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GEOTECHNICAL ENGINEERING REPORT

City of Marysville State Avenue Corridor Widening Project

MARYSVILLE, WASHINGTON

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SHANNON & WILSON

City of Marysville State Avenue Corridor Widening Project
Marysville, Washington

Geotechnical Engineering Report

Shannon & Wilson participated in this project as a subconsultant to HDR Engineering, Inc. Our scope of services was specified in Task Order 0007 issued under our Master Geotechnical Subconsultant Agreement with HDR dated October 14, 2016.

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EXECUTIVE SUMMARY

The State Avenue Corridor Widening Project in Marysville, Washington, will expand the existing State Avenue from three to five lanes between 100th Street NE and 116th Street NE. The Project will include curb, gutter, and sidewalk improvements along with utility relocation, street illumination, signal improvements, and new stormwater facilities. The Project will widen the existing roadway embankment in the Quilceda Creek vicinity north of 100th Street NE and will replace the existing culvert with a single-span bridge over Quilceda Creek. Four new wing walls, ranging from 10 to 25 feet high, will support the embankment fill adjacent to the bridge.

This geotechnical engineering report presents our field explorations and laboratory testing, geotechnical engineering analyses, and conclusions and recommendations to support design of the proposed State Avenue improvements. Design and construction of the Project considers applicable design standards and Project-specific considerations.

The roadway widening, bridge construction, and utility improvements in the Quilceda Creek area are planned to maintain two-way traffic throughout construction. We understand the construction sequencing will be coordinated with the U.S. Army Corps of Engineers (USACE) and Washington Department of Fish and Wildlife (WDFW) permit requirements for construction below the ordinary high water mark (OHWM) only during the allowable fish window.

Results of subsurface explorations performed for the Project in the Quilceda Creek area indicate that the existing embankment consists of approximately 40 feet of very loose to loose fill. In addition, potentially liquefiable soils and peat deposits are present under an approximately 200-foot-long section of the embankment. Based on our evaluations, sections of the existing roadway embankment in the Quilceda Creek crossing area, without any improvements or additional walls, does not meet stability criteria provided in the Washington State Department of Transportation (WSDOT) Geotechnical Design Manual (GDM).

Our November 2017 30% design geotechnical report was based on the concept of roadway widening using a combination of embankment slopes and structural earth retaining walls with ground improvement. The 30% design concept replaced the existing box culvert with a fish-passable culvert structure. Following the completion of the 30% design construction cost estimate, along with input from a value engineering (VE) study, the State Avenue Corridor Improvement project was re-envisioned with a single-span bridge over the Quilceda Creek. The revised design concept widens the existing roadway embankment using a combination of sloped granular fill and lightweight expanded polystyrene (EPS) fill. The existing culvert is replaced with a 100-foot-long single-span bridge over Quilceda Creek with four wing walls extending from the bridge abutments to support the adjacent embankment.

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ACRONYMS

AASHTO	American Association of State Highway Transportation Officials
CAPWAP	Case Pile Wave Analysis Program
City	City of Marysville
DOE	Washington State Department of Ecology
EFW	equivalent fluid weight
EPS	expanded polystyrene
FS	factor of safety
g	gravity
GDM	WSDOT Geotechnical Design Manual
H	wall height
H:V	Horizontal to Vertical
LRFD	Load and Resistance Factor Design
OHWM	ordinary high water mark
PDA	Pile Driving Analyzer
PGA	peak ground acceleration
SPT	Standard Penetration Test
SWMMWW	Stormwater Management Manual for Western Washington
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
VE	value engineering
WDFW	Washington Department of Fish and Wildlife
WEAP	Wave Equation Analysis Pile
WSDOT	Washington State Department of Transportation

1 INTRODUCTION

1.1 General

This report presents the results of our geotechnical engineering studies for design of the proposed State Avenue Corridor Widening Project in Marysville, Washington. The City of Marysville (City) plans to widen State Avenue between 100th Street NE and 116th Street NE. The Project includes widening of the existing roadway embankment in the Quilceda Creek vicinity along with replacement of the existing culvert with a new single-span bridge over the creek. The Project will include new wing walls extending from the bridge abutment to retain embankment fill through the creek area. The Project site is shown in Figure 1, Vicinity Map.

Our scope of services includes performing subsurface explorations, groundwater monitoring, and laboratory testing to evaluate subsurface conditions; performing engineering analyses to provide recommendations for seismic design, retaining walls, bridge foundations, and stormwater infiltration; and developing design and construction recommendations for use by HDR and the City.

This report presents our field explorations and laboratory testing, geotechnical engineering analyses, and conclusions and recommendations to support final design of the proposed State Avenue improvements.

1.2 Site and Project Description

The State Avenue Corridor Widening Project site is located along State Avenue in Marysville, Washington, as shown in Figure 1. This roadway is part of an important north-south corridor that provides connection between downtown Marysville and Smokey Point. The Project alignment extends north from 100th Street NE to 116th Street NE, as shown in Figure 2. This section of State Avenue currently consists of a three-lane asphalt road with 6- to 8-foot-wide shoulders. The corridor crosses Quilceda Creek north of 100th Street NE on a fill embankment up to 40 feet high with steep vegetated banks extending across the ravine. The creek passes under the roadway in a concrete box culvert.

The corridor widening Project will expand the existing State Avenue from three to five lanes. The Project will include curb, gutter, and sidewalk improvements along with utility relocation, street illumination, signal improvements, and new stormwater facilities. Multiple roadway-widening alternatives were considered during the proposal and design stages for the Quilceda Creek culvert replacement and embankment widening. Our draft geotechnical report dated November 2017 was prepared for the 30% design concept that supported the roadway widening on a combination of embankment slopes and structural earth retaining walls with ground improvement. The 30% design concept replaced the existing box culvert with a fish-passable culvert structure. Based on the 30% design construction cost estimate, along with input from the VE study, the State Avenue Corridor Improvement project was re-envisioned with a single-span bridge over the Quilceda Creek. This revised design concept widens the existing embankment using a combination of granular fill and lightweight EPS fill. Four wing walls will extend from the bridge abutments to support the adjacent embankments. Wing walls on the west side of the alignment will consist of non-structural, geofoam block walls with shotcrete facing. The walls are designated Geofoam Wall 1 and Geofoam Wall 2. Wing walls on the east side of the alignment, designated Retaining Wall 3 and Retaining Wall 4, will consist of permanent soldier pile and lagging walls with partial height lightweight backfill. The proposed widening, bridge, and wing walls are shown in Figures 2 and 3. The Project also includes additional walls for support of the roadway (Retaining Walls 5 and 6), a new Wet Pond treatment facility, and infiltration galleries.

2 SUBSURFACE CONDITIONS

2.1 General

We evaluated the subsurface conditions at the site by reviewing existing data and completing geotechnical borings, as summarized below:

- **Existing Data:** We reviewed publicly available information on the Washington State Department of Natural Resources Geologic Information Portal website along with our Shannon & Wilson archives. The City also reviewed their files for available subsurface information. We were unable to locate existing geotechnical borings from these sources. We reviewed the geologic maps of the area to inform our geological understanding of the area and our interpretation of the field explorations.
- **Field Explorations:** We completed 11 soil borings and two hand auger borings to provide subsurface information along the Project alignment. Soil borings B-1-17 through B-9-17 and hand augers HA-1-17 and HA-2-17 were completed for the initial design concept in June 2017. Soil borings B-10-18 and B-11-18 were performed in February 2018 to provide additional deeper subsurface information for the proposed bridge foundations. The approximate boring locations are shown in Figures 2 and 3 and are described as follows:
  - Borings B-1-17 through B-4-17 were shallow borings, drilled to depths of about 20 feet, to provide subsurface information for infiltration facilities and luminaire and signal pole foundations along the alignment.

  - Borings B-5-17 through B-9-17 were drilled through the embankment at Quilceda Creek to provide subsurface information for embankment widening and retaining wall design. Borings B-5-17 through B-9-17 were drilled to depths of about 90 to 110 feet.
  - Borings B-10-18 and B-11-18 were intended to provide additional, deeper subsurface information for the proposed bridge foundations. The borings extended to depths between 210 and 240 feet.
  - Two hand auger borings, designated HA-1-17 and HA-2-17, were performed at the base of the Quilceda Creek embankment as shown in Figure 3. The shallow hand borings were advanced using hand tools and drilled to depths of about 7 and 14 feet to provide subsurface information at the base of the embankment.

A description of the field explorations and the logs of the borings are presented in Appendix A.

- **Laboratory Testing:** Samples collected from the borings performed in June 2017 and February 2018 were tested to evaluate index properties. Descriptions of the laboratory tests and the results are presented in Appendix B.

The following sections describe the regional geology and observed subsurface conditions as estimated from the field explorations.

2.2 Regional Geology

The Project area is located in the northern portion of the Puget Lowland, which is an elongated, north-south depression situated between the Olympic Mountains and the Cascade Range. Repeated continental glaciations (glacial events) in this region strongly influenced the present-day topography and geology in the Project area. During each glacial event, glacial ice originated in the Coast Range and Canadian Rockies and flowed south into the Puget Lowland. Each glaciation deposited new sediment and partially eroded existing deposits. During the intervening periods when glacial ice was not present, stream processes, wave action, and landsliding eroded and reworked some of the glacially derived sediment, further complicating the geologic setting. In the Project area, the glacial and interglacial deposits are estimated to be thicker than 1,600 feet (Hall and Othberg, 1974).

During the most recent glaciation that covered the central Puget Lowland (termed Vashon), glacial ice is estimated to have been about 3,000 feet thick in the Project area (Thorson, 1980; Minard, 1985). As the ice sheet advanced southward, it deposited sediments in front of the ice in lakes and meltwater streams before subsequently overriding and compacting (overconsolidating) these deposits. The ice also smeared and reworked the uppermost overridden sediments, emplacing a mantle of unsorted, unstratified till along its base and sculpting the ridge-and-trough topography that characterizes the uplands to the east and west of the Project area. Between these uplands lies a broad north-south-oriented trough (termed Marysville trough) that extends from the mouth of the Snohomish River at Marysville to the Stillaguamish River at Arlington. Subglacial meltwater streams scoured out this elongated channel beneath the overriding ice sheet.

As the Vashon ice sheet stalled and the ice front began retreating north, large blocks of stagnant ice were stranded in the Marysville trough. This stagnating ice formed a complex and ephemeral topography within the trough, characterized by protruding mounds of still-melting ice and lake-filled depressions (kettle lakes) previously occupied by ice. Outwash streams from the retreating ice front flowed south through this terrain, depositing mostly well-drained sand and lesser amounts of fine gravel, silt, and clay across the Marysville trough (termed Recessional Outwash, Marysville Sand Member [Minard, 1985]). Associated and interfingered with these sandy outwash deposits are fine-grained deposits of silt and clay that infilled depressions and kettle lakes (termed Recessional Outwash, Clay Member [Minard, 1985]).

Recessional outwash is typically exposed at ground surface near the Project area, but modern streams such as Quilceda Creek have locally incised these materials and deposited alluvial sand, silt, peat, and wood. Recent alluvium overlies recessional outwash deposits and locally underlies modern fill deposits.

2.3 Geologic Units and Subsurface Profile

Our interpretations of existing subsurface conditions along the Project alignment are shown in the generalized subsurface profile presented in Figure 4. The surficial geologic materials encountered in subsurface explorations include:

- **Fill:** Very loose to medium dense, brown, silty sand; poorly graded sand; and poorly graded gravel. The fill depth along the alignment ranges from less than 5 feet along the roadway north of approximate Station 109+00 to a thickness of about 40 feet in the vicinity of the Quilceda Creek channel.
- **Peat:** Very soft to stiff, brown to black organic soil to organic soil with sand. Peat overlies and interfingers with modern alluvium in Quilceda Creek. Peat thickness ranges from less than 1 to 5 feet.
- **Recent Alluvium:** Loose to medium dense, brown to gray, poorly graded sand with silt and silty sand interbedded with disseminated plant debris, roots, twigs, logs, and peat. Recent alluvium is deposited by modern streams and rivers and is present only in Quilceda Creek within the Project area. Alluvium thickness varies from 3 to 37 feet.

- **Recessional Outwash, Marysville Sand Member:** Medium dense to very dense, poorly graded sand, silty sand, sandy silt, silt, and little fine gravel. South-flowing meltwater outwash streams from the retreating Vashon ice sheet deposited these sediments, which infill the Marysville trough. Interbedded silt and clay are common in the vicinity of the town of Marysville, Washington (Minard, 1985).
- **Recessional Outwash, Clay Member:** Medium stiff to hard silt, silty clay, and lean clay deposited in ponds and lakes in the Marysville trough. These deposits are associated and interbedded with the Marysville Sand Member.

2.4 Groundwater Conditions

The depth to groundwater was estimated in each borehole during drilling operations, as indicated in the Appendix A borings logs. Groundwater monitoring wells were also installed in borings B-1-17, B-2-17, B-4-17, B-8-17, and B-10-18. The monitoring well at boring B-18-18 was installed to measure deep groundwater, between approximately 180 and 195 feet depth, for constructability considerations. All other wells were intended to capture shallow groundwater.

Monitoring devices with dataloggers were installed in the wells to enable long-term monitoring. Groundwater measurements at the well locations are presented in Exhibit 2-1. The monitoring devices were in place in summer months when groundwater levels tend to be lowest through winter and spring when groundwater levels rise. Exhibit 2-1 reflects the highest measured groundwater levels. Groundwater measurements in the deep well at boring B-10-18 are higher than those observed at boring B-8-17, indicating potentially confined groundwater conditions with depth.

Exhibit 2-1: Measured Groundwater in Monitoring Wells

Boring/ Monitoring Well	Well Screen Depth	Measured Groundwater Depth	Measured Groundwater Elevation
B-1-17	15.3 to 20.3 feet	13.9	55.8 feet
B-2-17	15.2 to 20.2 feet	None Observed. > 20 feet	None Observed. Below 43.9 feet
B-4-17	15.6 to 20.6 feet	None Observed. > 20 feet	None Observed. Below 31.5 feet
B-8-17	79.7 to 89.7 feet	32.4 feet	25.8 feet
B-10-18	179.1 to 193.9 feet	14.6 feet	43.4 feet

3 ENGINEERING STUDIES AND RECOMMENDATIONS

Geotechnical studies for the Project focus on the Quilceda Creek area. The Quilceda Creek area is referred in this report as the 400-foot-long section of the alignment between centerline stations 101+00 and 105+00. This section of roadway currently consists of an embankment up to 40 feet high extending across the ravine that encompasses Quilceda Creek. The creek passes through the embankment in a concrete box culvert. Project improvements include approximately 25 feet of embankment widening to the west of the existing embankment along with a new single-span bridge over Quilceda Creek. Geotechnical studies and recommendations are prepared for features outside the Quilceda Creek area as noted.

We prepared our design recommendations for the proposed State Avenue Corridor Widening Project considering the Project configuration as described herein. The subsequent sections summarize our analyses and provide design recommendations in accordance with the Project design criteria.

3.1 Design Criteria and Considerations

3.1.1 Design Standards

Geotechnical design is performed in general accordance with the WSDOT GDM (WSDOT, 2015). Numerous sections of the WSDOT GDM reference the American Association of State Highway Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD) Bridge Design Specifications (AASHTO, 2015). Specific AASHTO design requirements are noted in the discussion of analyses.

3.1.2 Project-Specific Considerations

Design of the State Avenue Corridor Widening is shaped by additional Project considerations and challenges related to transportation and environmental impacts. Based on discussions with HDR, we understand these factors include:

- **Traffic Impacts:** State Avenue is a critical north-south corridor in the City providing connection between the downtown core and Smokey Point. Due to the corridor importance, design and construction are coordinated to allow for maintenance of two-way traffic operation for the entire construction duration.
- **Environmental Impacts:** Joint Aquatic Resources Permit Application permitting with the USACE and WDFW limits construction impacts to the wetland areas surrounding Quilceda Creek. In accordance with permitting requirements, construction below the OHWM elevation must be completed within the allowable fish window. All construction below the OHWM is proposed to be completed within one fish window.

3.1.3 Wall and Embankment Stability Criteria

The GDM provides stability criteria for retaining walls and embankments under static, seismic, and post-seismic loading, as provided in Appendix C, Exhibit C-1. As described in Section 3.3, the existing roadway embankment in the Quilceda Creek crossing area does not meet the GDM stability criteria due to the existing poorly compacted embankment soil and underlying liquefiable soils and peat deposits. Design of new retaining walls requires significant measures to satisfy seismic stability requirements. The GDM stability requirements and design implications have been discussed with the City and design team. Due to the importance of this transportation corridor, the City has directed design of improved roadway sections to meet GDM static and seismic stability requirements. With this direction, the design team has adopted engineering solutions that achieve the stability requirements while also seeking to reduce cost and facilitate construction. Abutment Walls 1 and 2 and Retaining Walls 3 and 4 are designed to satisfy the GDM static, seismic, and post-seismic stability criteria.

Wing walls Geofoam Wall 1 and Geofoam Wall 2 are considered non-structural walls, consisting of stacked geofoam blocks bearing on existing embankment fill. The use of lightweight geofoam blocks and the planned grading consistent with existing conditions, and no steeper than 2 Horizontal to 1 Vertical (2H:1V), does not impact or improve the stability of the existing slopes. The geofoam wing walls may settle and slump during a design seismic event.

Roadway embankment sections that are not a part of the widening and culvert replacement will remain in their existing condition and will not be improved to meet GDM stability requirements.

3.2 Seismic Design

3.2.1 Site Response Analyses

The WSDOT GDM states that seismic design should be performed in accordance with AASHTO LRFD Bridge Design Specifications. AASHTO seismic design includes a design ground motion that corresponds to 7% probability of exceedance in 75 years or a 975-year return period.

The seismological inputs required to develop the design response spectrum are the peak ground acceleration (PGA), short-period spectral acceleration (S_s), and spectral acceleration at the 1 second period (S_1) for the design ground motion. The coefficients are based on the regional probabilistic ground motion studies conducted by the U.S. Geological Survey (USGS, 2013). These ground motions are included in Exhibit 3-1.

The spectral response acceleration values are scaled by site soil response factors to account for site amplification/damping effects. Based on the subsurface conditions in the Quilceda Creek vicinity, it is our opinion that the overall site conditions for the bridge, bridge abutments, and Retaining Walls 3 and 4 correspond to Site Class E. Site Class E is defined as a soil profile that has a depth-averaged blow count less than 15 blows per foot. Site conditions for Retaining Walls 5 and 6 and the Wet Pond facility typically correspond to Site Class D, defined as a soil profile that has a depth-averaged blow count between 15 and 50 blows per foot. Site soil response factors are presented in Exhibit 3-1.

Exhibit 3-1: Response Spectrum Parameters for Site Class D and Site Class E

	Site Class D	Site Class E
Soft Rock Peak Ground Acceleration, PGA	0.35 gravity (g)	0.35 g
Soft Rock Short Period Spectral Acceleration, S_S	0.79 g	0.79 g
Soft Rock Spectral Acceleration at 1 second Period, S_1	0.27 g	0.27 g
Spectral Response Acceleration Coefficient, S_{DS}	0.93 g	0.91 g
Spectral Response Acceleration Coefficient, S_{D1}	0.50 g	0.78 g
Acceleration Coefficient, A_S	0.40 g	0.37 g

3.2.2 Liquefaction

Liquefaction of loose, saturated, cohesionless soil due to ground shaking has been studied over the past 35 years. These studies resulted in methods to estimate liquefaction potential that are based on both laboratory and field procedures. The most widely used approach is empirical and based on correlations between Standard Penetration Test (SPT) resistance (N-value), PGA, earthquake magnitude, and soil fines content.

We used three methods to evaluate liquefaction potential at this site based on the SPT data: Youd and others (2001), Idriss and Boulanger (2008), and Cetin and others (2004). We performed the liquefaction analyses for an earthquake of magnitude 7.1 and the site class modified design acceleration of 0.37 g. The characteristic magnitude was determined from the deaggregation analyses conducted by the USGS in 2008.

The GDM requires that liquefaction hazard mitigation measures be developed if the factor of safety (FS) against liquefaction is less than 1.2. We estimated a FS against liquefaction of less than 1.2 in alluvial soils below the groundwater table in borings in the Quilceda Creek vicinity, as summarized in Exhibit 3-2. Based on these results, a liquefaction zone is considered with varying elevation extents between approximate Stations 102+00 and 104+25.

Exhibit 3-2: Summary of Potential Liquefaction

Boring ID	Potential Liquefiable Soil Elevation Range	Estimated Post-Liquefaction Settlement
B-7-17	+28 to +20 feet	5 to 9 inches
B-8-17	+28 to -6 feet	10 to 17 inches
B-9-17[1]	+28 to +22 feet	2 to 6 inches
B-10-18	+28 to +3 feet -18 to -35 feet	20 to 30 inches
B-11-18	+28 to +5 feet -5 to -21 feet	20 to 30 inches

NOTES:

1 Two additional isolated samples in B-9-17 below elevation +0 feet have FS values below 1.2. However, the behavior of the isolated samples is anticipated to be controlled by the surrounding non-liquefiable soil and is therefore not considered to reflect a liquefaction hazard.

In addition, settlement may occur in loose to medium dense, cohesionless soil that undergoes liquefaction during ground shaking. This ground settlement may not occur uniformly over an area. Differential settlement could impact existing or proposed embankments and structures supported by loose to medium dense soil. We estimated seismic-induced post-liquefaction settlement using the methods of Tokimatsu and Seed (1987) and Ishihara and Yoshimine (1992). Estimated settlement values are included in Exhibit 3-2.

3.3 Existing Quilceda Creek Embankment

3.3.1 Current Condition

The existing embankment through the Quilceda Creek area is approximately 40 feet high in the center of the ravine. The embankment is approximately 45 feet wide at the top and approximately 160 to 180 feet wide at the base. The embankment side slopes are heavily vegetated and typically stand at slope angles between 27 and 35 degrees with some locally steeper sections.

Based on the six soil borings completed along this section of the roadway, embankment fill material generally consists of poorly graded sand with silt to silty sand. The subsurface profile in Figure 4 shows SPT values of the embankment fill range between 2 and 9 blows per foot for most of the Quilceda Creek crossing, indicating very loose to loose conditions. As described in Section 3.2.2, liquefiable soil is present below the embankment to a maximum depth corresponding to elevation -35 feet. In addition, a 5- to 10-foot-thick layer of peat is encountered at various depths below the embankment.

3.3.2 Global Stability Analyses

The existing embankment stability was evaluated as part of the 30% design evaluation. Our analysis considered five cross sections of the Quilceda Creek crossing using the approach described in Appendix C. Section 3.3 summaries the existing embankment stability FS values for the sections evaluated. Stability results are presented in Appendix C.

Exhibit 3-3: Summary of Slope Stability Factor of Safety (FS) Values for Existing Embankment

Embankment Section	Approx. Embankment Height	Static Factor of Safety (FS)	Seismic FS
Station 101+75	35 feet	1.42	1.01
Station 102+00	35 feet	1.23	0.93
Station 102+25	37 feet	1.19	0.88
Station 102+50	40 feet	1.07	0.81
Station 103+75	40 feet	1.07	0.81

The static stability FS values for the existing embankment ranged from 1.07 to 1.4 and were generally less than the GDM embankment stability requirements in Exhibit C-1. The FS values reflect the challenging subsurface conditions for design and construction of proposed roadway improvements. The FS values are documented herein for future potential improvement by the City.

3.4 Proposed Bridge Foundations

Roadway widening through the Quilceda Creek ravine will include replacement of a portion of the existing embankment with a single-span bridge over the creek at the approximate location shown in Figures 2 and 3. The bridge will extend between roadway centerline stations 102+53.52 (Abutment 1) and 103+55.84 (Abutment 2) and will be skewed for alignment with the Quilceda Creek. Bridge foundations will consist of 3-foot-diameter closed-end steel pipe piles. The piles will be installed in a single row of seven piles at 12-foot center-to-center spacing at each abutment location. The upper portion of the pipe piles includes concrete infill for increased lateral resistance. We recommend piles be installed with conical tips, instead of a flat bottom plate, to facilitate advancement to design tip elevations.

Exhibit 3-4 provides the estimated pile tip elevations and axial loads provided by HDR. Axial and lateral resistance recommendations are provided in the subsequent sections. Constructability recommendations are provided in Section 4.

Exhibit 3-4: Pile Lengths and Axial Loads Provided by HDR

	Estimated Tip Elevation	Service Limit Axial Load	Strength Limit Axial Load	Extreme Event I Axial Load
Abutment 1	-83 feet	403 kips/pile	522 kips/pile	400 kips/pile
Abutment 2	-91.5 feet	406 kips/pile	526 kips/pile	403 kips/pile

3.4.1 Axial Resistance

Figures 5 and 6 present the estimated axial resistance plots for 3-foot-diameter closed-end steel pipe piles at Abutments 1 and 2, respectively. The plots present nominal side and base resistance, and factored total compression and uplift resistance, for Strength and Extreme Event limits states in accordance with AASHTO and GDM requirements. The axial resistance recommendations incorporate the following assumptions:

- Strength Limit resistance factors assume that dynamic testing with signal matching will be performed during pile installation to confirm the axial resistance. Dynamic testing recommendations are discussed further in Section 4.4.2.
- Extreme Event axial resistance neglects the resistance within and above potentially liquefiable layers. Estimated post-seismic downdrag loads at each abutment are provided in the axial resistance figures.

Pile group behavior is a function of the pile spacing and soil type. As indicated in Figures 5 and 6, piles will be embedded in a layered cohesive and cohesionless soil profile. Based on the loading and tip elevations provided in Exhibit 3-4, pile tips will bear in silt, silty clay, and lean clay deposits. The group behavior is therefore considered to be based on cohesive soil response. In AASHTO, axial resistance of the pile groups in cohesive soil is considered the lesser of the sum of individual nominal resistance of each pile in the group or the nominal resistance of an equivalent pier within a block of soil bounded by the piles. Our analysis indicates the group axial resistance is controlled by the sum of the individual nominal resistance of each pile in the group. No additional reduction to axial resistance is required.

We evaluated Service Limit settlement for Abutment 1 and 2 piles based on estimated tip elevations and Service Limit loads provided by HDR. Settlement analysis of the pile group is based on the equivalent footing approach described in AASHTO. The analysis considers primarily elastic compression settlement. Fine-grained materials, as encountered below the pile tip elevations, are not anticipated to have significant consolidation settlement due to their relatively low plasticity, high silt and sand content, and interbedded nature. We estimate Service Limit settlements to be approximately 1 inch at Abutment 1 and Abutment 2.

3.4.2 Lateral Resistance

Lateral loads acting on the structure may be resisted by lateral soil resistance provided by the driven piles. Table 1 presents recommended input parameters for lateral resistance analysis using the LPILE program (Ensoft, 2018).

Group interaction effects reduces the lateral efficiency of closely spaced pile groups. Lateral efficiency may be incorporated in the analysis through p-multiplier (reduction) factors based on the pile group spacing. AASHTO Table 10.7.2.4-1 provides p-multipliers depending on the load direction and pile group configuration. For loading perpendicular to the pile row, we recommend a p-multiplier of 0.9 corresponding to a 12-foot center-to-center spacing, which is four pile diameters. Loading in the direction of the pile row requires row-specific p-multipliers, as found in AASHTO Table 10.7.2.4-1.

As described in Section 3.5.1, the bridge piles are used to form the abutment pile and lagging walls. The piles are therefore designed to resistance the abutment wall pressures and to provide global stability shear reinforcement. Additional design requirements for the abutment piles are provided in Section 3.5.1.

3.5 Abutment and Retaining Walls (Permanent Walls)

The Project includes several new permanent walls to retain soil behind the bridge and widened roadway sections. The wall locations are shown in Figures 2 and 3 and are briefly described as follows:

- Abutment Walls 1 and 2 will utilize the bridge foundation piles to form a pile and lagging wall at the bridge abutments. The abutment walls will include permanent concrete fascia.
- Retaining Walls 3 and 4 will extend from the bridge abutments to support the east side of the embankment at Quilceda Creek. The walls will be cantilever soldier pile and lagging walls with partial height light-weight backfill.
- Retaining Wall 5, also a cantilever soldier pile and lagging wall, will support the roadway adjacent to the construction equipment business north of the Quilceda Creek area.
- Retaining Wall 6 will support the existing driveway to the construction equipment business north of the Quilceda Creek area. Retaining Wall 6 is planned as a concrete block wall.
- The Wet Pond facility west of the City of Marysville Maintenance Facility will be constructed below grade and will include cast-in-place concrete retaining walls.
- Geofoam Walls 1 and 2 will extend from the bridge abutments to develop grades on the west side of the embankment at Quilceda Creek. The geofoam walls are non-structural

walls that consist of stacked lightweight geofoam blocks on existing embankment fill. These elements will include a thin layer of shotcrete that will act as a protective cover and will mimic the look and feel of the adjacent retaining walls.

AASHTO requires retaining walls be designed to resist static and seismic lateral earth pressures. Lateral earth pressures acting on retaining walls depend on many factors, including the type of backfill or adjacent native soil, groundwater conditions, drainage provisions, and wall flexibility. Under static loading, if the wall is free to yield at the top an amount more than 0.1% of the wall height, then the wall should be designed for active earth pressures. If wall movement will be less than 0.1% of the wall height, the wall should be designed for at-rest earth pressures. Retaining walls may develop resistance through passive pressure acting on wall footings or developed on the embedded portion of piles.

Walls are also designed to satisfy global stability requirements, as needed. Abutment Walls 1 and 2 and Retaining Walls 3 and 4 include liquefiable soil extending to depths ranging from approximately elevation -21 to -35 feet, and an approximate 5-foot-thick peat deposit at varying depths. The combination of liquefiable soil and peat deposits result in potential global instability of the wall systems under static, seismic, and post-seismic conditions. The piles forming the wall therefore extend below the peat and liquefiable soil and are designed to provide shear resistance to achieve global stability.

The following sections present specific recommendations for individual Project walls.

3.5.1 Abutment Walls 1 and 2

Abutment Walls 1 and 2 will utilize the 3-foot-diameter closed-end bridge foundation piles to form the pile and lagging walls. The base of wall will be at elevation +33 feet extending up to meet the bridge elevation at +58 feet. The slope in front of the abutment walls will extend down to the Quilceda Creek at a 2H:1V slope to approximate elevation +15 feet. The construction sequencing plans for piles to be installed from the existing roadway grade. Excavation for the pile cap and abutments will proceed in lifts, with wood lagging placed between the piles. Permanent concrete facing will be installed following bridge construction.

The abutment walls may be designed with a rigid connection to the bridge structure that can enable development of passive pressure at the opposing abutment for increased lateral resistance. Alternatively, the abutment walls may be designed for a pinned connection that incorporates only the passive pressure acting on the individual abutment piles. Figure 7 presents lateral earth pressures for Abutment Walls 1 and 2 for pinned and rigid connections.

Global stability analysis results are presented in Appendix C, Figures C-6 through C-9, for static, seismic, and post-seismic conditions. In order to meet GDM FS requirements, the abutment wall piles shall be embedded to a tip elevation of -24 feet or deeper. Exhibit 3-5 provides the required pile shear resistance for global stability under static, seismic, and post-seismic conditions based on the design of 12-foot center-to-center pile spacing.

Exhibit 3-5: Abutment Walls Required Pile Shear Resistance for Global Stability

Abutment	Center-to-Center Pile Spacing	Required Pile Shear Resistance for Global Stability[1]		
		Static	Seismic	Post-Seismic
South	12 feet	325 kips	850 kips	700 kips
North	12 feet	525 kips	625 kips	700 kips

NOTE:

1 Two cross sections were evaluated at each abutment considering normal and skewed cross sections. Required pile shear resistance values reflect maximum values of the cross sections analyzed.

3.5.2 Retaining Walls 3 and 4

Retaining Walls 3 and 4 will support the embankment slopes extending down to the Quilceda Creek at the east side of the bridge abutments. The wall and grading plan in the creek vicinity are planned to minimize wall height as feasible, while maintaining 2H:1V slopes in front of the walls sloping down to the Quilceda Creek at approximate elevation +15 feet. The base of walls is located at elevation +33 feet, consistent with the base of the abutment walls. Wall heights vary along their length, with a height of approximately 25 feet adjacent to the bridge abutment and decreasing to approximately 11 feet at the far end.

Retaining Walls 3 and 4 are planned as cantilever soldier pile and lagging walls and will be constructed through existing, loose embankment fill. According to HDR, soldier piles will be located at 8- or 10-foot center-to-center spacing. . In order to minimize lateral earth pressures acting on the walls, and to eliminate potential tieback or deadman anchors, partial height EPS backfill is planned behind the walls. EPS will be placed behind the wall to maintain a maximum 11-foot fill height behind the wall. We understand the EPS will be covered with an 18-inch-thick layer of planting material to support small vegetation. Backslopes behind the wall are maintained at a maximum 2H:1V.

Figure 8 presents lateral earth pressure recommendations for Retaining Walls 3 and 4 located in existing fill. The partial height EPS backfill extents are indicated schematically on the figure. Global stability analysis results are presented in Appendix C, Figures C-10 through C-14, for static, seismic, and post-seismic conditions. In order to meet GDM FS requirements, the abutment wall piles shall be embedded to a tip elevation of -30 feet or deeper. Exhibit 3-6 provides the required pile shear resistance for global stability under static, seismic, and post-seismic conditions.

Exhibit 3-6: Retaining Walls 3 and 4 Required Pile Shear Resistance for Global Stability

		Required Pile Shear Resistance for Global Stability[1]		
Wall Height	Center-to-Center Pile Spacing	Static	Seismic	Post-Seismic
12 to 18 feet	8 feet	200 kips	775 kips	415 kips
< 12 feet	10 feet	150 kips	1,050 kips	550 kips

NOTE:

1 Conditions for Retaining Walls 1 through 4 were generalized-based models of Retaining Wall 1 and 2 at various heights. Required pile shear resistance values reflect maximum values of the cross sections analyzed for the respective wall heights.

3.5.3 Retaining Wall 5

Retaining Wall 5 will be a cantilever soldier pile and lagging wall supporting the roadway adjacent the construction equipment business north of Quilceda Creek. Figure 9 presents Retaining Wall 5 lateral earth pressures and all recommendations.

3.5.4 Retaining Wall 6 and Wet Pond Walls

Retaining Wall 6 and the walls supporting the Wet Pond facility will consist of concrete block and cast-in-place concrete cantilever walls, respectively. These walls may be designed using an equivalent fluid pressure, as presented in Exhibit 3-7. To determine the earth pressures acting on the wall, the EFP should be multiplied by the wall height to determine the triangular earth pressure distribution. The seismic earth pressure shown represents the total seismic equivalent fluid weight (EFW) and does not need to be added to the static EFW.

Exhibit 3-7: Wall 6 and Wet Pond Retaining Wall Recommendations

	Wall 6		Wet Pond	
	Static	Seismic	Static	Seismic
Active Equivalent Fluid Weight	35 pcf	49 ksf	48 pcf	80 pcf
Passive Equivalent Fluid Weight[1]	375 pcf	325 pcf	375 pcf	325 pcf
Factored Friction Coefficient[2]	0.27		0.27	
Factored Bearing Resistance[3]	3 ksf		2.5 ksf	

NOTES:

1 Passive pressures are unfactored. AASHTO recommends a resistance factor of 0.75 for passive resistance.

2 Friction coefficient includes the AASHTO-recommended resistance factor of 0.8 for sliding resistance.

3 Bearing resistance includes the AASHTO-recommended resistance factor of 0.45.

pcf = pounds per cubic foot; ksf = kips per square foot

Lateral earth pressures may be resisted by passive pressure acting on wall footings and friction at the base of the footing. Passive pressures and frictional coefficients developed at the wall locations are provided in Exhibit 3-7. These values are based on the assumption that the wall footings extend at least 24 inches below the lowest adjacent grade and that the ground surface is horizontal for a minimum distance of 1½ times the embedment depth. Exhibit 3-7 also includes the factored axial bearing resistance for the wall footings.

Design of the wet pond facility includes settlement analysis using a modulus of subgrade reaction. We recommend a modulus of subgrade reaction of 120 ksf, corresponding to approximately ½ inch settlement, for design of the wet pond.

3.5.5 Geofoam Walls 1 and 2

Geofoam Walls 1 and 2 are non-structural elements that will extend from the bridge abutments to develop grades on the west side of the embankment at Quilceda Creek. The walls will consist of stacked geofoam blocks bearing on existing embankment fill.

As described in Section 3.3.2, the existing embankment in the vicinity has static stability FS values less than the GDM requirements. Some re-grading of the slopes in front of Geofoam Walls 1 and 2 is planned to enable removal of the existing culvert; however, we understand slopes will not be steepened greater than 2H:1V. The placement of lightweight geofoam blocks on top of the existing slopes will also not add additional load to the slope. Therefore, Geofoam Walls 1 and 2 will not impact or improve the stability of the existing slopes. The geofoam walls may settle and slump during a design seismic event.

3.6 Embankment Widening

The existing embankment supporting State Avenue through the Quilceda Creek vicinity is approximately 40 feet high. The embankment is about 45 feet wide at the top and between 160 and 180 feet wide at the base. The proposed roadway improvements will widen State Avenue approximately 25 feet, increasing the top of embankment width to about 70 feet. The roadway widening will be accomplished by fill placement on the west side of the roadway. Proposed embankment slopes will be maintained at 2H:1V or flatter.

Design and construction of the embankment widening must account for multiple factors, including the following:

- **Global Stability Requirements:** As discussed in Section 3.1.3 and Appendix C, Exhibit C-1, embankments will be designed for a static FS of 1.3. Analysis of the existing embankment presented in Section 3.3.2 indicates existing conditions do not necessarily meet the WSDOT GDM requirements due to the presence of loose fill and peat deposits underlying the embankment.
- **Settlement Considerations:** The embankment widening will be accomplished by up to a 25-foot-wide, 40-foot-high wedge of fill placed on the west side of the existing embankment. This fill placement will result in settlement of the very loose to loose existing embankment fill and underlying alluvial, peat, and recessional deposits.

Long-term settlement needs to be minimized to prevent adverse impact to the State Avenue roadway, along with planned utilities under the roadway.

Accounting for these factors, the embankment widening is planned using the combination of pre-load fill and partial height lightweight EPS backfill. Granular backfill will be used for new fill placement above the Quilceda Creek 100-year flood level up to elevation +35 feet. Lightweight EPS backfill will be placed above elevation +35 feet to construct the embankment slope up the roadway grade around elevation +58 feet. Prior to EPS placement, a 5-foot-high preload fill is planned above the granular fill for long-term settlement mitigation. The preload is planned to be in place for up to four months.

3.6.1 Global Stability Analysis

We evaluated global stability of the embankment widening using the approach described in Appendix C to achieve global stability requirements in Appendix C, Exhibit C-1. Our analyses considered full-height granular fill and partial-height lightweight EPS fill at multiple sections. Results of our stability analyses are summarized in Exhibit 3-8. As noted in the exhibit, the target FS of 1.3 is not satisfied for the full-height fill case at all sections analyzed. The partial-height lightweight EPS fill provides a buttress effect on the embankment such that the target FS values are achieved.

