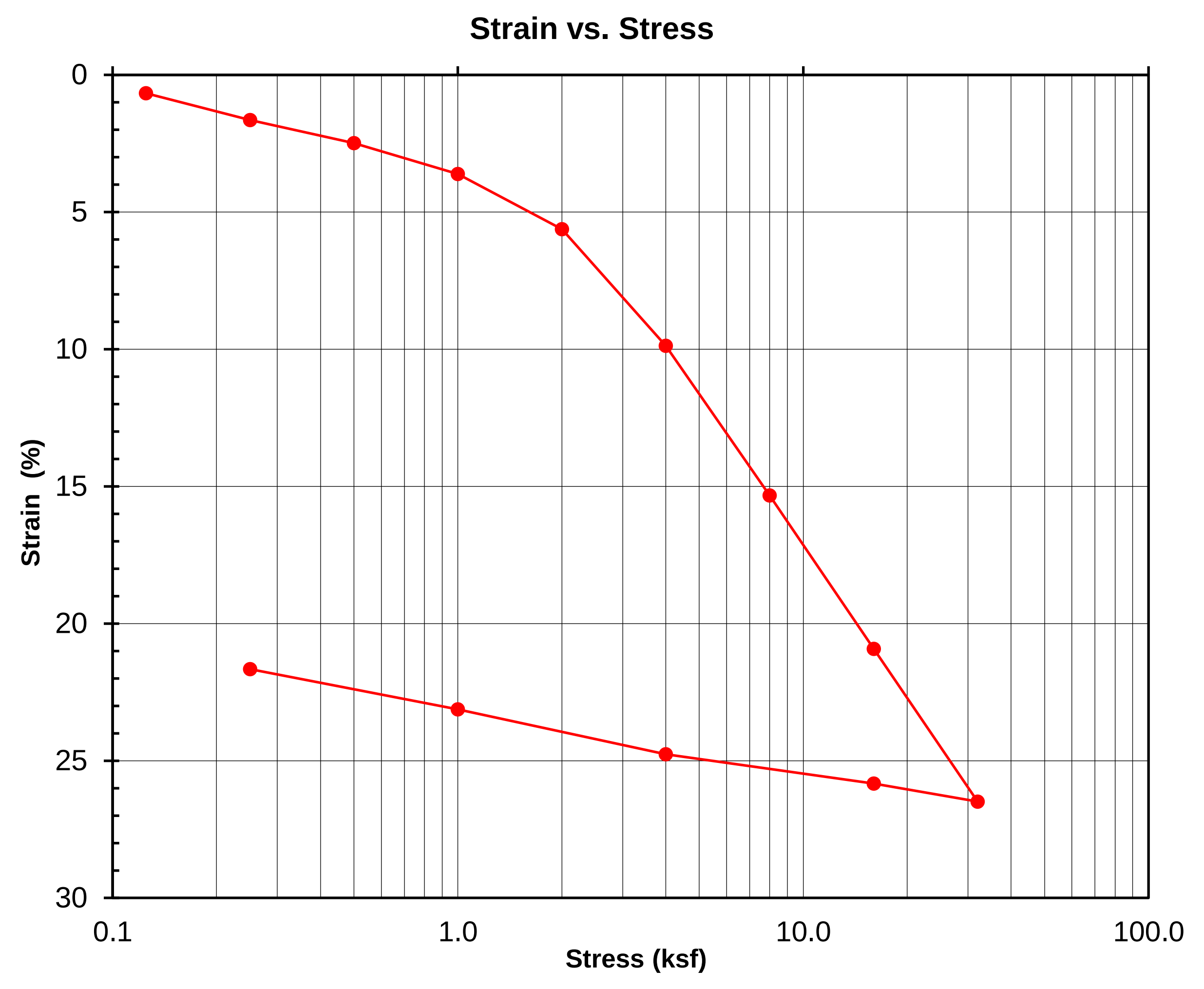
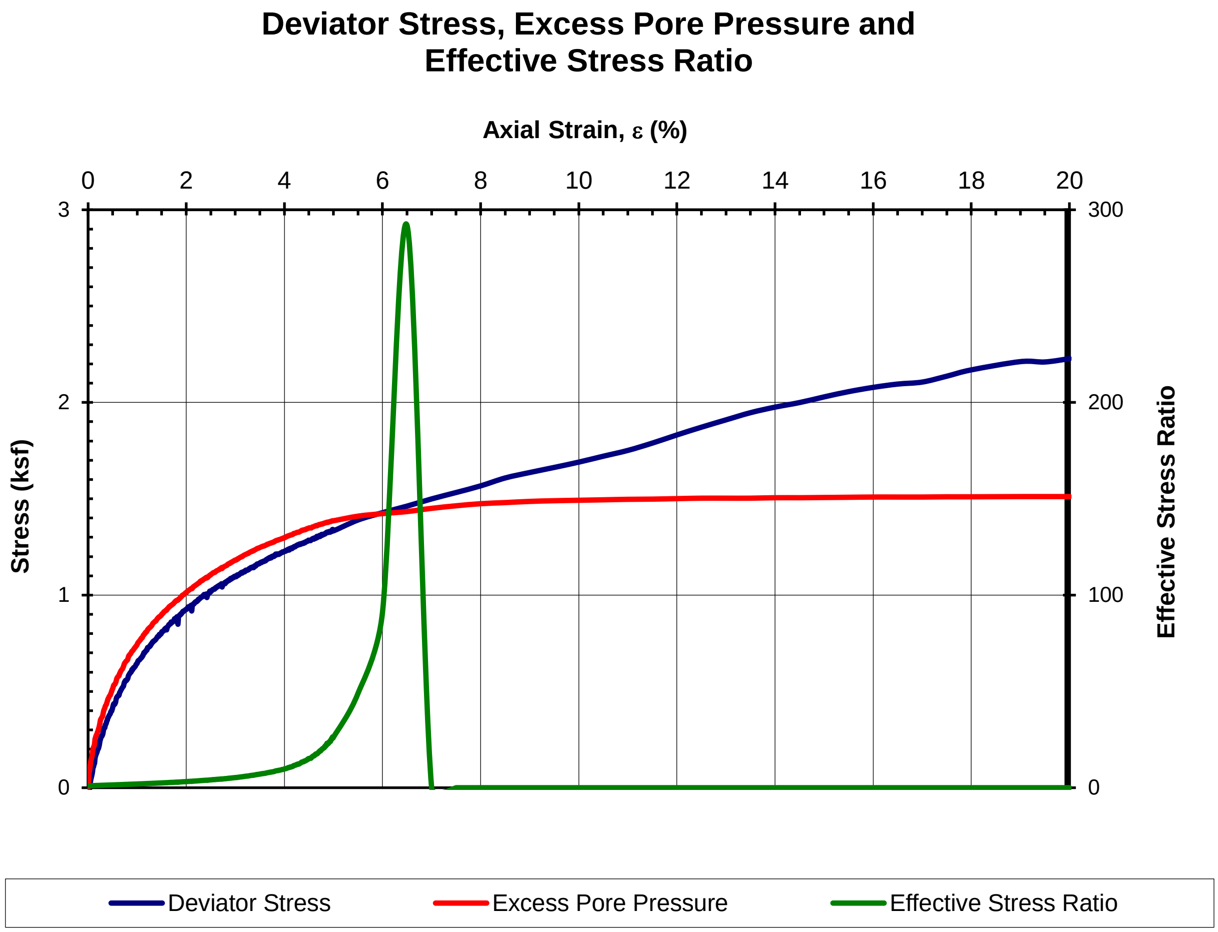


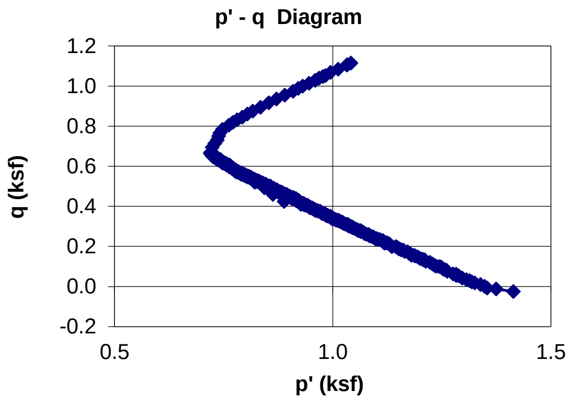
FIGURE 6

Consolidated-Undrained Triaxial Compression Test for Cohesive Soils (ASTM D4767)

Project Name:	Lower Coal Creek			Date:	11/20/2015
Project No.:	2010-021 T200	Exploration ID:			B-1
Technician:	Jherrera	Sample No:			S-3
Sample Description:	Dark Brown, PEAT/Organic SILT (PT/OL)			Sample Depth, ft:	15-17
Strain Rate, %/min:	0.0055	Effective Confining Pressure, ksf:			1.4
Initial Moisture, %	294.8	Initial Wet Density, pcf:	74.3	Initial Dry Density, pcf:	18.8
Final Moisture, %	207.5	Final Wet Density, pcf:	92.5	Final Dry Density, pcf:	30.1

Shear Plots:



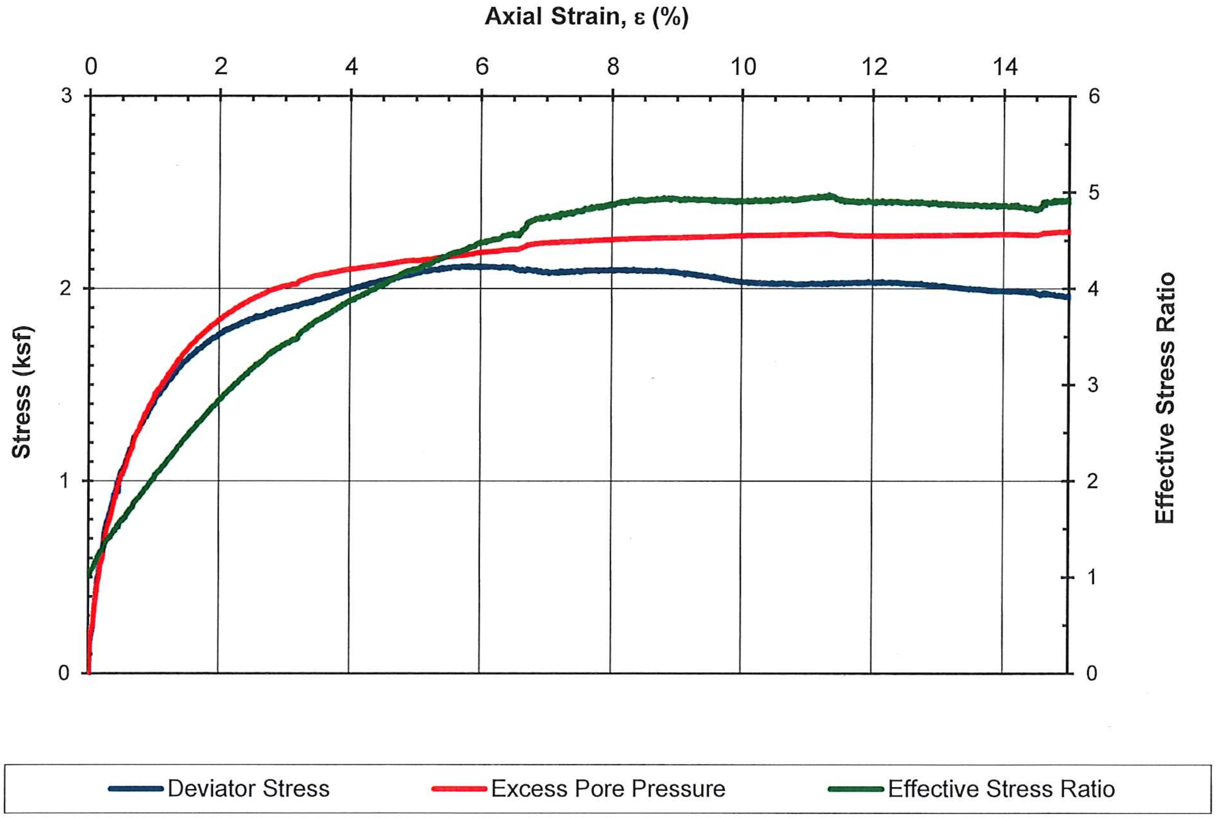


Reviewed by: ____________________ Figure 6

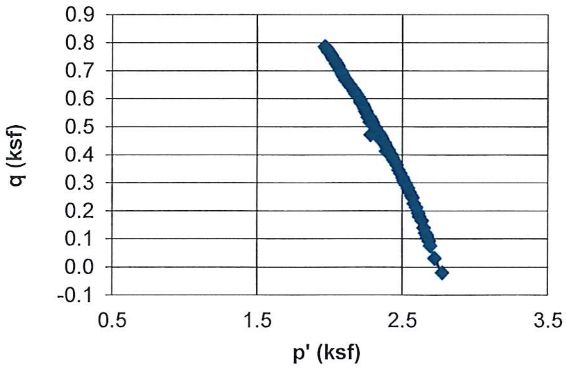
Consolidated-Undrained Triaxial Compression Test for Cohesive Soils (ASTM D4767)