Exhibit 3-8: Summary of Slope Stability Factor of Safety (FS) Values for Proposed Embankment Widening

Embankment Section	Full Height Granular Fill Static FS	Partial Height Lightweight Fill Static FS
Station 102+25	1.24	1.38
Station 104+00	1.07	1.36

3.6.2 Settlement Analysis

3.6.2.1 General

We performed three-dimensional settlement analyses of the proposed roadway widening in the Quilceda Creek vicinity using the settlement analysis software Settle3D (Rocscience, Inc., 2017). Settlement contributions due to roadway fill placement typically include immediate settlement, primary consolidation settlement, and secondary compression settlement. Immediate settlement is assumed to occur as the fill is placed. Long-term settlement due to primary consolidation settlement and secondary compression settlement could occur over periods ranging from months to years, depending on the soil consolidation properties. Cohesionless soil deposits, including the existing fill, alluvium, and recessional outwash sand layers indicated in Figure 4, would contribute to immediate settlement. Cohesive soil deposits, including the peat and recessional clay deposits (see Figure 4), could contribute to the long-term primary and secondary consolidation settlement. In general, the peat deposits are highly compressible and are anticipated to result in significant long-term settlement along the alignment. However, the recessional clay deposits are considered less susceptible to long-term settlement due to their relatively low plasticity, high silt and sand content, and interbedded nature.

Our settlement analyses were intended to estimate the maximum anticipated settlement over the 75-year design life. Our analysis estimates settlement with time due to its importance for roadway construction, utility performance, and long-term roadway maintenance. We evaluated three settlement cases:

- **Full-Height Granular Fill:** Settlement evaluated for embankment widening consisting entirely of granular fill.
- **Partial-Height Lightweight EPS Fill:** Settlement evaluated for lightweight EPS fill placement above elevation +35 feet.
- **Partial-Height Lightweight EPS Fill with 5-Foot Preload**: Settlement evaluated for lightweight EPS fill placement above elevation +35 feet. Analysis includes 5-foot-high preload above granular fill prior to lightweight fill placement. Preload is considered in place for four months.

Additional details and results are provided in the following sections.

3.6.2.2 Settle3D Model Input

Our three-dimensional settlement model is based on the proposed roadway cross sections provided by HDR dated July 26, 2018. Our analysis targeted critical sections along the alignment considering the combination of new fill extents and depths of peat deposits. The selected sections are located at roadway centerline Station 102+25 and 104+00. The selected sections are intended to represent maximum anticipated settlements along the alignment. Actual settlements may vary along the alignment.

Appendix D, Table D-1, presents the settlement model input parameters. Settlement analyses require estimates of the soil elastic moduli, along with primary and secondary consolidation parameters. The elastic modulus (Es) of the cohesionless soil layers based on published correlations to SPT N-values and soil type, cone penetrometer test tip resistance values, and our experience with similar soils. Consolidation testing was not performed for the Project. We estimated these properties based on published correlations with laboratory index tests and our experience in similar soil conditions. In addition, we considered results of consolidation testing for the currently ongoing Marysville First Street Bypass project with similar subsurface conditions.

3.6.2.3 Estimated Settlement

Appendix D, Exhibits D-1 through D-6, present settlement estimates at roadway station 102+25 and 104+00. In general, our three-dimensional settlement analyses indicate significant settlement due to fill placement for the embankment widening. The estimated settlement varies across the roadway section, with maximum settlement of approximately 15 to 20 inches occurring around the toe of the existing embankment. In general, the settlement decreases across the roadway section, with about 30 to 60% of the maximum settlement occurring at the western edge of the roadway, decreasing to negligible settlement at the eastern roadway edge.

The settlement analysis results of the Full-Height Granular Fill and Partial-Height Lightweight Fill models indicate 60 to 80% of the estimated settlement will occur within the first four months following fill placement. Remaining settlement will occur over the 75-year design life, posing potential maintenance and performance issues for the roadway and utilities. Settlement analyses of the Partial-Height Lightweight Fill with 5-Foot Preload demonstrates that the preload accelerates the settlement process such that the majority of settlement occurs within the first four months.

3.6.3 Surcharge Recommendations

The three-dimensional settlement analysis demonstrates that the 5-foot-high preload placed above the granular fill prior to lightweight fill placement effectively minimizes long-term settlement of the roadway and embankment. The preload is planned to be in place for up to four months. We recommend settlement and pore water pressure monitoring during the four-month preload period to confirm performance. Settlement monitoring recommendations are provided in Section 4.8.

3.6.4 Expanded Polystyrene (EPS) Recommendations

EPS requires specific protection measures to facilitate long-term performance as lightweight fill under the roadway and embankment. We recommend a minimum 6-inch-thick layer of levelling granular fill and a 6- to 12-inch-thick reinforced concrete load distribution slab be constructed between the pavement section and top of EPS blocks. In addition, the EPS should be encapsulated by a protective geomembrane. Additional details for the geomembrane and construction protective measures are provided in Section 4.7.

3.7 Temporary Shoring

Temporary shoring is planned to facilitate construction of individual sides of the bridge and roadway while maintaining two-way traffic on the other side. Temporary shoring will be located along the proposed roadway centerline in the vicinity of the bridge abutments. We understand temporary shoring may consist of cantilever or tieback steel sheet piles or soldier pile and lagging walls up to approximately 15 feet high. Figure 11 presents lateral earth pressures for design of temporary shoring.

Due to the loose to very loose condition of the existing embankment material, a single row of tiebacks may be required for temporary shoring design. The tieback anchor bond zone should be located in the recessional glacial deposits encountered below the embankment fill and liquefiable alluvial deposits. Figure 12 provides recommended top of tieback bond zone elevations for consideration in design. We recommend a nominal bond zone adhesion value of 2 kips per square foot in the recessional glacial deposits.

3.8 Stormwater Infiltration

We understand that stormwater infiltration facilities are being considered for the Project in the vicinity of borings B-1-17 and B-2-17. We estimated long-term infiltration rates based on correlations with grain size analysis results performed on representative samples from the soil borings.

Our analysis used the soil grain size analysis method in the 2014 Stormwater Management Manual for Western Washington (SWMMWW) (Washington State Department of Ecology [DOE], 2014). The method utilizes the D_{10}, D_{60}, and D_{90} values, which correspond to the grain sizes in millimeters for which 10, 60, and 90% of the sample is finer. The method also utilizes f_{fines}, which is the fraction of soil by weight that passes the number 200 sieve.

Exhibit 3-9 presents long-term infiltration rates for individual samples in borings B-1-17 and B-2-17. The infiltration rates vary with depth in the borings. Design long-term infiltration rates are provided in the exhibit. The design values were selected in consultation with HDR, accounting for the depth of the facilities and variation at boring locations. Design of infiltration facilities should also consider the groundwater measurements presented in Exhibit 2-1.

Exhibit 3-9: Summary of Estimated and Design Long-Term Infiltration Rates

Boring	Sample Number	Sample Depth (feet)	2014 SWMMWW Infiltration Rate (inches/hour)	Design Infiltration Rate (inches/hour)
B-1-17	S-2	5.0	9.6	5.0
	S-4	10.0	5.1	
	S-5	12.5	7.5	
B-2-17	S-2	5.0	12.4	4.0
	S-3	7.5	4.8	
	S-4	10	4.1	

4 CONSTRUCTION CONSIDERATIONS

The applicability of the design recommendations provided in this report is contingent upon quality construction practice. The following sections present our recommended construction considerations.

4.1 Site Preparation

We recommend that the site be cleared and existing pavement, utility lines (as appropriate), roots, stumps, grass, and construction debris be removed from beneath the proposed structures and all areas to be graded. Topsoil is not considered suitable for reuse as structural fill and should be removed from the site.

In areas to be filled, the exposed soil surface (after clearing and stripping and prior to any fill placement or foundation construction) should be compacted using a vibratory roller. Native subgrade soils should be proof rolled and, if necessary, compacted to achieve at least 95% of the Modified Proctor maximum dry density. The proof-rolling operations should consist of several passes of a heavy (10-ton or heavier static weight) vibratory roller to compact the surface to a dense, unyielding condition. The density of the subgrade should be evaluated by an experienced field representative from our firm by probing with a steel T-bar. Areas that are wet, soft, loose, or yielding under the compaction process should be further compacted, removed and reconditioned, or replaced with compacted structural fill so that a dense and unyielding condition is achieved.

4.2 Excavation

Unshored, temporary excavation slopes may be used where planned excavation limits will not undermine existing structures or utilities, interfere with other construction, or extend beyond construction limits. Where there is not enough area for sloped excavations, temporary shoring should be provided. If shallow temporary shoring is required, we recommend that it be designed to withstand the lateral earth pressures provided in the temporary shoring section of this report.

The suitable slopes for soil excavation will depend on the following factors: (a) the presence of groundwater; (b) the type and density of the soils; (c) the depth of excavation; (d) surcharge loading adjacent to the excavation such as that from excavated material, existing structures, or construction equipment; and (e) the time of construction. Due to the very loose to loose condition of the existing embankment fill in the Quilceda Creek vicinity, steep construction slopes may not be feasible. Temporary construction slopes flatter than 1.5H:1V to 2H:1V may be required for stability and for protection of the State Avenue traffic maintained during construction.

If wetted by surface water, the slopes may be subject to erosion. Slope protection consisting of a plastic covering weighted down with sand bags should be employed, as appropriate, during construction in order to reduce erosional effects.

Consistent with conventional construction practice, temporary excavation slopes should be made the responsibility of the Contractor. The Contractor is continually at the site and is able to observe the nature and conditions of the subsurface materials encountered, including groundwater, and has responsibility for the methods, sequence, and schedule of construction. If instability is detected, slopes should be flattened or shored. Regardless of the construction method used, all excavation work should be accomplished in compliance with applicable local, state, and federal safety codes.

4.3 Backfill and Compaction

Retaining wall and embankment fill material should consist of structural fill. Structural fill soil should consist of a well-graded mixture of sand and gravel, free of organics, debris, and rubbish. If imported structural fill is used, it should contain no more than 15% fines (material passing the No. 200 mesh sieve, based on the minus ¾-inch fraction) in dry conditions; the fines should be non-plastic; and the moisture content should be within ±2% of its optimum. Structural fill should have a maximum particle size of 3 inches. As an alternative, gravel borrow (WSDOT Standard Specification 9-03.14(1)) or an approved substitute could be used.

If earthwork takes place in wet weather or wet conditions, no matter what time of the year, the structural material should contain no more than 5% fines passing the No. 200 sieve. Fines should be non-plastic.

Prior to placement of structural fill, any ponding water should be drained from the area. Structural fill should be placed in horizontal layers and systematically compacted to a dense, unyielding condition. In general, the thickness of soil layers before compaction should not exceed 8 inches for heavy equipment compactors or 4 inches for hand-operated mechanical compactors. Structural fill should be compacted to a minimum 95% of the Modified Proctor maximum dry density.

4.4 Closed-End Pipe Piles

4.4.1 General Installation

We anticipate closed-end pipe piles will be installed using an impact pile-driving hammer. We recommend fixed-lead pile driving equipment to maintain pile-hammer alignment. The closed-end piles should be fitted with a conical tip to facilitate advancement to the design pile tip elevations. Obstructions, such as logs, may be encountered during pile installation.

The pile-driving hammer will be selected by the Contractor. We recommend the Contractor submit wave equation analysis for the selected hammer. The Wave Equation Analysis Pile (WEAP) analysis should demonstrate that the piles can be installed to the desired capacity and tip elevation with reasonable blow counts and driving stresses, and without damaging the piles. Results of the WEAP analysis should be used to develop pile-driving criteria for the Project.

Pile driving should be monitored by taking a continuous driving record of each pile. Pile-driving records should record the hammer stroke, blows per foot, time, date, and other pertinent information. The record should include the pile tip elevation and driving criteria.

4.4.2 Dynamic Testing

As discussed in Section 3.4.1, axial resistance recommendations incorporate AASHTO resistance factors based on the assumption that dynamic testing will be performed on a minimum of 2% of production piles. For the Project, we recommend dynamic testing a minimum of two piles per abutment. Dynamic testing should consist of Pile Driving Analyzer (PDA) with Case Pile Wave Analysis Program (CAPWAP) signal matching. We recommend PDA/CAPWAP testing be performed at the end of impact pile driving and at the beginning of restrike following a minimum 14-day set-up period.

4.4.3 Impact of Pile Driving

There is potential for damage to existing structures, including utilities, due to vibrations caused by pile-driving operations. Depending on utility sensitivity, a vibration monitoring program and criteria should be considered.

4.5 Tieback Installation and Testing

Tieback anchor holes should be drilled in a manner that will minimize loss of ground and not endanger previously installed anchors or undermine existing pavement or utilities. Based on the loose to very loose embankment fill material, we recommend that tiebacks be drilled, grouted, and installed using casing.

In the anchor no-load zone, tieback holes should be filled with a material such as a sand pozzolan mixture that will not adhere to the tieback rod and will prevent caving. We recommend that no-load zone lengths not be left open overnight. Alternatively, a bond breaker could be used around the tiebacks in the no-load zone, and the zone could be filled with concrete or lean concrete backfill. However, a minimum 12-inch buffer zone of sand is required directly behind the soldier pile.

All temporary anchors should be proof tested in 25% (0.25P) increments to 133% of their design capacity (1.33P). Each load increment should be held until the deformation stabilizes (normally about one minute) and the load and corresponding deformation are recorded. After reaching 1.33P, the load should be held for at least ten minutes, to evaluate creep, and then be reduced to the lock-off load.

Prior to installing production anchors within a particular soil stratum, performance tests should be accomplished for each anchor type and/or installation method that will be used. The number of tendons in the selected anchors should be increased as required to complete the performance tests. Approximately 3 to 5% of temporary production anchors, randomly selected, should be performance tested by loading in 0.25P increments to 200% of design capacity (2.0P). The 200% load should be held constant for a minimum period of at least 60 minutes.

We recommend that all temporary anchors be locked off at 80 to 90% of the design load to provide some wall flexibility. Anchors that do not meet the testing acceptance criteria should be locked off at 50% of the failure load and replaced with additional anchors, as required.

Load testing and acceptance criteria for all tieback anchors should be as recommended by the Post-Tensioning Institute Manual, Chapter 4, Recommendations for Pre-Stressed Rock and Soil Anchors. As described above in the manual, the following tests should be accomplished.

Initial Lift-Off Readings: After transferring the load to the stress anchorage and prior to removing the jack, a lift-off reading should be made. The load determined from the lift-off reading should be within 5% of the lock-off load, the end anchorage should be reset, and another lift-off reading should be made.

Lift-Off Test: Lift-off tests may be conducted on selected anchors, both during and after construction, to check the magnitude of seating and transfer load losses and to determine whether long-term losses are occurring.

Acceptance Criteria: The results of each anchor test should be evaluated in order to determine anchor acceptability. An anchor would be acceptable provided:

- The total movement obtained from performance and proof tests exceeds 80% of the theoretical elastic elongation of the design free stressing length.
- The total movement obtained from performance and proof tests does not exceed the theoretical elastic elongation of the design free stressing length plus one-half of the bond length.
- For the proof test held ten minutes, the creep rate during the final test load does not exceed 0.04 inch per log cycle of time and is linear or decreasing creep rate, regardless of tendon length and load. Otherwise, the anchor should be held for an additional 60 minutes at the required test load.
- For the performance tests or proof creep tests held 60 minutes, the creep rate during the final test load does not exceed 0.08 inch per log cycle of time and is a linear or decreasing creep rate, regardless of tendon length and load.

4.6 Pile and Lagging Wall Monitoring

We recommend monitoring be performed for temporary shoring and permanent pile and lagging walls (Abutment Walls 1 and 2 and Retaining Walls 3 through 5). We recommend that optical survey points be established no more than 2 feet behind the walls at a horizontal spacing of no more than 20 feet along the wall, and that two additional sets of survey points be established at distances generally corresponding to 0.5H and H behind the wall, where H is the height of the wall height. An additional set of optical survey points should be established on the retaining walls as excavation progresses. We recommend at least every other pile should be monitored as the excavation progresses. Both the horizontal and vertical movements should be surveyed; the baseline readings must be taken prior to excavation.

Monitoring points should be evaluated twice a week during construction or as excavation/ backfill progress dictates. If horizontal movements are observed to be in excess of a total of 1 inch or ½ inch between successive readings, wall construction should be stopped to determine the cause of the movement and to establish the type and extent of remedial construction. If, after the excavation/backfill is complete, the survey readings indicate that the movement rate has significantly decreased or stopped, the reading frequency should be re-evaluated.

4.7 Expanded Polystyrene (EPS) Backfill

Prior to installation, EPS blocks should be stored above ground and protected from moisture and covered with an opaque material to prevent ultraviolet light degradation.

EPS will degrade when exposed directly to or to the vapors of hydrocarbons and many organic solvents. EPS should be protected from possible exposure to these materials during construction and throughout the project design life. Any geofoam that comes in contact with hydrocarbons, including diesel and gasoline fuel, must be completely removed and replaced.

The EPS blocks should be placed in a staggered pattern so that the joints between blocks do not align with joints of underlying or overlying rows. The principal axis of the blocks (long vs. short direction) should be alternated for each row. A drainage layer should be placed on the slope behind the EPS blocks and below the lowest row of EPS blocks. The drainage material below the first row of geofoam blocks should be graded so that they are placed on a smooth, level surface. A drainage layer should be placed between the EPS blocks and the wall face, as indicated in Figure 10.

EPS backfill should be protected against potential fuel spills. We recommend a protective geomembrane be installed over the top of the EPS blocks, between the wall face drainage layer and EPS blocks, and wrap around the base to encapsulate the EPS blocks. The geomembrane should consist of minimum 36 mil hydrocarbon-resistant polyethylene with a minimum coefficient of friction of 0.5 at its interface with EPS. We recommend a minimum 6-inch-thick layer of levelling granular fill and a 6- to 12-inch-thick load distribution slab be constructed between the pavement section and top of EPS blocks.

4.8 Embankment and Preload Settlement Monitoring

As described in Section 3.6.4, we recommend a monitoring program to evaluate settlement due to the embankment construction and preload. We recommend the monitoring program consist of settlement plates distributed along the alignment. For preliminary planning purposes, we recommend five sections of monitoring points at approximate roadway centerline stations 101+50, 102+00, 102+25, 103+75, and 104+00. Each section should include a monitoring plate at the edge of the existing roadway, edge of proposed roadway, and under the center of the preload fill.

In addition, we recommend piezometers be installed at five locations corresponding to the settlement monitoring plate locations under the center of the preload fill. The piezometers will measure the pore pressure changes due to fill placement and soil consolidation. The piezometers will be monitored during the preload period to confirm pore water pressures return to hydrostatic conditions with completion of consolidation settlement. Piezometers should consist of vibrating wire piezometers with a corresponding four-channel datalogger to automatically monitor pore pressure at different depth intervals. Due to the variability of the peat and fine-grained material deposits, we recommend piezometer locations be drilled using hollow-stem auger drilling equipment with continuous sample to depths ranging from 10 to 60 feet below existing grade. We recommend Shannon & Wilson observe the drilling and sampling operations and select monitoring depths based on the observed conditions.

All settlement plates and piezometers should be installed and initial readings taken prior to fill placement. Settlement plates should be read daily during fill placement and twice a week during the preload period. We will determine when the preload can be removed based on these readings. The settlement plate readings need to include the elevation of the plate as well as the elevation of the fill. The datalogger, attached to the piezometer, will be set to automatically take readings at the desired intervals.

4.9 Wet Weather and Wet Condition Considerations

In the Seattle area, wet weather generally begins about mid-October and continues through about May, although rainy periods may occur at any time of year. Therefore, it would be advisable to schedule earthwork during the dry weather months of June through September. Most of the soil at the site contains sufficient silt/clay fines to produce an unstable mixture when wet. Such soil is highly susceptible to changes in water content and tends to become unstable and difficult or impossible to compact if the moisture content significantly exceeds the optimum. In addition, during wet weather months, the groundwater levels may increase, resulting in seepage into site excavations. Performing earthwork during dry weather would reduce these problems and costs associated with rainwater and handling of wet soil. However, should wet weather/wet condition earthwork be unavoidable, the following recommendations are provided:

- The ground surface in and surrounding the construction area should be sloped as much as possible to promote runoff of precipitation away from work areas and to prevent ponding of water.
- Work areas or slopes should be covered with plastic. The use of sloping, ditching, sumps, dewatering, and other measures should be employed as necessary to permit proper completion of the work.

- Bales of straw and/or geotextile silt fences should be used to control surface soil movement and erosion along the downslope sides of the disturbed areas.
- Fill material to be placed should meet the requirements of Section 4.3.
- Earthwork should be accomplished in small sections to minimize exposure to wet conditions. That is, each section should be small enough so that the removal of unsuitable soils and placement and compaction of clean granular backfill can be accomplished on the same day. The size of construction equipment may have to be limited to prevent soil disturbance.
- No soil should be left uncompacted and exposed to moisture.
- In-place soil or fill soil that becomes wet and unstable and/or too wet to suitably compact should be removed and replaced with clean, granular soil (see gradation requirements above).
- Excavation and placement of geofoam and backfill material should be observed on a full-time basis by a geotechnical engineer or engineer’s representative experienced in earthwork to determine that all work is being accomplished in accordance with the intent of the specifications.
- Grading and earthwork should not be accomplished during periods of heavy, continuous rainfall.

We recommend the above requirements for wet weather/wet condition earthwork be incorporated into the contract specifications.

4.10 Construction Observation

We recommend that Shannon & Wilson be retained to provide geotechnical construction observation services to verify that the subsurface conditions encountered and materials used are the same as we assumed for the design recommendations presented in this report. Our services would include observing pile driving, soldier pile installation, lagging installation, tieback placement and stressing, fill placement and compaction, drainage, settlement monitoring, dynamic PDA and CAPWAP pile monitoring, and other geotechnical-related earthwork activities.

5 LIMITATIONS

This report was prepared for the exclusive use of the City and HDR for specific application to the design and construction of the State Avenue Corridor Widening Project. The analyses and recommendations presented in this report apply to the proposed design developed by HDR. This report is not intended to be used or relied upon for any other purpose. Further, it should only be relied on for information based on factual data, such as those interpreted from the exploration logs. Unanticipated soil conditions are commonly encountered. Soil conditions cannot be fully determined by merely taking soil samples from explorations. Such unexpected conditions frequently require that additional expenditures be made to attain properly constructed projects. Our judgments, conclusions, and interpretations presented in this report should not be construed as a warranty of subsurface conditions. The analyses, conclusions, and recommendations presented in this report were prepared in accordance with generally accepted professional geotechnical engineering principles and practice in this area at this time. No other warranty, either express or implied, is made.

The analyses, conclusions, and recommendations are based on our understanding of the Project as described herein and site conditions as they existed at the time our explorations were performed. For the purpose of presenting design recommendations, we assumed that the subsurface conditions in the Project area are not significantly different from those disclosed by our recent explorations.

If, during construction, subsurface conditions different from those encountered in the explorations are observed or appear to be present, we should be advised at once so that we can review these conditions and reconsider our recommendations where necessary. If conditions have changed due to construction operations at or adjacent to the site, we recommend that the geotechnical design report be reviewed to determine the applicability of the conclusions and recommendations considering the changed conditions.

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

6 REFERENCES

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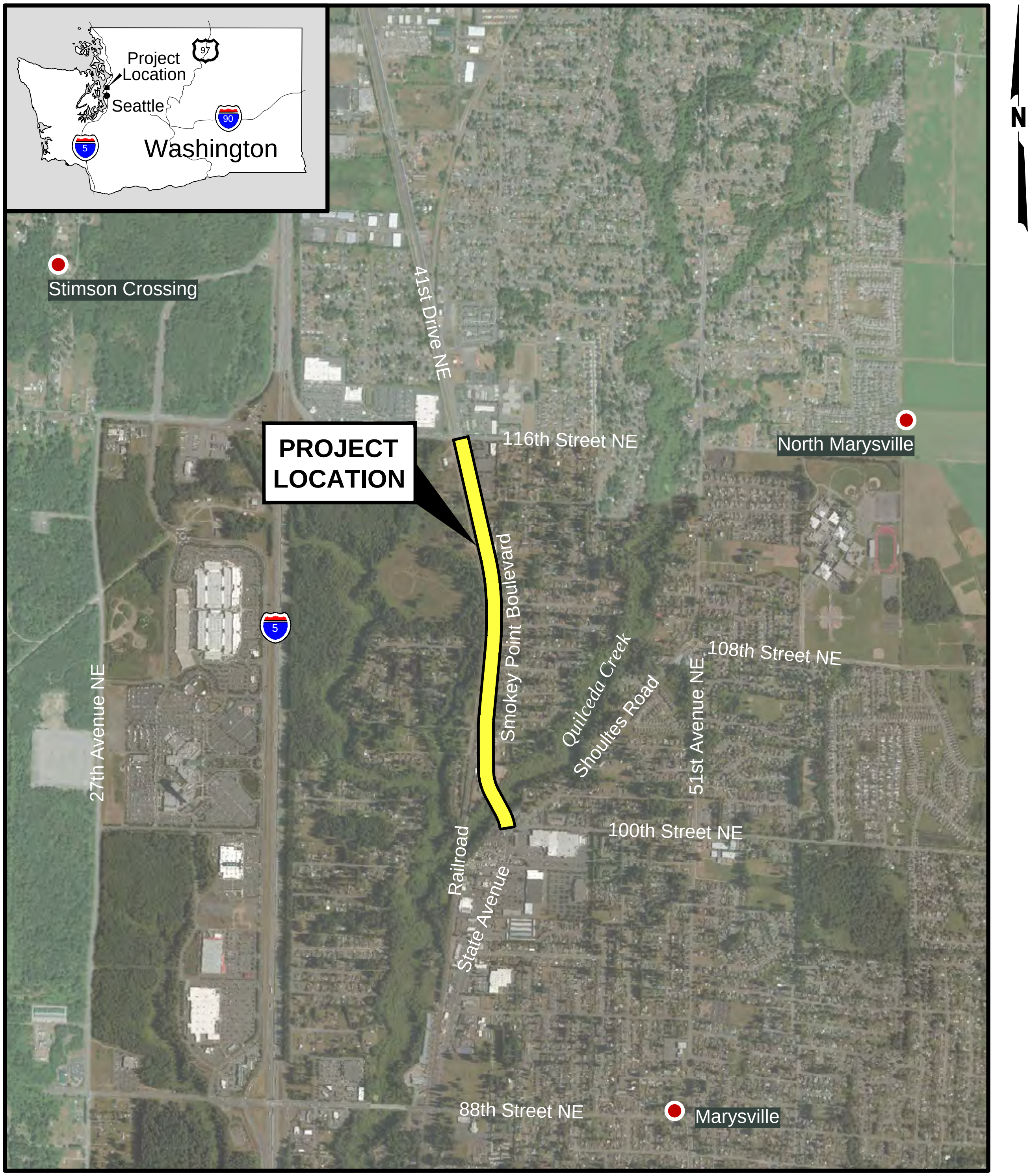
TABLE 1 - PARAMETERS FOR LATERAL RESISTANCE ANALYSIS USING LPILE

	Elevation (feet)		Layer Thickness (feet)	Layer Description	Lile Soil Model	Effective Unit Weight (pcf)	Friction Angle (°)		Modulus of Subgrade Reaction (pci)		Undrained Shear Strength (ksf)	Strain Factor e50 (-)
	Top	Bottom					Static	Liquefied	Static	Liquefied		
Abutment 1 (Borings BH-8-17, BH-10-18)	33	28	5	Roadway Fill (Hf)	Sand	110	29	22	20	10	-	-
	28	15	13	Roadway Fill (Hf)	Sand	47.6	29	10	15	5	-	-
	15	-5	20	Sand with Silt (Ha)	Sand	47.6	31	12	45	15	-	-
	-5	-10	5	Organic Silt and Elastic Silt (Hp, Hl)	Soft Clay	37.6	-	-	-	-	400	0.009
	-10	-20	10	Silty Sand to Well Graded Silt with Sand	Sand	52.6	35	35	45	45	-	-
	-20	-33	13	Silt, Silty Sand, Lean Clay with Sand, Silt (Qvrm, Qvrc)	Sand	57.6	30	30	65	65	-	-
	-33	-59	26	Sand, Silty Sand, Silt, and Lean Clay (Qvrc, Qvrm)	Sand	57.6	34	24	70	70	-	-
	-59	-115	56	Lean Clay, Silt, Silty Sand (Qvrc)	Stiff Clay w/out Free Water	57.6	-	-	-	-	1250	0.007
	-115	-139	24	Silt with Sand, Silt, to Lean Clay (Qvrc, Qvrm)	Sand	57.6	35	35	75	75	-	-
	-139		-172	Lean Clay and Sandy Silt (Qvrc)	Stiff Clay w/out Free Water	57.6	-	-	-	-	2500	0.006
Abutment 2 (Boring BH-11-18)	33	28	5	Roadway Fill (Hf)	Sand	110	28	21	15	10	-	-
	28	16	12	Roadway Fill (Hf)	Sand	47.6	28	10	15	5	-	-
	16	0	16	Silty Sand and Sand with Silt (Ha)	Sand	47.6	28	10	15	5	-	-
	0	-5	5	Organic Silt (Hp)	Soft Clay	37.6	-	-	-	-	400	0.009
	-5	-25	20	Silty Sand (Ha)	Sand	52.6	32	24	50	35	-	-
	-25	-30	5	Silt to Silt with Sand (Qvrc)	Sand	47.6	29	29	25	25	-	-
	-30	-42	12	Silty sand (Qvrm)	Sand	57.6	33	33	65	65	-	-
	-42	-49	7	Lean Clay to Silt (Qvrc)	Stiff Clay w/out Free Water	47.6	-	-	-	-	850	0.008
	-49	-84	35	Silty Sand, Lean Clay, Silt with Sand (Qvrm)	Sand	57.6	33	33	65	65	-	-
	-84	-110	26	Silt, Silt with Sand, Lean Clay (Qvrc)	Stiff Clay w/out Free Water	57.6	-	-	-	-	1500	0.0076
	-110	-132	22	Silt with Sand to Lean Clay (Qvrc, Qvrm)	Sand	57.6	35	35	75	75	-	-
	-132	-173.5	41.5	Lean Clay and Sandy Silt (Qvrc)	Stiff Clay w/out Free Water	57.6	-	-	-	-	2400	0.006



0 2,000 4,000

Approximate Scale in Feet

NOTE

Bing Map Image adapted from aerial imagery provided
by Autodesk Live Maps and Microsoft Bing Maps
reprinted with permission from Microsoft Corporation.

City of Marysville
State Avenue Corridor Widening Project
Marysville, Washington

VICINITY MAP

September 2019 21-1-22406-003

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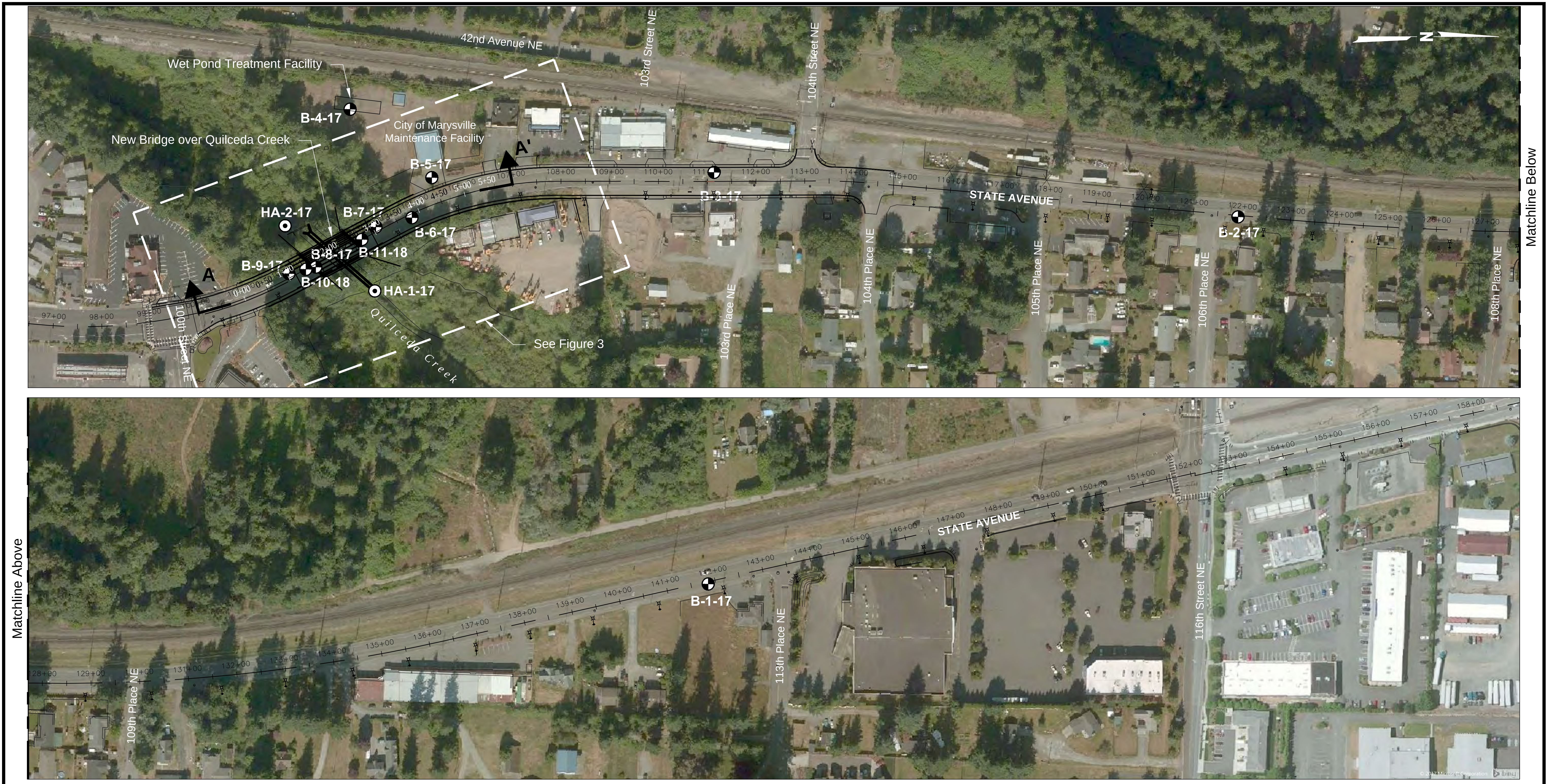
FIG. 1

Filename: J:\211\22406\003\21-1-22406-003 Fig 1 - Vicinity Map.dwg Date: 09-06-2019 Login: sac



NOTE

Figure adapted from file *XRef_COM_StateAve-RD.dwg* dated 07/06/2016, *17010-SV-BS.dwg* received 07/14/2017, and *Cross_Sections-60_Percent.dwg, ILLUMINATION XREF.dwg,* and *ROADWAY LAYOUT XREF.dwg*, received 03-19-2018, and *XP-ALIGN.dwg, XP-BRIDGE.dwg, XP-RET WALL KEY PLAN.dwg,* and *XP-ROADWAY.dwg*, received 08-23-2018. Aerial imagery provided by Bing! used in accordance with Microsoft Corporation Product Print Rights.

0 200 400

Scale in Feet

LEGEND

B-1-17 ⊕	Boring Designation and Approximate Location
HA-1-17 ⊙	Hand Auger Designation and Approximate Location
A ↑	Generalized Subsurface Profile (See Figure 4)

City of Marysville
State Avenue Corridor Widening Project
Marysville, Washington

SITE AND EXPLORATION PLAN

September 2019 21-1-22406-003

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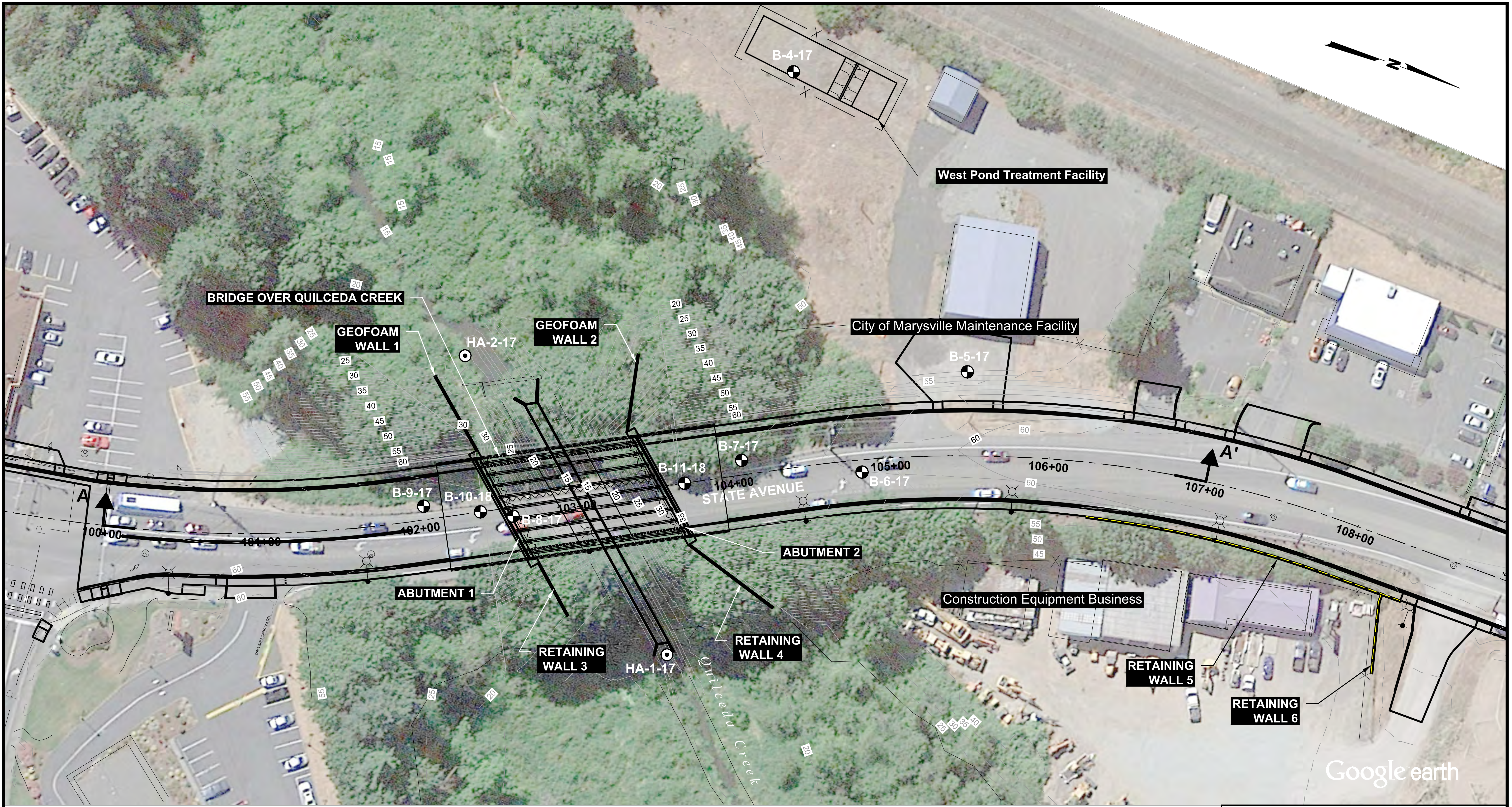
FIG. 2

Filename: J:\211\22406\003\21-1-22406-003 Site and Profile_Version 2018.dwg Layout: FIG 2 Date: 09-06-2019 Login: sac

Filename: J:\211\22406\003\21-1-22406-003 Fig 3 - Quilceda Crossing.dwg Layout: FIG 3 Date: 09-12-2019 Login: sac



NOTE

Figure adapted from file *XRef_COM_StateAve-RD.dwg* dated 07/06/2016, *17010-SV-BS.dwg* received 07/14/2017, and *Cross_Sections-60_Percent.dwg, ILLUMINATION XREF.dwg,* and *ROADWAY LAYOUT XREF.dwg*, received 03-19-2018, and *XP-ALIGN.dwg, XP-BRIDGE.dwg, XP-RET WALL KEY PLAN.dwg,* and *XP-ROADWAY.dwg*, received 08-23-2018. Aerial imagery provided by Google Earth Pro, reproduced by permission granted by Google Earth ™ Mapping Service.

0 60 120

Scale in Feet

CONTOUR LEGEND

— 20 —	Existing Contour Major
—30—	Proposed Contour Major
——	Proposed Contour Minor

LEGEND

B-1-17 ◐	Boring Designation and Approximate Location
HA-1-17 ⊙	Hand Auger Designation and Approximate Location
A ↑	Generalized Subsurface Profile (See Figure 4)

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

SITE PLAN
QUILCEDA CREEK CROSSING

September 2019 21-1-22406-003

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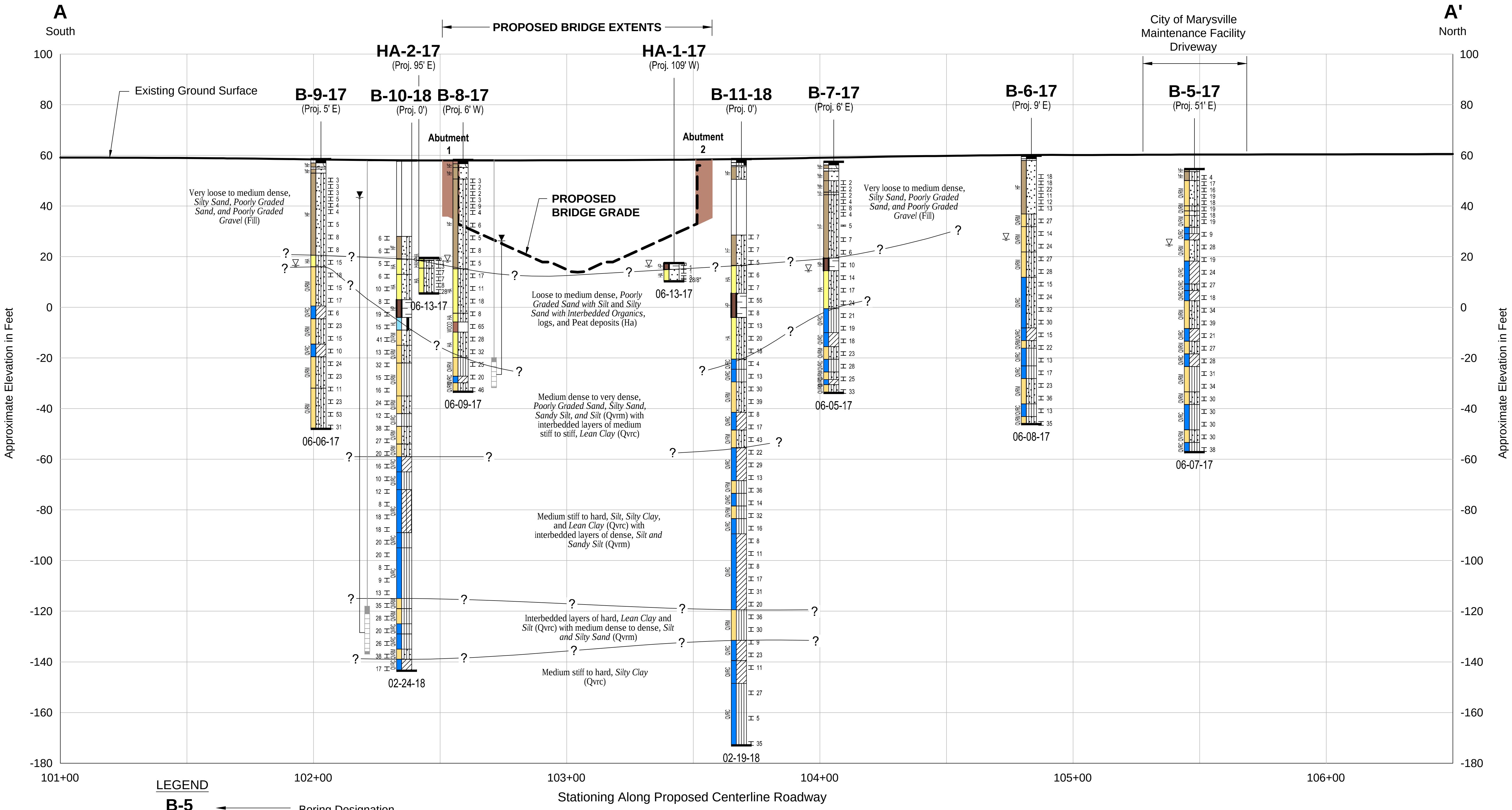
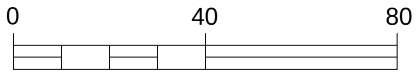
FIG. 3

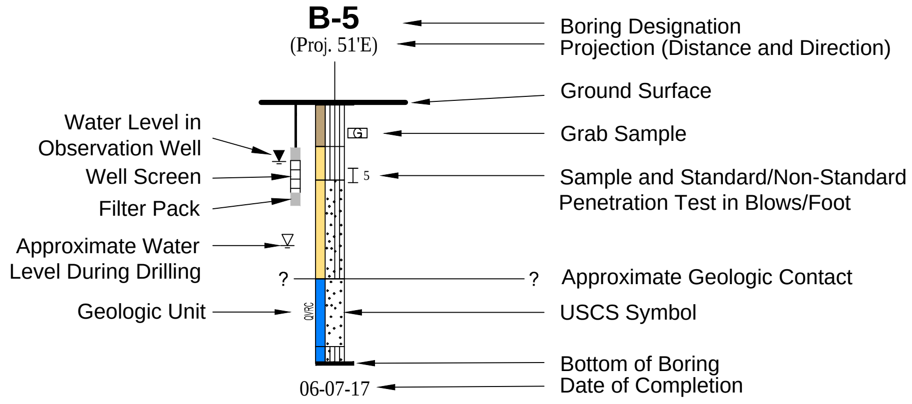


Stationing Along Proposed Centerline Roadway



Scale in Feet
Vertical = Horizontal

LEGEND



GEOLOGIC UNITS

Holocene Deposits

▨	Hf	Topsoil/Fill
▨	Ha	Alluvium
▨	Hp	Peat Deposits
▨	Wood	Wood

Quaternary Vashon Deposits

▨	Qvrm	Recessional Outwash, Marysville Sand Member
▨	Qvrc	Recessional Outwash, Clay Member

NOTE

Ground surface and structure locations based on client files received 6-21-18.

City of Marysville
State Avenue Corridor Widening Project
Marysville, Washington

GENERALIZED SUBSURFACE PROFILE A-A'

September 2019
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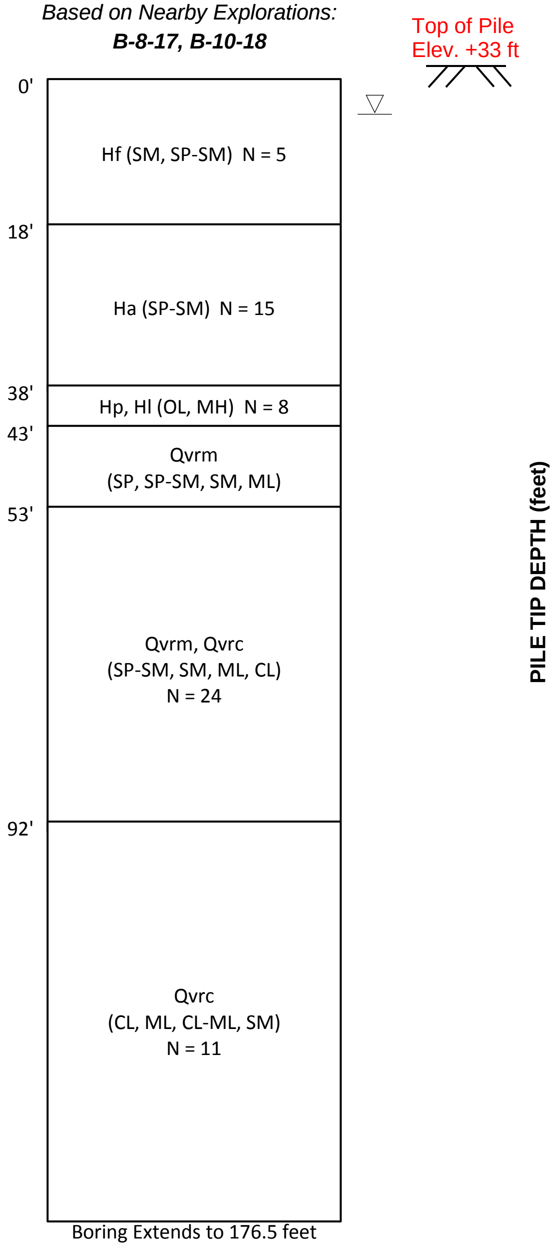
FIG. 4

Filename: J:\211\22406\003\21-1-22406-003 Fig 4 - Profile.dwg Layout: Layout Date: 09-09-2019 Login: JRS

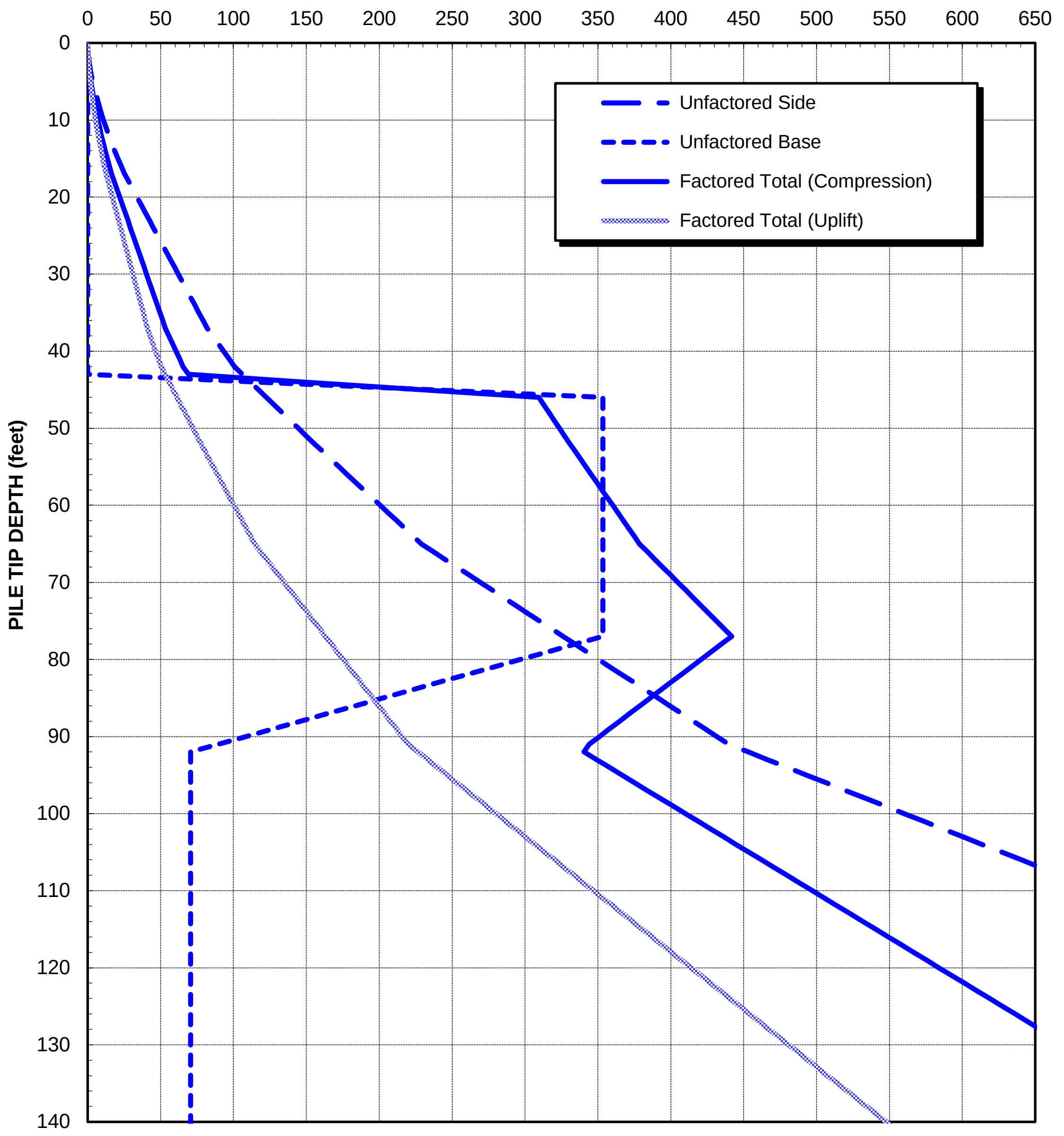
ASSUMED SUBSURFACE PROFILE

Based on Nearby Explorations:
B-8-17, B-10-18



STRENGTH LIMIT

AXIAL RESISTANCE (kips)

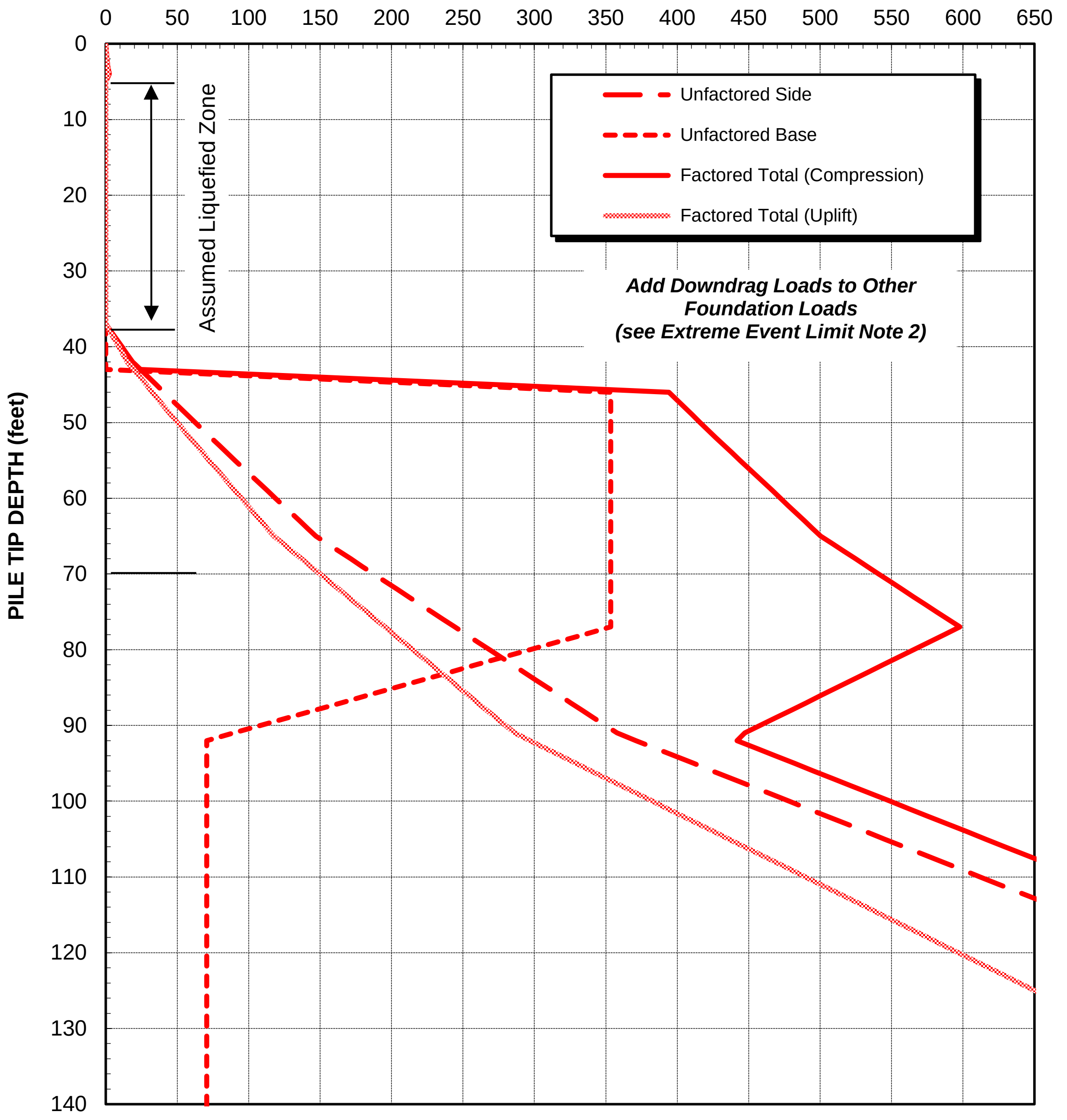


STRENGTH LIMIT NOTES:

1. Recommended compression resistance factors are 0.65 and 0.65 for side and base resistance, respectively. See general note 3 below.
2. Pile uplift capacity can be estimated by using the unfactored side resistance shown above and a recommended resistance factor of 0.5 .

EXTREME EVENT LIMIT

AXIAL RESISTANCE (kips)



EXTREME EVENT LIMIT NOTES:

1. Recommended resistance factors are 1.0 and 0.8 for Extreme Event compression and uplift, respectively.
2. Unfactored downdrag force is estimated to be 40 kips. Per the WSDOT GDM, a load factor of 1.25 is recommended to determine factored downdrag force. Downdrag force is recommended to be applied with post-earthquake loading.

GENERAL NOTES

1. The analyses were performed based on guidelines included in the WSDOT Geotechnical Design Manual (GDM) and local experience. The analyses are based on a single pile and do not consider group action of closely spaced piles (closer than 6 diameters, center to center).
2. Factored total pile resistance shown on plots is determined by adding its unfactored side and base resistances multiplied by the appropriate resistance factors as noted above.
3. Recommended resistance factors are based on the assumption that dynamic testing will be performed on a minimum of 2 percent of production piles.
4. Estimated capacities assume that the driven piles will be installed after construction of the approach embankments. Downdrag loads due to potential fill embankment settlement have not been included.

City of Marysville
State Avenue Corridor Widening Project
Marysville, Washington

AXIAL PILE RESISTANCE
3-FOOT DIAMETER CLOSED END PIPE
ABUTMENT 1

September 2019 21-1-22406-003

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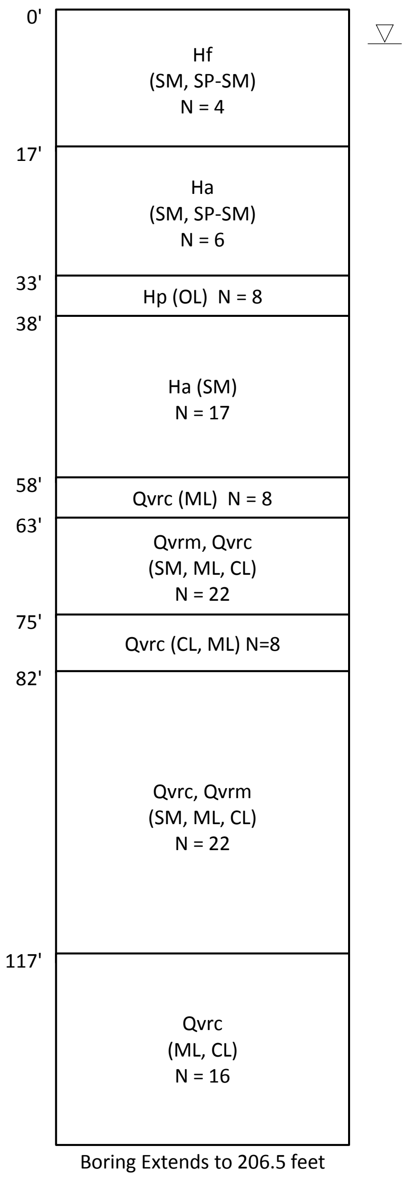
FIG. 5

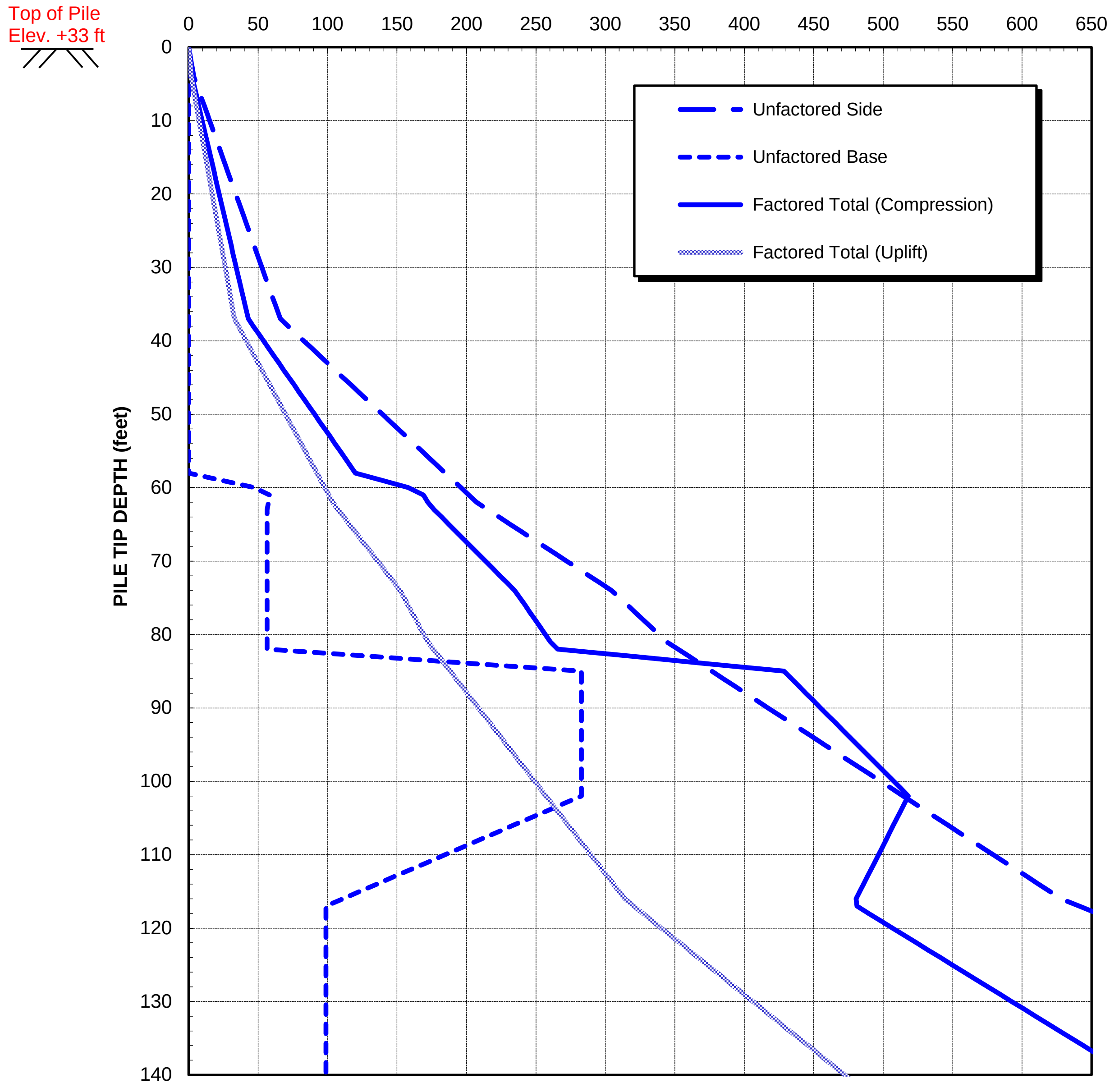
ASSUMED SUBSURFACE PROFILE

Based on Nearby Explorations:
B-11-18



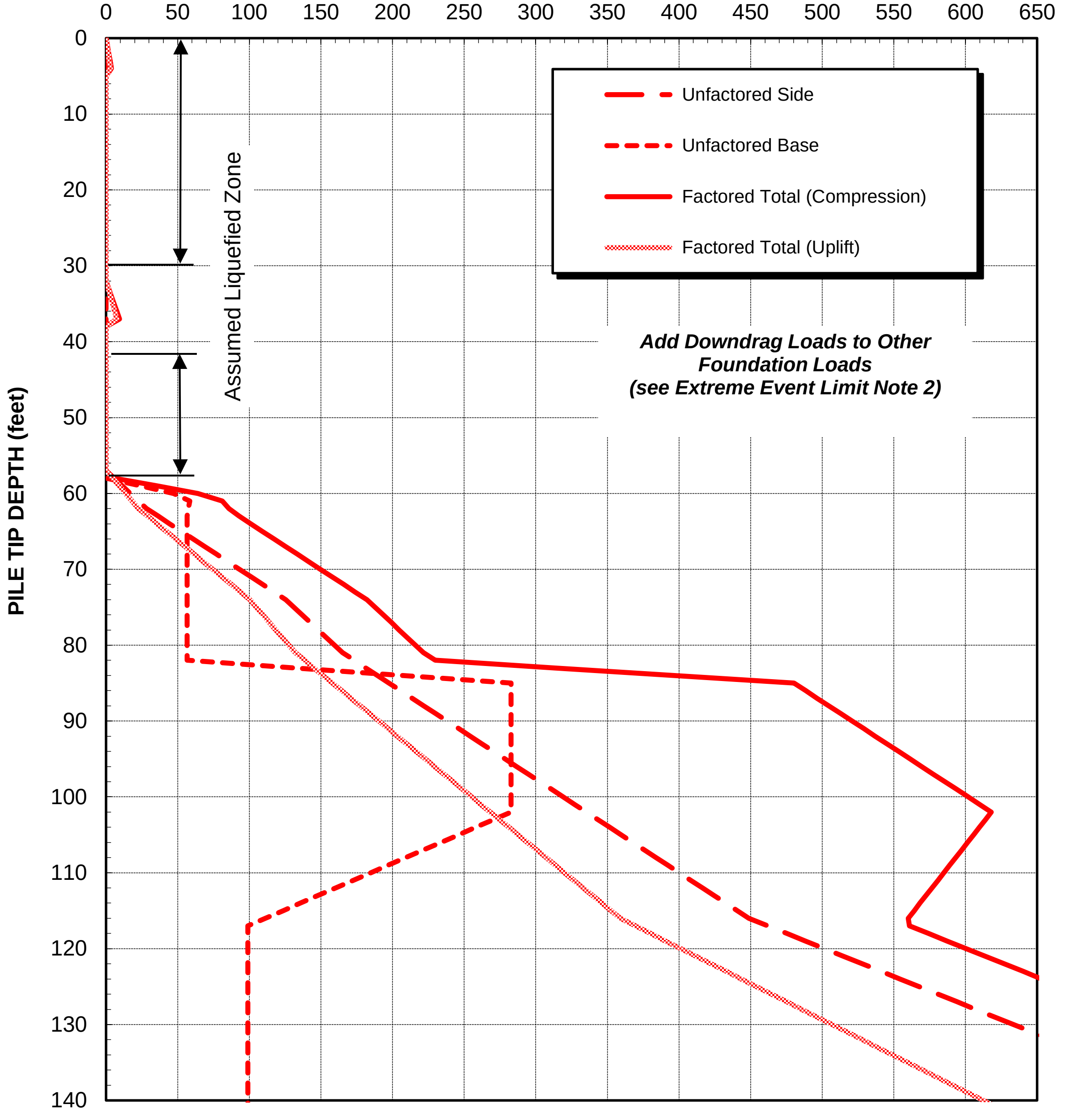
STRENGTH LIMIT

AXIAL RESISTANCE (kips)



EXTREME EVENT LIMIT

AXIAL RESISTANCE (kips)



STRENGTH LIMIT NOTES:

1. Recommended compression resistance factors are 0.65 and 0.65 for side and base resistance, respectively. See general note 3 below.
2. Pile uplift capacity can be estimated by using the unfactored side resistance shown above and a recommended resistance factor of 0.5 .

EXTREME EVENT LIMIT NOTES:

1. Recommended resistance factors are 1.0 and 0.8 for Extreme Event compression and uplift, respectively.
2. Unfactored downdrag force is estimated to be 180 kips. Per the WSDOT GDM, a load factor of 1.25 is recommended to determine factored downdrag force. Downdrag force is recommended to be applied with post-earthquake loading.

GENERAL NOTES

1. The analyses were performed based on guidelines included in the WSDOT Geotechnical Design Manual (GDM) and local experience. The analyses are based on a single pile and do not consider group action of closely spaced piles (closer than 6 diameters, center to center).
2. Factored total pile resistance shown on plots is determined by adding its unfactored side and base resistances multiplied by the appropriate resistance factors as noted above.
3. Recommended resistance factors are based on the assumption that dynamic testing will be performed on a minimum of 2 percent of production piles.
4. Estimated capacities assume that the driven piles will be installed after construction of the approach embankments. Downdrag loads due to potential fill embankment settlement have not been included.

City of Marysville
State Avenue Corridor Widening Project
Marysville, Washington

AXIAL PILE RESISTANCE
3-FOOT DIAMETER CLOSED END PIPE
ABUTMENT 2

September 2019 21-1-22406-003

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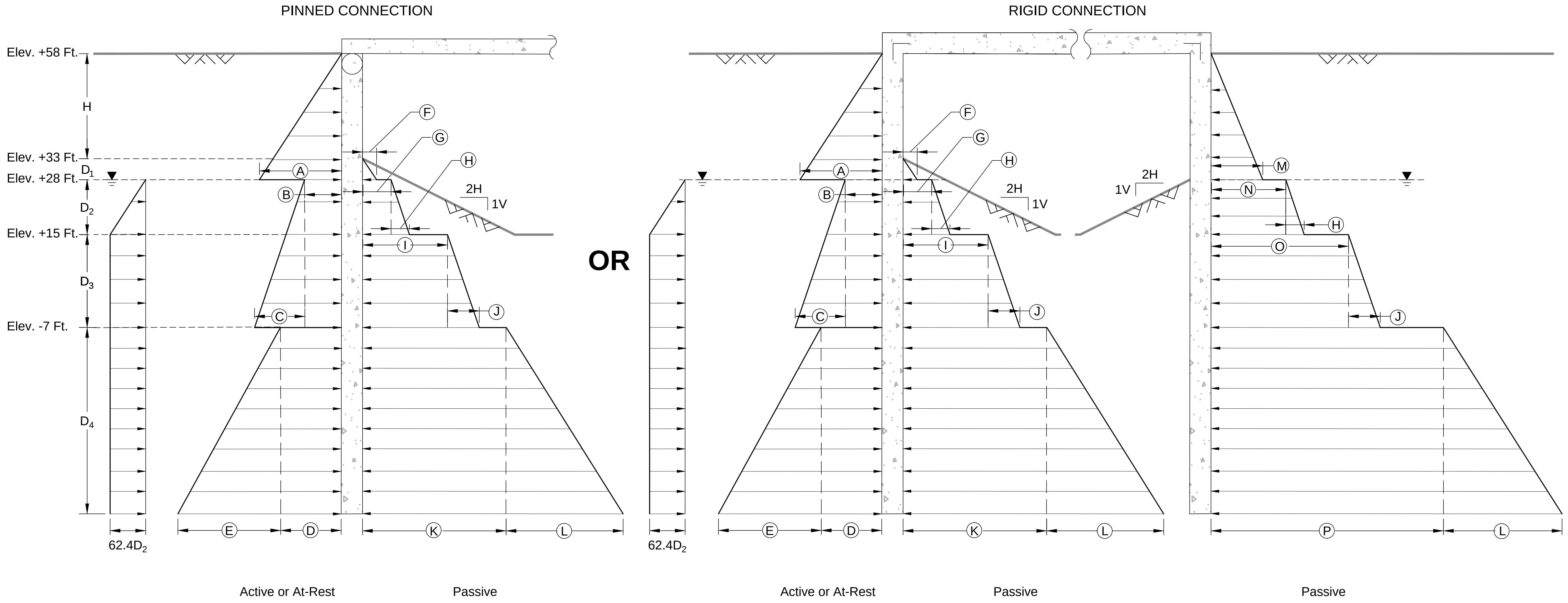
FIG. 6



NOTES

1. Pressures are in pounds per square foot (psf) per foot of wall. Earth pressures are for a continuous wall system.
2. All pressures are unfactored.
3. Above grade (Elev 33 Ft.), active and at-rest pressures are assumed to act over the pile spacing. Below grade, active and at-rest pressures are assumed to act over the pile width.
4. Passive pressure for the upper two feet should be ignored. Passive pressures act over the minimum of three times the pile diameter or the pile spacing.
5. Passive pressures incorporate wall friction for driven closed-end steel pipe piles.
6. Seismic active and at-rest earth pressures act over the exposed wall height, H, only. Static pressures apply for depths D_1, D_2, and below.
7. Passive pressures are reduced for seismic loading as indicated.
8. See report Exhibit 3-5 for required pile shear resistance to satisfy static and seismic global stability criteria.
9. Lateral earth pressures assume drained conditions behind the wall. See Figure 10 for drainage recommendations.

	Active		At-Rest	
	Static	Seismic[6]	Static	Seismic[6]
A	$37(H+D_1)$	$52(H+D_1)$	$58(H+D_1)$	$71(H+D_1)$
B	$37(H+D_1)$	-	$58(H+D_1)$	-
C	$16(D_2+D_3)$	-	$26(D_2+D_3)$	-
D	$15(H+D_1+D_2+D_3)$	-	$25(H+D_1+D_2+D_3)$	-
E	$15D_4$	-	$27D_4$	-

	Passive	
	Static	Seismic[6]
F	$95D_1$	$65D_1$
G	$95D_1$	$65D_1$
H	$40D_2$	$30D_2$
I	$450D_1+200D_2$	$365D_1+160D_2$
J	$200D_3$	$160D_3$
K	$605D_1+360(D_2+D_3)$	$540D_1+235(D_2+D_3)$
L	$320D_4$	$285D_4$
M	$95(H+D_1)$	$65(H+D_1)$
N	$95(H+D_1)$	$65(H+D_1)$
O	$450(H+D_1)+200D_2$	$365(H+D_1)+160D_2$
P	$605(H+D_1)+260(D_2+D_3)$	$540(H+D_1)+235(D_2+D_3)$

Not to Scale

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

ABUTMENT WALLS 1 AND 2
LATERAL EARTH PRESSURES

September 2019 21-1-22406-003

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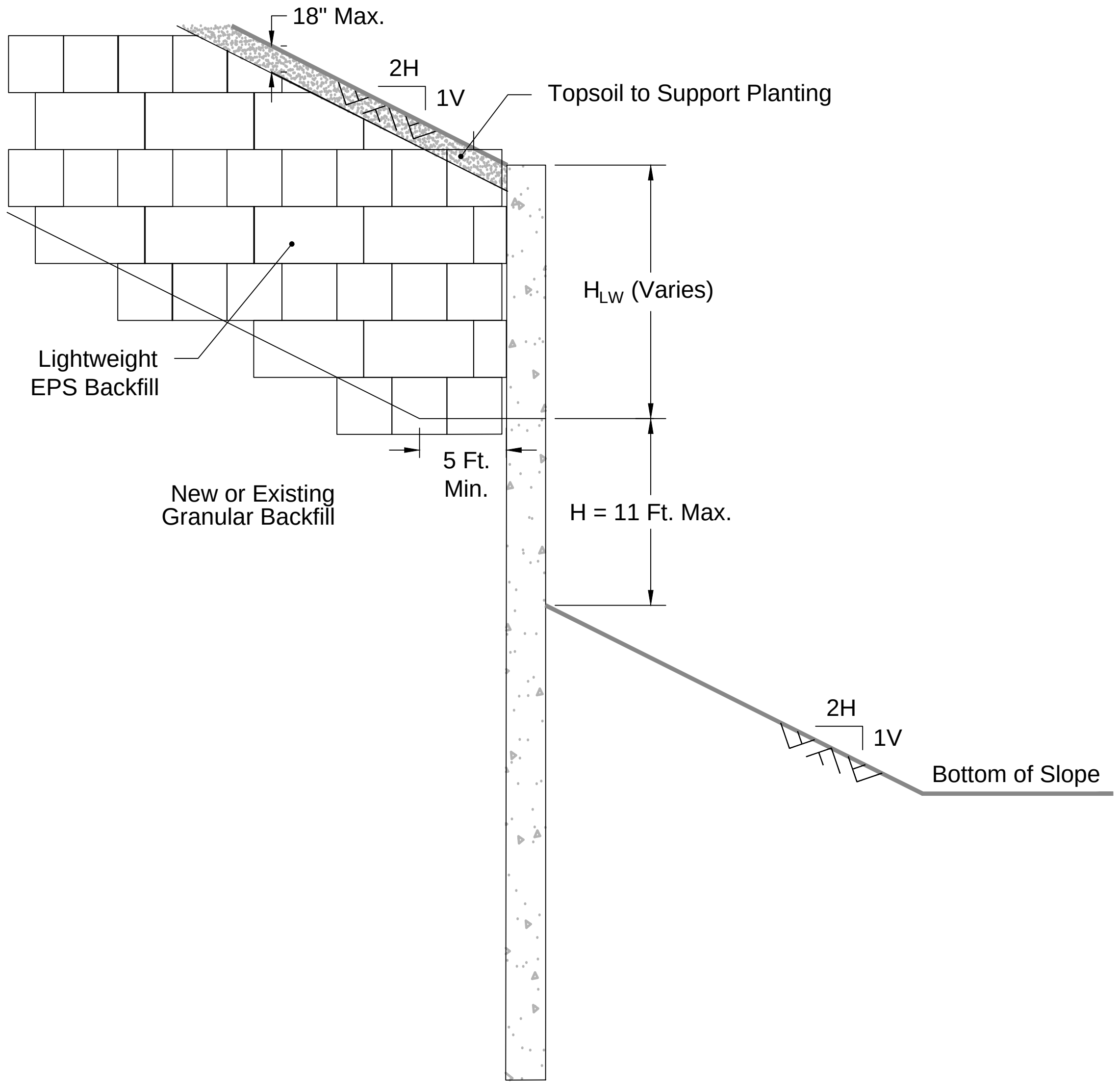
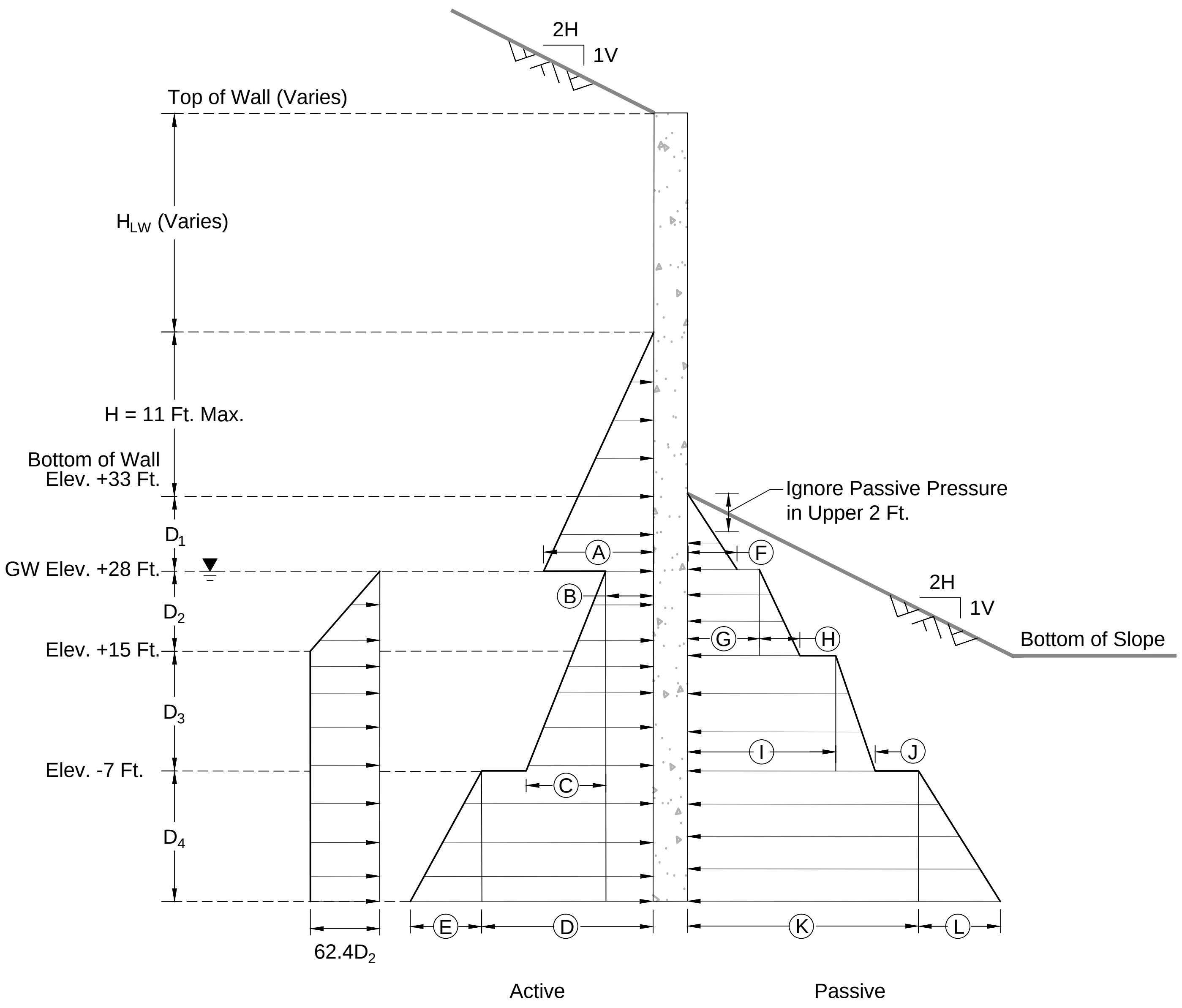
FIG. 7

Filename: J:\211\22406\003\21-1-22406-003 Fig 7 - LEP-Abutment Walls.dwg Layout: Layout Date: 09-06-2019 Login: sac



CANTILEVER WALL



NOTES

1. Pressures are in pounds per square foot (psf) per foot of wall. Earth pressures are for a continuous wall system.
2. All pressures are unfactored.
3. Above bottom of wall, active pressures are assumed to act over the pile spacing. Below grade, active and at-rest pressures are assumed to act over the pile width.
4. Passive pressure for the upper two feet should be ignored. Passive pressures act over the minimum of three times the pile diameter or the pile spacing.
5. Passive pressures incorporate wall friction for drilled piles backfilled with concrete.
6. Seismic active earth pressures act over the exposed wall height, H, only. Static active pressures apply for depths D_1 through D_4.
7. Passive pressures are reduced for seismic loading as indicated.
8. See report Exhibit 3-6 for required pile shear resistance to satisfy static and seismic global stability criteria.
9. Lateral earth pressures assume drained conditions behind the wall. See Figure 10 for drainage recommendations.