Project Name:	Lower Coal Creek		Date:	12/1/2015	
Project No.:	2010-021 T200		Exploration ID:	B-1	
Technician:	Jherrera		Sample No:	S-7	
Sample Description:	Grayish brown SILT with organics (MH/ML)		Sample Depth, ft:	24.0-26.0	
Strain Rate, %/min:	0.0055		Effective Confining Pressure, ksf:	2.8	
Initial Moisture, %	57.8	Initial Wet Density, pcf:	101.5	Initial Dry Density, pcf:	64.3
Final Moisture, %	49.9	Final Wet Density, pcf:	132.6	Final Dry Density, pcf:	88.5
Shear Plots:					

Deviator Stress, Excess Pore Pressure and Effective Stress Ratio



p' - q Diagram

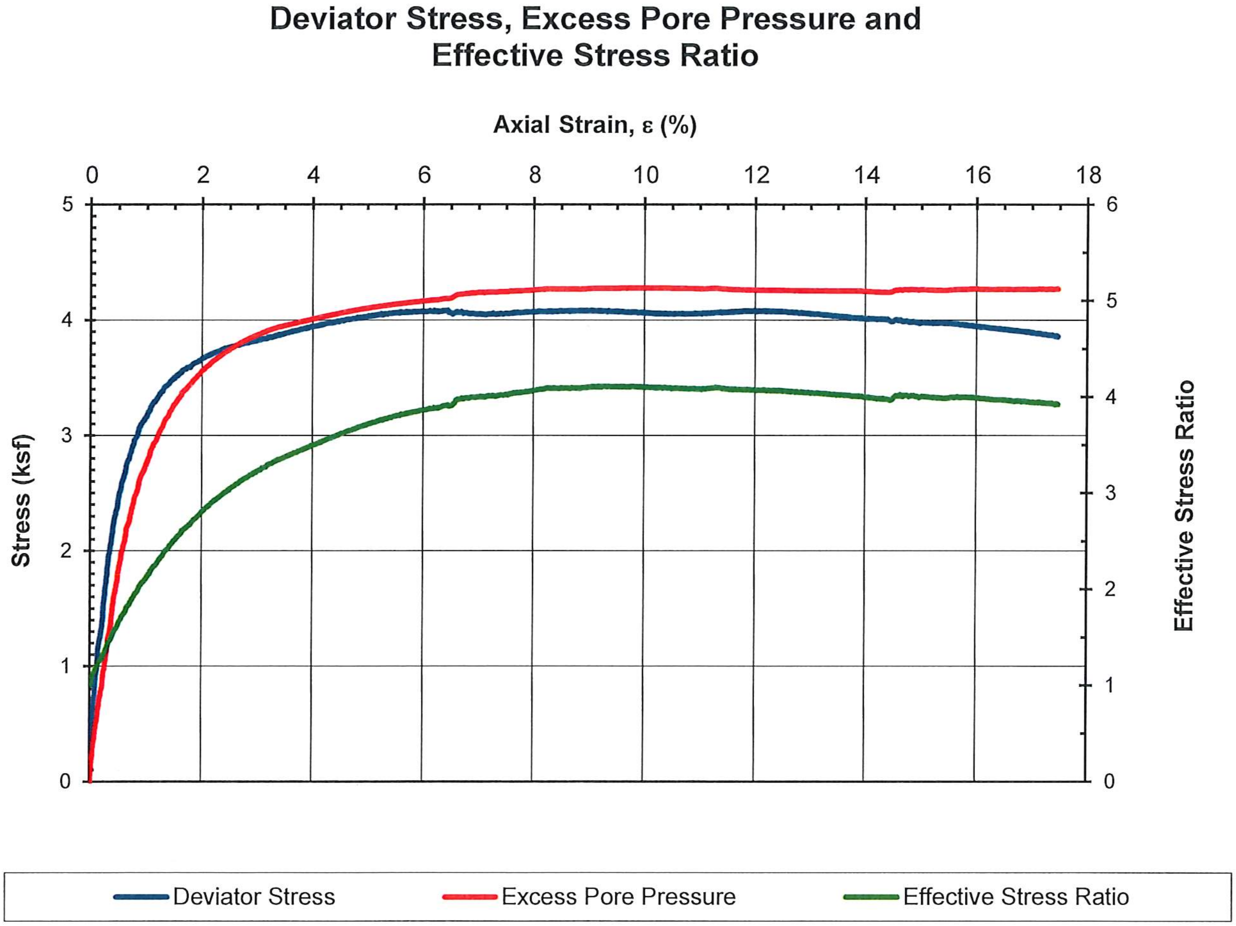


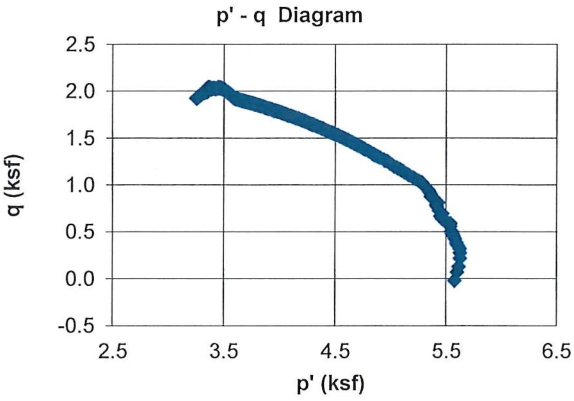
Reviewed by: ______________________ Figure ________

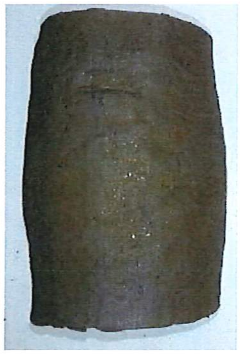
Consolidated-Undrained Triaxial Compression Test for Cohesive Soils (ASTM D4767)

Project Name:	Lower Coal Creek			Date:	12/1/2015
Project No.:	2010-021 T200	Exploration ID:			B-3
Technician:	Jherrera	Sample No:			S-8
Sample Description:	Grayish brown SILT with organics (ML)			Sample Depth, ft:	22.5-24.5
Strain Rate, %/min:	0.0055	Effective Confining Pressure, ksf:			5.6
Initial Moisture, %	48.1	Initial Wet Density, pcf:	109.4	Initial Dry Density, pcf:	73.9
Final Moisture, %	38.2	Final Wet Density, pcf:	114.8	Final Dry Density, pcf:	83.2

Shear Plots:







Reviewed by: ____________________ Figure ________

APPENDIX C

Nearby Exploration Logs By Others

Earth Solutions NW, LLC
2603 151st Pl. NE
Redmond, WA 98052
Telephone: 4252843300
Fax: 4252842855

BORING NUMBER B-1

CLIENT STF Construction

PROJECT NAME 79 Skagit Key

PROJECT NUMBER 0229

PROJECT LOCATION Bellevue, Washington

DATE STARTED 10/5/05 **COMPLETED** 10/5/05

GROUND ELEVATION **HOLE SIZE**

DRILLING CONTRACTOR Boretec

GROUND WATER LEVELS:

DRILLING METHOD HSA

▽ **AT TIME OF DRILLING** 5.0 ft

LOGGED BY SSR **CHECKED BY** SSR

AT END OF DRILLING —

NOTES Grass Yard

AFTER DRILLING —

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0					SM	▩	Brown silty SAND, loose to medium dense, moist (Fill) -mottled
2.5	SS	100	4-5-6 (11)	MC = 20.00%	ML	▩	Brown mottled SILT, medium dense, moist (Fill)
5.0 ▽	SS	100	4-3-3 (6)	MC = 38.20%	SM	▩	Black silty SAND, loose, wet (Fill)
	SS	100	1-1-1 (2)	MC = 59.00%			-coal fragments
10	SS	100	1-2-1 (3)	MC = 41.70%			
15	SS	100	1-1-1 (2)	MC = 282.40%			
16.0					OL	▤	Brown organic SILT, very soft, wet
20.0							

CLIENT STF Construction
PROJECT NAME 79 Skagit Key
PROJECT NUMBER 0229
PROJECT LOCATION Bellevue, Washington

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
20	SS	100	1-1-1 (2)	MC = 609.90%	PT		Brown fibrous PEAT, soft, wet
25	SS	100	1-1-1 (2)	MC = 50.80%	CH	25.0	Gray fat CLAY, soft, wet
							-silty sand layers
30	SS	100	1-1-1 (2)	MC = 63.80%			-fibrous peat layers
35	SS	100	1-1-1 (2)	MC = 37.40%			
40	SS	100	1-1-1 (2)	MC = 62.10%	MH	40.0	Gray elastic SILT, very soft, wet
							-organic layers

CLIENT STF Construction
PROJECT NAME 79 Skagit Key
PROJECT NUMBER 0229
PROJECT LOCATION Bellevue, Washington

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
					MH	▥	Gray elastic SILT, very soft, wet *(continued)*
45						45.0	
	☒ SS	100	1-1-1 (2)	MC = 81.60%	CH	▨	Gray fat CLAY, very soft, wet
							-sand layers
50	☒ SS	100	1-1-1 (2)	MC = 46.90%			-contains sand and silt layers
55	☒ SS	100	1-1-1 (2)	MC = 24.30%			
						57.5	
					SM	░	Gray silty SAND, medium dense, wet
60	☒ SS	100	2-7-9 (16)	MC = 24.30%			
						61.5	**Boring terminated at 61.5 feet below existing grade. Groundwater table encountered at 5.0 feet during drilling. Boring backfilled with bentonite and cuttings.** **Bottom of hole at 61.5 feet.**

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BORING NUMBER B-2

PAGE 1 OF 3

CLIENT STF Construction

PROJECT NAME 79 Skagit Key

PROJECT NUMBER 0229

PROJECT LOCATION Bellevue, Washington

DATE STARTED 10/5/05 **COMPLETED** 10/5/05

GROUND ELEVATION **HOLE SIZE**

DRILLING CONTRACTOR Boretec

GROUND WATER LEVELS:

DRILLING METHOD HSA

∇ **AT TIME OF DRILLING** 5.0 ft

LOGGED BY SSR **CHECKED BY** SSR

AT END OF DRILLING —

NOTES Landscape Area

AFTER DRILLING —

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0					SM		Brown silty SAND, loose, moist (Fill)
					ML	2.0	Brown mottled SILT, loose, moist (Fill)
	SS	100					
5	SS	100	2-6-4 (10)	MC = 26.70%			∇ -sand layers -coal layers
	SS	100	1-2-1 (3)	MC = 48.60%	SM	7.5	Black silty SAND, very loose, water bearing (Fill)
10	SS	100	1-2-1 (3)	MC = 27.50%			-coal with silty sand - fill
15	SS	67	1-1	MC = 230.30%	OL	15.0	Brown organic SILT, very soft, wet
20						20.0	

CLIENT STF Construction
PROJECT NAME 79 Skagit Key
PROJECT NUMBER 0229
PROJECT LOCATION Bellevue, Washington

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
20	SS	100	1-1-1 (2)	MC = 494.50%	PT		Brown fibrous PEAT, soft, wet
25	SS	100	1-1-1 (2)	MC = 67.20%	CH	25.0	Gray fat CLAY, very soft, wet
30	SS	100	2-1-1 (2)	MC = 58.90%			-sand layers
35	SS	100	1-1-1 (2)	MC = 40.00%			-silt layers
40	SS	100	1-1-1 (2)	MC = 42.10%	MH	40.0	Gray elastic SILT, very soft, wet -trace organics

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BORING NUMBER B-

PAGE 3 OF

CLIENT STF Construction
PROJECT NAME 79 Skagit Key
PROJECT NUMBER 0229
PROJECT LOCATION Bellevue, Washington

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
							Gray elastic SILT, very soft, wet *(continued)*
45	☒ SS	100	1-1-1 (2)	MC = 42.60%	MH		-sand layers
50	☒ SS	100	3-3-5 (8)	MC = 19.90%	SP	50.0	Gray poorly graded SAND, loose, water bearing
55	☒ SS	100	2-3-2 (5)	MC = 187.40%	PT	55.0	Brown fibrous PEAT, soft, wet -silty sand in tip
					SM	57.0	Gray silty SAND, medium dense, wet
60	☒ SS	100	12-13-15 (28)	MC = 23.20%		61.5	Boring terminated at 61.5 feet below existing grade. Groundwater table encountered at 5.0 feet during drilling. Boring backfilled with bentonite and cuttings. Bottom of hole at 61.5 feet.