		Active	
		Static	Seismic
Existing Fill	A	$67(H+D_1)$	$90(H+D_1)$
New Fill		$45(H+D_1)$	$69(H+D_1)$
	B	$40(H+D_1)$	-
	C	$17(D_2+D_3)$	-
	D	$35(H+D_1)+15(D_2+D_3)$	-
	E	$18D_4$	-

	Passive	
	Static	Seismic
F	$95D_1$	$65D_1$
G	$110D_1$	$80D_1$
H	$50D_2$	$35D_2$
I	$500D_1+220D_2$	$375D_1+165D_2$
J	$220D_3$	$165D_3$
K	$660D_1+285(D_2+D_3)$	$570D_1+250(D_2+D_3)$
L	$350D_4$	$300D_4$

LEGEND

H = Wall Height of Normal Weight Fill (ft)

H_{LW} = Height of Lightweight Fill (ft)

Not to Scale

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

RETAINING WALLS 3 AND 4 LATERAL EARTH PRESSURES

September 2019 21-1-22406-003

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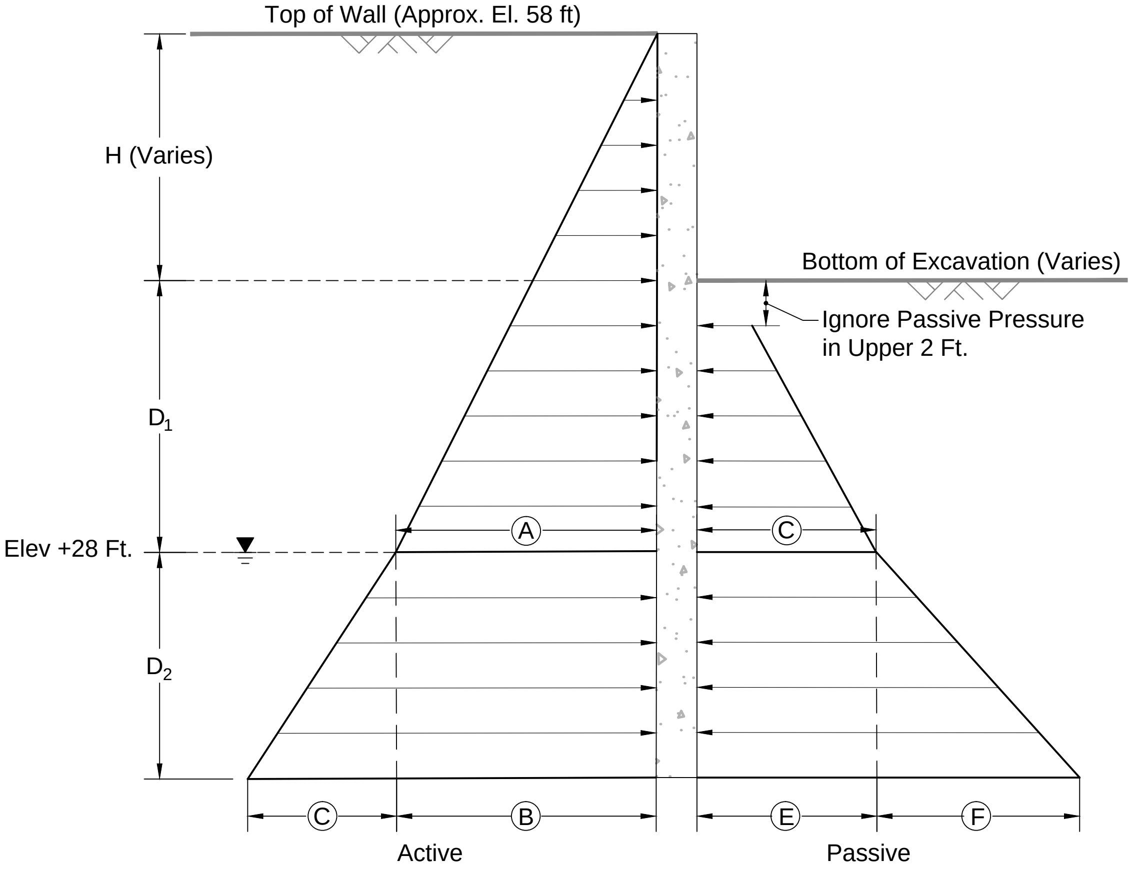
FIG. 8

Filename: J:\211\22406\003\21-1-22406-003 Fig 8 - LEP-Retaining Walls 3 and 4.dwg Layout: Layout Date: 09-06-2019 Login: sac



	Active	
	Static	Seismic
A	35(H+D_1)	51(H+D_1)
B	35(H+D_1)	-
C	18D_2	-

	Passive	
	Static	Seismic
D	430D_1	375D_1
E	430D_1	375D_1
F	210D_2	180D_2

NOTES

1. Pressures are in pounds per square foot (psf) per foot of wall. Earth pressures are for a continuous wall system.
2. All pressures are unfactored.
3. Above bottom of wall, active pressures are assumed to act over the pile spacing. Below grade, active pressures are assumed to act over the pile width.
4. Passive pressures act over the minimum of three times the pile diameter or the pile spacing. Passive pressure for the upper two feet should be ignored.
5. Seismic active earth pressures act over the exposed wall height, H, only. Static active pressures apply for depths D_1 and D_2.
6. Passive pressures are reduced for seismic loading as indicated.
7. Lateral earth pressures assume level ground conditions in front of and behind the wall.
8. Lateral earth pressures assume drained conditions behind the wall. See Figure 10 for drainage recommendations.

Not to Scale

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

RETAINING WALL 5
LATERAL EARTH PRESSURES

September 2019 21-1-22406-003

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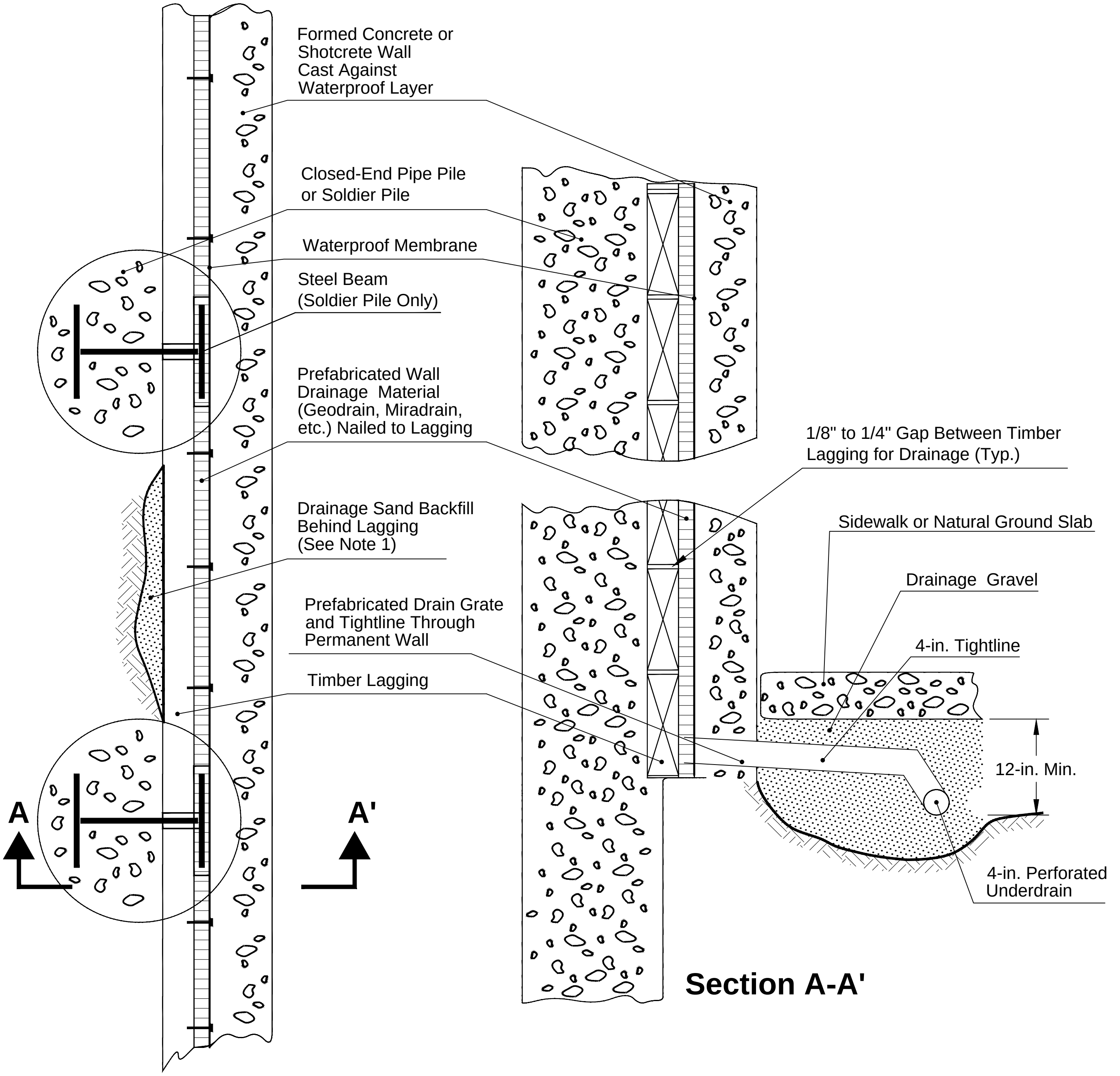
FIG. 9

Filename: J:\211\22406\003\21-1-22406-003 Fig 9 - LEP-Retaining Wall 5.dwg Layout: Layout Date: 09-06-2019 Login: sac



PLAN VIEW

Section A-A'

Not to Scale

NOTES

1. Drainage sand shall meet requirements of WSDOT Standard Specification 9-13.13(1) Sand Drainage Blanket.

2. Wall drainage material: Geodrain, Miradrain 6000 or equivalent drainage composite. Permeable geosynthetic face of drainage material placed against timber lagging.

3. Clean-outs should be provided in the underdrain system.

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

PILE AND LAGGING WALL DRAINAGE RECOMMENDATIONS

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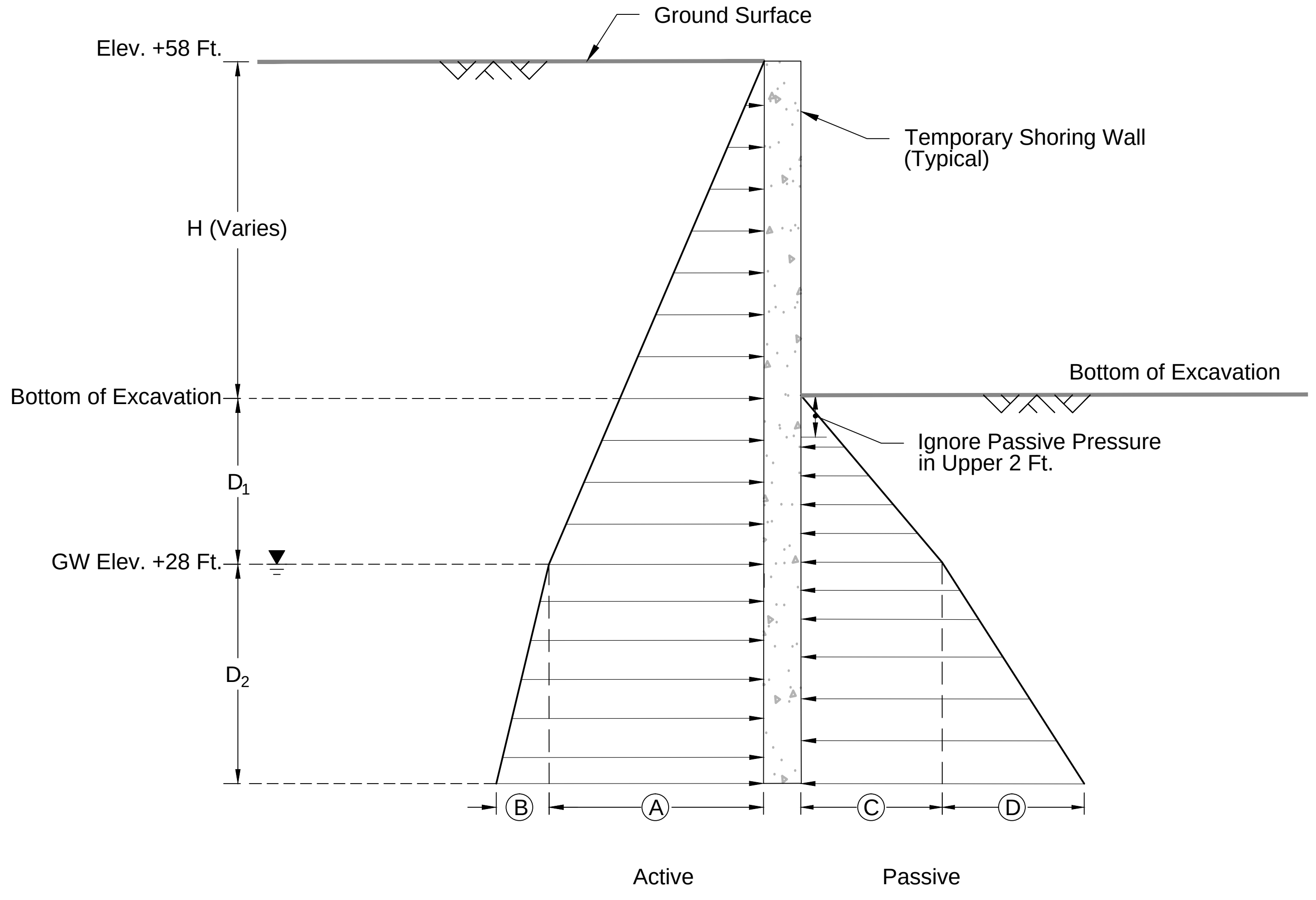
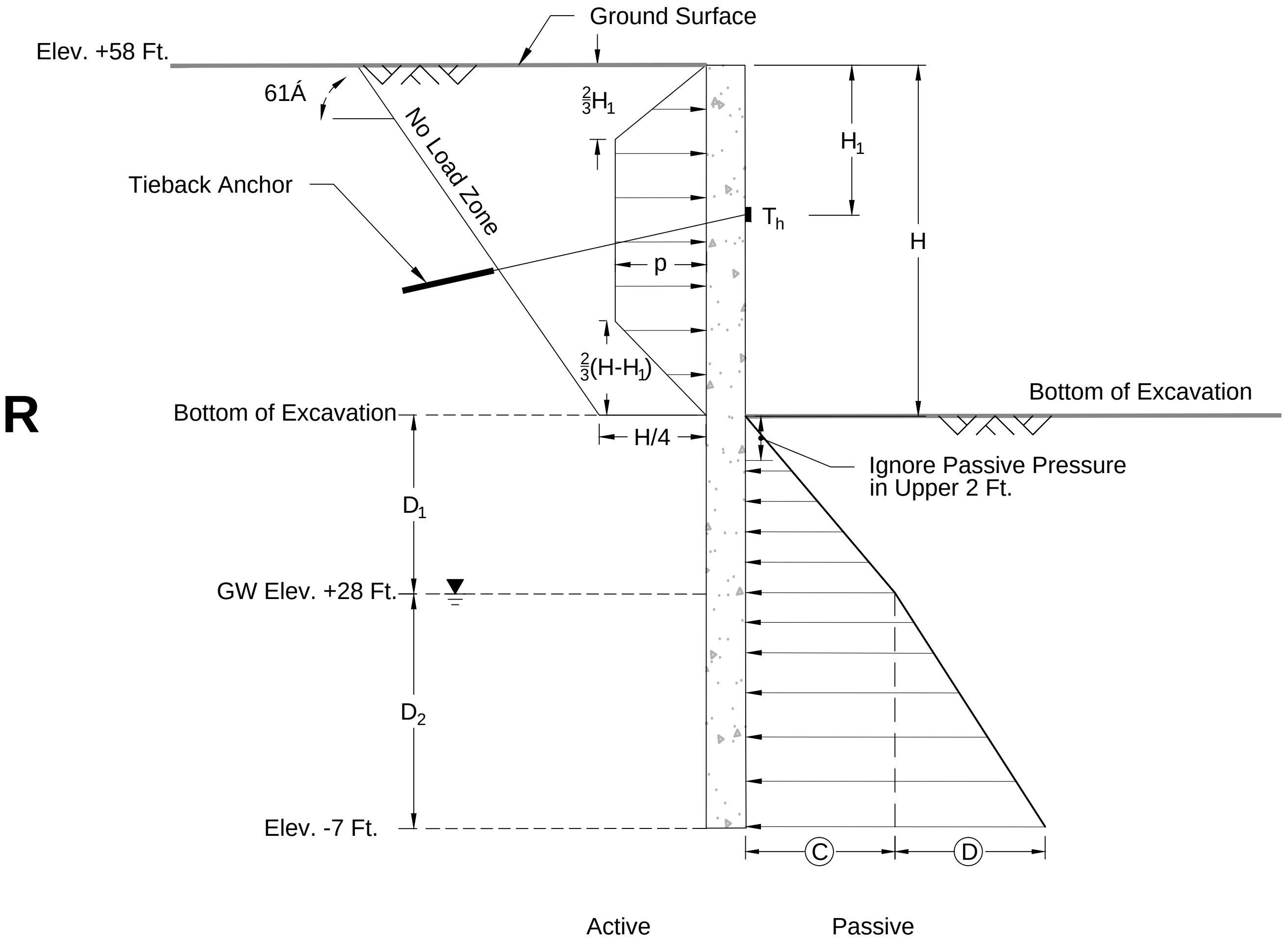
FIG. 10

CANTILEVER SHORING WALL



OR

SINGLE TIEBACK SHORING WALL



NOTES

1. Pressures are in pounds per square foot (psf) per foot of wall. Earth pressures are for a continuous wall system.
2. All pressures are unfactored.
3. Above bottom of wall, active pressures are assumed to act over the pile spacing. Below grade, active and at-rest pressures are assumed to act over the pile width.
4. Passive pressures act over the minimum of three times the pile diameter or the pile spacing.
5. Passive pressure for the upper two feet should be ignored.
6. Lateral earth pressures assume level ground conditions in front of and behind the wall.
7. See Figure 12 for recommended bond zone locations.
8. Lateral earth pressures assume drained conditions behind the wall.

Active	Static
A	$40(H+D_1)$
B	$17D_2$
p	40H

Passive	Static
C	$325D_1$
D	$140D_2$

LEGEND

H = Total Wall Height (ft)

H_1 = Distance from Ground Surface to Ground Anchor (ft)

T_h = Horizontal Load in Ground Anchor (kip/ft)

Not to Scale

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

TEMPORARY SHORING WALL LATERAL EARTH PRESSURES

September 2019 21-1-22406-003

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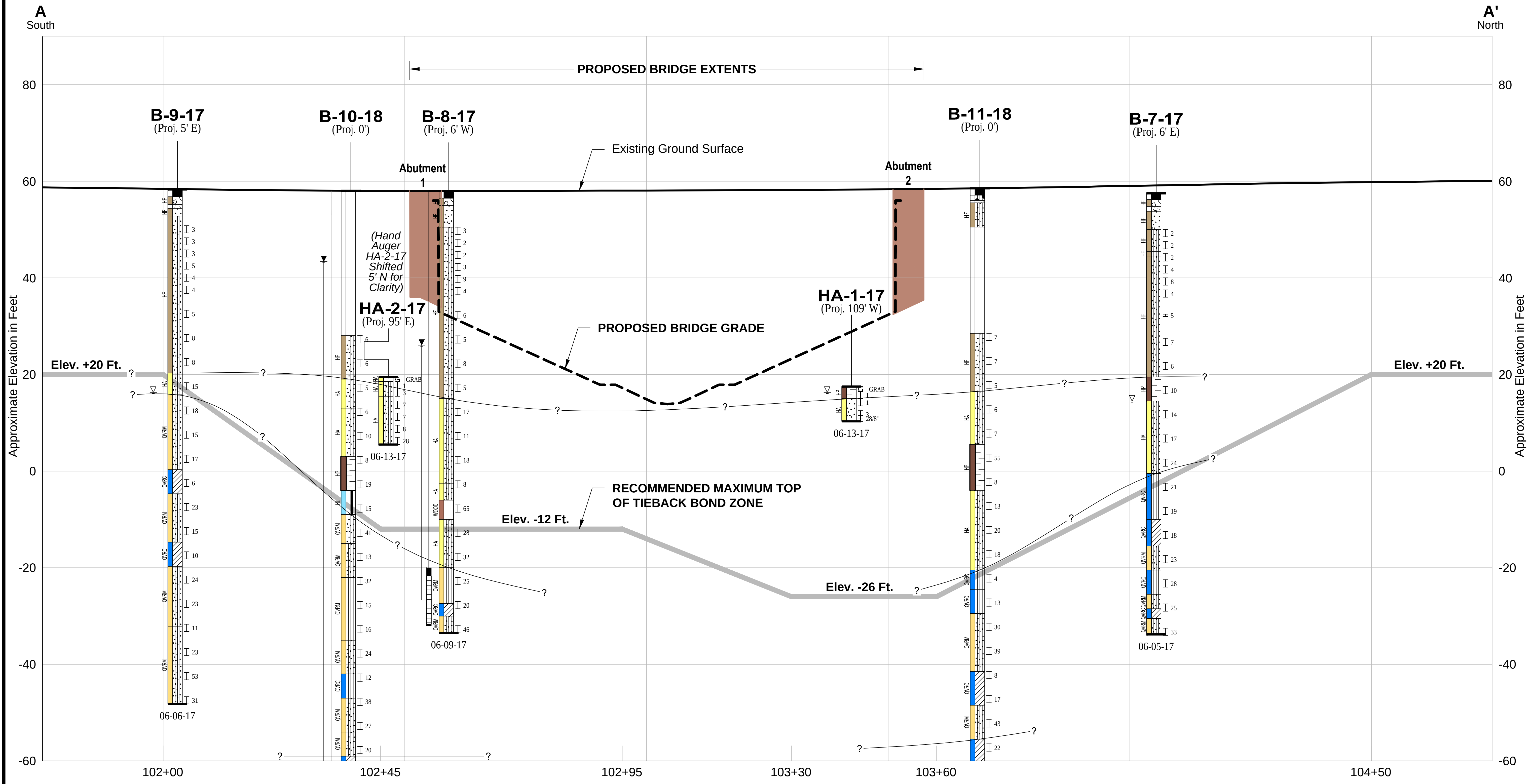
FIG. 11

Filename: J:\211\22406\003\21-1-22406-003 Fig 11 - LEP-Temp Shoring Wall.dwg Layout: Layout Date: 09-06-2019 Login: sac



0 20 40

Scale in Feet
Vertical = Horizontal

LEGEND

Elev. +20 Ft. ▬ Recommended Maximum Top of Tieback Bond Zone with Elevations in Feet

NOTE

Ground surface and structure locations based on client files received 6-21-18.

City of Marysville
State Avenue Corridor Widening Project
Marysville, Washington

RECOMMENDED TOP OF TIEBACK BOND ZONE ELEVATIONS

September 2019 21-1-22406-003

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FIG. 12

Filename: J:\211\22406\003\21-1-22406-003 Site and Profile_Version 2018.dwg Layout: FIG 12 Date: 09-06-2019 Login: sac

APPENDIX A: FIELD EXPLORATIONS

Appendix A

Field Explorations

CONTENTS

Figures

A.1 GENERAL

The subsurface exploration program consisted of drilling nine soil borings and installing four groundwater monitoring wells. The explorations were located based on our understanding of the Project.

A.2 GEOTECHNICAL BORINGS

Geotechnical borings, designated B-1-17 through B-9-17, B-10-18, and B-11-18, were drilled to evaluate subsurface conditions along the State Avenue Project alignment. The boring locations are shown in the Site and Exploration Plan, Figure 2, after the main report text. Borings B-1-17 through B-9-17 were completed between June 1 to 13, 2017. Borings B-10-18 and B-11-18 were completed between February 15 to 24, 2018. All drilling was completed by Holt Service, Inc. of Puyallup, Washington, using a full-size, rubber tire-mounted Mobile Drill B-59 drill rig. Holt advanced the geotechnical borings using a combination of hollow-stem auger and mud rotary drilling techniques. Hollow-stem auger drilling procedures were generally used above the groundwater table and used a 4-inch-diameter auger to advance the hole. Mud rotary drilling was generally used below the groundwater table and consists of using a drill bit to advance the boring. During mud rotary drilling, bentonite drilling mud is pumped to the bottom of the excavation, which circulates to the borehole surface, carrying the soil cuttings for collection and disposal. The presence of the drilling mud inside the borehole reduces the potential for heave from groundwater pressure at the base of the borehole and supports the borehole walls, minimizing soil caving or collapse during excavation. The spoils from drilling operations were collected in 55-gallon barrels and disposed of off site. After completion, boreholes were backfilled with bentonite chips.

A.3 GROUNDWATER MONITORING WELLS

As part of the investigation, groundwater monitoring wells were installed in borings B-1-17, B-2-17, B-4-17, B-8-17, and B-10-18 to evaluate groundwater conditions. The observation wells were constructed of new, commercially fabricated, threaded, flush-jointed, 2-inch-diameter, Schedule 40 polyvinyl chloride (PVC). The well screens consisted of new, commercially fabricated, threaded, 5- or 10-foot-long, flush-jointed, 2-inch-diameter, machine-slotted PVC. A 5-foot-long well screen was placed at the bottom of borings B-1-17, B-2-17, and B-4-17, 15 to 20 feet below ground surface. A 10-foot-long well screen was placed at the bottom of boring B-8-17, 80 to 90 feet below ground surface. A 15-foot-long well screen was placed at the bottom of boring B-10-18, 180 to 195 feet below ground surface. A silica sand filter pack was poured in the annular space between the boring wall and the well screen to about 2 to 3 feet above the screen. A minimum 2-foot-thick bentonite seal was placed in the annulus above the filter pack to within 3 feet of the ground surface.

The well was completed flush with the surrounding grade by placing an 8-inch-diameter, flush-mounted steel monument over the top of the borehole. The steel monument was set in place with quick-set concrete. The remaining portion of the borehole was filled with a bentonite/cement grout, bentonite grout, and bentonite pellets.

A.4 SOIL SAMPLING AND CLASSIFICATION

A representative from Shannon & Wilson was present throughout the field exploration to observe the drilling and sampling operations, retrieve representative soil samples for subsequent laboratory testing, and to prepare descriptive field logs of the explorations. Soil sample classifications were based on ASTM Designation: D2487-98, Standard Test Method for Classification of Soil for Engineering Purposes, and ASTM Designation: D2488-93, Standard Recommended Practice for Description of Soils (Visual-Manual Procedure) (ASTM, 2014a). The Unified Soil Classification System, as described in Figure A-1 of this appendix, was used to classify the material encountered. Figures A-2 through A-10 present our explorations logs.

Disturbed soil samples were obtained in conjunction with the Standard Penetration Test (SPT). SPTs were performed in general accordance with ASTM Designation: D1586, Test Method for Penetration Test and Split-Barrel Sampling of Soils (ASTM, 2014a and 2014b). SPTs were collected in all the borings at 2.5-foot intervals in the upper 20 feet and at 5-foot intervals thereafter. The SPT consists of driving a 2-inch outside-diameter split-spoon sampler a total distance of 18 inches below the bottom of the drill hole with a 140-pound hammer falling 30 inches. The number of blows required to advance the split spoon from 6 to 18 inches of penetration is termed the Standard Penetration Resistance (N-value). This value is an empirical parameter that provides a means for evaluating the relative density, or compactness, of granular soils and the consistency, or stiffness, of cohesive soils. The terminology used to describe the relative density or consistency of the soil is presented in Figure A-1. The N-values are plotted at the appropriate depths on the boring logs presented in this appendix.

The split-spoon sampler used during the penetration testing recovers a disturbed sample of the soil, which is useful for identification and classification purposes. The samples were classified and recorded in field logs by our representatives. The samples were then sealed in jars and returned to our laboratory for testing.

A.5 REFERENCES

ASTM International (ASTM), 2014a, Annual book of standards, construction, v. 4.08, soil and rock (I): D420 - D5876: West Conshohocken, Penn., ASTM International, 1 v.

ASTM International (ASTM), 2014b, Standard practices for preserving and transporting soil samples, D4220-14: West Conshohocken, Pa., ASTM International, Annual book of standards, v. 04.08, soil and rock (I): D420 - D5876, 9 p., available: www.astm.org.

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

S&W INORGANIC SOIL CONSTITUENT DEFINITIONS

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

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

MOISTURE CONTENT TERMS

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

STANDARD PENETRATION TEST (SPT) SPECIFICATIONS

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

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

PARTICLE SIZE DEFINITIONS

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

RELATIVE DENSITY / CONSISTENCY

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

WELL AND BACKFILL SYMBOLS

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

PERCENTAGES TERMS [1, 2]

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

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

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

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

SOIL DESCRIPTION AND LOG KEY

September 2018 21-1-22406-003

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FIG. A-1
Sheet 1 of 3

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

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

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

NOTES

1. Dual symbols *(symbols separated by a hyphen, i.e., SP-SM, Sand with Silt)* are used for soils with between 5% and 12% fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart. Graphics shown on the logs for these soil types are a combination of the two graphic symbols (e.g., SP and SM).
2. Borderline symbols *(symbols separated by a slash, i.e., CL/ML, Lean Clay to Silt; SP-SM/SM, Sand with Silt to Silty Sand)* indicate that the soil properties are close to the defining boundary between two groups.

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

SOIL DESCRIPTION AND LOG KEY

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FIG. A-1
Sheet 2 of 3

SOIL_CLASS_KEY_PG2 21-22406.GPJ SHAN_WIL.GDT 9/6/18

GRADATION TERMS

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

CEMENTATION TERMS[1]

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

PLASTICITY[2]

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

ADDITIONAL TERMS

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

PARTICLE ANGULARITY AND SHAPE TERMS[1]

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

ACRONYMS AND ABBREVIATIONS

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

STRUCTURE TERMS[1]

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

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

SOIL DESCRIPTION AND LOG KEY

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FIG. A-1
Sheet 3 of 3

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

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

Total Depth: 21.5 ft.
Top Elevation: 69.7 ft.
Vert. Datum: NAVD88
Horiz. Datum: WASP N

Northing: 403,071 ft.
Easting: 1,312,779 ft.
Station: -
Offset: -

Drilling Method: Hollow Stem Auger
Drilling Company: Holt
Drill Rig Equipment: Truck
Other Comments:

Hole Diam.: 8 in.
Rod Diam.: NWJ
Hammer Type: Automatic

SOIL DESCRIPTION

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

Asphalt.

Concrete.

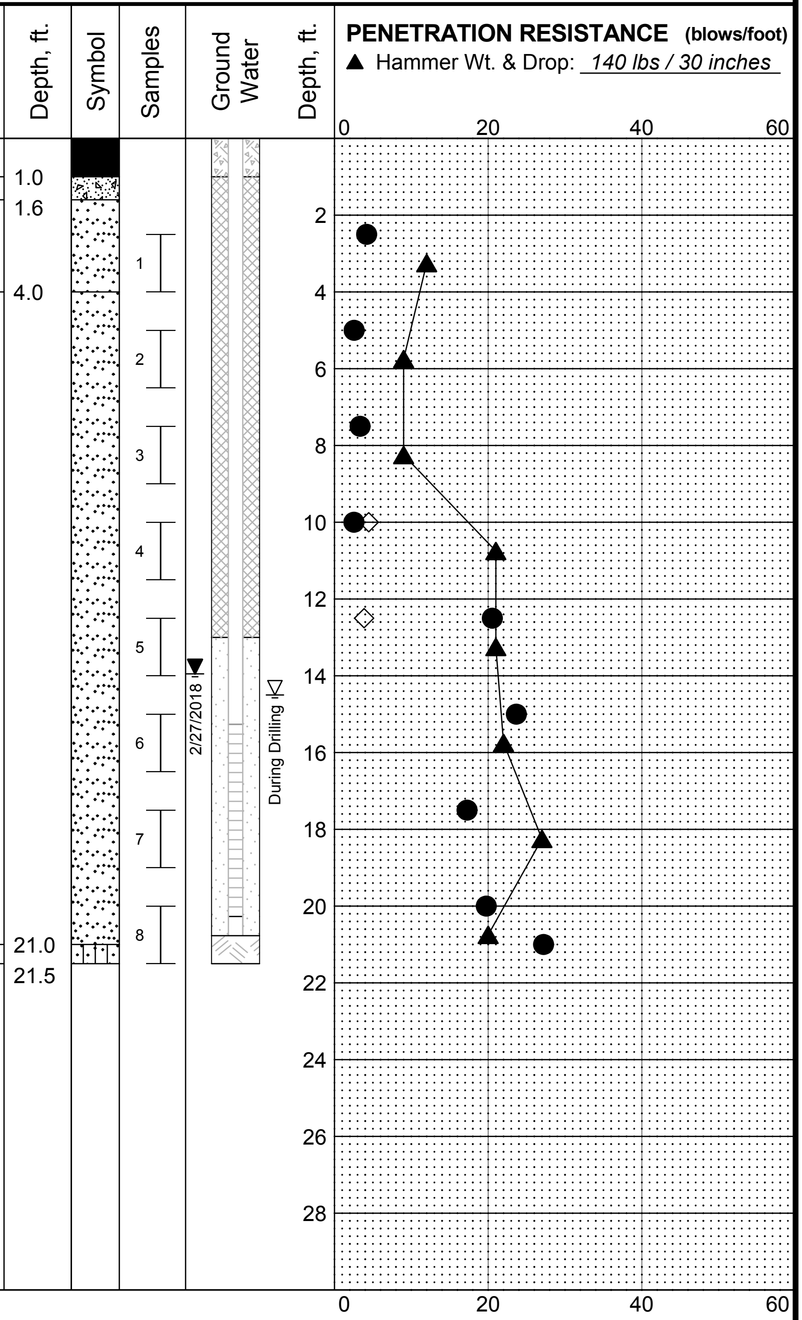
Loose, brown, *Poorly Graded Sand (SP)*; moist; mostly fine to medium sand; trace coarse sand.
Fill (Hf)

Loose to medium dense, brown, *Poorly Graded Sand (SP)* to *Poorly Graded Sand with Silt (SP-SM)*; moist; trace to little subrounded gravel locally; mostly fine to medium sand; trace coarse sand.
Recessional Outwash, Marysville Sand Member (Qvrm)

- 2-inch-thick silty fine sand to sandy silt interbed at 13 feet.
- Becomes wet, gray below 14.5 feet.