BORING NO. 1

TEST DATA

Depth in Feet	Lab Tests	Moisture Content	Dry Density	Blow-Count	Samples	Group Symbol	DESCRIPTION
0						SM	DARK BROWN SILTY GRAVELLY SAND (LOOSE, WET) (FILL)
				6	◪	OL CO	BROWN ORGANIC SILT AND BLACK COAL FRAGMENTS (SOFT, LOOSE, MOIST TO WET)
5							
				4	◪		
10							
						OL	BROWN ORGANIC SILT (VERY SOFT, WET)
				PUSHED	◪		
15							
						OL PT	INTERBEDDED BROWN ORGANIC SILT AND DARK BROWN PEAT (VERY SOFT, WET)
				1	◪		
20							
						PT	DARK BROWN PEAT WITH ORGANIC SILT (VERY SOFT, WET)
				PUSHED	◪		
25							
				1	◪	SM ML	GRAY SILTY FINE SAND AND FINE SANDY SILT (VERY LOOSE, SOFT, SATURATED)
30							
						SP-SM	GRAY FINE TO MEDIUM SAND WITH SILT AND A TRACE OF COAL FRAGMENTS (VERY LOOSE, SATURATED)
				PUSHED	◪		
35							
						ML	GRAY SILT WITH LENSES OF SILTY FINE SAND (VERY SOFT, WET)
				2	◪		
40							

Note: See Figure 2 for Explanation of Symbols

GeoEngineers Incorporated

LOG OF BORING

FIGURE 3

NLT:EL 983-01 9/26/86

BORING NO. 1
(continued)

TEST DATA

DEPTH IN FEET	Lab Tests	Moisture Content	Dry Density	Blow-Count	Samples	Group Symbol	DESCRIPTION
40							
				PUSHED	◪	OL	GRAYISH-BROWN ORGANIC SILT AND SILT (VERY SOFT, SATURATED)
45							
				14	◪	SP	GRAY FINE SAND WITH A TRACE OF SILT AND LENSES OF SILTY FINE SAND (VERY LOOSE, WET)
50							
				6	◪	SM ML	INTERBEDDED GRAY SILTY FINE SAND AND SILT (LOOSE, MEDIUM STIFF, WET)
55							
				5	◪	GP	GRAY FINE GRAVEL (LOOSE, SATURATED)
						SP-SM	GRAY FINE SAND WITH SILT (LOOSE, SATURATED)
60							
						GW	GRAY SANDY GRAVEL WITH A TRACE OF SILT (DENSE, TO VERY DENSE, SATURATED)
				56	◪		
65							
						SW	GRAY GRAVELLY SAND WITH A TRACE OF SILT (DENSE, SATURATED)
				32	◪	ML	GRAY FINE SANDY SILT (VERY STIFF, WET)
70							
				62	◪	SP-SM	GRAY FINE SAND WITH SILT AND A TRACE OF FINE GRAVEL (DENSE TO VERY DENSE, SATURATED)
75							
						SP	GRAY FINE SAND WITH A TRACE OF SILT AND FINE GRAVEL (VERY DENSE, SATURATED)
				66	◪		
80							

BORING COMPLETED AT 79 FEET ON 9/23/86

WATER LEVEL AT APPROXIMATELY 4 FEET AT TIME OF DRILLING

Note: See Figure 2 for Explanation of Symbols

NLT:el 9/26/86 983-01

GeoEngineers Incorporated

LOG OF BORING

FIGURE 4

PROJECT NAME: Tarbert Residence
PROJECT NO.: TNT-1

Client: Todd Tarbert
Project Location: Bellevue, Washington
Date Exploration Completed: 11/11/93
Ground Surface Elevation: Unknown

BORING LOG B-1
Page 1 of 2
Figure A-1
241

Depth in Feet	Sample	Blows Per Six Inches	SOIL DESCRIPTION	Laboratory Test Information
0			Loose, damp, black, fine gravel-sized COAL fragments and medium stiff, damp, brown, organic SILT. Qyal OL-85	68 Skagit Key
	S-1	7 4 3 2 2 1		
5	S-2	∇		
			Very soft, wet, tan and dark brown, organic SILT. OL-95	
10	S-3	1/12" 1		
15	S-4	0 1/12"		
20	S-5	1 1 2		
			Interlayered, very soft, wet, gray, clayey SILT, dark brown, organic SILT and silty, medium to fine SAND. OL/ML-75	
25	S-6	0/12" 1		
30	S-7	1/12" 3		
35	S-8	0 2 3	Very loose, wet, gray, silty, fine SAND and fine sandy SILT. SM/ML-50	
40	S-9	0 1/12"		
45	S-10	15 10 14	Medium dense, wet, gray, silty, fine SAND and fine sandy SILT.	

PROJECT NAME: Tarbert sidence
PROJECT NO.: TNT-1

Client: Todd Tarbert
Project Location: Bellevue, nington
Date Exploration Completed: 11/11/93
Ground Surface Elevation: Unknown

BORING LOG B-1
Page 2 of 2
Figure A-1

241

Depth in Feet	Sample	Blows Per Six Inches	SOIL DESCRIPTION	Laboratory Test Information
45			Medium dense, wet, gray, silty, fine SAND and fine sandy SILT. Qal SM/ML- 50	
50	S-11	4 8 11		
55	S-12	12 10 12	-slightly gravelly, medium to fine sand layer. SM - 30	
60	S-13	0 7 8	-very stiff, silty clay lense ~~CL-ML~~ ~~80~~ 60 SC-SM	
65	S-14	50/3"	Very dense, wet, gray, slightly gravelly to gravelly, medium to fine SAND. QVA SP-SM 5 Hard drilling from 65-1/2 to 67-1/2 feet.	
70	S-15	60/5"	Two-feet heave, spun out before sampling.	
75	S-16	50/3"	Four-foot heave, spun out before sampling.	
			Bottom of boring at 74-1/4 feet below existing ground surface. Groundwater encountered at 24-1/2 feet at time of drilling.	
80				
85				
90				

PROJECT NAME: Tarbert .idence
PROJECT NO.: TNT-1

Client: Todd Tarbert
Project Location: Bellevue, V.. .ington
Date Exploration Completed: 11/11/93
Ground Surface Elevation: Unknown

BORING LOG B-2
Page 1 of 2
Figure A-2 242

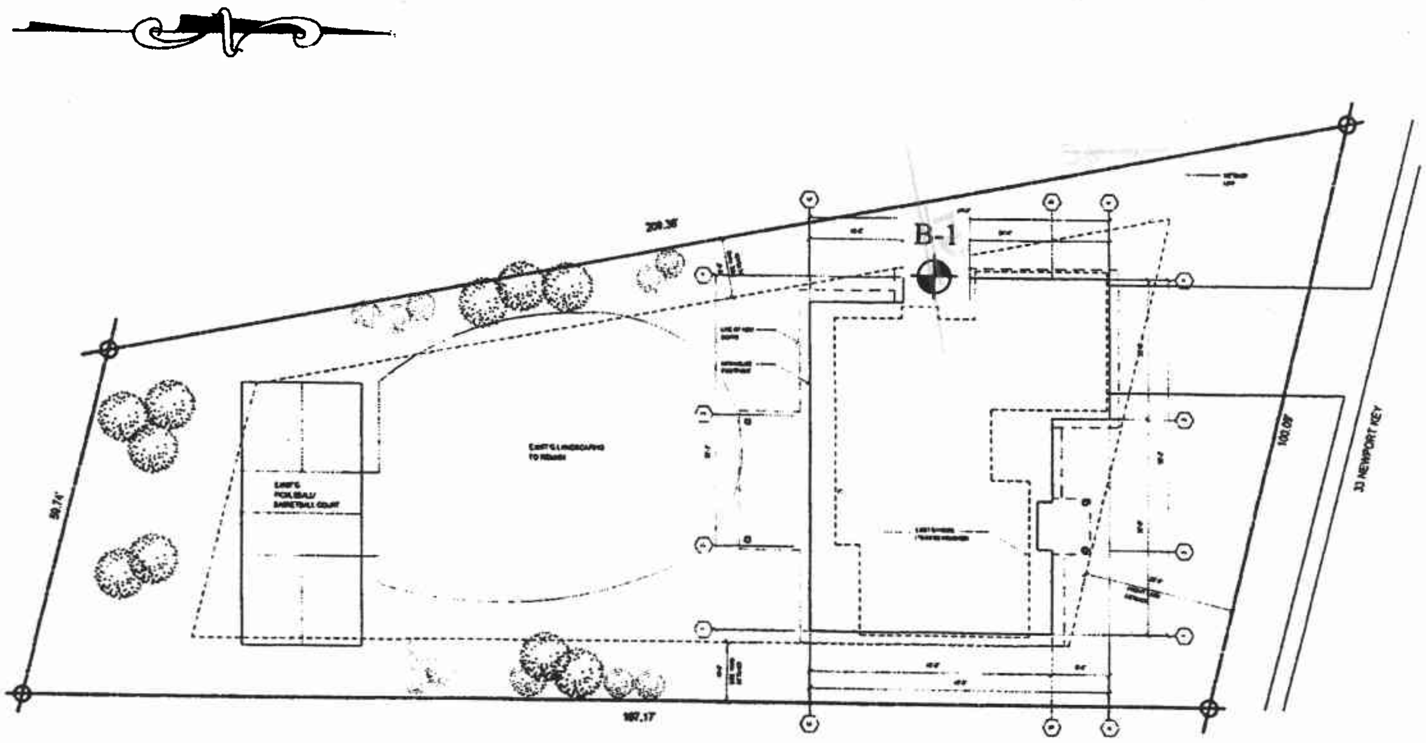
Depth in Feet	Sample	Blows Per Six Inches	SOIL DESCRIPTION	Laboratory Test Information
0			Loose, damp, black, fine gravel-sized COAL fragments and medium SAND. SP-5 Qyal	
	S-1	6 4 3		
5			Very loose, wet, gray, fine to medium SAND with trace gravel and organics.	
		▽		
	S-2	3 1/12"		
10				
			Very soft to medium stiff, tan and dark brown, organic SILT. OL-95	
	S-3	1/12" 2		
15				
	S-4	1 2 3		
20				
	S-5	1 1 2		
25			Very loose, wet, brown and gray, silty, fine SAND and fine sandy SILT with scattered organics. sm/ML-50	
	S-6	0 1 2		
30				
	S-7	4 2 3		
35				
			Soft, wet, gray, clayey SILT, and very loose, silty, fine SAND and fine sandy SILT with scattered organics. sm/CLML-70	
	S-8	0 1 1		
40				
	S-9	2 0 0		
45				

PROJECT NAME: Tarbert Residence
PROJECT NO.: TNT-1

Client: Todd Tarbert
Project Location: Bellevue, Washington
Date Exploration Completed: 11/11/93
Ground Surface Elevation: Unknown

BORING LOG B-2
Page 2 of 2
Figure A-2 242

Depth in Feet	Sample	Blows Per Six Inches	SOIL DESCRIPTION	Laboratory Test Information
45			Soft, wet, gray, clayey SILT and very loose, silty, fine SAND and fine sandy SILT with scattered organics. SM/CL-ML 70 Qyal ↓	
	S-10	6 15 24		
50			Dense, wet, gray, slightly silty to silty, medium SAND. SM-15 QVA ↓	
		4 5 12	Four-foot heave washed out before sampling. 1-inch recovery, medium SAND.	
55				
	S-11	8 16 16		
60			Dense to very dense, wet, gray, medium to fine SAND. SP-5	
	S-12	16 12 20	One-foot heave, spun out before sampling.	
65				
	S-13	17 26 41	-sandy gravel lense	
70				
	S-14	50/4"	-sandy gravel lense	
75			Bottom of boring at 74-1/3 feet below existing ground surface.	
80				
85				
90				



0 30 60

SCALE IN FEET

LEGEND:

⊕ **B-1** BORING NUMBER AND APPROXIMATE LOCATION

Reference PDF file provided by DAN JENKINS, dated 09/22/03.

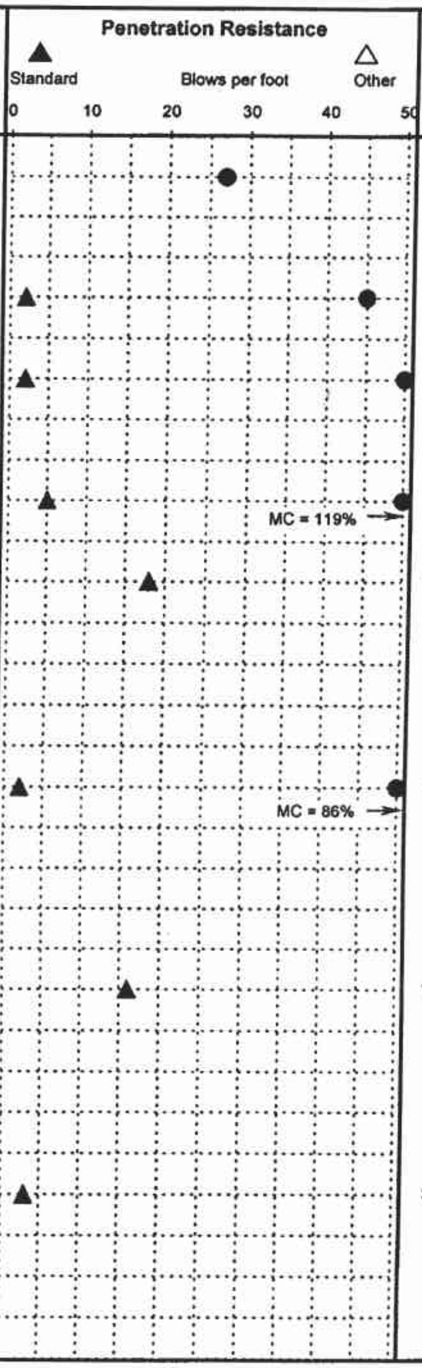
Zipper Zeman Associates, Inc. Geotechnical and Environmental Consulting 811 1st Avenue, Suite 404 Seattle, Washington 98104 Tele: (206) 264-8295 Fax: (206) 264-4818	Project No. J-1798 Date: Feb., 2004 Drawn by: J.D. Scale: As Noted	Proposed Jenkins Residence 33 Newport Key Bellevue, Washington **FIGURE 1: SITE & EXPLORATION PLAN**

PROJECT: Jenkins Residence **JOB NO.:** J-1798 **BORING:** B-1 **PAGE 1 OF 1**

Location: 33 Newport Key, Bellevue, WA **Approximate Elevation:**

Depth (ft)	Soil Description	Sample Type	Sample Number	Ground Water	N-values	Testing
0	3 inches of (loose), moist, brown, 1-1/2" minus crushed landscape gravel over (very loose), moist to wet, brown to dark brown, silty SAND with some gravel and scattered organics (fill).	cuttings	S-1			
	Very loose, wet, mottled gray and brown, silty SAND (46% fines content) with interbedded layers of fine to medium SAND and very soft SILT.	⌶	S-2a S-2b		2	200W
5		⌶	S-3a S-3b S-3c	▼ ATD	2	
	Medium stiff, wet, brown, organic SILT with abundant organic fibers (13% organic content).	⌶	S-4		5	OC
10	Blowcount overstated on buried wood at 11 feet.	⌶	S-5		18	
15	Becomes soft, fibrous organic SILT (13% organic content).	⌶	S-6		2	OC
	Medium dense, saturated, gray, gravelly SAND.					
20		⌶	S-7		16	
	Soft, saturated, gray, SILT with some clay.					
25	Very loose, saturated, gray, silty fine SAND.	⌶	S-8		3	
	Boring completed at 26.5 feet below the ground surface on 2/2/04. Groundwater seepage observed at 5 feet at the time of drilling.					
30						

Penetration Resistance



Explanation

⌶ 2-inch O.D. split spoon sample
Ⅱ 3-inch I.D Shelby tube sample
⊗ No Recovery
▼ ATD Groundwater level at time of drilling

Monitoring Well Key
▨ Clean Sand
▩ Bentonite
■ Grout/Concrete
▤ Screened Casing
☐ Blank Casing

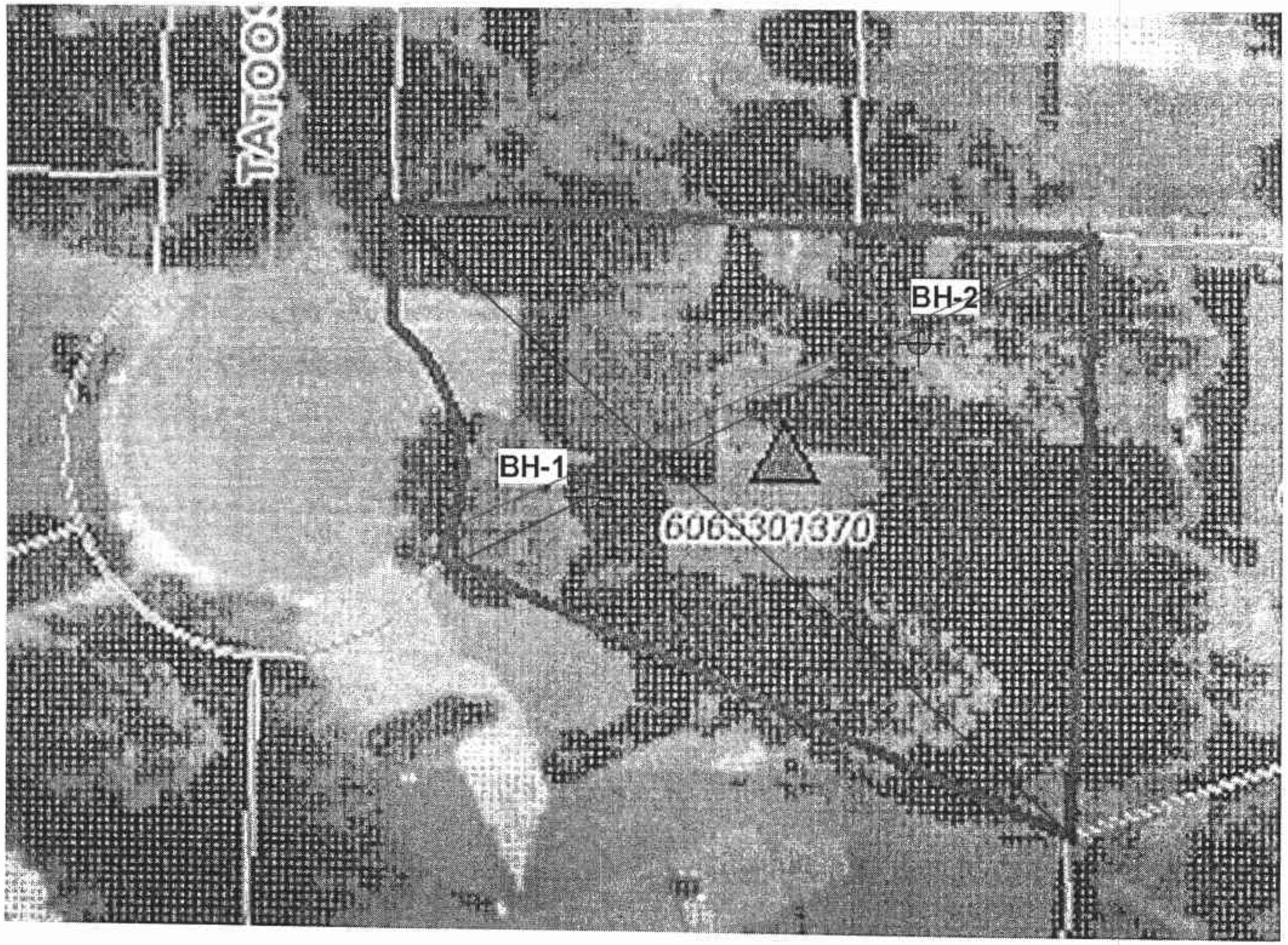
Moisture Content
Plastic Limit ├──●──┤ Liquid Limit
Natural

Testing Key
OC = Organic Content
200W = 200 Wash Analysis

Zipper Zeman Associates, Inc.
Geotechnical and Environmental Consulting

BORING LOG **Figure A-1**
Date Drilled: 2/2/2004 **Logged By:** EL

file.grf w/ file.dat 11/10/06 (10:27) MHX



not to scale

Legend:

BH-1 ⊕ Approx. Borehole Location

Note: Base map modified
from King Couty GIS Image.

PanGEO
INCORPORATED

Proposed Sherman Residence
33 Tatoosh KY
Bellevue, Washington

SITE AND EXPLORATION MAP

Project No. 06-160	Figure No. 2

RELATIVE DENSITY / CONSISTENCY

SAND / GRAVEL			SILT / CLAY		
Density	SPT N-values	Approx. Relative Density (%)	Consistency	SPT N-values	Approx. Undrained Shear Strength (psf)
Very Loose	<4	<15	Very Soft	<2	<250
Loose	4 to 10	15 - 35	Soft	2 to 4	250 - 500
Med. Dense	10 to 30	35 - 65	Med. Stiff	4 to 8	500 - 1000
Dense	30 to 50	65 - 85	Stiff	8 to 15	1000 - 2000
Very Dense	>50	85 - 100	Very Stiff	15 to 30	2000 - 4000
			Hard	>30	>4000

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS		GROUP DESCRIPTIONS	
Gravel 50% or more of the coarse fraction retained on the #4 sieve. Use dual symbols (eg. GP-GM) for 5% to 12% fines.	GRAVEL (<5% fines)	GW	Well-graded GRAVEL
		GP	Poorly-graded GRAVEL
	GRAVEL (>12% fines)	GM	Silty GRAVEL
		GC	Clayey GRAVEL
Sand 50% or more of the coarse fraction passing the #4 sieve. Use dual symbols (eg. SP-SM) for 5% to 12% fines.	SAND (<5% fines)	SW	Well-graded SAND
		SP	Poorly-graded SAND
	SAND (>12% fines)	SM	Silty SAND
		SC	Clayey SAND
Silt and Clay 50%or more passing #200 sieve	Liquid Limit < 50	ML	SILT
		CL	Lean SILT
		OL	Organic SILT or CLAY
	Liquid Limit > 50	MH	Elastic SILT
		CH	Fat CLAY
		OH	Organic SILT or CLAY
Highly Organic Soils		PT	PEAT

Notes:
1. Soil exploration logs contain material descriptions based on visual observation and field tests using a system modified from the Uniform Soil Classification System (USCS). Where necessary laboratory tests have been conducted (as noted in the "Other Tests" column), unit descriptions may include a classification. Please refer to the discussions in the report text for a more complete description of the subsurface conditions.
2. The graphic symbols given above are not inclusive of all symbols that may appear on the borehole logs. Other symbols may be used where field observations indicated mixed soil constituents or dual constituent materials.