Medium dense, brown, *Silty Sand (SM)*; wet; very fine to fine sand; trace lenses of sandy silt.
Recessional Outwash, Marysville Sand Member (Qvrm)

BOTTOM OF BORING
COMPLETED 6/2/2017



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

LEGEND

* Sample Not Recovered
Ⲓ 2.0" O.D. Split Spoon Sample

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

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

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

LOG OF BORING B-1-17

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FIG. A-2

MASTER_LOG_E 21-22406.GPJ SHAN_WIL.GDT 9/6/18 Log: BMC Rev: SDN Typ: LKN

REV 3 - Approved for Submittal

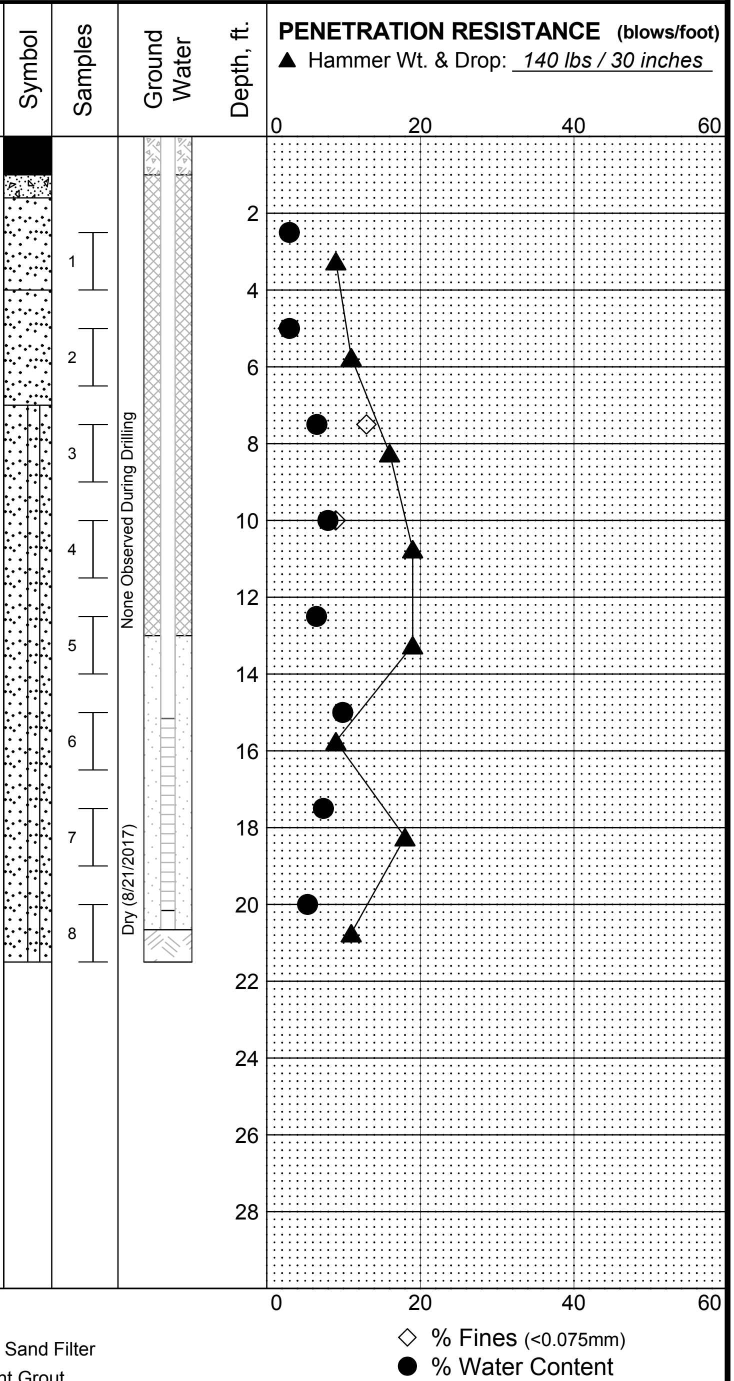
Total Depth:	*21.5 ft.*	Northing:	*401,098 ft.*	Drilling Method:	*Hollow Stem Auger*	Hole Diam.:	*8 in.*
Top Elevation:	*63.9 ft.*	Easting:	*1,312,951 ft.*	Drilling Company:	*Holt*	Rod Diam.:	*NWJ*
Vert. Datum:	*NAVD88*	Station:	*-*	Drill Rig Equipment:	*Truck*	Hammer Type:	*Automatic*
Horiz. Datum:	*WASP N*	Offset:	*-*	Other Comments:			

SOIL DESCRIPTION

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

SOIL DESCRIPTION	Depth, ft.
Asphalt.	1.0
Concrete.	1.6
Loose, brown, *Poorly Graded Sand (SP)*; moist; mostly fine to medium sand; trace coarse sand. Fill (Hf)	4.0
Loose to medium dense, gray-brown, *Poorly Graded Sand (SP)*; moist; mostly fine to medium sand; trace coarse sand. Recessional Outwash, Marysville Sand Member (Qvrm)	7.0
Medium dense, brown to yellow-brown, *Poorly Graded Sand with Silt (SP-SM)* to *Silty Sand (SM)*; moist; trace fine gravel; fine to medium sand; iron-oxide staining locally. Recessional Outwash, Marysville Sand Member (Qvrm) - 4-inch bed of silty sand from 8 to 8.3 feet. - Silty very fine sand from 16 to 18.5 feet.	21.5

BOTTOM OF BORING
COMPLETED 6/2/2017



LEGEND

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

NOTES

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

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

LOG OF BORING B-2-17

September 2017 21-1-22406-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

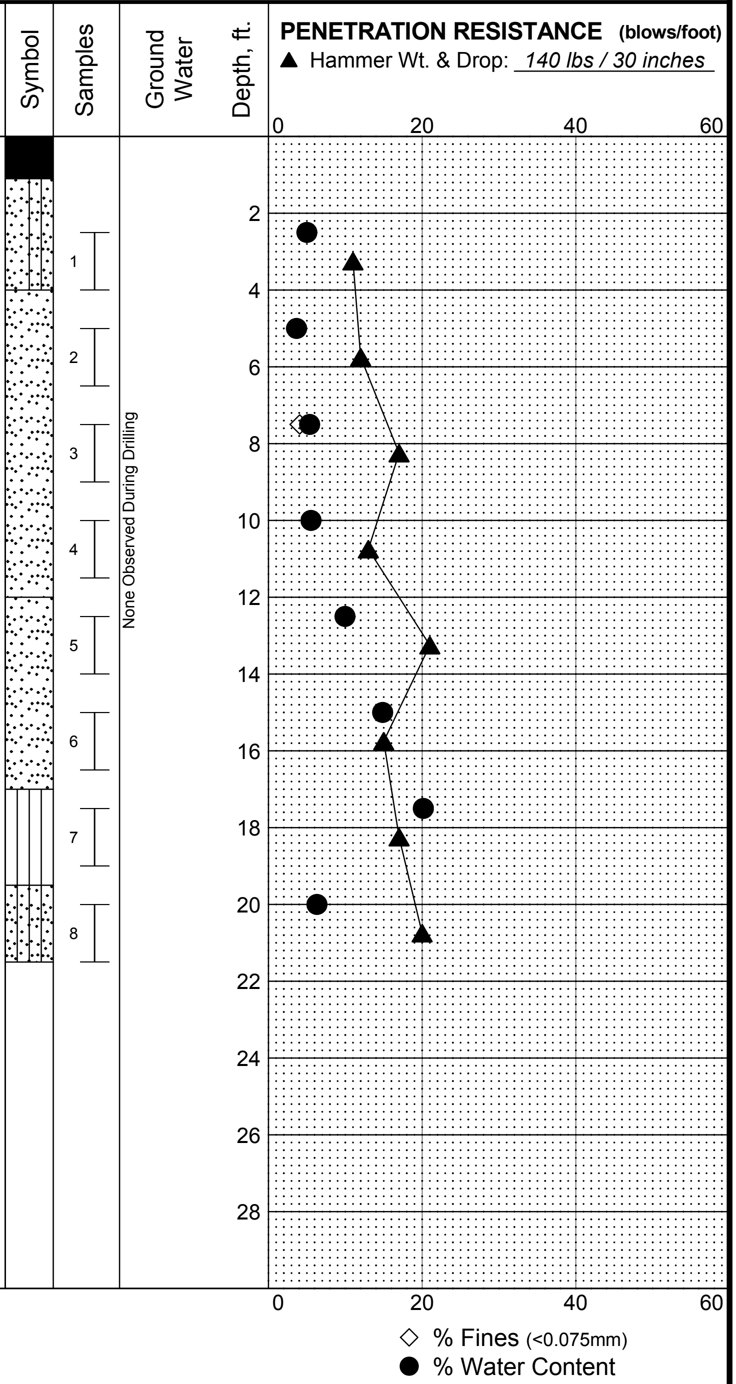
FIG. A-3

REV 3 - Approved for Submittal

Total Depth: 21.5 ft.
Top Elevation: 61.8 ft.
Vert. Datum: NAVD88
Horiz. Datum: WASP N
Northing: 400,024 ft.
Easting: 1,312,860 ft.
Station: -
Offset: -
Drilling Method: Hollow Stem Auger
Drilling Company: Holt
Drill Rig Equipment: Truck
Other Comments:
Hole Diam.: 8 in.
Rod Diam.: NWJ
Hammer Type: Automatic

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.
Asphalt.	1.1
Medium dense, yellow-brown, *Poorly Graded Sand with Silt (SP-SM)* to *Silty Sand (SM)*; moist; trace fine gravel; fine to medium sand; trace coarse sand. Fill (Hf)	4.0
Medium dense, brown, *Poorly Graded Sand (SP)* to *Poorly Graded Sand with Silt (SP-SM)*; moist; trace fine gravel; trace coarse sand; fine to medium sand; trace iron-oxide staining. Recessional Outwash, Marysville Sand Member (Qvrm)	12.0
Medium dense, brown, interbedded *Silty Sand (SM)* and *Sandy Silt (ML)*; moist; fine to medium sand; iron-oxide staining locally. Recessional Outwash, Marysville Sand Member (Qvrm)	17.0
Very stiff, brown, *Silt (ML)*; moist; trace fine sand; laminated. Recessional Outwash, Marysville Sand Member (Qvrm)	19.5
Medium dense, brown, *Silty Sand (SM)*; moist; fine sand; trace iron-oxide staining. Recessional Outwash, Marysville Sand Member (Qvrm)	21.5

BOTTOM OF BORING
COMPLETED 6/2/17



LEGEND
* Sample Not Recovered
⌶ 2.0" O.D. Split Spoon Sample

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

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

LOG OF BORING B-3-17

September 2017
21-1-22406-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-4

REV 3 - Approved for Submittal

Log: BMC/SAM Rev: SDN Typ: AYA

MASTER_LOG_E 21-22406.GPJ SHAN_WIL.GDT 9/6/18

Total Depth: *21.5 ft.*
Top Elevation: *51.5 ft.*
Vert. Datum: *NAVD88*
Horiz. Datum: *WASP N*
Northing: *399,277 ft.*
Easting: *1,312,730 ft.*
Station: *-*
Offset: *-*
Drilling Method: *Hollow Stem Auger*
Drilling Company: *Holt*
Drill Rig Equipment: *Truck*
Other Comments:
Hole Diam.: *8 in.*
Rod Diam.: *NWJ*
Hammer Type: *Automatic*

SOIL DESCRIPTION

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

Depth, ft.

Topsoil. 0.5

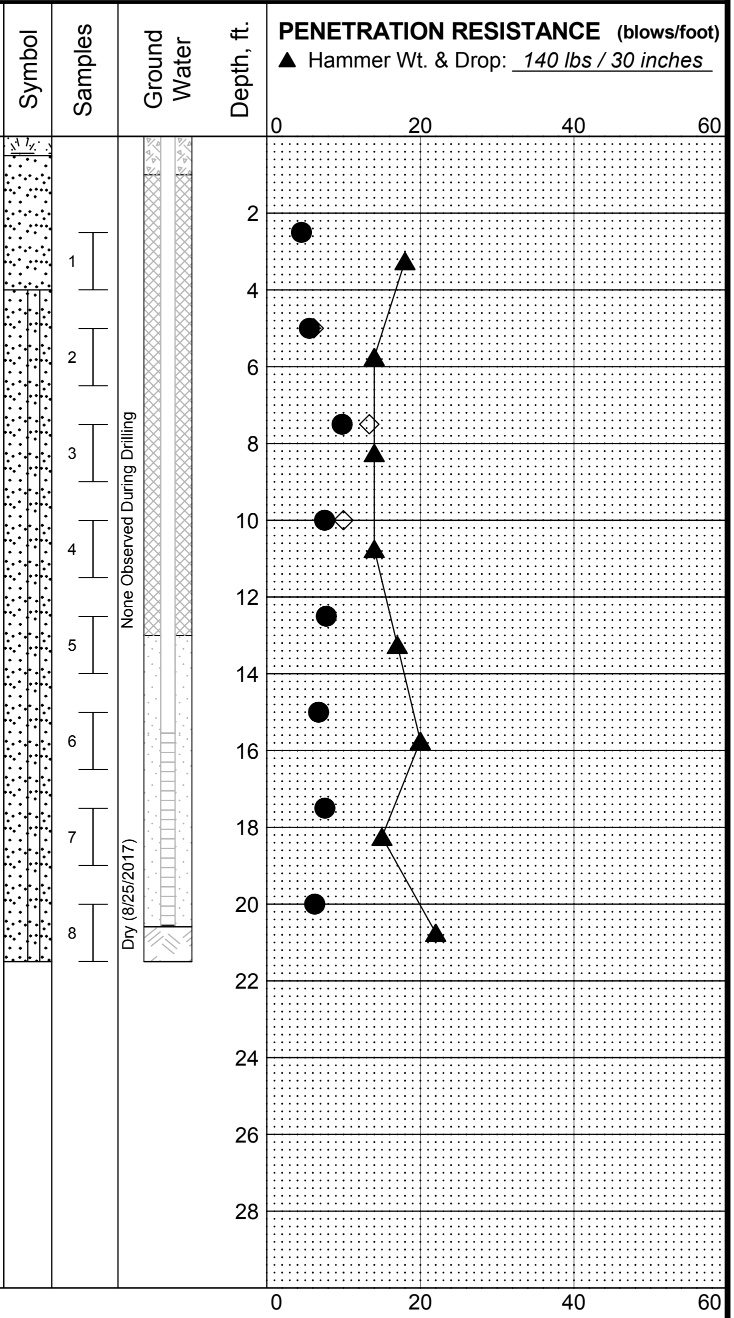
Medium dense, gray-brown, *Poorly Graded Sand (SP)* to *Poorly Graded Sand with Silt (SP-SM)*; moist; trace fine gravel; fine to medium sand.
Fill (Hf)
- Trace fine gravel and coarse sand at 2.5 feet.

4.0

Medium dense, gray-brown, *Poorly Graded Sand with Silt (SP-SM)* to *Silty Sand (SM)*; moist; fine to medium sand.
Recessional Outwash, Marysville Sand Member (Qvrm)
- 0.5 inch-thick bed of laminated silt at 8.4 feet.
- 0.25 inch-thick bed of sandy silt at 13.0 feet.

21.5

BOTTOM OF BORING
COMPLETED 6/1/2017



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

LEGEND

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

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

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

LOG OF BORING B-4-17

September 2017 21-1-22406-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

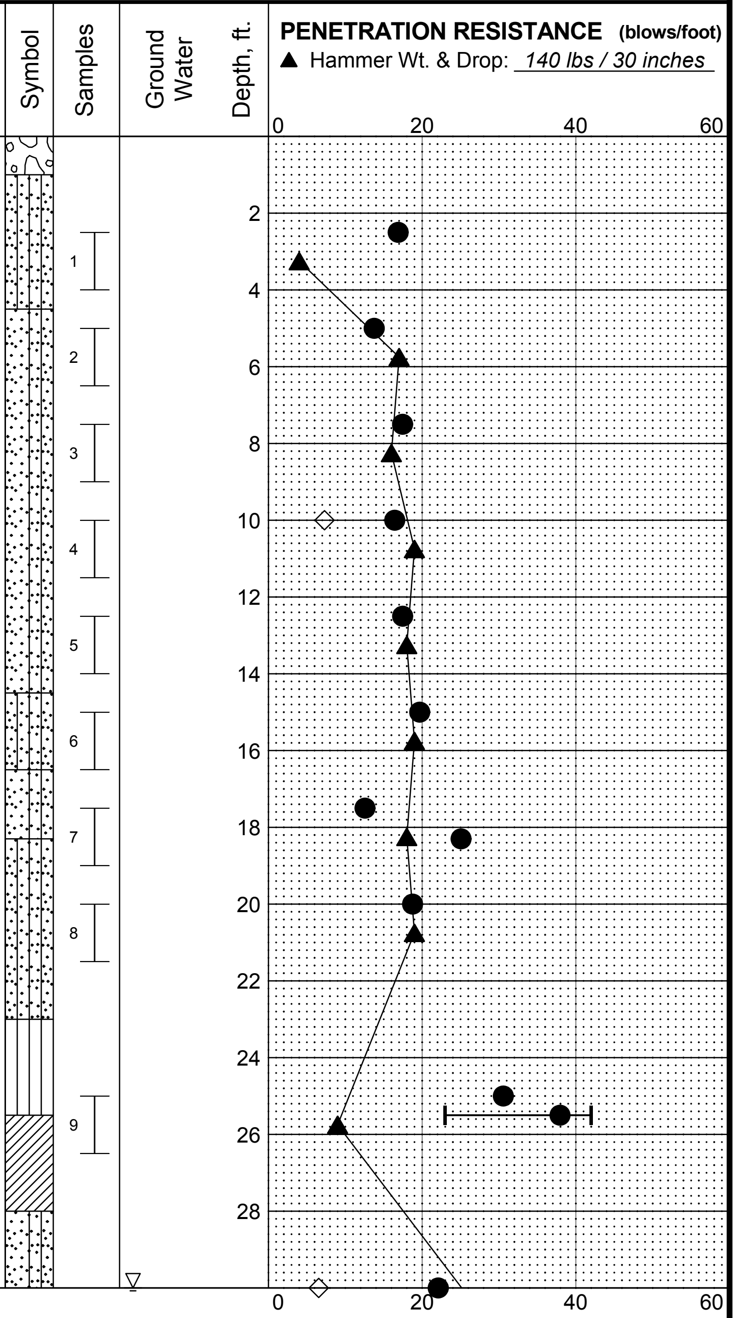
FIG. A-5

MASTER_LOG_E 21-22406.GPJ SHAN_WIL.GDT 9/6/18 Log: BMC/SAW Rev: SDN Typ: LKN

REV 3 - Approved for Submittal

Total Depth:	*111.8 ft.*	Northing:	*399,445 ft.*	Drilling Method:	*Mud Rotary*	Hole Diam.:	*8 in.*
Top Elevation:	*54.6 ft.*	Easting:	*1,312,871 ft.*	Drilling Company:	*Holt*	Rod Diam.:	*NWJ*
Vert. Datum:	*NAVD88*	Station:	*-*	Drill Rig Equipment:	*Truck*	Hammer Type:	*Automatic*
Horiz. Datum:	*WASP N*	Offset:	*-*	Other Comments:			

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.
Poorly Graded Gravel with Sand (GP); moist; subangular to subrounded gravel; fine to coarse sand. Fill (Hf)	1.0
Loose, brown, *Silty Sand (SM)*; moist; trace coarse sand; fine to medium sand. Fill (Hf)	4.5
Medium dense, brown, *Poorly Graded Sand with Silt (SP-SM)*; moist; trace fine gravel; trace coarse sand; fine to medium sand; laminated locally. Recessional Outwash, Marysville Sand Member (Qvrm)	
Medium dense, brown, interbedded, *Silty Sand (SM)* and *Sandy Silt (ML)*; moist; fine to medium sand; iron-oxide staining locally. Recessional Outwash, Marysville Sand Member (Qvrm)	14.5 16.5
Medium dense, gray-brown, *Poorly Graded Sand with Silt (SP-SM)*; moist; fine to medium sand; iron-oxide staining. Recessional Outwash, Marysville Sand Member (Qvrm)	18.3
Medium dense, brown, interbedded, *Silty Sand (SM)* and *Silt with Sand (ML)*; moist; fine sand; iron-oxide staining locally. Recessional Outwash, Marysville Sand Member (Qvrm)	23.0 25.5
Stiff, brown, *Silt (ML)*; moist; trace to little fine sand partings and lenses; iron-oxide staining. Recessional Outwash, Clay Member (Qvrc)	28.0



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered

⌶ 2.0" O.D. Split Spoon Sample

∇ Ground Water Level ATD

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit

Natural Water Content

NOTES

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

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

LOG OF BORING B-5-17

September 2017 21-1-22406-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-6
Sheet 1 of 4

Log: BMC Rev: SDN Typ: LKN

MASTER_LOG_E 21-22406.GPJ SHAN_WIL.GDT 9/6/18

REV 3 - Approved for Submittal

Total Depth: 111.8 ft.
Northing: 399,445 ft.
Drilling Method: Mud Rotary
Hole Diam.: 8 in.
Top Elevation: 54.6 ft.
Easting: 1,312,871 ft.
Drilling Company: Holt
Rod Diam.: NWJ
Vert. Datum: NAVD88
Station: -
Drill Rig Equipment: Truck
Hammer Type: Automatic
Horiz. Datum: WASP N
Offset: -
Other Comments:

SOIL DESCRIPTION

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

Stiff, brown, *Lean Clay (CL)*; moist; trace lenses and partings of fine sand; iron-oxide staining along laminations.
Recessional Outwash, Clay Member (Qvrc)

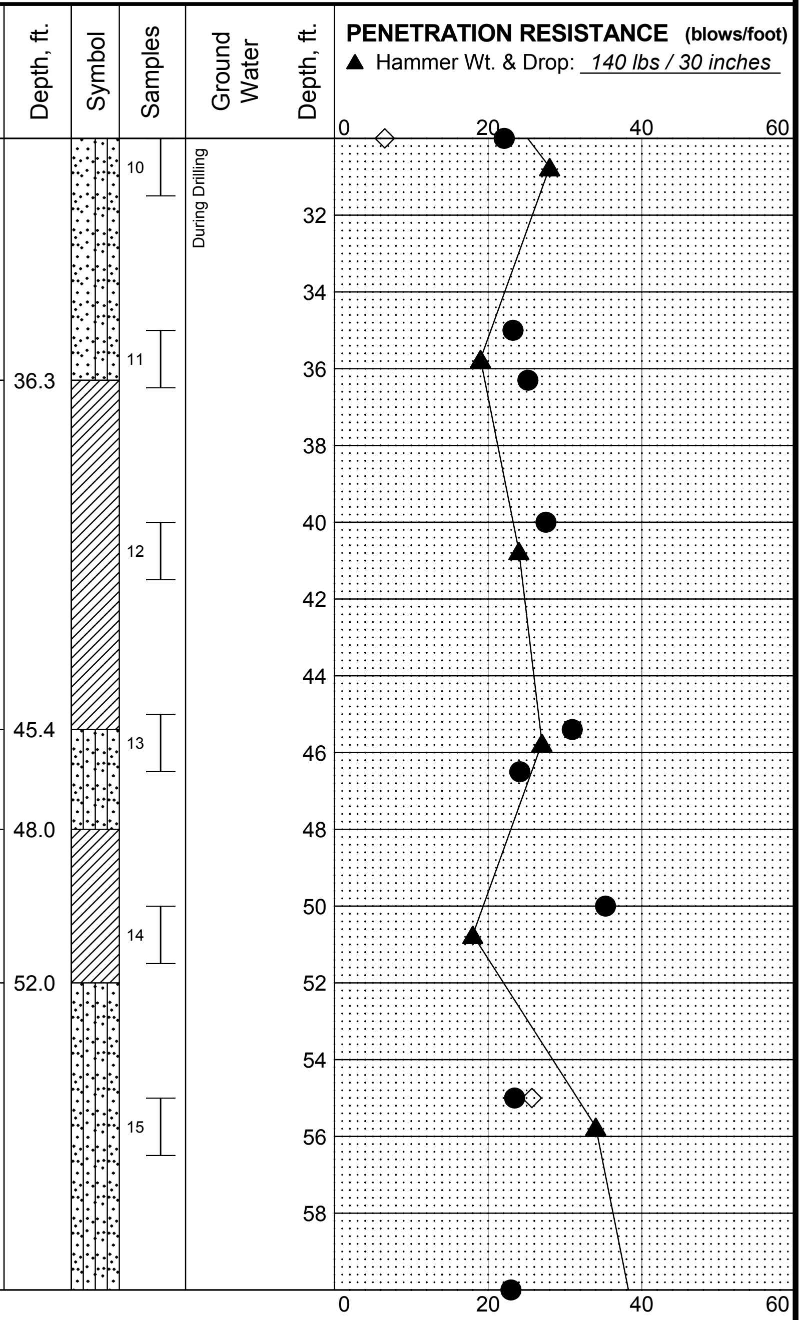
Medium dense, brown, *Poorly Graded Sand with Silt (SP-SM)* to *Silty Sand (SM)*; moist to wet; silt and sand laminations locally; trace of iron-oxide staining.
Recessional Outwash, Marysville Sand Member (Qvrm)

Very stiff, brown, interbedded, *Lean Clay with Sand (CL)*, *Silty Sand (SM)* and *Sandy Silt (ML)*; wet; fine to medium sand; laminated; iron-oxide staining along laminae.
Recessional Outwash, Clay Member (Qvrc)/Marysville Sand Member (Qvrm)

Medium dense, brown, *Silty Sand (SM)*; wet; fine sand; iron-oxide staining throughout; laminated locally.
Recessional Outwash, Clay Member (Qvrc)

Very stiff, brown, interbedded, *Lean Clay (CL)* and *Sandy Silt (ML)*; wet; little laminations of fine sand; iron-oxide staining along laminae.
Recessional Outwash, Clay Member (Qvrc)

Dense, brown *Silty Sand (SM)*; wet; fine to medium sand; lenses of silt; laminated silt and sand; strong bands of iron-oxide staining at 53.9 and 61 feet.
Recessional Outwash, Marysville Sand Member (Qvrm)



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
⊻ Ground Water Level ATD
⌶ 2.0" O.D. Split Spoon Sample

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

NOTES

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

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

LOG OF BORING B-5-17

September 2017
21-1-22406-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-6
Sheet 2 of 4

REV 3 - Approved for Submittal

Log: BMC Rev: SDN Typ: LKN

MASTER_LOG_E 21-22406.GPJ SHAN_WIL.GDT 9/6/18

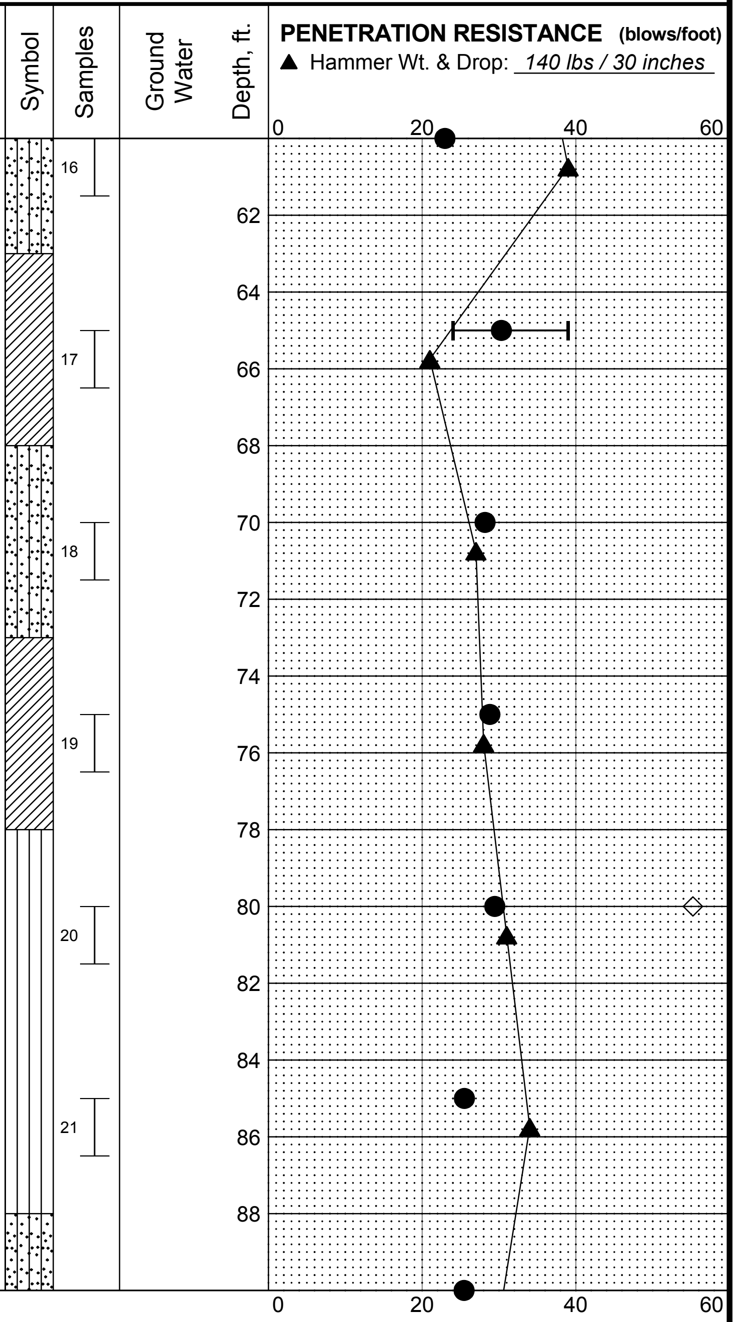
Total Depth: 111.8 ft.
Top Elevation: 54.6 ft.
Vert. Datum: NAVD88
Horiz. Datum: WASP N

Northing: 399,445 ft.
Easting: 1,312,871 ft.
Station: -
Offset: -

Drilling Method: Mud Rotary
Drilling Company: Holt
Drill Rig Equipment: Truck
Other Comments:

Hole Diam.: 8 in.
Rod Diam.: NWJ
Hammer Type: Automatic

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.
	63.0
Very stiff, gray, *Lean Clay (CL)*; moist to wet; few partings and beds up to 1/4-inch-thick of silty sand and sandy silt; laminated. Recessional Outwash, Clay Member (Qvrc)	68.0
Medium dense, gray, *Silty Sand (SM)*; wet; very fine sand; strong iron-oxide staining from 70.8 to 71 feet. Recessional Outwash, Marysville Sand Member (Qvrm)	73.0
Interbedded, gray, very stiff, *Lean Clay (CL)* and medium dense, gray, *Silty Sand (SM)* and *Sandy Silt (ML)*; wet; very fine sand. Recessional Outwash, Clay Member (Qvrc)	78.0
Dense, gray, *Sandy Silt (ML)* to *Silty Sand (SM)*; wet; very fine to fine sand; dilatant. Recessional Outwash, Marysville Sand Member (Qvrm)	88.0
Interbedded, dense, gray, *Silty Sand (SM)* and very stiff, gray, *Sandy Silt (ML)*; wet; fine sand;	



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
⌶ 2.0" O.D. Split Spoon Sample
⊻ Ground Water Level ATD

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

NOTES

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

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

LOG OF BORING B-5-17

September 2017
21-1-22406-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-6
Sheet 3 of 4

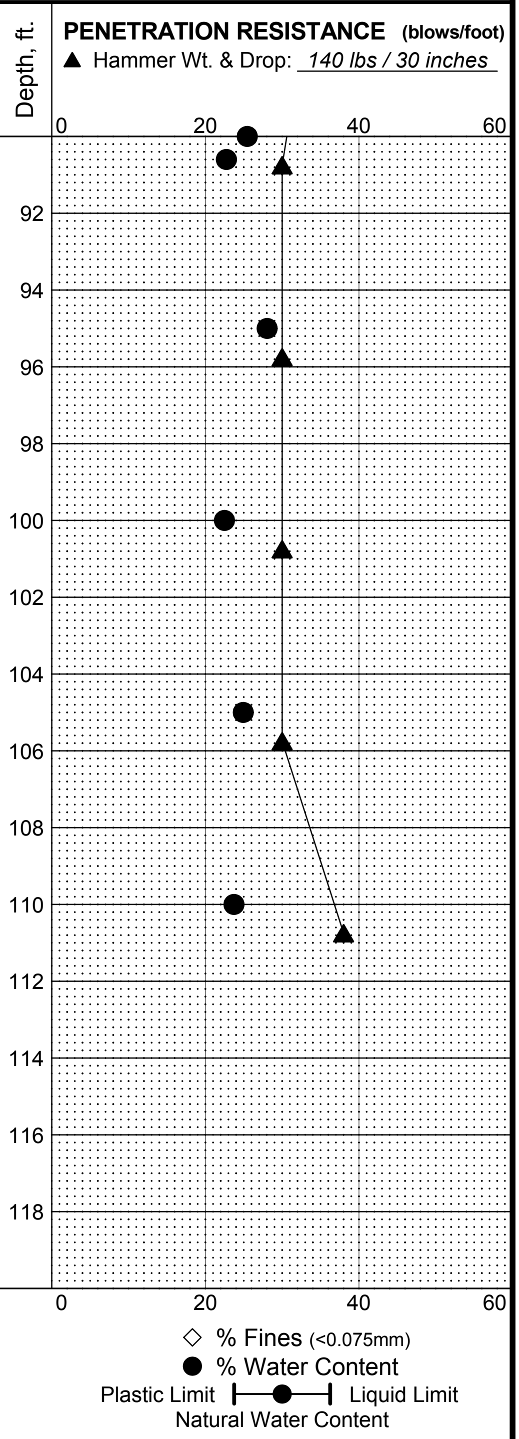
REV 3 - Approved for Submittal

Total Depth:	111.8 ft.	Northing:	399,445 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	8 in.
Top Elevation:	54.6 ft.	Easting:	1,312,871 ft.	Drilling Company:	Holt	Rod Diam.:	NWJ
Vert. Datum:	NAVD88	Station:	-	Drill Rig Equipment:	Truck	Hammer Type:	Automatic
Horiz. Datum:	WASP N	Offset:	-	Other Comments:			

SOIL DESCRIPTION

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

SOIL DESCRIPTION	Depth, ft.	Samples
dilatant. Recessional Outwash, Marysville Sand Member (Qvrm)		22
Very stiff, gray, *Silt (ML)*, *Sandy Silt (ML)* and *Lean Clay (CL)*; moist; trace very fine sand partings; laminated; clayey locally. Recessional Outwash, Clay Member (Qvrc)	93.0	23 24
Dense, gray, *Silty Sand (SM)*; wet; very fine to fine sand; dilatant. Recessional Outwash, Marysville Sand Member (Qvrm)	103.0	25
Interbedded, hard, gray, *Lean Clay (CL)*, *Sandy Silt (ML)*, and dense, gray, *Silty Sand (SM)*; moist to wet. Recessional Outwash, Clay Member (Qvrc)/Marysville Sand Member (Qvrm)	108.0	26
BOTTOM OF BORING COMPLETED 6/7/2017	111.8	



LEGEND

* Sample Not Recovered

⌶ 2.0" O.D. Split Spoon Sample

∇ Ground Water Level ATD

NOTES

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

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

LOG OF BORING B-5-17

September 2017 21-1-22406-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-6
Sheet 4 of 4

REV 3 - Approved for Submittal

Total Depth: 106 ft.
Top Elevation: 59.9 ft.
Vert. Datum: NAVD88
Horiz. Datum: WASP N

Northing: 399,404 ft.
Easting: 1,312,953 ft.
Station: -
Offset: -

Drilling Method: Mud Rotary
Drilling Company: Holt
Drill Rig Equipment: Truck
Other Comments:

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

SOIL DESCRIPTION

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

Asphalt.

1.2

Concrete slab.

1.9

Medium dense, gray-brown, *Poorly Graded Sand (SP)* to *Poorly Graded Sand with Silt (SP-SM)*; moist to wet; fine to medium sand; trace organics; iron-oxide staining locally.
Fill (Hf)

23.0

Medium dense, gray-brown, *Silty Sand with Gravel (SM)*; moist; fine gravel; fine to coarse sand; trace iron-oxide staining.
Recessional Outwash, Marysville Sand Member (Qvrm)

28.0

Medium dense, brown, *Silty Sand (SM)*; moist to wet; fine to medium sand; trace iron-oxide

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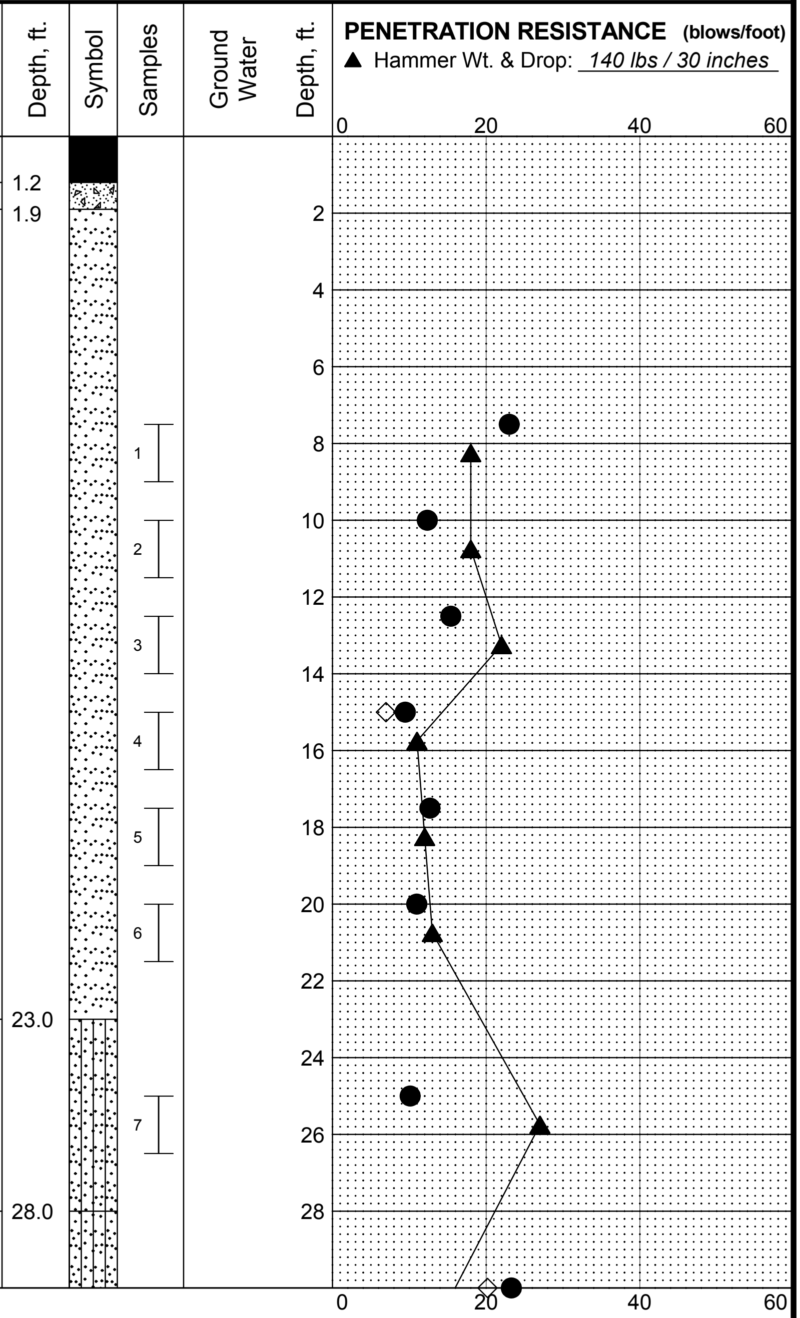

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
⌶ 2.0" O.D. Split Spoon Sample
⊻ Ground Water Level ATD

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
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City of Marysville
State Avenue Corridor Widening
Marysville, Washington

LOG OF BORING B-6-17

September 2017
21-1-22406-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-7
Sheet 1 of 4

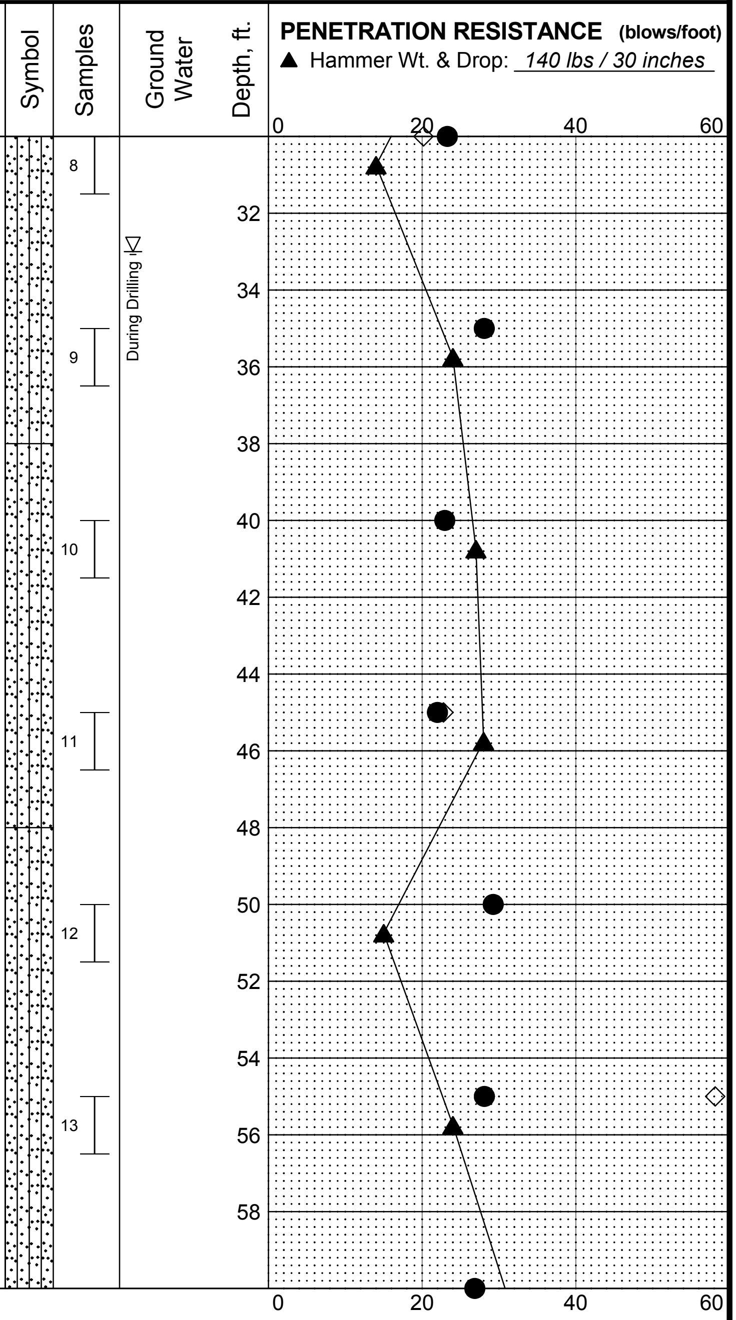
REV 3 - Approved for Submittal

Total Depth: 106 ft.
Top Elevation: 59.9 ft.
Vert. Datum: NAVD88
Horiz. Datum: WASP N
Northing: 399,404 ft.
Easting: 1,312,953 ft.
Station: -
Offset: -
Drilling Method: Mud Rotary
Drilling Company: Holt
Drill Rig Equipment: Truck
Other Comments:
Hole Diam.: 6 in.
Rod Diam.: NWJ
Hammer Type: Automatic