DESCRIPTIONS OF SOIL STRUCTURES

Layered: Units of material distinguished by color and/or composition from material units above and below

Laminated: Layers of soil typically 0.05 to 1mm thick, max. 1 cm

Lens: Layer of soil that pinches out laterally

Interlayered: Alternating layers of differing soil material

Pocket: Erratic, discontinuous deposit of limited extent

Homogeneous: Soil with uniform color and composition throughout

Fissured: Breaks along defined planes

Slickensided: Fracture planes that are polished or glossy

Blocky: Angular soil lumps that resist breakdown

Disrupted: Soil that is broken and mixed

Scattered: Less than one per foot

Numerous: More than one per foot

BCN: Angle between bedding plane and a plane normal to core axis

COMPONENT DEFINITIONS

COMPONENT	SIZE / SIEVE RANGE	COMPONENT	SIZE / SIEVE RANGE
Boulder:	> 12 inches	**Sand**	
Cobbles:	3 to 12 inches	**Coarse Sand:**	#4 to #10 sieve (4.5 to 2.0 mm)
Gravel		**Medium Sand:**	#10 to #40 sieve (2.0 to 0.42 mm)
Coarse Gravel:	3 to 3/4 inches	**Fine Sand:**	#40 to #200 sieve (0.42 to 0.074 mm)
Fine Gravel:	3/4 inches to #4 sieve	**Silt**	0.074 to 0.002 mm
		Clay	<0.002 mm

TEST SYMBOLS

for In Situ and Laboratory Tests listed in "Other Tests" column.

CBR	California Bearing Ratio
Comp	Compaction Tests
Con	Consolidation
DD	Dry Density
DS	Direct Shear
%F	Fines Content
GS	Grain Size
Perm	Permeability
PP	Pocket Penetrometer
R	R-value
SG	Specific Gravity
TV	Torvane
TXC	Triaxial Compression
UCC	Unconfined Compression

SYMBOLS

Sample/In Situ test types and intervals

☒	2-inch OD Split Spoon, SPT (140-lb. hammer, 30" drop)
⧗	3.25-inch OD Spilt Spoon (300-lb hammer, 30" drop)
▚	Non-standard penetration test (see boring log for details)
■	Thin wall (Shelby) tube
✋	Grab
▯	Rock core
◫	Vane Shear

MONITORING WELL

▽ Groundwater Level at time of drilling (ATD)

▼ Static Groundwater Level

Cement / Concrete Seal

Bentonite grout / seal

Silica sand backfill

Slotted tip

Slough

Bottom of Boring

MOISTURE CONTENT

Dry	Dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water

PanGEO INCORPORATED
Phone: 206.262.0370

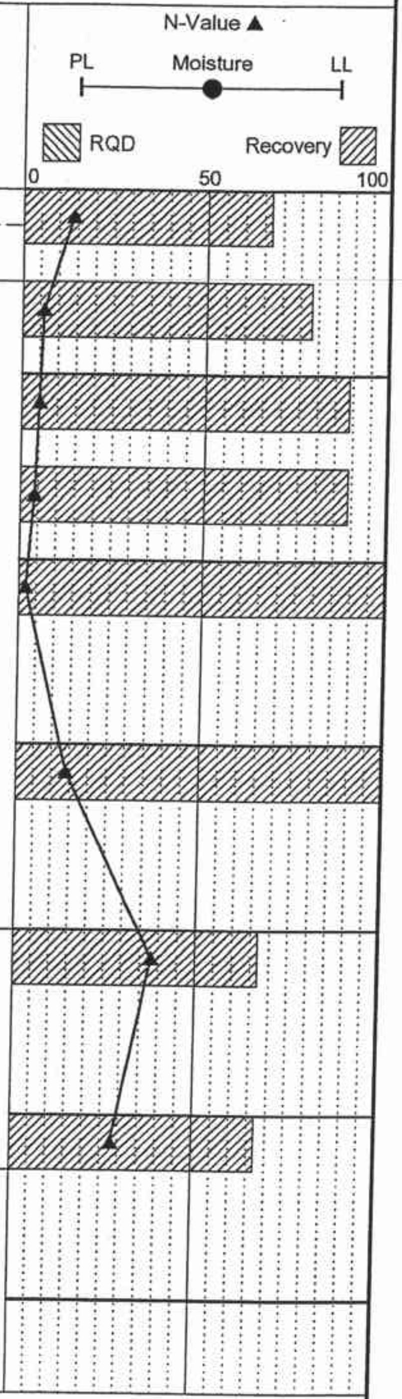
Terms and Symbols for Boring and Test Pit Logs

Figure 3

Project: 33 Tatoosh KY
Job Number: 06-160
Location: Bellevue, WA
Coordinates: Northing: , Easting:

Surface Elevation:
Top of Casing Elev.: na
Drilling Method: HSA/Acker
Sampling Method: SPT/Cathead

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0	S-1	☒	2 4 10			Sod over loose, moist, black, organic rich silty sand (Topsoil).
						Loose, moist, reddish-brown, sandy SILT/silty SAND with prevalent organics (Fill/Disturbed Soil); Blowcount overstated on root;.
	S-2	☒	2 3 3			Loose, moist to wet, orange-brown, medium SAND with some silt and trace organics and charcoal bits (Alluvium); Heavy iron oxide staining at about 3 1/2 feet;.
5	S-3	☒	2 3 2			Becomes wet, heavy iron oxide staining, fine to medium SAND with some silt and trace organics; 1-inch lens of soft silt at 6 feet;.
	S-4	☒	1 2 2			Becomes gray, saturated, fine to medium SAND with interlayered lenses of gray, soft silt containing organics (leaves).
10	S-5	☒	0 1 1			Becomes soft, wet, SILT with some fine sand and prevalent organics (wood pieces and leaves); 4-inch lens of fine to medium SAND with prevalent organics at 10 feet;.
15	S-6	☒	2 3 11			Becomes medium dense, saturated, silty to some fine SAND with some fine gravel and scattered organics; medium rounded gravel at about 16 1/2 feet;.
20	S-7	☒	9 18 20			Medium dense to dense, saturated, gray, gravelly SAND/sandy GRAVEL with trace silt and scattered organics (Alluvium); Approximately 1 to 2 feet of heave noted at 20 & 25 feet;.
25	S-8	☒	9 15 13			
						Bottom of Boring..
30						



Completion Depth: 26.5ft
Date Borehole Started: 10/3/06
Date Borehole Completed: 10/3/06
Logged By: JCR
Drilling Company: CN Drilling

Remarks: Boring located approximately 7 feet north and 3 feet east of NE corner of existing house. Groundwater at time of drilling was approximately 7 feet below existing grade.

PanGEO
INCORPORATED
Phone: 206.262.0370

LOG OF TEST BORING BH-1

Figure 4

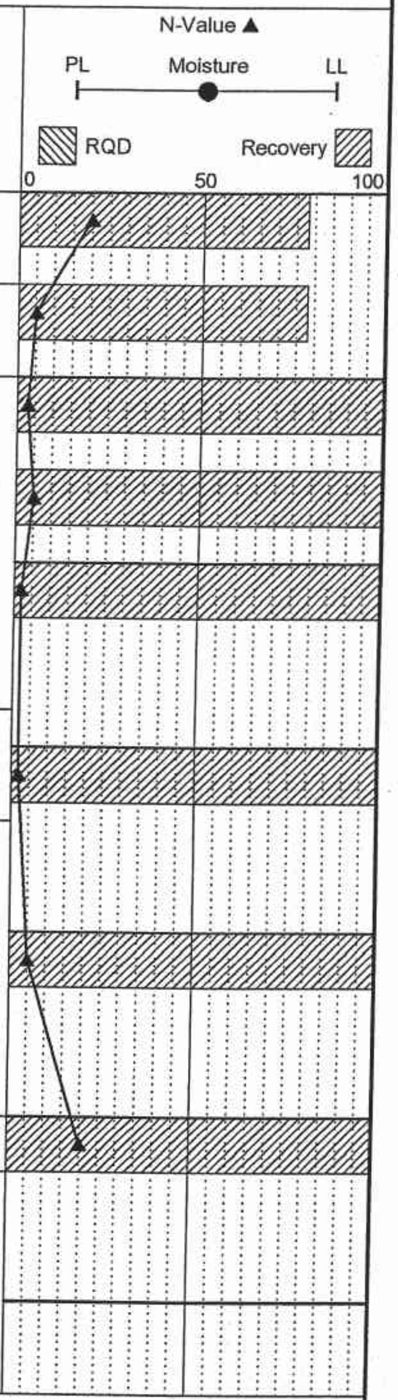
The stratification lines represent approximate boundaries. The transition may be gradual.

Sheet 1 of 1

Project: 33 Tatoosh KY
Job Number: 06-160
Location: Bellevue, WA
Coordinates: Northing: , Easting:

Surface Elevation:
Top of Casing Elev.: na
Drilling Method: HSA/Acker
Sampling Method: SPT/Cathead

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0	S-1	☒	6 7 13			Sod over loose to medium dense, moist, tan-brown, silty SAND with prevalent organics (Fill/Disturbed Soil).
	S-2	☒	2 2 3			Loose, moist, brown with heavy rust staining, fine to medium SAND with trace silt and scattered organics (Alluvium).
5	S-3	☒	1 1 2			Soft, moist to wet, gray-brown with heavy iron oxide staining, clayey SILT with prevalent organics (Alluvium).
	S-4	☒	1 2 3		▽	Becomes medium stiff, wet, with scattered organics; 4-inch lens of fine to medium SAND with trace silt at approximately 8 feet.
10	S-5	☒	1 1 1			Becomes soft, brown, SILT with numerous organics (wood and leaves); 2-inch medium sand lens at approximately 11 1/2 feet.
15	S-6	☒	1 1 1			Very soft, dark brown, saturated PEAT with some silt.
						Loose/medium stiff, gray, interlayered SILT and fine SAND with some silt, saturated.
20	S-7	☒	1 1 4			
25	S-8	☒	4 10 10			Medium dense, saturated, gray, gravelly SAND with trace silt (Alluvium); Approximately 2 feet of heave at 25 feet.
						Bottom of Boring..
30						



Completion Depth: 26.5ft
Date Borehole Started: 10/3/06
Date Borehole Completed: 10/3/06
Logged By: JCR
Drilling Company: CN Drilling

Remarks: Boring located in front yard, approximately 11 feet south of existing garage, and 13 feet west of existing house. Groundwater at time of drilling was approximately 8 feet below existing grade.

PanGEO INCORPORATED
Phone: 206.262.0370

LOG OF TEST BORING BH-2

Figure 5

The stratification lines represent approximate boundaries. The transition may be gradual.