SOIL DESCRIPTION

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

SOIL DESCRIPTION	Depth, ft.
staining; trace bed of tan clay. Recessional Outwash, Marysville Sand Member (Qvrm) - Two 1/4-inch-thick silt interbeds at 35 and 35.2 feet.	
Medium dense, brown, *Silty Sand (SM)* to *Poorly Graded Sand with Silt (SP-SM)*; wet; trace coarse sand; fine to medium sand; iron-oxide staining locally. Recessional Outwash, Marysville Sand Member (Qvrm)	38.0
Medium dense, brown, interbedded *Silty Sand (SM)*, very stiff *Sandy Silt (ML)* and *Lean Clay (CL)*; wet; fine to medium sand; laminations and interbeds up to 6-inch-thick; iron-oxide staining in sand beds. Recessional Outwash, Clay Member (Qvrc)/Marysville Sand Member (Qvrm)	48.0



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
⌶ 2.0" O.D. Split Spoon Sample
⊻ Ground Water Level ATD

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

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

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

LOG OF BORING B-6-17

September 2017 21-1-22406-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-7
Sheet 2 of 4

REV 3 - Approved for Submittal

Log: BMC Rev: SDN Typ: LKN

MASTER_LOG_E 21-22406.GPJ SHAN_WIL.GDT 9/6/18

Total Depth:	106 ft.	Northing:	399,404 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	6 in.
Top Elevation:	59.9 ft.	Easting:	1,312,953 ft.	Drilling Company:	Holt	Rod Diam.:	NWJ
Vert. Datum:	NAVD88	Station:	-	Drill Rig Equipment:	Truck	Hammer Type:	Automatic
Horiz. Datum:	WASP N	Offset:	-	Other Comments:			

SOIL DESCRIPTION

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

68.0

Stiff, gray, *Lean Clay (CL)*; moist; fine sand laminations and interbeds up to 1/2 inch thick.
Recessional Outwash, Clay Member (Qvrc)

73.0

Medium dense, brown to gray, *Silty Sand (SM)*; wet; fine to medium sand; trace silt laminations; moderate iron-oxide staining.
Recessional Outwash, Marysville Sand Member (Qvrm)

76.0

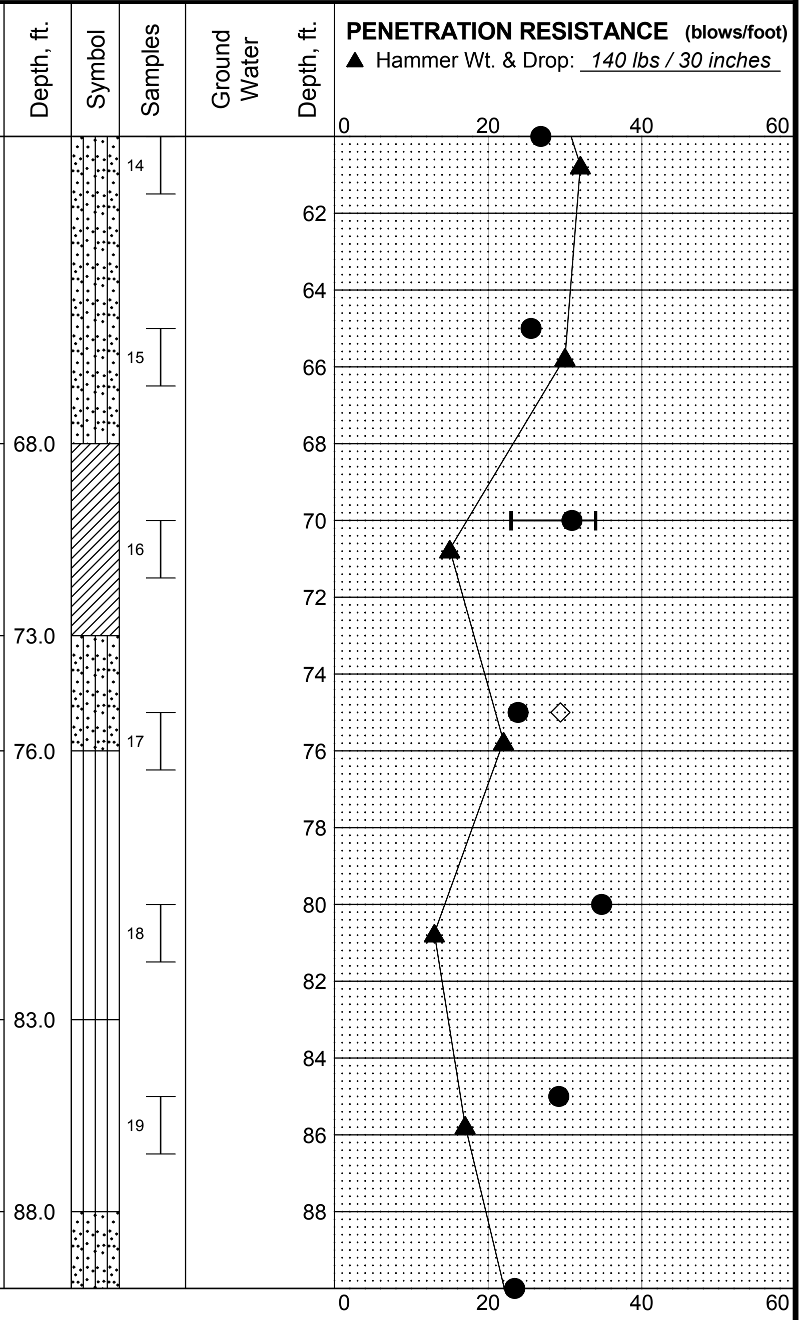
Stiff, gray, *Sandy Silt (ML)*; wet; little fine sand interbeds up to 1/2-inch-thick; laminated fine sand and silt.
Recessional Outwash, Clay Member (Qvrc)

83.0

Very stiff, gray, interbedded *Sandy Silt (ML)*, *Silt (ML)* and medium dense *Silty Sand (SM)*; wet; fine sand.
Recessional Outwash, Clay Member (Qvrc)/Marysville Sand Member (Qvrm)

88.0

Medium dense to dense, gray, *Silty Sand (SM)*; wet; fine to medium sand; silt laminations and



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
⌶ 2.0" O.D. Split Spoon Sample
⊻ Ground Water Level ATD

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

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

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

LOG OF BORING B-6-17

September 2017 21-1-22406-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-7
Sheet 3 of 4

REV 3 - Approved for Submittal

Log: BMC Rev: SDN Typ: LKN

MASTER_LOG_E 21-22406.GPJ SHAN_WIL.GDT 9/6/18

Total Depth: 106 ft.
Top Elevation: 59.9 ft.
Vert. Datum: NAVD88
Horiz. Datum: WASP N
Northing: 399,404 ft.
Easting: 1,312,953 ft.
Station: -
Offset: -
Drilling Method: Mud Rotary
Drilling Company: Holt
Drill Rig Equipment: Truck
Other Comments:
Hole Diam.: 6 in.
Rod Diam.: NWJ
Hammer Type: Automatic

SOIL DESCRIPTION

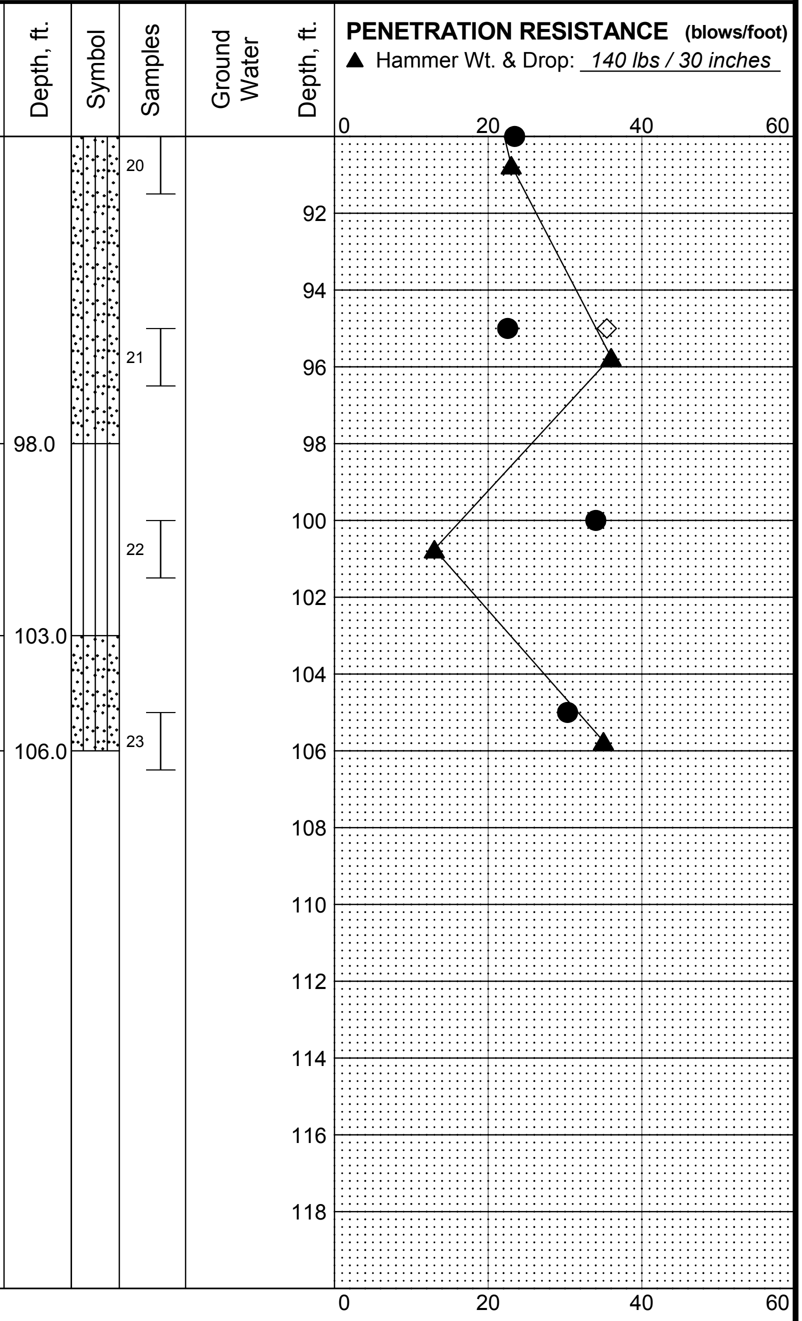
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

interbeds up to 4 inches thick locally.
Recessional Outwash, Marysville Sand Member (Qvrm)

Stiff, gray, *Lean Clay (CL)* to *Silt (ML)*; moist.
Recessional Outwash, Clay Member (Qvrc)

Dense, gray, *Silty Sand (SM)*; wet; fine sand; little silt partings and beds.
Recessional Outwash, Marysville Sand Member (Qvrm)

BOTTOM OF BORING
COMPLETED 6/8/2017



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

LEGEND

* Sample Not Recovered
⌶ 2.0" O.D. Split Spoon Sample
⊻ Ground Water Level ATD

NOTES

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

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

LOG OF BORING B-6-17

September 2017
21-1-22406-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-7
Sheet 4 of 4

REV 3 - Approved for Submittal

MASTER_LOG_E 21-22406.GPJ SHAN_WIL.GDT 9/6/18
Log: BMC Rev: SDN Typ: LKN

Total Depth: 91.3 ft.
Top Elevation: 57.5 ft.
Vert. Datum: NAVD88
Horiz. Datum: WASP N

Northing: 399,330 ft.
Easting: 1,312,972 ft.
Station: -
Offset: -

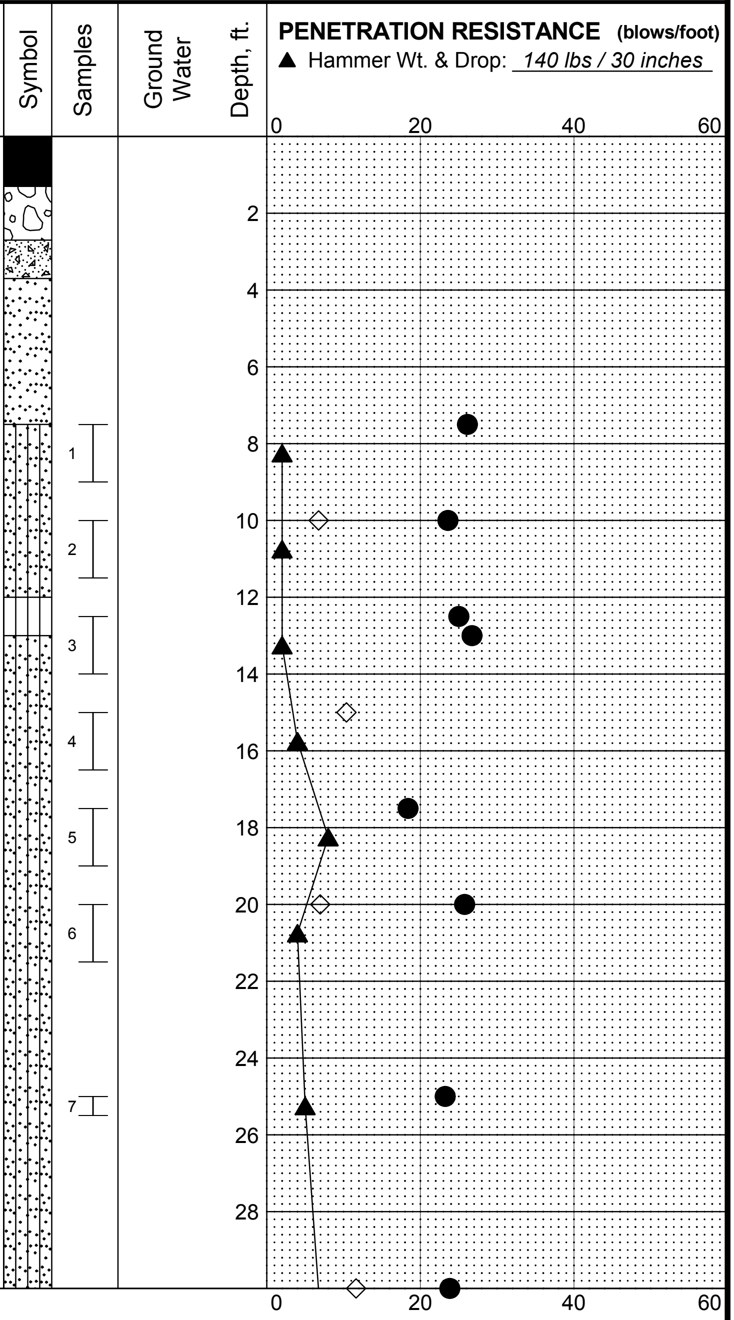
Drilling Method: Mud Rotary
Drilling Company: Holt
Drill Rig Equipment: Truck
Other Comments:

Hole Diam.: 8 in.
Rod Diam.: NWJ
Hammer Type: Automatic

SOIL DESCRIPTION

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

Soil Description	Depth, ft.
Asphalt.	1.3
Brown, *Poorly Graded Gravel with Sand and Cobbles (GP)*; moist; subrounded cobbles; fine to coarse gravel. Road Fill (Hf)	2.7
Concrete.	3.7
Brown, *Poorly Graded Sand (SP)*; moist; fine to coarse sand. Fill (Hf)	7.5
Very loose, brown, *Silty Sand (SM)* to *Poorly Graded Sand with Silt (SP-SM)*; wet; trace coarse sand; mostly fine to medium sand; trace woody material and charcoal. Fill (Hf)	12.0
Very soft, dark red-brown, *Sandy Silt (ML)*; moist; trace coarse sand; fine to medium sand; trace charcoal; chaotically mixed; completely oxidized. Fill (Hf)	13.0
Very loose to loose, brown to gray-brown, *Silty Sand (SM)* to *Poorly Graded Sand with Silt (SP-SM)*; moist; trace fine subrounded gravel; few coarse sand; fine to medium sand mostly; iron-oxide staining locally; trace charcoal and wood. Fill (Hf)	



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
⌶ 2.0" O.D. Split Spoon Sample
⊻ Ground Water Level ATD

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

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
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City of Marysville
State Avenue Corridor Widening
Marysville, Washington

LOG OF BORING B-7-17

September 2017
21-1-22406-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-8
Sheet 1 of 4

REV 3 - Approved for Submittal

Total Depth:	91.3 ft.	Northing:	399,330 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	8 in.
Top Elevation:	57.5 ft.	Easting:	1,312,972 ft.	Drilling Company:	Holt	Rod Diam.:	NWJ
Vert. Datum:	NAVD88	Station:	-	Drill Rig Equipment:	Truck	Hammer Type:	Automatic
Horiz. Datum:	WASP N	Offset:	-	Other Comments:			

SOIL DESCRIPTION

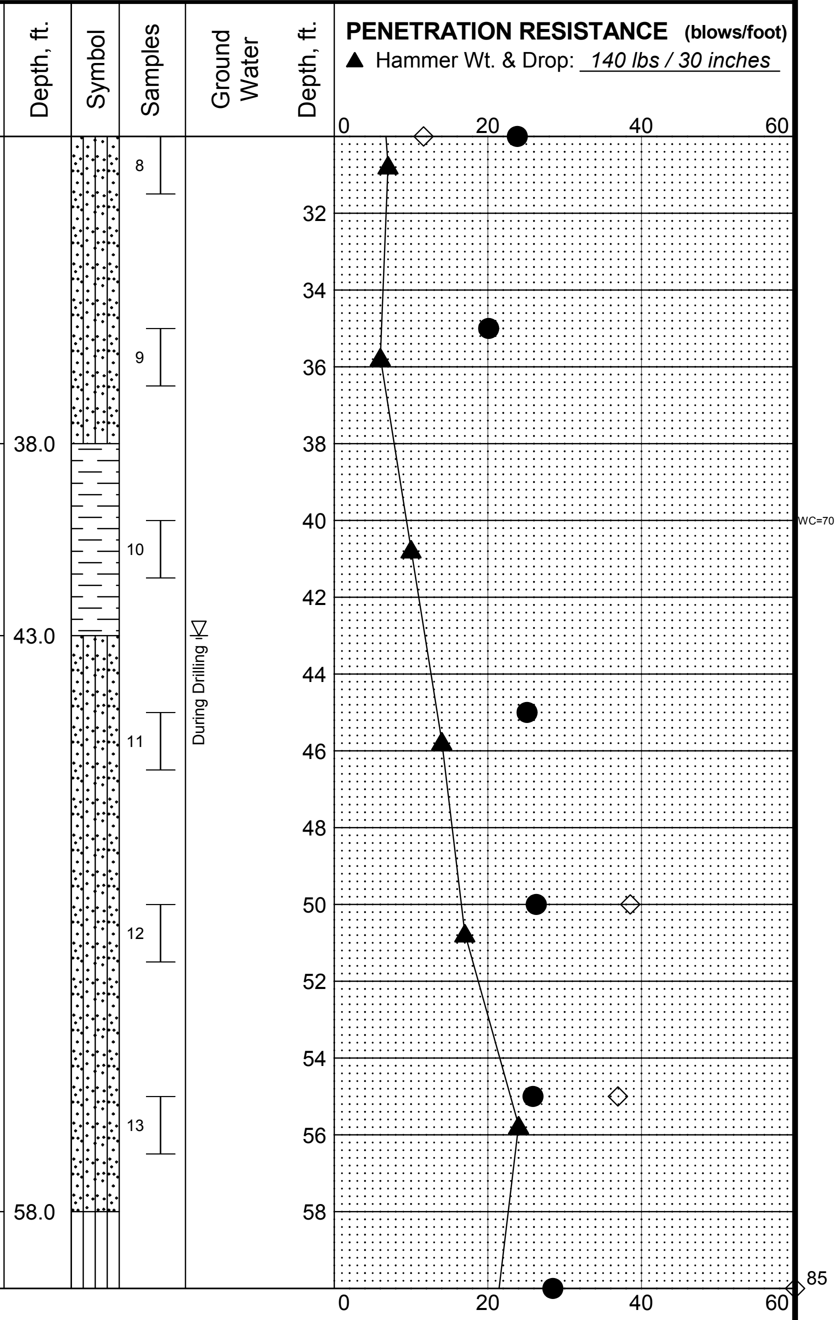
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

- 1.5-inch-thick bed of dark red-brown laminated sitly sand with charcoal at 36.2 feet.

Stiff, black, *Organic Soil (OL)* and *Organic Soil with Sand (OL)*; moist; fine to medium sand locally; wood, stems roots.
Peat Deposits (Hp)

Medium dense, brown to red-brown, *Silty Sand (SM)*; wet; fine to medium sand; few clay and silt interbeds 1/4- to 1-inch-thick; iron-oxide stianing locally.
Recent Alluvium (Ha)

Interlaminated and interbedded, very stiff, brown to gray-brown, *Silt (ML)*, *Sandy Silt*



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
⌶ 2.0" O.D. Split Spoon Sample
⊻ Ground Water Level ATD

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

NOTES

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

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

LOG OF BORING B-7-17

September 2017
21-1-22406-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-8
Sheet 2 of 4

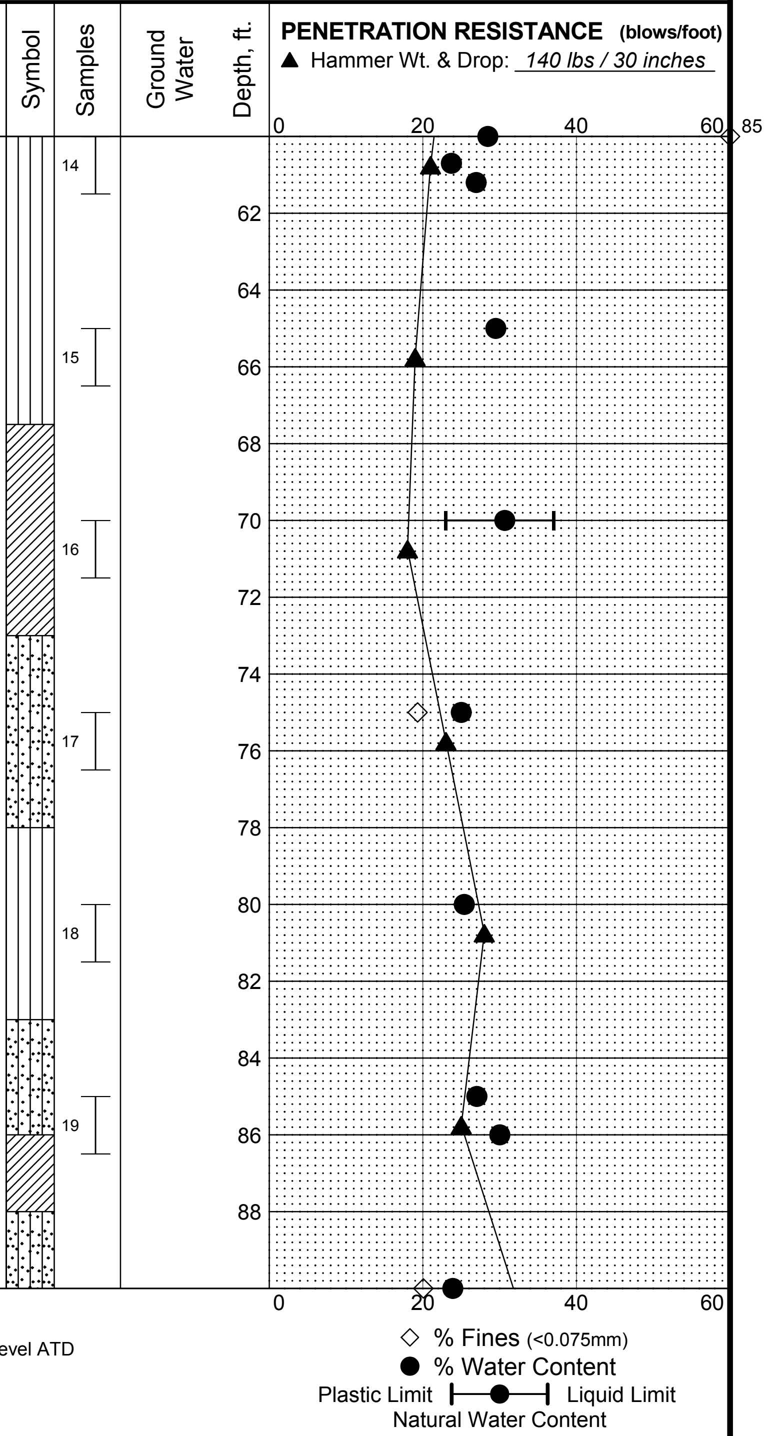
Total Depth: 91.3 ft.
Top Elevation: 57.5 ft.
Vert. Datum: NAVD88
Horiz. Datum: WASP N

Northing: 399,330 ft.
Easting: 1,312,972 ft.
Station: -
Offset: -

Drilling Method: Mud Rotary
Drilling Company: Holt
Drill Rig Equipment: Truck
Other Comments:

Hole Diam.: 8 in.
Rod Diam.: NWJ
Hammer Type: Automatic

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.
(ML), and medium dense, *Silty Sand (SM)*; moist to wet; few to some silty fine sand; mostly silt and sandy silt; iron-oxide staining locally. Recessional Outwash, Clay Member (Qvrc) - 0.5 feet of silty sand at 60.7 feet.	67.5
Very stiff, gray, *Lean Clay (CL)*; moist; few to little disseminated silt; trace silt partings. Recessional Outwash, Clay Member (Qvrc)	73.0
Medium dense, gray, *Silty Sand (SM)*; moist to wet; fine to medium sand; trace lenses of silt. Recessional Outwash, Marysville Sand Member (Qvrm)	78.0
Interbedded, stiff to very stiff, gray, *Silt (ML)* and *Lean Clay (CL)*; wet; trace very fine sand partings; fine to coarse silt; clay is locally silty. Recessional Outwash, Clay Member (Qvrc)	83.0
Medium dense, gray, *Silty Sand (SM)*; wet; trace lenses of clayey silt; dilatant. Recessional Outwash, Marysville Sand Member (Qvrm)	86.0
Interbedded, very stiff, gray, *Lean Clay (CL)* and *Silt (ML)*; moist; laminated. Recessional Outwash, Clay Member (Qvrc)	88.0



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered

⊻ Ground Water Level ATD

⌶ 2.0" O.D. Split Spoon Sample

NOTES

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

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Marysville, Washington

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SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-8
Sheet 3 of 4

REV 3 - Approved for Submittal

Total Depth: 91.3 ft.
Top Elevation: 57.5 ft.
Vert. Datum: NAVD88
Horiz. Datum: WASP N

Northing: 399,330 ft.
Easting: 1,312,972 ft.
Station: -
Offset: -

Drilling Method: Mud Rotary
Drilling Company: Holt
Drill Rig Equipment: Truck
Other Comments:

Hole Diam.: 8 in.
Rod Diam.: NWJ
Hammer Type: Automatic

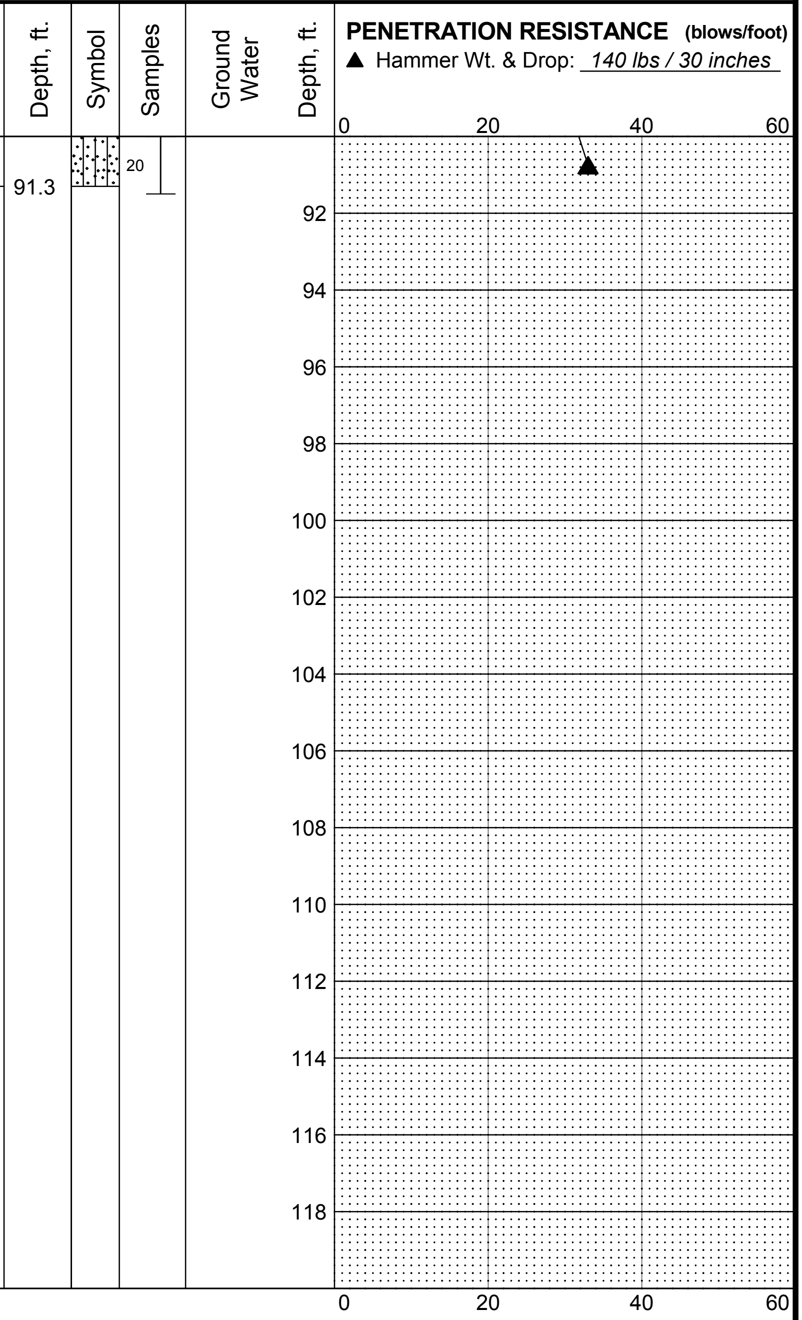
SOIL DESCRIPTION

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

Dense, gray, *Silty Sand (SM)*; wet; fine to medium sand; few silt interbeds. Recessional Outwash, Marysville Sand Member (Qvrm)

91.3

BOTTOM OF BORING
COMPLETED 6/5/2017



LEGEND

* Sample Not Recovered
⌶ 2.0" O.D. Split Spoon Sample
⊻ Ground Water Level ATD

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

NOTES

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

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

LOG OF BORING B-7-17

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SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-8
Sheet 4 of 4

REV 3 - Approved for Submittal

Total Depth: 91.5 ft.
Top Elevation: 58.2 ft.
Vert. Datum: NAVD88
Horiz. Datum: WASP N
Northing: 399,216 ft.
Easting: 1,313,052 ft.
Station: -
Offset: -
Drilling Method: Mud Rotary
Drilling Company: Holt
Drill Rig Equipment: Truck
Other Comments:
Hole Diam.: 6 in.
Rod Diam.: NWJ
Hammer Type: Automatic

SOIL DESCRIPTION

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

Asphalt.

1.5

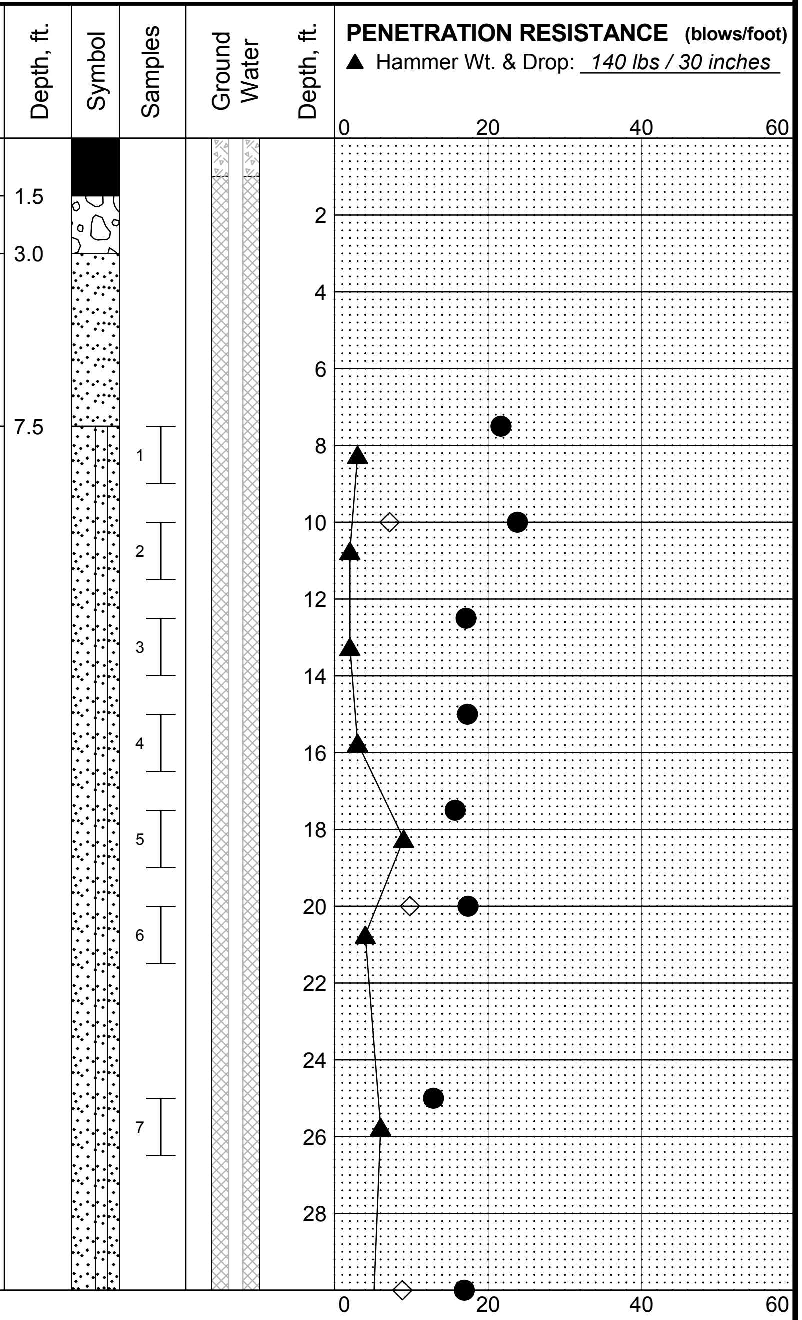
Brown, *Poorly Graded Gravel with Sand (GP)*; moist; fine to coarse, subrounded gravel; fine to coarse sand.
Fill (Hf)

3.0

Brown, *Poorly Graded Sand with Gravel (SP)*; moist; fine gravel; fine to coarse sand; few roots.
Fill (Hf)

7.5

Very loose to loose, red-brown, *Poorly Graded Sand with Silt (SP-SM)* to *Silty Sand (SM)*; moist to wet; trace fine gravel; trace coarse sand; fine to medium sand; trace roots, charcoal, and wood; iron-oxide staining.
Fill (Hf)



CONTINUED NEXT SHEET

LEGEND

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

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

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

NOTES

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

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

LOG OF BORING B-8-17

September 2017
21-1-22406-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-9
Sheet 1 of 4

REV 3 - Approved for Submittal

Total Depth:	91.5 ft.	Northing:	399,216 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	6 in.
Top Elevation:	58.2 ft.	Easting:	1,313,052 ft.	Drilling Company:	Holt	Rod Diam.:	NWJ
Vert. Datum:	NAVD88	Station:	-	Drill Rig Equipment:	Truck	Hammer Type:	Automatic
Horiz. Datum:	WASP N	Offset:	-	Other Comments:			

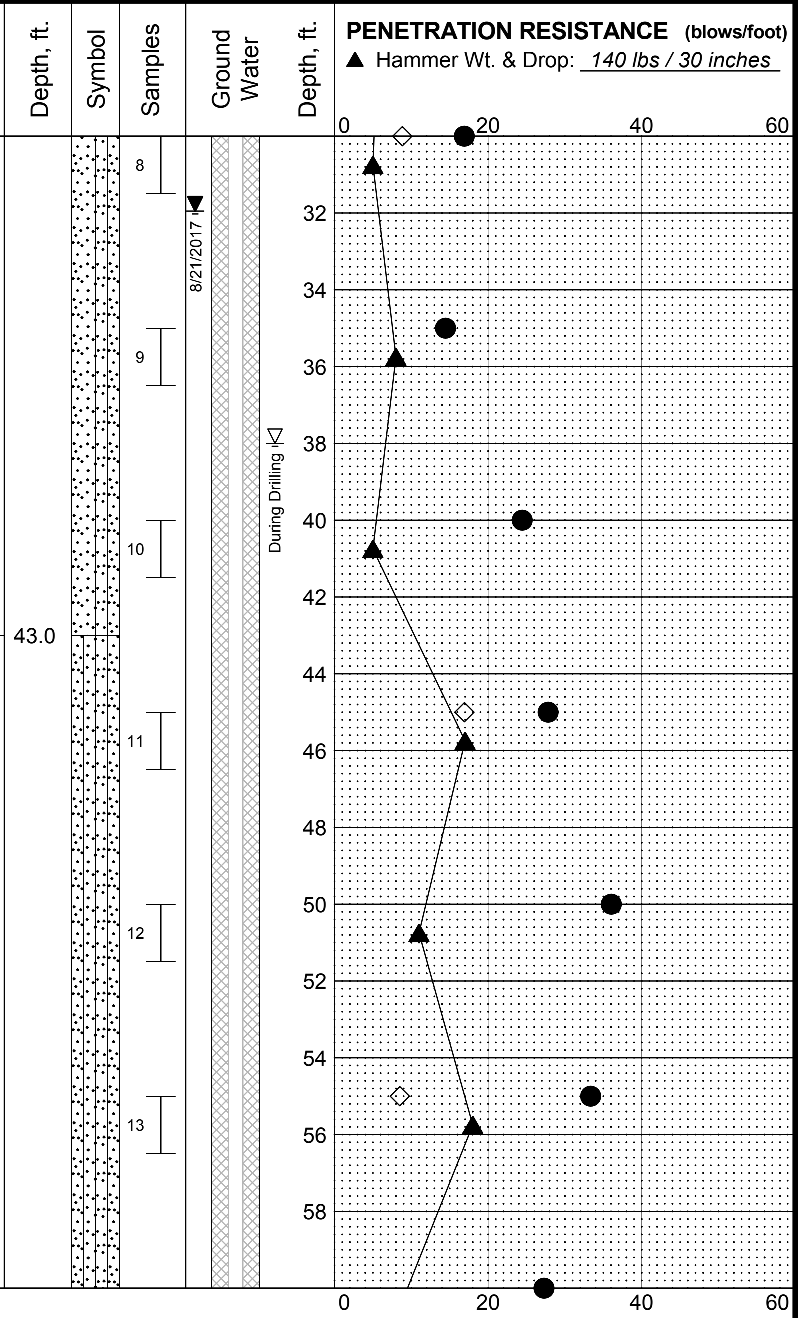
SOIL DESCRIPTION

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

- 1-inch-thick band of iron-oxide staining at 30.5 feet.