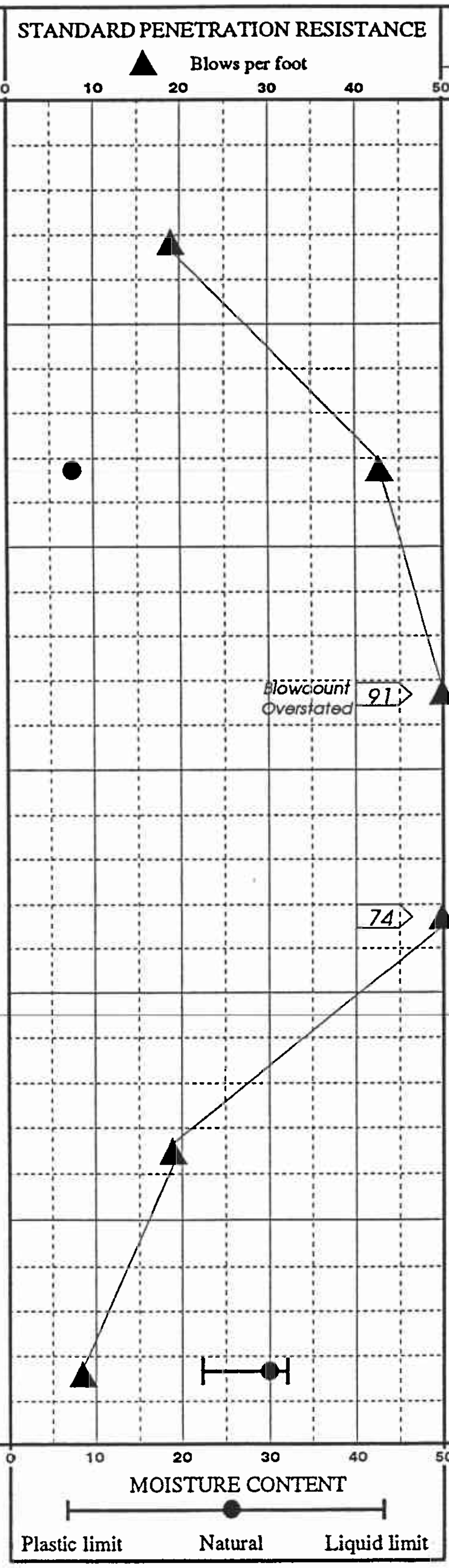
Sheet 1 of 1

PROJECT: *SR-405* W.O. *W-7748* BORING NO.*RZA-1*

Page 1 of 3

Approximate ground surface elevation: *62 feet*

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	TESTING
0	*Grass and topsoil*				
	Medium dense, moist to wet, grey and dark brown, silty fine to medium SAND, some gravel, trace organics (roots) (Fill)	I	*S-1*		
5					
	Becomes dense	I	*S-2*		▦
10					
	Very dense, moist, grey and brown, silty fine to medium SAND, gravelly. Some organics (roots and wood chips).	I	*S-3*		
15					
	Very dense, moist to wet, brown some grey, some rust brown streaks, silty fine SAND gravelly	I	*S-4*		
20					
	Medium dense, moist, brown and black, alluvial COAL interbedded with silty fine SAND and abundant organics (wood fragments)	I	*S-5*		
25					
	Medium stiff, wet, dark brown, clayey SILT, trace sand, trace organics (roots and twigs)	I	*S-6*		
30					



LEGEND

I 2-inch OD split-spoon sample

▦ Grain size analysis

RZA AGRA, Inc
Engineering & Environmental Services

11335 NE 122nd Way, Suite 100
Kirkland, Washington 98034-6918

Drilling started: *24 April 1992* Drilling completed: *24 April 1992* Logged by: *WBB*

PROJECT: *SR-405* W.O. *W-7748* BORING NO. *RZA-1*

DEPTH (feet)	SOIL DESCRIPTION Approximate ground surface elevation: *62 feet*	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	STANDARD PENETRATION RESISTANCE ▲ Blows per foot 0 10 20 30 40 50	Page 3 of 3 TESTING
60						
	Hard, moist, grey, SILT, trace sand, trace gravel	I	S-13		97/10" ▲	
65						
	Hard moist, grey SILT, trace sand	I	S-14		50/5" ▲	
70						
	Very dense, saturated, grey, fine to coarse SAND, some gravel	I	S-15		50/4.5" ▲	
75						
		X	S-16		50/4" ▲	
80	*Boring terminated at approximately 79 feet*					
85						
90					0 10 20 30 40 50	

MOISTURE CONTENT

Plastic limit ├──●──┤ Liquid limit
Natural

LEGEND

I 2-inch OD split-spoon sample

X Sample not recovered

RZA AGRA, Inc
Engineering & Environmental Services

11335 NE 122nd Way, Suite 100
Kirkland, Washington 98034-6918

Drilling started: *24 April 1992* Drilling completed: *24 April 1992* Logged by: *WBB*

Boring No. B-2 403

Logged by: MFS

Date: 2/13/96 to 2/14/96

Approximate Elev. 52

Graph/ USCS	Soil Description	Relative Density	Depth (ft.)	Sample	(N) Blows/ foot	Water Content (%)		
	FILL: Brown silty SAND/SAND with SILT and gravel, moist. Sm-25	Loose		I	5	5.0		
SM	Gray-brown to dark brown silty SAND/sandy SILT with gravel, wet, mottled. sm/ml-65	Qyal ↓ Loose	5	I	11	12.0		
			▽	I	8	15.6		
			10	I	3	16.0		
	Gray-brown silty SAND with gravel, wet, with some organic, organic odor. Sm-25	Loose		I	3	25.8		
SM	Gray silty SAND, wet, trace of gravel, some organic mottling. Sm-30	Loose	15	I	5	36.0		
	Note: Becomes medium dense at 18 feet.			I	11	41.9		
SP/PT	Gray SAND with SILT and some PEAT, wet, strong organic odor. Sm/pt-50	Qp Loose ↓	20	I	5	60.8		
				I	12	49.1		
ML/CL	CL-ML-95 Dark gray to black SILT with CLAY, wet, trace of gravel, strong organic odor.	Medium Stiff	25	I	7	39.3		
SP	Dark gray medium SAND with gravel, wet, trace of SILT. SP-4	QvA Dense to Very Dense		I	46	8.1		
			30	I	50/6"	15.3		

Boring terminated at 31 feet.
Groundwater encountered at 7 feet.

TERRA ASSOCIATES
Geotechnical Consultants

BORING LOG
PEDESTRIAN RECREATION TRAIL
BELLEVUE, WASHINGTON

Proj. No. T-3084 | Date 2/96 | Figure A-3

Boring No. B-3 (404)

Logged by: MFS

Date: 2/14/96

Approximate Elev. 56

Graph/ USCS	Soil Description	Relative Density	Depth (ft.)	Sample	(N) Blows/ foot	Water Content (%)		
	FILL: Olive-gray silty SAND with gravel, moist.	Loose						
SM	Gray-brown silty SAND with gravel, moist. Sm-25	Qyal Medium Dense	5	I	10	4.1		
SP	Black medium SAND, wet, trace of silt, with organic. SP-4	Loose ↓	∇ 10	I	8	46.4		
ML	Dark gray SILT, wet, trace of organic, faint organic odor. ML-100	Medium Stiff		⊤	5	50.9		

Boring terminated at 14 feet.
Groundwater encountered at 10 feet.

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Geotechnical Consultants

BORING LOG
PEDESTRIAN RECREATION TRAIL
BELLEVUE, WASHINGTON

Proj. No. T-3084 | Date 2/96 | Figure A-4

Boring No. B-4 (405)

Logged by: MFS

Date: 2/14/96

Approximate Elev. 46

Graph/ USCS	Soil Description	Relative Density	Depth (ft.)	Sample	(N) Blows/ foot	Water Content (%)		
	Topsoil: Organic Layer							
SP/SM	Native: Dark brown SILT with sand, wet. Qal	Soft	▽					
SP	Black medium SAND, wet, with organic, trace of silt. ↓	Loose SP-4			2	62.8		
ML	Dark gray SILT, wet with some organic, faint organic odor.	Very Soft ML-100	5		1/18"	49.0		
SP/SM	Gray fine to medium SAND with silt, wet, faint organic odor.	Very Loose SP-Sm 10			1/18"	27.9		
ML/CL	Gray SILT with clay, wet, faint organic odor. CL-ML-100	Soft				42.3		
SM	Gray silty SAND, wet. Sm-30	Loose	10		4	39.2		
ML/CL	CL-ML 100 Gray to gray-brown SILT with CLAY, wet, some brown mottling, faint organic odor.	Medium Stiff			8	29.7		
SP/GP	SP/GP-4 QUA Gray sandy GRAVEL/gravelly sand, wet.	Very Dense	15		50/4.5" 50/6"	11.8 11.7		

Boring terminated at 18.5 feet.
Groundwater encountered at 1 foot.

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ASSOCIATES
Geotechnical Consultants

BORING LOG
PEDESTRIAN RECREATION TRAIL
BELLEVUE, WASHINGTON

Proj. No. T-3084	Date 2/96	Figure A-5

Boring No. B-5 (406)

Logged by: MFS

Date: 2/15/96

Approximate Elev. 46

Graph/ USCS	Soil Description	Relative Density	Depth (ft.)	Sample	(N) Blows/ foot	Water Content (%)		
	Topsoil: Organic Layer							
SM	Native: Dark brown silty SAND, wet, with organic.	Loose Qyal	▽ 5					
ML/CL	Gray silty CLAY/clayey SILT, wet, with trace of organic, some charcoal. CL-ML 100	↓ Soft		I	1	61.7		
ML/CL	Gray silty CLAY with sand, wet, with some organic, black mottling. CL-ML 80 Note: Becomes medium stiff at 12.5 feet.	Soft Medium Stiff	10	I I I	1 0 20	45.0 47.7 27.9		
GP/SP	QVA Gray sandy GRAVEL/gravelly SAND, wet. SP/GP-4	Dense to Very Dense	15	I	50/3"	15.0		

Boring terminated at 16 feet.
Groundwater encountered at 2 feet.

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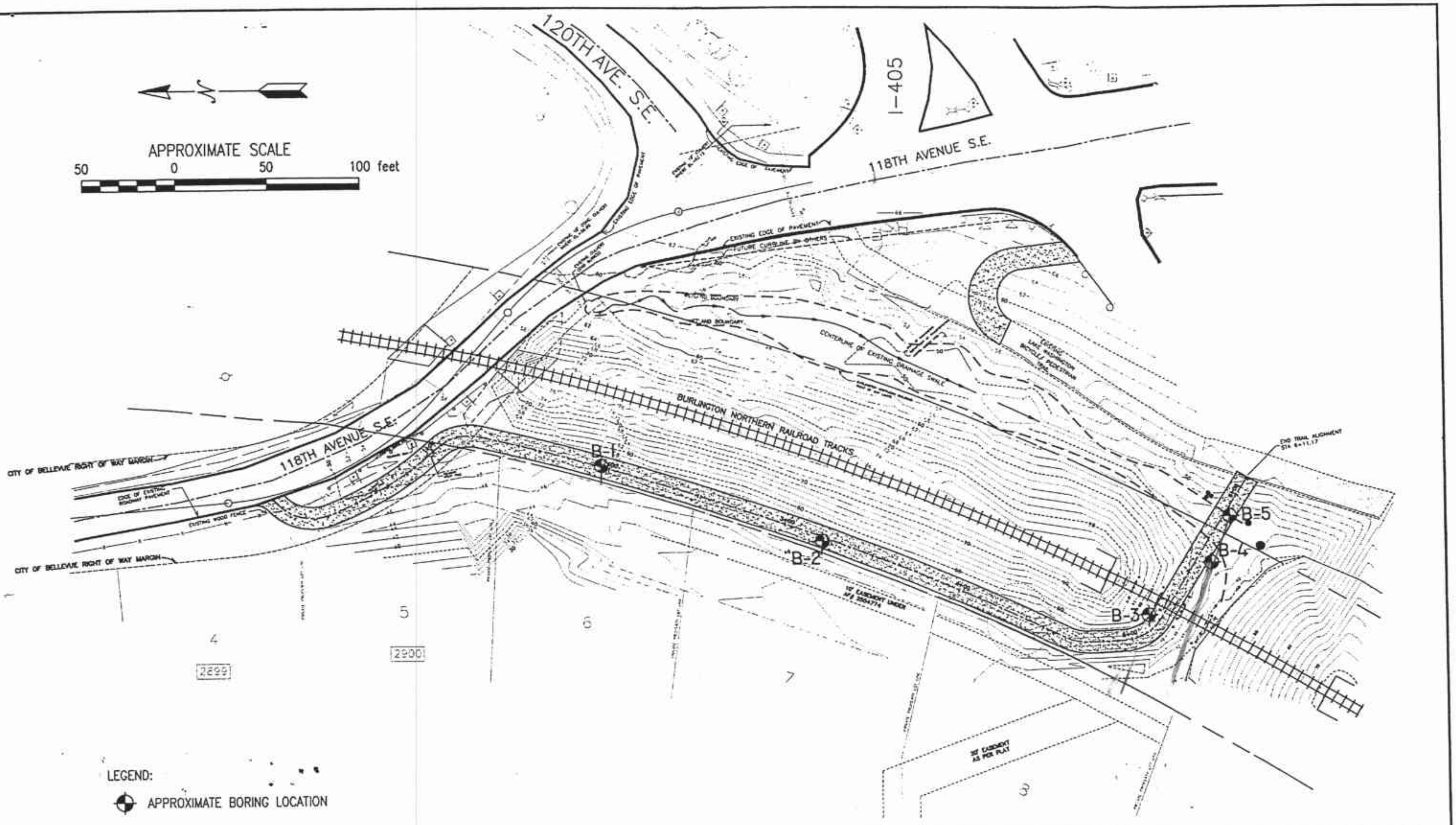
BORING LOG
PEDESTRIAN RECREATION TRAIL
BELLEVUE, WASHINGTON

Proj. No. T-3084	Date 2/96	Figure A-6



LEGEND:

⯐ APPROXIMATE BORING LOCATION

REFERENCE:
AUTOCAD FILE OF SITE PLAN PROVIDED BY AKB CONSULTING ENGINEERS, INC., FOR CAPITOL IMPROVEMENT PROJECT No. PW-W/B-42, DATED 2/18/96.

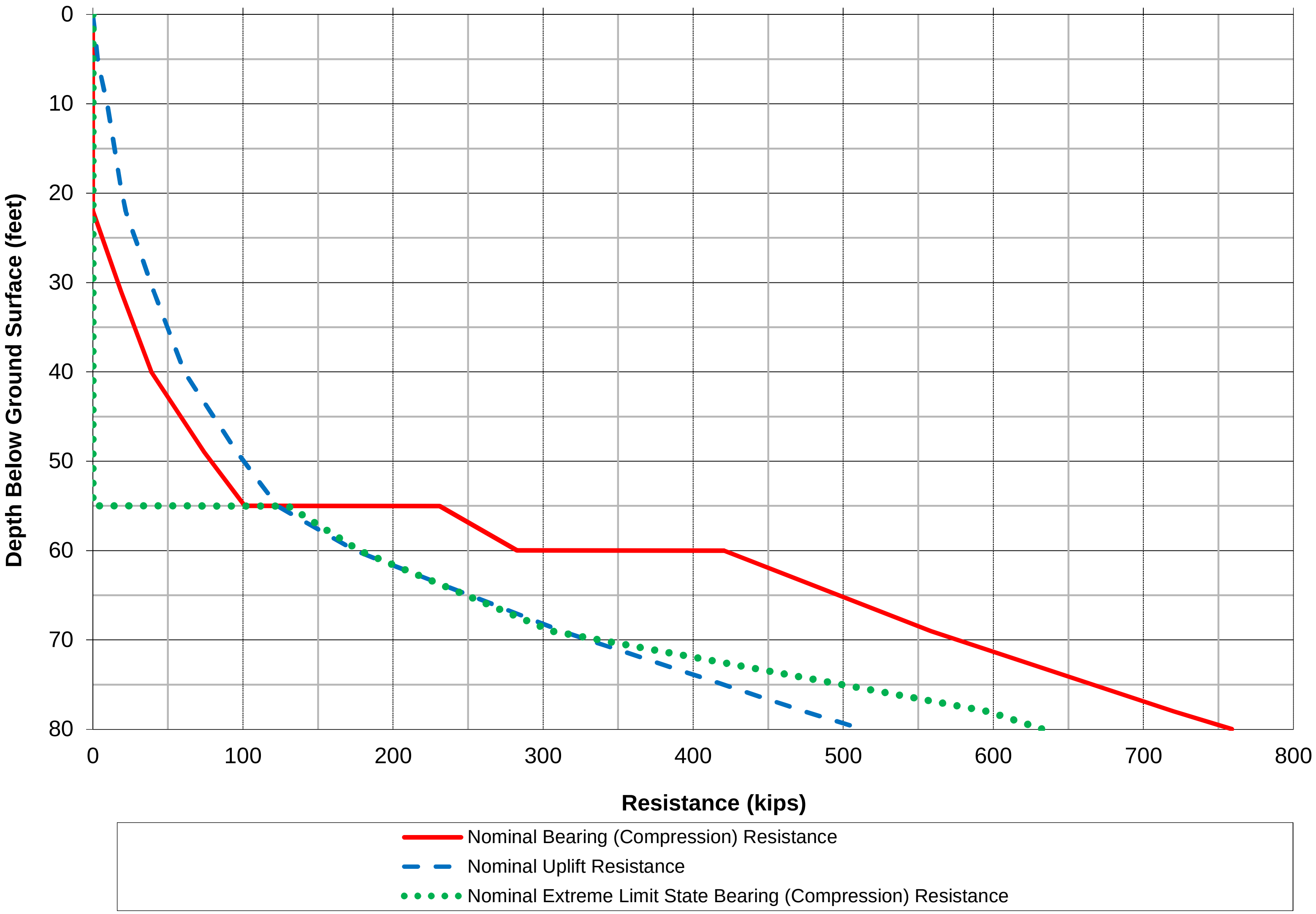
TERRA
ASSOCIATES
Geotechnical Consultants

EXPLORATION LOCATION PLAN
PEDESTRIAN RECREATION TRAIL
BELLEVUE, WASHINGTON

Proj. No. 3084	Date 2/96	Figure 2

APPENDIX D

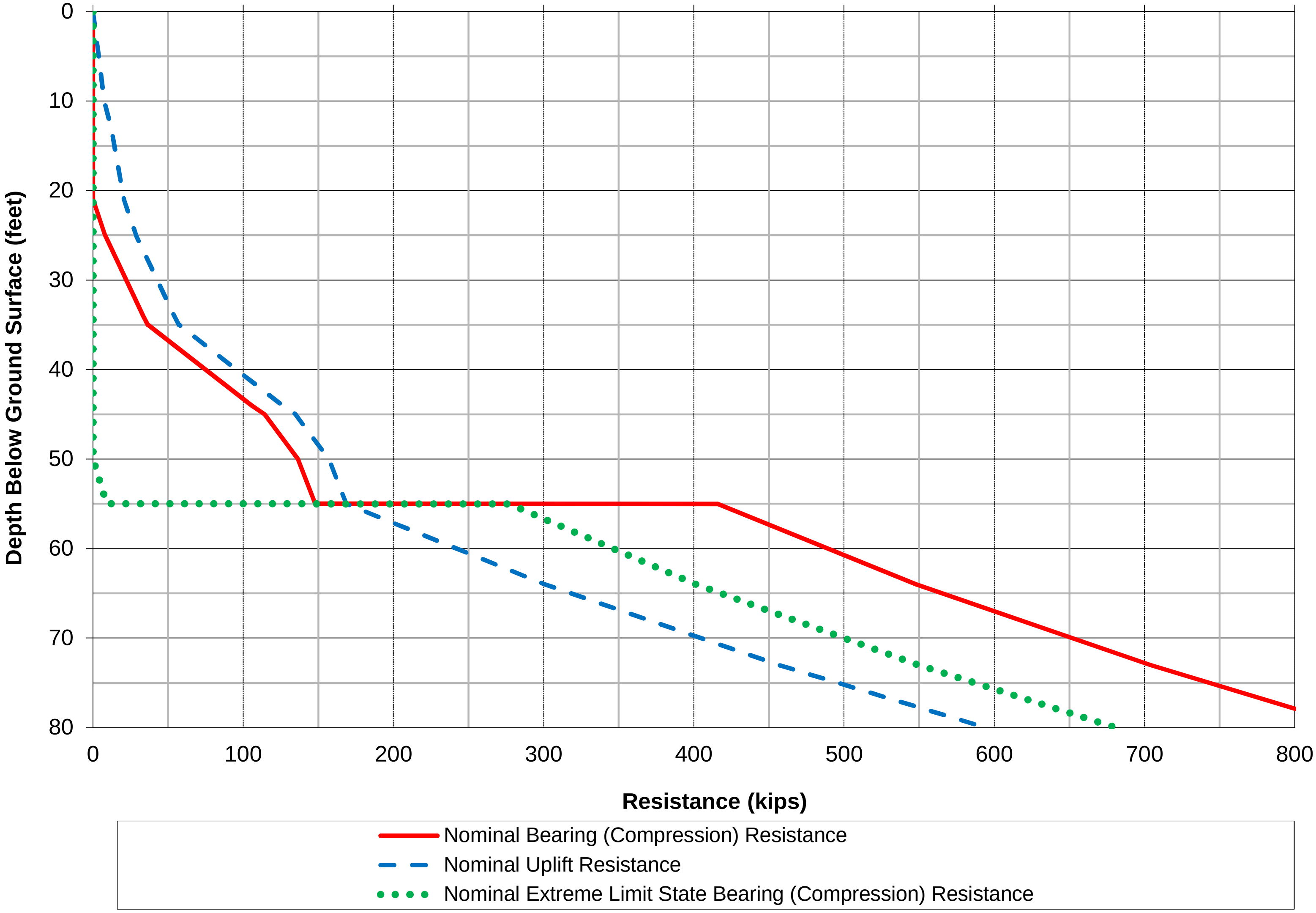
Driven Pile Resistance Charts



Notes:
1) Nominal bearing resistance shown on this plot is unfactored and can be used with appropriate resistance factors shown in report text to determine the Strength, Service, and Extreme limit state pile resistances.
2) The unfactored downdrag load (DD) for the Strength and Service limits states is equal to 22 kips.
3) The unfactored downdrag load (DD) for the Extreme limit state is equal to 52 kips.

Figure D-1
Lower Skagit Key Estimated Axial Pile Nominal Resistance
Driven, Closed-End, 18-inch Diameter, Steel Pipe Pile