- 1/2-inch bed of wood and bark at 35.2 feet.

Medium dense, gray to green-gray, *Silty Sand (SM)* to *Poorly Graded Sand with Silt (SP-SM)*; moist to wet; fine to medium sand, grades down to fine to coarse sand; little brown lenses and interbeds of peat and wood.
Recent Alluvium (Ha)



CONTINUED NEXT SHEET

LEGEND

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

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

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

NOTES

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

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

LOG OF BORING B-8-17

September 2017 21-1-22406-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-9
Sheet 2 of 4

Log: BMC Rev: SDN Typ: LKN

MASTER_LOG_E 21-22406.GPJ SHAN_WIL.GDT 9/6/18

REV 3 - Approved for Submittal

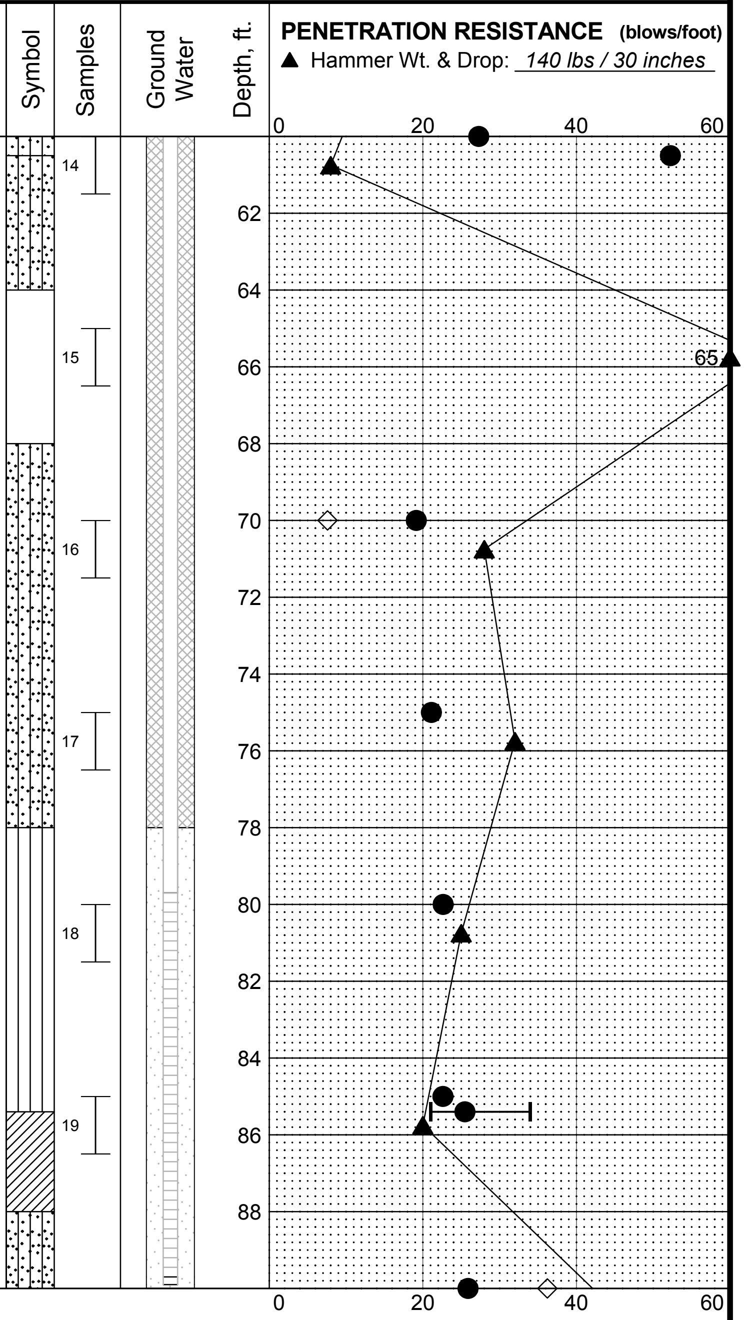
Total Depth: 91.5 ft.
Top Elevation: 58.2 ft.
Vert. Datum: NAVD88
Horiz. Datum: WASP N

Northing: 399,216 ft.
Easting: 1,313,052 ft.
Station: -
Offset: -

Drilling Method: Mud Rotary
Drilling Company: Holt
Drill Rig Equipment: Truck
Other Comments:

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

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.
Loose, dark gray, *Silty Sand (SM)*, *Silt (ML)* and *Organic Soil (OL)*; moist; fine sand, silt, and organic-rich laminations; few wood. Recent Alluvium (Ha)	60.5
Very dense, yellow, *Wood*; wet; intact wood log. - Blowcounts at 65 feet are artificially high due to the presence of wood.	64.0
Medium dense to dense, gray, *Silty Sand (SM)* to *Well Graded Sand with Silt (SW-SM)*; wet; fine to coarse subangular sand; few fine sand interbeds up to 1-inch-thick; trace to few organic-rich laminations; trace wood locally. Recent Alluvium (Ha)	68.0
Interbedded, gray, very stiff *Silt (ML)* and medium dense *Silty Sand (SM)*; moist; fine sand; mostly non-plastic, dilatant silt and sand; low to medium plasticity silt locally. Recessional Outwash, Marysville Sand Member (Qvrm) - 2 feet of wood at 78 feet.	78.0
Very stiff, gray, interbedded *Lean Clay with Sand (CL)* and *Silt (ML)*; moist; trace partings of fine sand locally. Recessional Outwash, Clay Member (Qvrc)	85.4
	88.0



CONTINUED NEXT SHEET

LEGEND

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

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

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

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

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

LOG OF BORING B-8-17

September 2017 21-1-22406-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-9
Sheet 3 of 4

REV 3 - Approved for Submittal

Total Depth:	91.5 ft.	Northing:	399,216 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	6 in.
Top Elevation:	58.2 ft.	Easting:	1,313,052 ft.	Drilling Company:	Holt	Rod Diam.:	NWJ
Vert. Datum:	NAVD88	Station:	-	Drill Rig Equipment:	Truck	Hammer Type:	Automatic
Horiz. Datum:	WASP N	Offset:	-	Other Comments:			

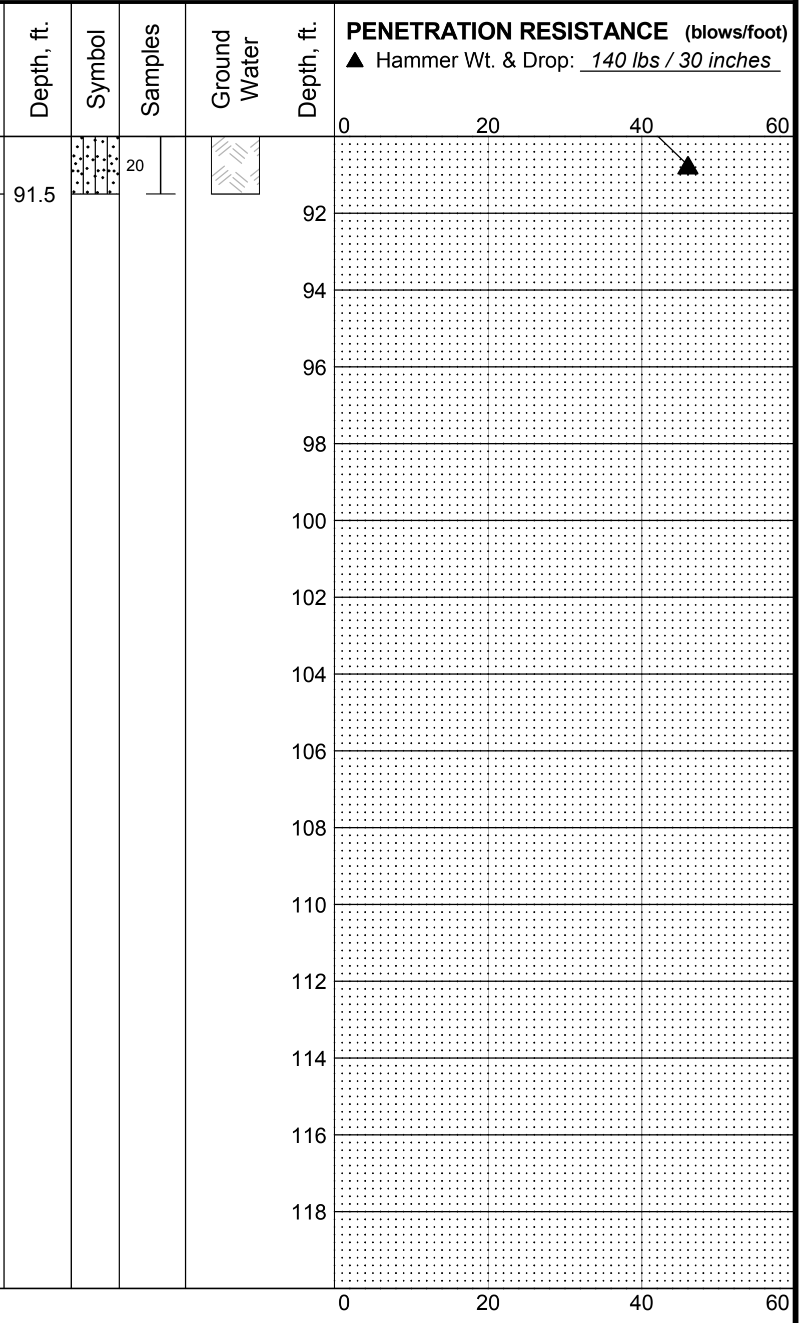
SOIL DESCRIPTION

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

- 3/4-inch-thick wet silty fine sand interbed at 85.6 feet.

Dense, gray, *Silty Sand (SM)*; wet; fine sand; silt laminations and beds locally.
Recessional Outwash, Marysville Sand Member (Qvrm)
- 1-inch-thick beds of silt at 91.0 and 91.3 feet.

BOTTOM OF BORING
COMPLETED 6/9/2017



LEGEND

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

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

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

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

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

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SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-9
Sheet 4 of 4

REV 3 - Approved for Submittal

Total Depth:	106.5 ft.	Northing:	399,151 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	8 in.
Top Elevation:	58.3 ft.	Easting:	1,313,068 ft.	Drilling Company:	Holt	Rod Diam.:	NWJ
Vert. Datum:	NAVD88	Station:	-	Drill Rig Equipment:	Truck	Hammer Type:	Automatic
Horiz. Datum:	WASP N	Offset:	-	Other Comments:			

SOIL DESCRIPTION

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

Depth, ft.

Asphalt.

1.5

Brown, *Poorly Graded Gravel with Sand and Cobbles (GP)*; moist; little subrounded cobbles; fine to coarse, subrounded gravel; fine to coarse sand.
Road Fill (Hf)

3.1

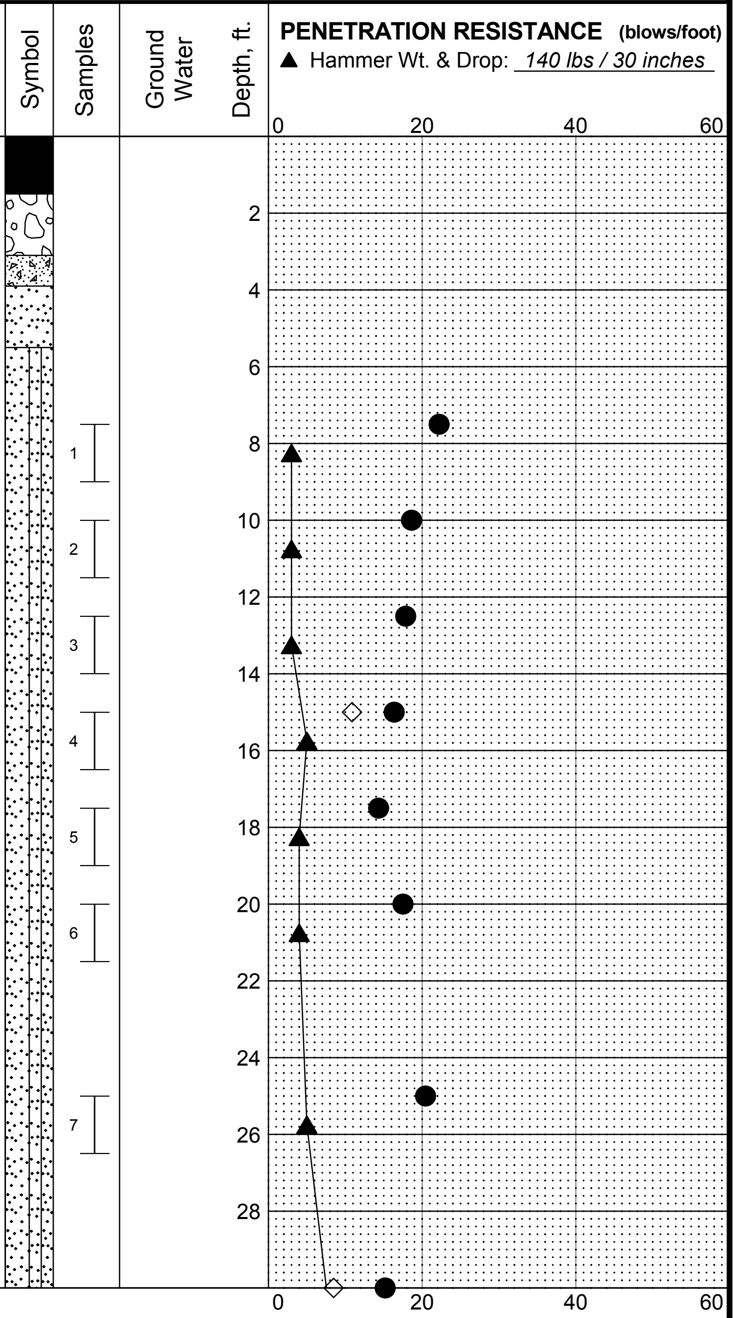
Concrete.

3.9

Brown, *Poorly Graded Sand with Gravel (SP)*; moist; fine to coarse, subrounded gravel; fine to coarse sand.
Road Fill (Hf)

5.5

Very loose to loose, brown, *Poorly Graded Sand with Silt (SP-SM)*; moist; trace fine gravel; mostly fine to medium sand; trace to few coarse sand; trace organics; trace lenses of silt; iron-oxide stained locally.
Fill (Hf)



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered

⌶ 2.0" O.D. Split Spoon Sample

⊻ Ground Water Level ATD

◇ % Fines (<0.075mm)

● % Water Content

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

NOTES

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

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

LOG OF BORING B-9-17

September 2017 21-1-22406-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-10
Sheet 1 of 4

Log: BMC Rev: SDN Typ: LKN

MASTER_LOG_E 21-22406.GPJ SHAN_WIL.GDT 9/6/18

REV 3 - Approved for Submittal

Total Depth:	106.5 ft.	Northing:	399,151 ft.	Drilling Method:	Mud Rotary	Hole Diam.:	8 in.
Top Elevation:	58.3 ft.	Easting:	1,313,068 ft.	Drilling Company:	Holt	Rod Diam.:	NWJ
Vert. Datum:	NAVD88	Station:	-	Drill Rig Equipment:	Truck	Hammer Type:	Automatic
Horiz. Datum:	WASP N	Offset:	-	Other Comments:			

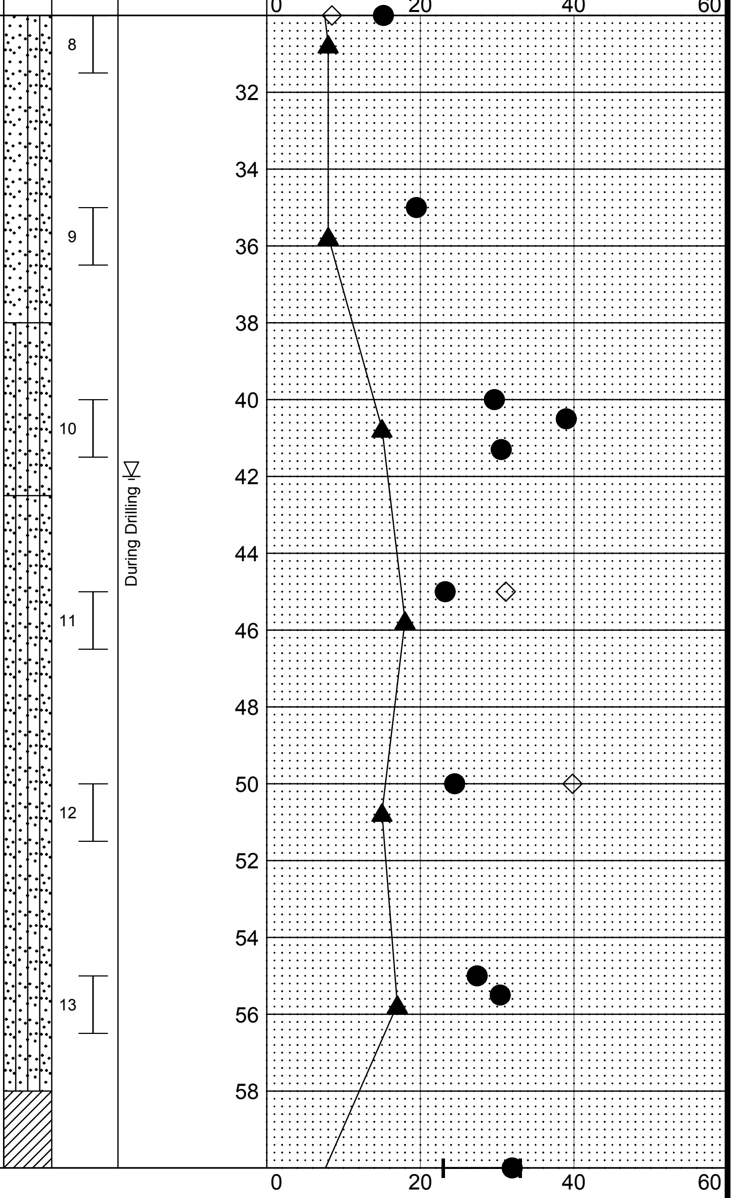
SOIL DESCRIPTION

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

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

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

SOIL DESCRIPTION	Depth, ft.
Interbedded, medium dense, gray, *Silty Sand (SM)* and stiff, blue-gray *Silt (ML)*; moist; fine to medium sand; few to some wood and disseminated organics. Recent Alluvium (Ha)	38.0
Interbedded, medium dense, brown, *Silty Sand (SM)*, *Silt (ML)* and *Sandy Silt (ML)*; wet; fine to medium sand; laminated; dilatant; trace iron-oxide stains. Recessional Outwash, Marysville Sand Member (Qvrm) - 3-inch-thick laminated silt bed at 50.8 feet, offset vertically by sand dikes originating in underlying silty sand bed; evidence of liquefaction.	42.5
Interbedded, medium siff, gray, *Lean Clay with Sand (CL)*, *Silt (ML)* and medium dense, gray	58.0



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
⌶ 2.0" O.D. Split Spoon Sample
⊽ Ground Water Level ATD

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

NOTES

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

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

LOG OF BORING B-9-17

September 2017 21-1-22406-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-10
Sheet 2 of 4

REV 3 - Approved for Submittal

Total Depth: 106.5 ft.
Top Elevation: 58.3 ft.
Vert. Datum: NAVD88
Horiz. Datum: WASP N

Northing: 399,151 ft.
Easting: 1,313,068 ft.
Station: -
Offset: -

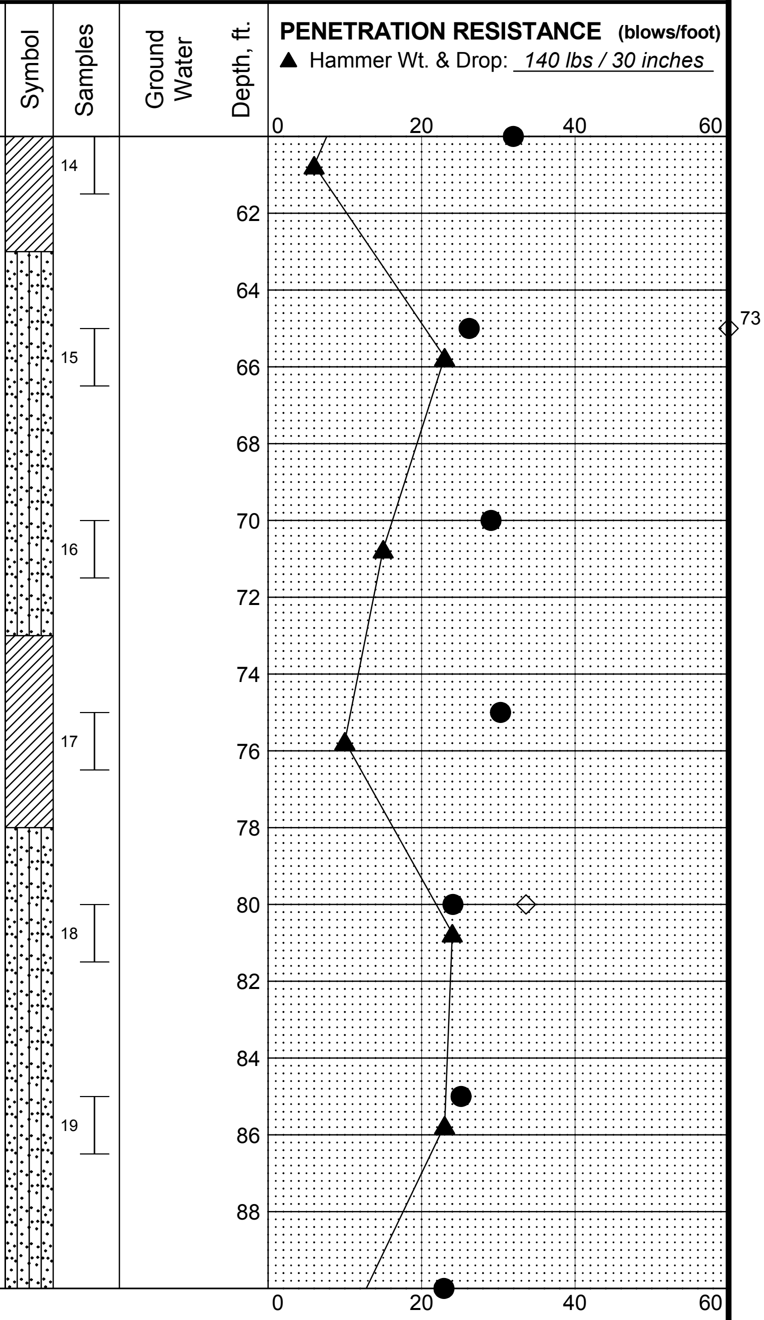
Drilling Method: Mud Rotary
Drilling Company: Holt
Drill Rig Equipment: Truck
Other Comments:

Hole Diam.: 8 in.
Rod Diam.: NWJ
Hammer Type: Automatic

SOIL DESCRIPTION

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

Soil Description	Depth, ft.
Silty Sand (SM); wet; very fine sand; silty clay and clayey silt. Recessional Outwash, Clay Member (Qvrc)/Marysville Sand Member (Qvrm)	63.0
Interbedded, medium dense, gray, *Silty Sand (SM)* and *Silt with Sand (ML)*; wet; very fine to fine sand. Recessional Outwash, Marysville Sand Member (Qvrm)	73.0
Stiff, gray, *Lean Clay (CL)*; moist; trace laminations of silt; few 1/2-inch-thick beds of silt with sand. Recessional Outwash, Clay Member (Qvrc)	78.0
Interbedded, medium dense, gray, *Silty Sand (SM)*, *Silt (ML)* and *Poorly Graded Sand with Silt (SP-SM)*; wet; fine to medium sand. Recessional Outwash, Marysville Sand Member (Qvrm)	



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
⌶ 2.0" O.D. Split Spoon Sample
⊻ Ground Water Level ATD

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

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

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

LOG OF BORING B-9-17

September 2017
21-1-22406-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-10
Sheet 3 of 4

REV 3 - Approved for Submittal

Total Depth:	*106.5 ft.*	Northing:	*399,151 ft.*	Drilling Method:	*Mud Rotary*	Hole Diam.:	*8 in.*
Top Elevation:	*58.3 ft.*	Easting:	*1,313,068 ft.*	Drilling Company:	*Holt*	Rod Diam.:	*NWJ*
Vert. Datum:	*NAVD88*	Station:	*-*	Drill Rig Equipment:	*Truck*	Hammer Type:	*Automatic*
Horiz. Datum:	*WASP N*	Offset:	*-*	Other Comments:			

SOIL DESCRIPTION

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

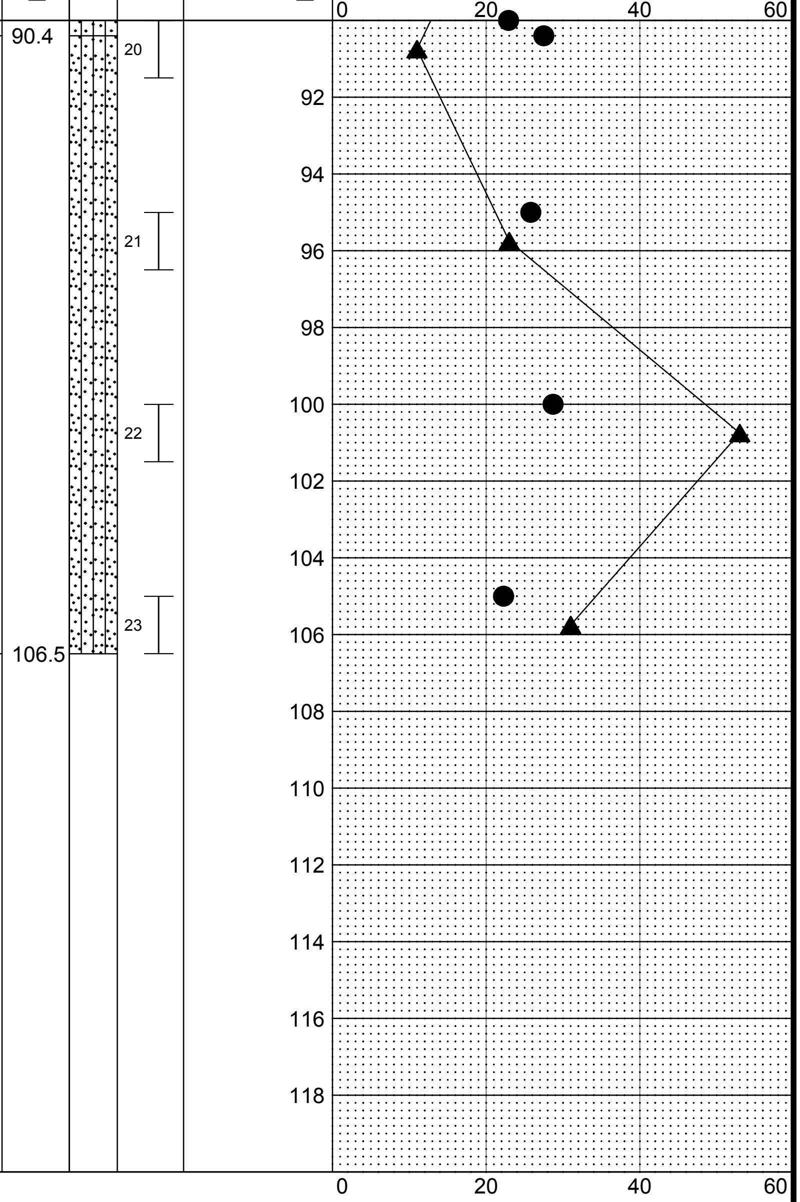
Depth, ft. | Symbol | Samples | Ground Water | Depth, ft.

PENETRATION RESISTANCE **(blows/foot)**

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

Interbedded, medium dense to very dense, gray, *Silty Sand (SM)*, *Silt (ML)* and hard *Lean Clay (CL)*; wet; fine sand; clayey silt and silty clay.
Recessional Outwash, Marysville Sand Member (Qvrm)/Clay Member (Qvrc)

BOTTOM OF BORING
COMPLETED 6/6/2017



LEGEND

* Sample Not Recovered

⌶ 2.0" O.D. Split Spoon Sample

▽ Ground Water Level ATD

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit

Natural Water Content

NOTES

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

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

LOG OF BORING B-9-17

September 2017 21-1-22406-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-10
Sheet 4 of 4

REV 3 - Approved for Submittal

Log: BMC Rev: SDN Typ: LKN

MASTER_LOG_E 21-22406.GPJ SHAN_WIL.GDT 9/6/18

Total Depth: 201.5 ft.
Top Elevation: ~
Vert. Datum: NAVD88
Horiz. Datum: WASP N

Northing:
Easting:
Station:
Offset:

Drilling Method: Mud Rotary
Drilling Company: Holt Services
Drill Rig Equipment: Mobile Drill B-59
Other Comments:

Hole Diam.: 6 in.
Rod Diam.: NWJ 2-7/8"
Hammer Type: Automatic

SOIL DESCRIPTION

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

- Samples not collected above 30 feet.

- Vacuum excavated to 7 feet.

30.0

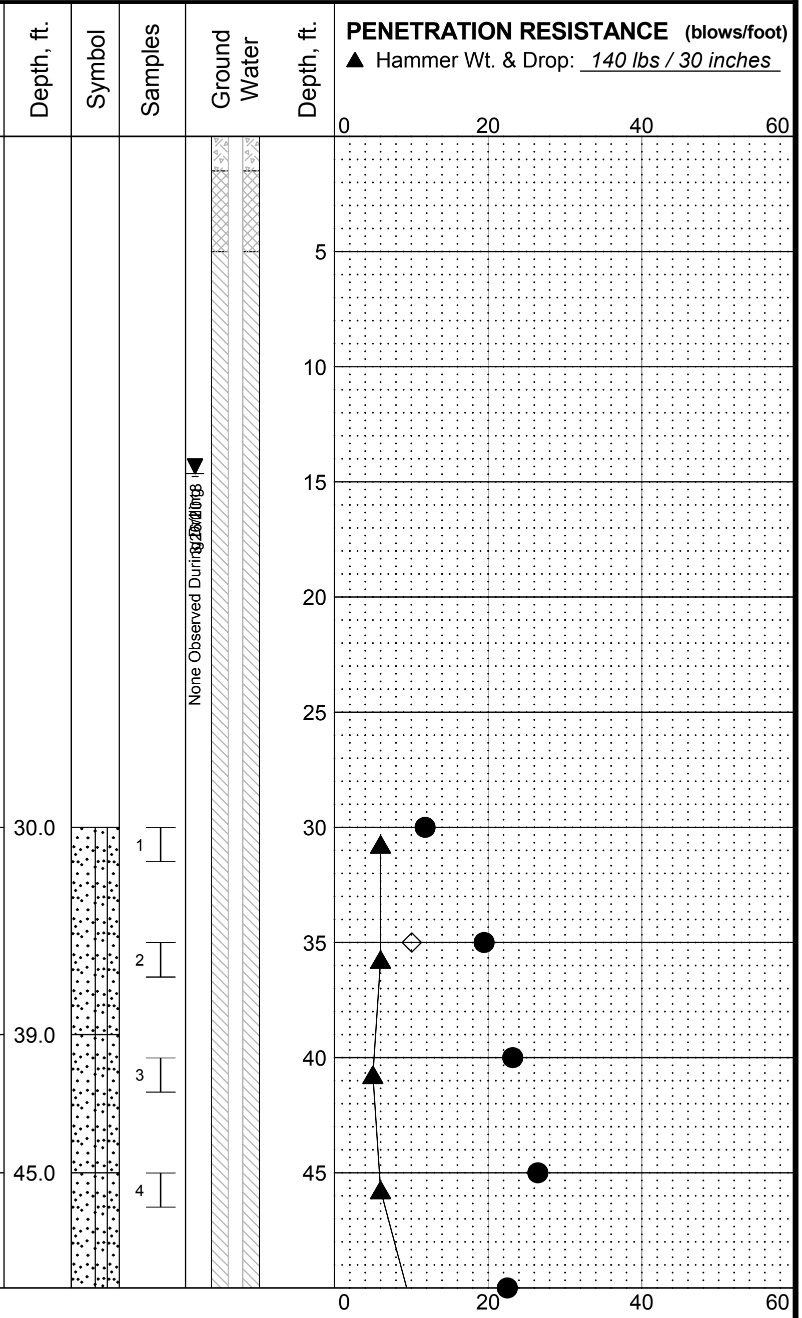
Loose, brown, *Poorly Graded Sand with Silt (SP-SM)*; moist; fine to medium sand; nonplastic fines.
Fill (Hf)

39.0

Loose, brown, *Poorly Graded Sand with Silt (SP-SM)*; wet; fine to medium sand; nonplastic fines.
Recent Alluvium (Ha)

45.0

Loose, gray-brown, *Poorly Graded Sand with Silt (SP-SM)*; wet; fine to medium sand; nonplastic fines; trace organics; few silty sand



CONTINUED NEXT SHEET

LEGEND

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

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

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

NOTES

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

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

LOG OF BORING B-10-18

September 2018
21-1-22406-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-11
Sheet 1 of 5

REV 3 - Approved for Submittal

Log: BWC Rev: EAS Typ: LKN

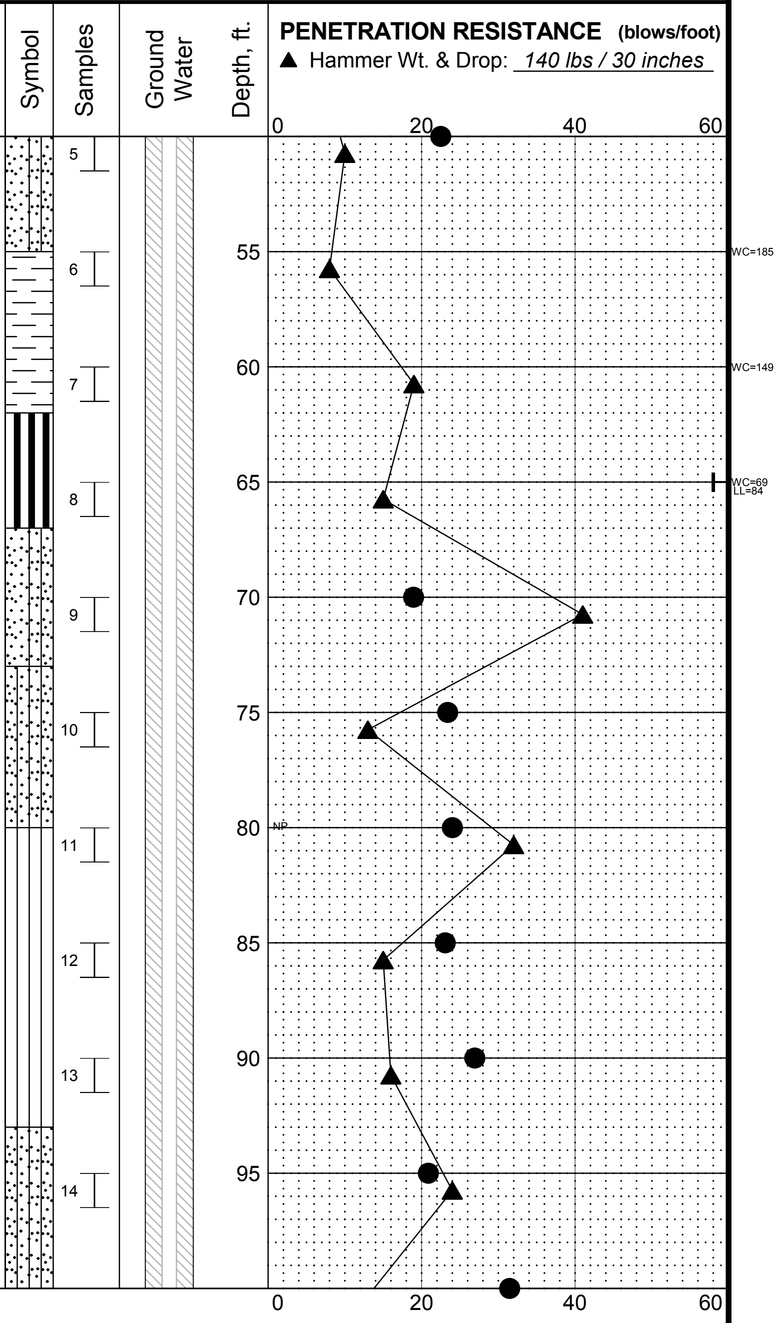
MASTER_LOG_E 21-22406.GPJ SHAN_WIL.GDT 9/6/18

Total Depth: 201.5 ft.
Top Elevation: ~
Vert. Datum: NAVD88
Horiz. Datum: WASP N
Northing:
Easting:
Station:
Offset:
Drilling Method: Mud Rotary
Drilling Company: Holt Services
Drill Rig Equipment: Mobile Drill B-59
Other Comments:
Hole Diam.: 6 in.
Rod Diam.: NWJ 2-7/8"
Hammer Type: Automatic

SOIL DESCRIPTION

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

SOIL DESCRIPTION	Depth, ft.
seams; few poorly graded sand seams. Recent Alluvium (Ha)	55.0
Stiff, dark brown, *Organic Silt (OL)*; moist; trace fine to coarse sand; low plasticity fines; mostly organics; few wood fragments. Peat (Hp) - Wood at 60 feet.	62.0
Medium dense, brown to gray *Elastic Silt with Sand (MH)*; moist; fine sand; low to medium plasticity fines; little organics and wood fragments. Recent Lacustrine (Hl)	67.0
Dense, gray, *Poorly Graded Sand with Silt (SP-SM)* to *Poorly Graded Sand (SP)*; wet; fine to coarse sand; nonplastic fines. Recessional Outwash/Marysville Sand Member (Qvrm)	73.0
Medium dense, gray, *Silty Sand (SM)*; wet; fine to medium sand; nonplastic fines; dilatant. Recessional Outwash/Marysville Sand Member (Qvrm)	80.0
Medium dense to dense, gray *Sandy Silt (ML)* to *Silt (ML)*; wet; fine sand; nonplastic to low plasticity fines; few silty sand seams. Recessional Outwash/Marysville Sand Member (Qvrm)	93.0
Medium dense, gray, *Silty Sand (SM)* and *Poorly Graded Sand (SP)*; wet; fine to coarse sand; nonplastic fines; few wood fragments. Recessional Outwash/Marysville Sand Member (Qvrm)	



CONTINUED NEXT SHEET

LEGEND

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

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

NOTES

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

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

LOG OF BORING B-10-18

September 2018
21-1-22406-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-11
Sheet 2 of 5

REV 3 - Approved for Submittal

Total Depth:	201.5 ft.	Northing:		Drilling Method:	Mud Rotary	Hole Diam.:	6 in.
Top Elevation:	~	Easting:		Drilling Company:	Holt Services	Rod Diam.:	NWJ 2-7/8"
Vert. Datum:	NAVD88	Station:		Drill Rig Equipment:	Mobile Drill B-59	Hammer Type:	Automatic
Horiz. Datum:	WASP N	Offset:		Other Comments:			

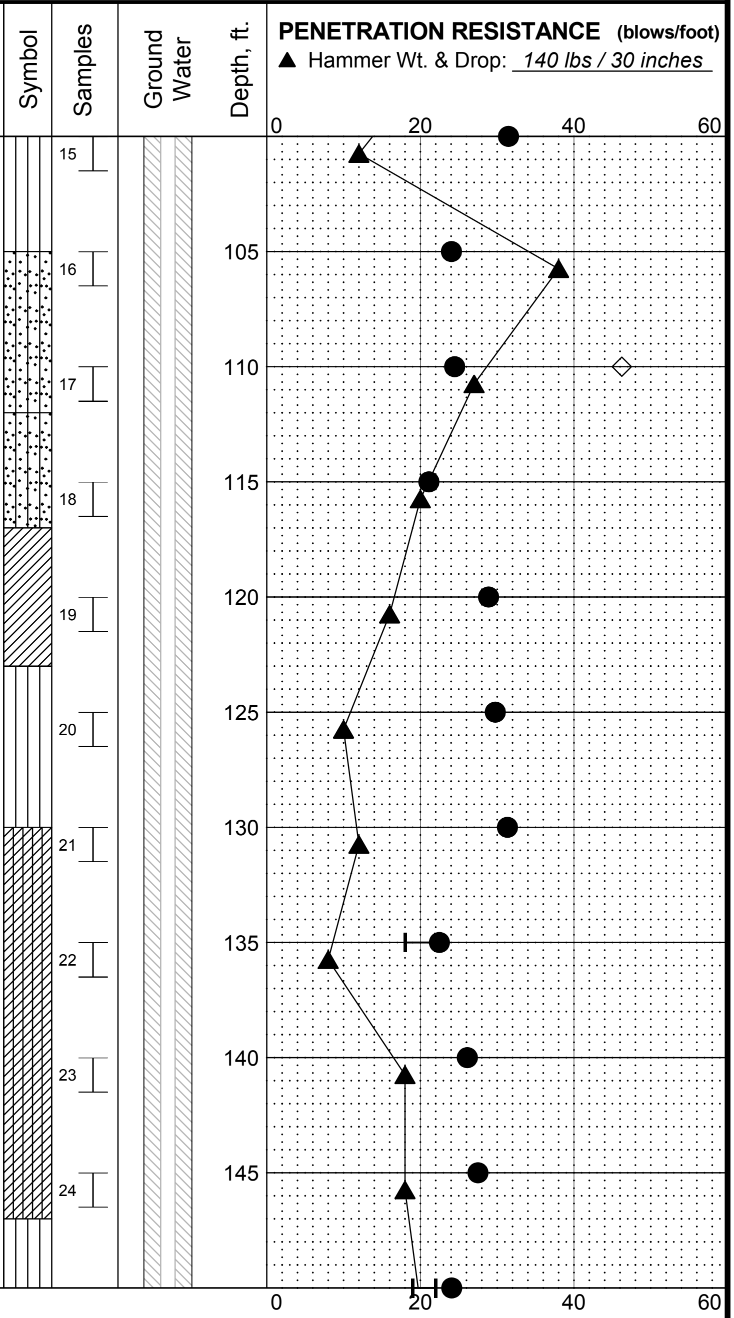
SOIL DESCRIPTION

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

Depth, ft.	Soil Description
100.0	Medium stiff, gray *Silt (ML)*; moist to wet; few fine sand; low plasticity fines; few silty sand pockets. Recessional Outwash/Marysville Clay Member (Qvrc)
105.0	Medium dense to dense, gray, *Silty Sand (SM)*; wet; fine to medium sand; nonplastic fines; dilatant. Recessional Outwash/Marysville Sand Member (Qvrm)
112.0	Medium dense, gray, *Silty Sand (SM)* and *Lean Clay (CL)*; moist to wet; fine to medium sand; nonplastic to medium plasticity fines; interbedded. Recessional Outwash/Marysville Sand Member (Qvrm)
117.0	Very stiff to medium dense, gray, *Lean Clay (CL)* and *Silty Sand (SM)*; wet; fine sand; nonplastic to medium plasticity fines; interbedded. Recessional Outwash/Marysville Clay Member (Qvrc)
123.0	Very stiff, gray *Silt (ML)* and *Silty Sand (SM)*; wet; fine sand; nonplastic to low plasticity fines; trace lean clay seams. Recessional Outwash/Marysville Clay Member (Qvrc)
130.0	Stiff to very stiff, gray, *Silty Clay (CL-ML)* and *Lean Clay (CL)* and *Silt with Sand (ML)*; moist to wet; fine sand; low to medium plasticity fines; interbedded. Recessional Outwash/Marysville Clay Member (Qvrc)
147.0	Very stiff, gray *Silt (ML)*; moist to wet; trace fine sand; low plasticity fines; dilatant.