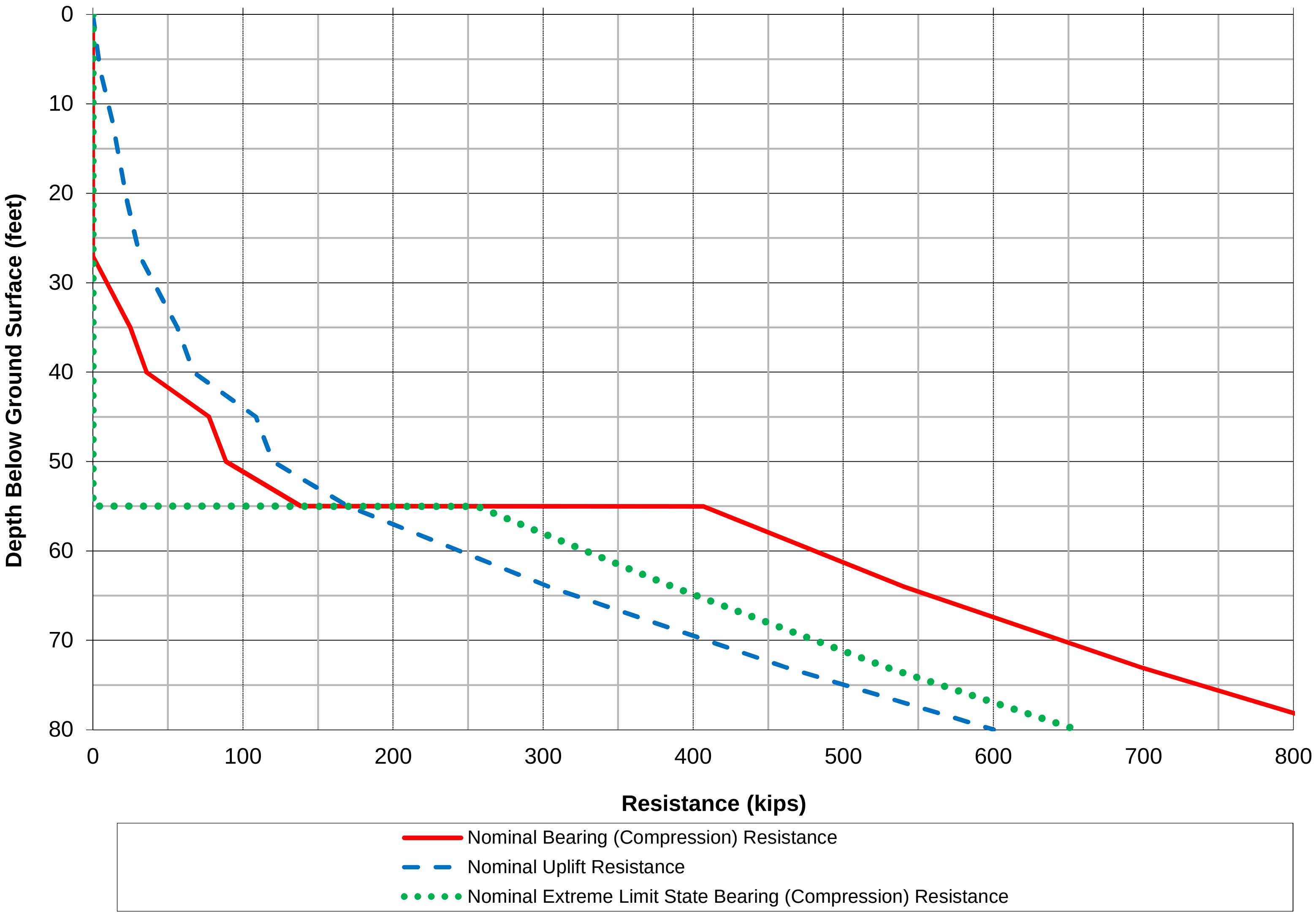
Aspect Consulting, LLC
October 2016



Notes:
1) Nominal bearing resistance shown on this plot is unfactored and can be used with appropriate resistance factors shown in report text to determine the Strength, Service, and Extreme limit state pile resistances.
2) The unfactored downdrag load (DD) for the Strength and Service limits states is equal to 21 kips.
3) The unfactored downdrag load (DD) for the Extreme limit state is equal to 97 kips.

Figure D-2
Newport Key Estimated Axial Pile Nominal Resistance
Driven, Closed-End, 18-inch Diameter, Steel Pipe Pile

Aspect Consulting, LLC
October 2016

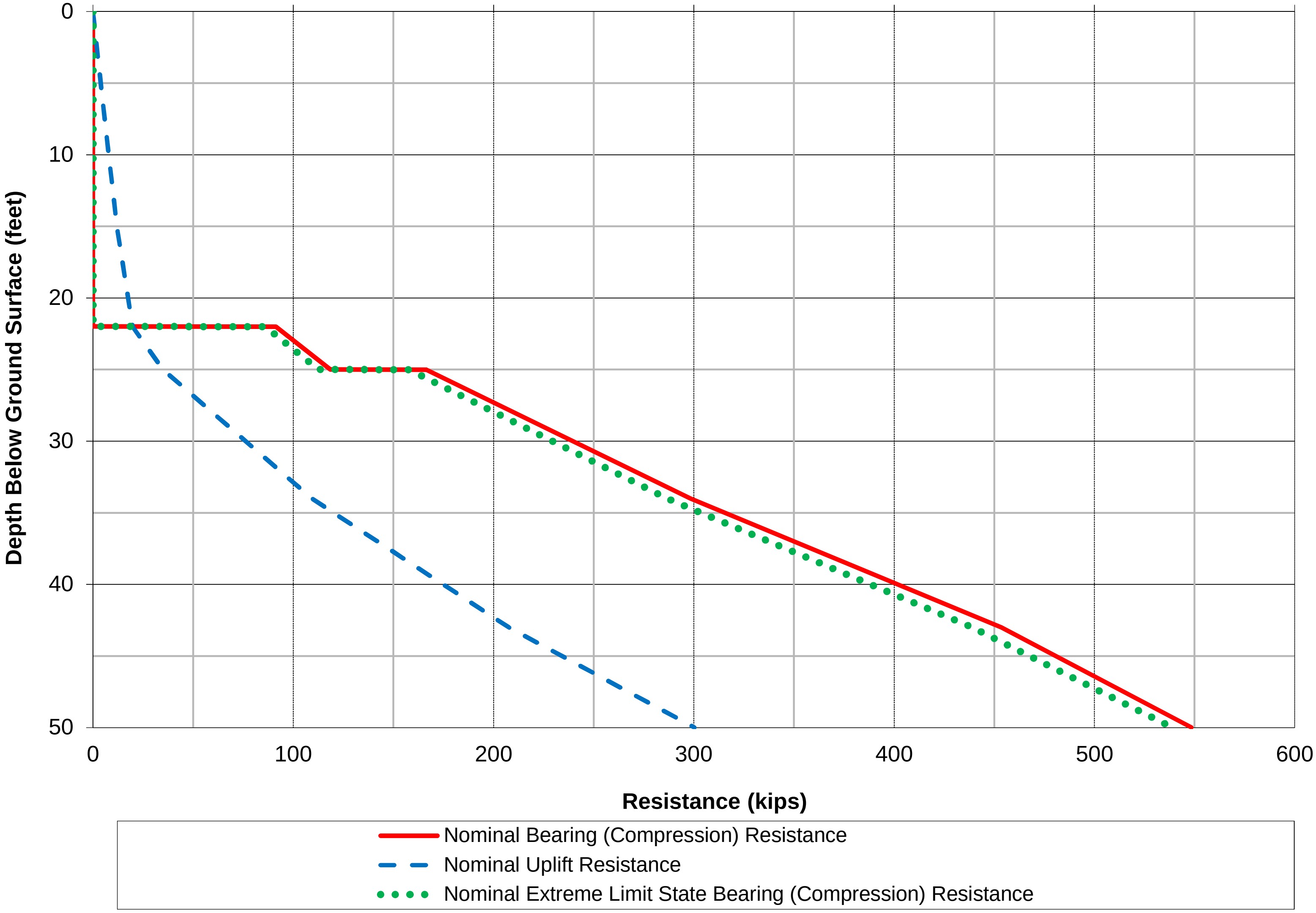


Notes:
1) Nominal bearing resistance shown on this plot is unfactored and can be used with appropriate resistance factors shown in report text to determine the Strength, Service, and Extreme limit state pile resistances.
2) The unfactored downdrag load (DD) for the Strength and Service limits states is equal to 31 kips.
3) The unfactored downdrag load (DD) for the Extreme limit state is equal to 76 kips.

Aspect Consulting, LLC
October 2016

Figure D-3

Glacier Key Estimated Axial Pile Nominal Resistance
Driven, Closed-End, 18-inch Diameter, Steel Pipe Pile

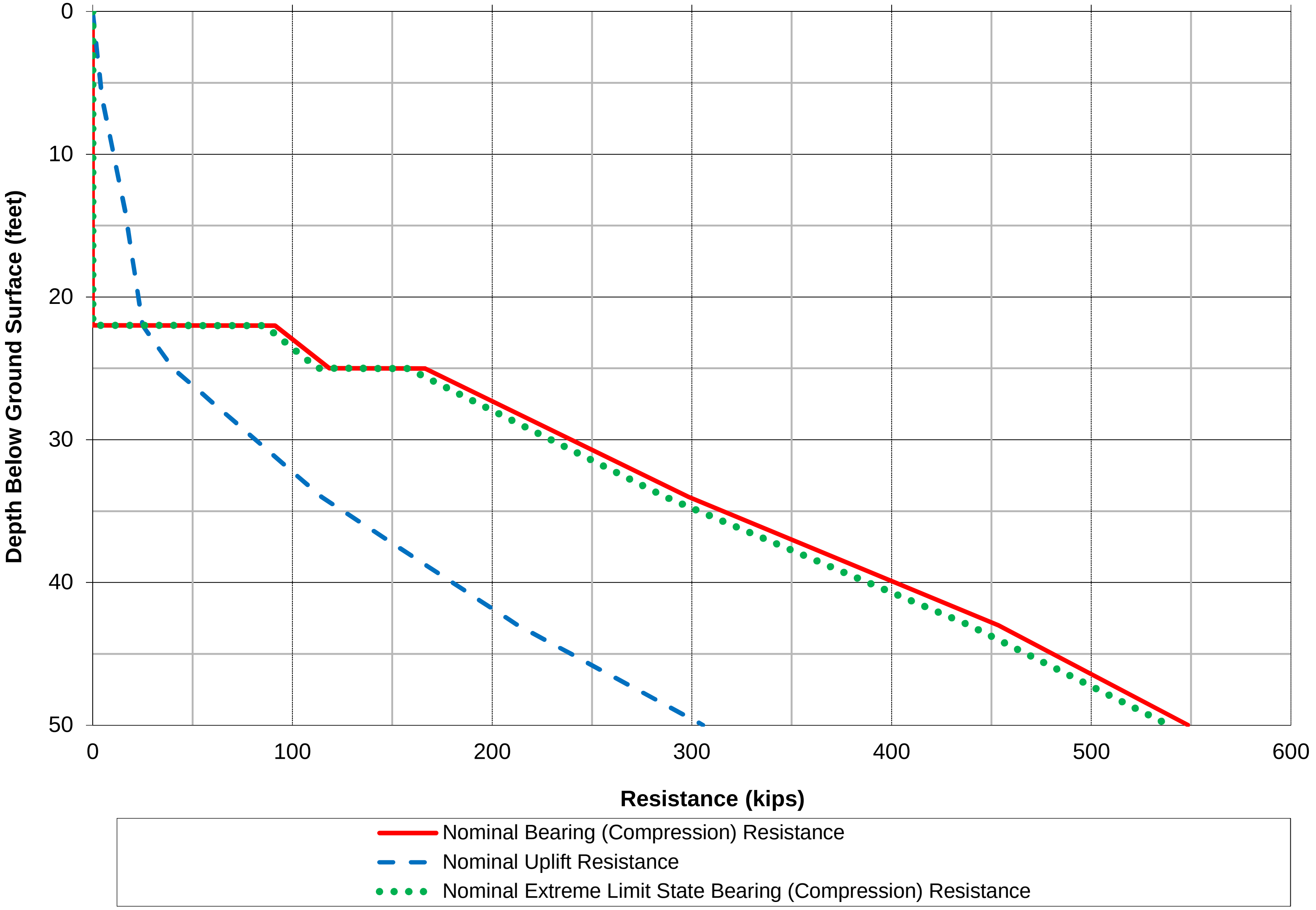


Notes:
1) Nominal bearing resistance shown on this plot is unfactored and can be used with appropriate resistance factors shown in report text to determine the Strength, Service, and Extreme limit state pile resistances.
2) The unfactored downdrag load (DD) for the Strength and Service limits states is equal to 20 kips.
3) The unfactored downdrag load (DD) for the Extreme limit state is equal to 10 kips.

Aspect Consulting, LLC
October 2016

Figure D-4

Upper Skagit Key Estimated Axial Pile Nominal Resistance
Driven, Closed-End, 18-inch Diameter, Steel Pipe Pile



Notes:
1) Nominal bearing resistance shown on this plot is unfactored and can be used with appropriate resistance factors shown in report text to determine the Strength, Service, and Extreme limit state pile resistances.
2) The unfactored downdrag load (DD) for the Strength and Service limits states is equal to 20 kips.
3) The unfactored downdrag load (DD) for the Extreme limit state is equal to 10 kips.

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October 2016

Figure D-5
Cascade Key Estimated Axial Pile Nominal Resistance
Driven, Closed-End, 18-inch Diameter, Steel Pipe Pile