PENETRATION RESISTANCE (blows/foot)

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



CONTINUED NEXT SHEET

LEGEND

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

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ├──●──┤ Liquid Limit

Natural Water Content

NOTES

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

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

LOG OF BORING B-10-18

September 2018 21-1-22406-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-11
Sheet 3 of 5

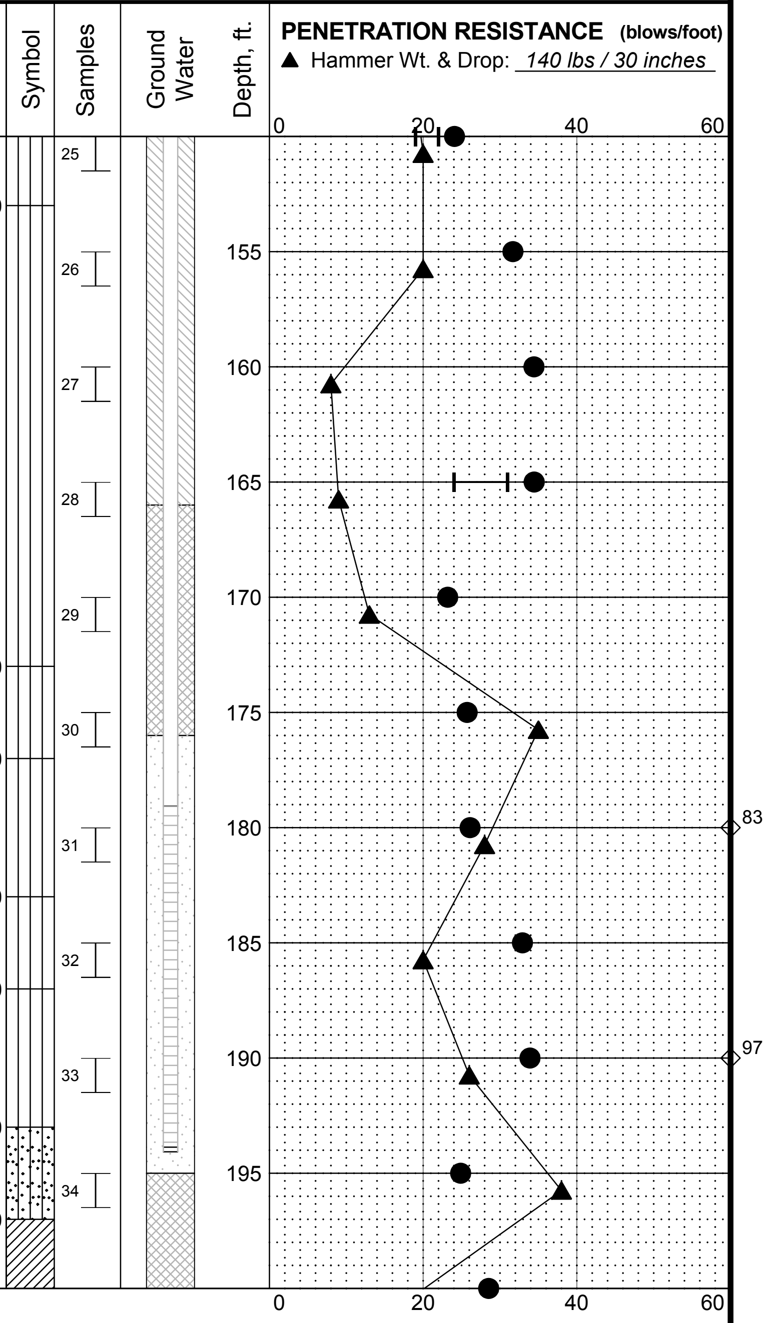
Log: BWC Rev: EAS Typ: LKN

MASTER_LOG_E 21-22406.GPJ SHAN_WIL.GDT 9/6/18

REV 3 - Approved for Submittal

Total Depth: 201.5 ft.
Top Elevation: ~
Vert. Datum: NAVD88
Horiz. Datum: WASP N
Northing:
Easting:
Station:
Offset:
Drilling Method: Mud Rotary
Drilling Company: Holt Services
Drill Rig Equipment: Mobile Drill B-59
Other Comments:
Hole Diam.: 6 in.
Rod Diam.: NWJ 2-7/8"
Hammer Type: Automatic

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.
Recessional Outwash/Marysville Clay Member (Qvrc)	153.0
Very stiff, gray, *Silt (ML)* and *Lean Clay (CL)*; moist to wet; trace to few fine sand; low to medium plasticity fines; interbedded; few sandy silt seams. Recessional Outwash/Marysville Clay Member (Qvrc)	173.0
Medium dense, gray *Silt with Sand (ML)*; wet; fine sand; nonplastic fines; dilatant. Recessional Outwash/Marysville Sand Member (Qvrm)	177.0
Medium dense, gray, *Silt with Sand (ML)* and *Silty Sand (SM)*; wet; fine sand; nonplastic to low plasticity fines; trace lean clay seams; interbedded. Recessional Outwash/Marysville Sand Member (Qvrm)	183.0
	187.0
Very stiff, gray *Silt with Sand (ML)* to *Lean Clay (CL)*; wet; fine sand; low to medium plasticity fines; interbedded. Recessional Outwash/Marysville Clay Member (Qvrc)	193.0
Medium dense to very stiff, gray *Silt (ML)* to *Lean Clay (CL)*; moist to wet; fine sand; low to medium plasticity fines; interbedded. Recessional Outwash/Marysville Clay Member	197.0



CONTINUED NEXT SHEET

LEGEND

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

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

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

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

LOG OF BORING B-10-18

September 2018 21-1-22406-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-11
Sheet 4 of 5

REV 3 - Approved for Submittal

Total Depth:	*201.5 ft.*	Northing:		Drilling Method:	*Mud Rotary*	Hole Diam.:	*6 in.*
Top Elevation:	*~*	Easting:		Drilling Company:	*Holt Services*	Rod Diam.:	*NWJ 2-7/8"*
Vert. Datum:	*NAVD88*	Station:		Drill Rig Equipment:	*Mobile Drill B-59*	Hammer Type:	*Automatic*
Horiz. Datum:	*WASP N*	Offset:		Other Comments:			

SOIL DESCRIPTION

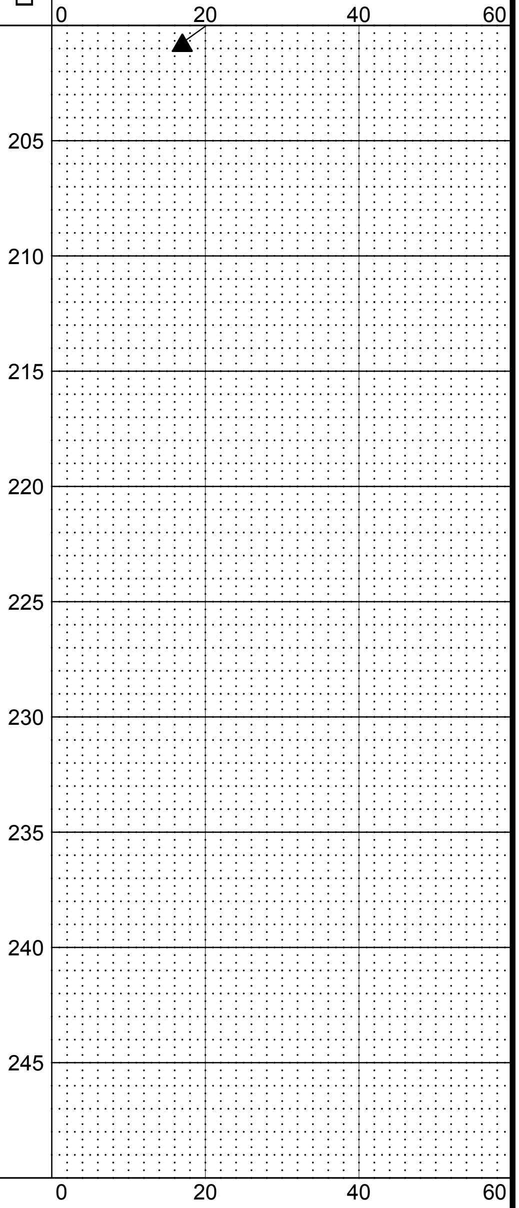
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

SOIL DESCRIPTION	Depth, ft.	Symbol	Samples	Ground Water
(Qvrc)		▨	35 ⌶	☒
Dense, gray, *Silty Sand (SM)*; wet; fine sand; nonplastic to medium plasticity fines; few lean clay seams; interbedded. Recessional Outwash/Marysville Sand Member (Qvrm)	201.5			
Very stiff, gray, *Lean Clay (CL)* to *Silt (ML)*; moist; few fine sand; low to medium plasticity fines. Recessional Outwash/Marysville Clay Member (Qvrc)				

BOTTOM OF BORING
COMPLETED 2/24/2018

PENETRATION RESISTANCE (blows/foot)

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



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

LEGEND

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

NOTES

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

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

LOG OF BORING B-10-18

September 2018 21-1-22406-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-11
Sheet 5 of 5

Log: BWC Rev: EAS Typ: LKN

MASTER_LOG_E 21-22406.GPJ SHAN_WIL.GDT 9/6/18

REV 3 - Approved for Submittal

Total Depth: 231.5 ft.
Top Elevation: ~
Vert. Datum: NAVD88
Horiz. Datum: WASP N

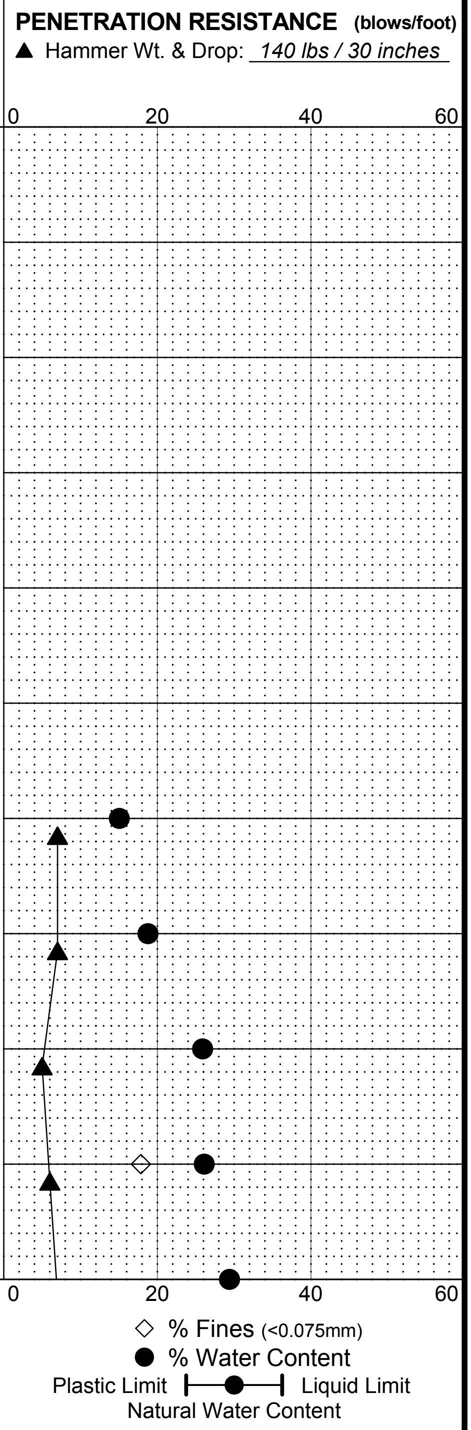
Northing:
Easting:
Station:
Offset:

Drilling Method: Mud Rotary
Drilling Company: Holt Services
Drill Rig Equipment: Mobile Drill B-59
Other Comments:

Hole Diam.: 6 in.
Rod Diam.: NWJ 2-7/8"
Hammer Type: Automatic

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.	Samples	Ground Water
Asphalt.	1.4		None Observed During Drilling
Subbase *(Gravel) (GM).*	2.5		
Brown to gray-brown Concrete.	3.0		
Silty Sand (SM) to *Poorly Graded Sand with Silt (SP-SM)*; moist to wet; mostly fine to medium sand; trace fine gravel; trace organics; iron-oxide staining. Fill (Hf) - Vacuum excavated to 8 feet.	8.0		
- No samples collected from 8 to 30 feet.	30.0		
Loose, brown, *Poorly Graded Sand with Silt (SP-SM)*; moist; trace fine, subangular gravel; fine to medium sand; nonplastic fines; trace organics. Fill (Hf)	42.0	1 2 3	
Loose, gray-brown, *Silty Sand (SM)* to *Poorly Graded Sand with Silt (SP-SM)*; wet; fine to medium sand; nonplastic to low plasticity fines; trace organics; trace wood fragments. Recent Alluvium (Ha)		4	

CONTINUED NEXT SHEET



LEGEND

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

NOTES

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

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

LOG OF BORING B-11-18

September 2018 21-1-22406-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-12
Sheet 1 of 5

REV 3 - Approved for Submittal

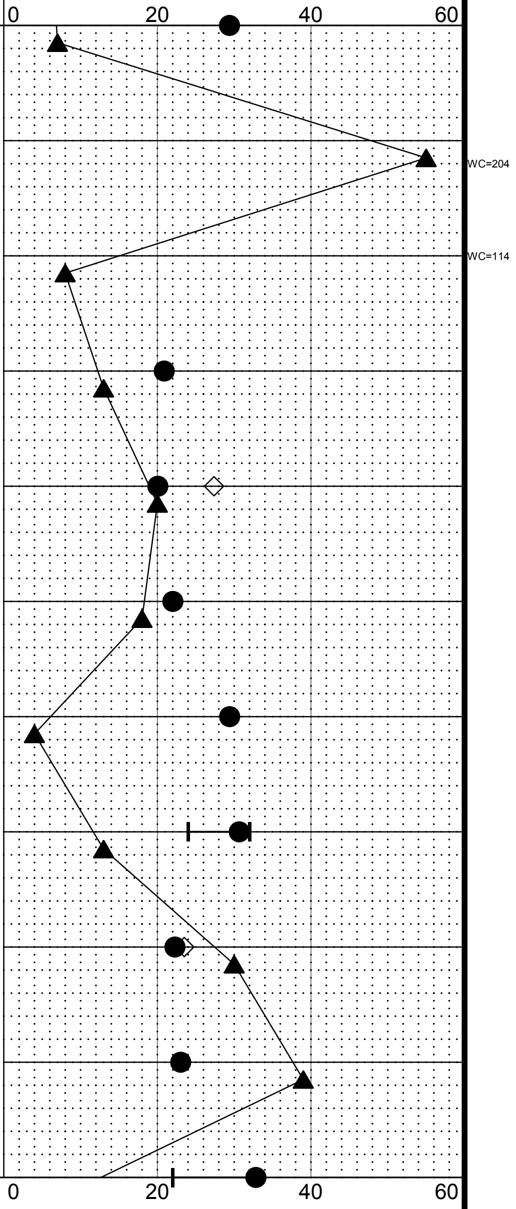
Total Depth: 231.5 ft.
Top Elevation: ~
Vert. Datum: NAVD88
Horiz. Datum: WASP N
Northing:
Easting:
Station:
Offset:
Drilling Method: Mud Rotary
Drilling Company: Holt Services
Drill Rig Equipment: Mobile Drill B-59
Other Comments:
Hole Diam.: 6 in.
Rod Diam.: NWJ 2-7/8"
Hammer Type: Automatic

SOIL DESCRIPTION

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

SOIL DESCRIPTION	Depth, ft.	Samples
		5
Stiff to hard, dark brown, *Organic Silt (OL)*; moist; trace to few fine sand; low plasticity fines; mostly organics and wood fragments. Peat (Hp) - Blow counts at 55 feet are artificially high due to the presence of wood.	53.0	6 7
Medium dense, brown to gray-brown, *Silty Sand (SM)*; wet; trace fine, subangular gravel; trace coarse sand; fine to medium sand; nonplastic fines; local iron-oxide staining; trace organics. Recent Alluvium (Ha)	62.5	8 9 10
Medium dense, gray *Silt (ML)* to *Silt with Sand (ML)*; wet; trace coarse sand; few fine to medium sand; nonplastic to low plasticity fines. Recessional Outwash/Marysville Clay Member (Qvrc)	79.0	11
Medium stiff, gray *Silt (ML)* to *Silt with Sand (ML)*; moist; fine sand; low plasticity fines. Recessional Outwash/Marysville Clay Member (Qvrc)	83.0	12
Medium dense to dense, *Silty Sand (SM)*; wet; fine to medium sand; nonplastic fines. Recessional Outwash/Marysville Sand Member (Qvrm)	88.0	13 14

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



CONTINUED NEXT SHEET

LEGEND
* Sample Not Recovered
⌶ 2.0" O.D. Split Spoon Sample

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

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

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

LOG OF BORING B-11-18

September 2018
21-1-22406-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-12
Sheet 2 of 5

Log: BWC Rev: EAS Typ: LKN

MASTER_LOG_E 21-22406.GPJ SHAN_WIL.GDT 9/6/18

REV 3 - Approved for Submittal

Total Depth: 231.5 ft.
Top Elevation: ~
Vert. Datum: NAVD88
Horiz. Datum: WASP N

Northing:
Easting:
Station:
Offset:

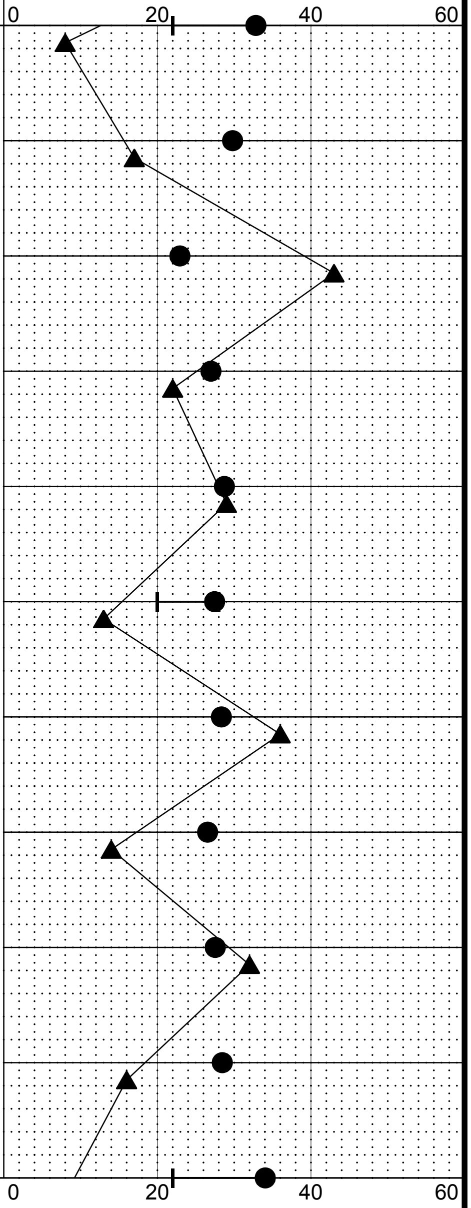
Drilling Method: Mud Rotary
Drilling Company: Holt Services
Drill Rig Equipment: Mobile Drill B-59
Other Comments:

Hole Diam.: 6 in.
Rod Diam.: NWJ 2-7/8"
Hammer Type: Automatic

Depth, ft.	SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.*	Samples
100.0	Stiff to very stiff, gray, *Lean Clay (CL)* to *Silt (ML)*; moist; trace fine sand; laminated; few silty, fine sand seams; low to medium plasticity fines. Recessional Outwash/Marysville Clay Member (Qvrc)	15 16
107.0	Dense, gray, *Silty Sand (SM)*; moist; fine sand; nonplastic fines. Recessional Outwash/Marysville Sand Member (Qvrm)	17
114.0	Stiff to very stiff, gray, *Lean Clay (CL)* to *Lean Clay with Sand (CL)*; moist; fine sand; low to medium plasticity fines; laminated; few silty, fine sand seams. Recessional Outwash/Marysville Clay Member (Qvrc)	18 19 20
127.0	Dense, gray *Silt with Sand (ML)* to *Silt (ML)*; wet; fine sand; nonplastic to low plasticity fines; dilatant. Recessional Outwash/Marysville Sand Member (Qvrm)	21
132.0	Stiff, gray *Silt with Sand (ML)*; moist; fine sand; low plasticity fines; few sandy silt layers; laminated. Recessional Outwash/Marysville Clay Member (Qvrc)	22
137.0	Medium dense, gray, *Sandy Silt (ML)*; wet; fine sand; nonplastic to low plasticity fines; few lean clay seams; dilatant. Recessional Outwash/Marysville Sand Member (Qvrm)	23
142.0		24
148.0		

CONTINUED NEXT SHEET

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



LEGEND
* Sample Not Recovered
⌶ 2.0" O.D. Split Spoon Sample

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

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

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

LOG OF BORING B-11-18

September 2018
21-1-22406-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-12
Sheet 3 of 5

REV 3 - Approved for Submittal

MASTER_LOG_E 21-22406.GPJ SHAN_WIL.GDT 9/6/18
Log: BWC Rev: EAS Typ: LKN

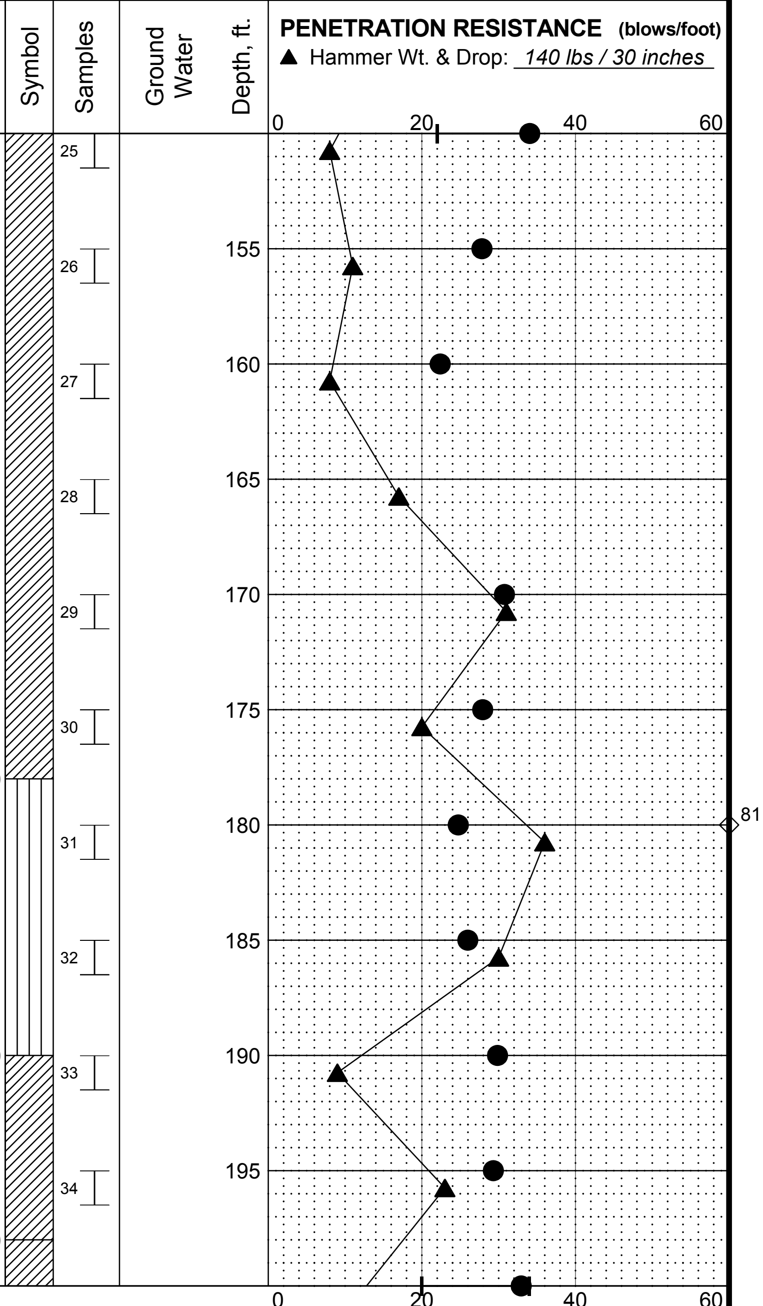
Total Depth: 231.5 ft.
Top Elevation: ~
Vert. Datum: NAVD88
Horiz. Datum: WASP N

Northing:
Easting:
Station:
Offset:

Drilling Method: *Mud Rotary*
Drilling Company: *Holt Services*
Drill Rig Equipment: *Mobile Drill B-59*
Other Comments:

Hole Diam.: *6 in.*
Rod Diam.: *NWJ 2-7/8"*
Hammer Type: *Automatic*

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.
Very stiff, gray *Silt (ML)* to *Silt with Sand (ML)* to *Lean Clay (CL)*; moist; fine sand; low to medium plasticity fines; laminated. Recessional Outwash/Marysville Clay Member (Qvrc)	
Stiff to hard, gray, *Lean Clay (CL)* to *Silt (ML)*; moist; few fine sand; low to medium plasticity fines; few sandy silt seams; laminated. Recessional Outwash/Marysville Clay Member (Qvrc)	178.0
Dense to hard, gray, *Silt with Sand (ML)* to *Lean Clay (CL)*; moist to wet; fine sand; nonplastic to medium plasticity fines; laminated. Recessional Outwash/Marysville Sand Member (Qvrm)	190.0
Stiff to very stiff, *Lean Clay (CL)* and *Sandy Silt (ML)*; moist to wet; fine sand; low to medium plasticity fines; few silty, fine sand seams; laminated. Recessional Outwash/Marysville Clay Member (Qvrc)	198.0



CONTINUED NEXT SHEET

LEGEND

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

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

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

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

LOG OF BORING B-11-18

September 2018 21-1-22406-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-12
Sheet 4 of 5

REV 3 - Approved for Submittal

Total Depth: 231.5 ft.
Top Elevation: ~
Vert. Datum: NAVD88
Horiz. Datum: WASP N
Northing:
Easting:
Station:
Offset:
Drilling Method: Mud Rotary
Drilling Company: Holt Services
Drill Rig Equipment: Mobile Drill B-59
Other Comments:
Hole Diam.: 6 in.
Rod Diam.: NWJ 2-7/8"
Hammer Type: Automatic

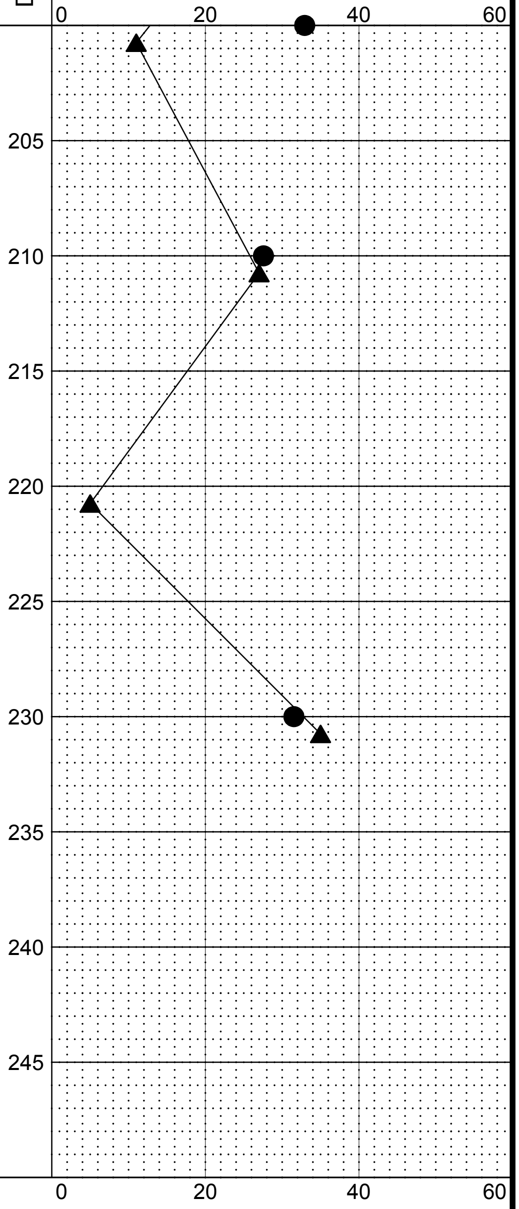
SOIL DESCRIPTION

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

SOIL DESCRIPTION	Depth, ft.	Samples
Stiff, gray, *Lean Clay (CL)*; moist; medium plasticity fines. Recessional Outwash/Marysville Clay Member (Qvrc)		35
Medium dense to dense and hard, gray *Silt (ML)* to *Silt with Sand (ML)* and *Lean Clay (CL)*; moist to wet; fine sand; low to medium plasticity fines. Recessional Outwash/Marysville Clay Member (Qvrc)	207.0	36 37 * 38
BOTTOM OF BORING COMPLETED 2/19/2018	231.5	

PENETRATION RESISTANCE (blows/foot)

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



LEGEND

* Sample Not Recovered

⌶ 2.0" O.D. Split Spoon Sample

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit

Natural Water Content

NOTES

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

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

LOG OF BORING B-11-18

September 2018 21-1-22406-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-12
Sheet 5 of 5

REV 3 - Approved for Submittal

MASTER_LOG_E 21-22406.GPJ SHAN_WIL.GDT 9/6/18

Log: BWC Rev: EAS Typ: LKN

Total Depth: 7.2 ft.
Top Elevation: 17.5 ft.
Vert. Datum: NAVD88
Horiz. Datum: WASP N
Northing: 399,328 ft.
Easting: 1,313,103 ft.
Station: -
Offset: -
Drilling Method: Hand Auger
Drilling Company: S&W
Drill Rig Equipment: Hand Auger
Other Comments:
Hole Diam.: 6 in.
Rod Diam.: 1"
Hammer Type: Manual

SOIL DESCRIPTION

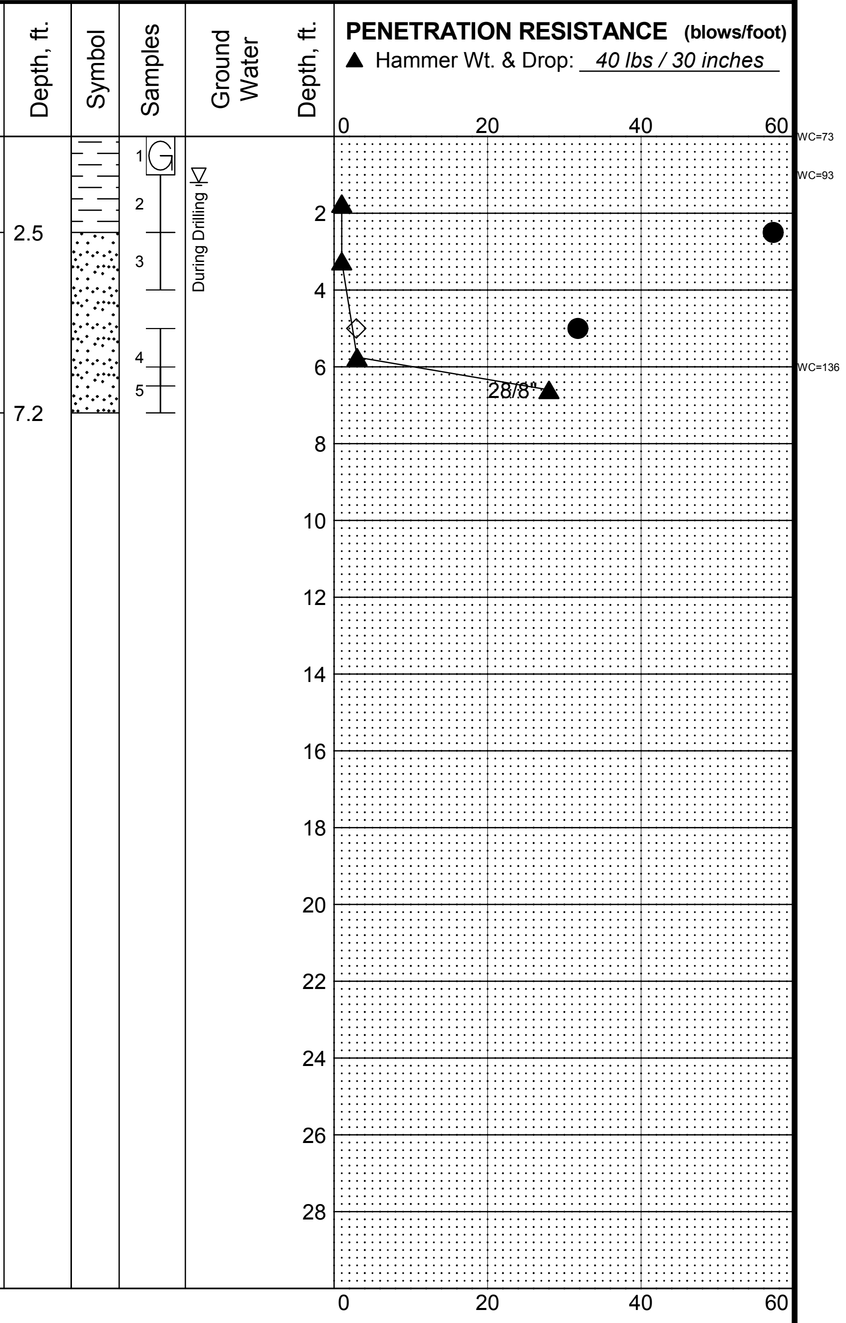
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Brown, *Organic Soil with Sand (OL)*; wet; fine to medium sand; little stems and roots; mostly fine disseminated plant matter.
Peat (Hp)

Very loose, olive gray, *Poorly Graded Sand (SP)* to *Poorly Graded Sand with Silt (SP-SM)*; wet; fine to coarse sand; little to some wood; interbeds and laminations of organic-rich material.
Recent Alluvium (Ha)
- Blow counts at 6 feet are artificially high due to the presence of wood.

BOTTOM OF BORING
COMPLETED 6/13/2017

Notes:
(a) We collected non-standard split-spoon samples using a 1.5-inch-outside-diameter, 1.0-inch-inside-diameter split-spoon sampler. We drove the sampler using a 40-pound hammer, falling freely from a height of 30 inches.
(b) The plotted blow counts are estimated equivalent Standard Penetration Test N-values derived from non-standard penetration test values.



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

LEGEND

* Sample Not Recovered
G Grab Sample
I Split Spoon
⊻ Ground Water Level ATD

NOTES

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

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

LOG OF BORING HA-1-17

September 2017
21-1-22406-003

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FIG. A-13

REV 3 - Approved for Submittal

Total Depth: 14 ft.
Top Elevation: 19.5 ft.
Vert. Datum: NAVD88
Horiz. Datum: WASP N
Northing: 399,144 ft.
Easting: 1,312,969 ft.
Station: -
Offset: -
Drilling Method: Hand Auger
Drilling Company: S&W
Drill Rig Equipment: Hand Auger
Other Comments:
Hole Diam.: 4 in.
Rod Diam.: 1"
Hammer Type: Manual

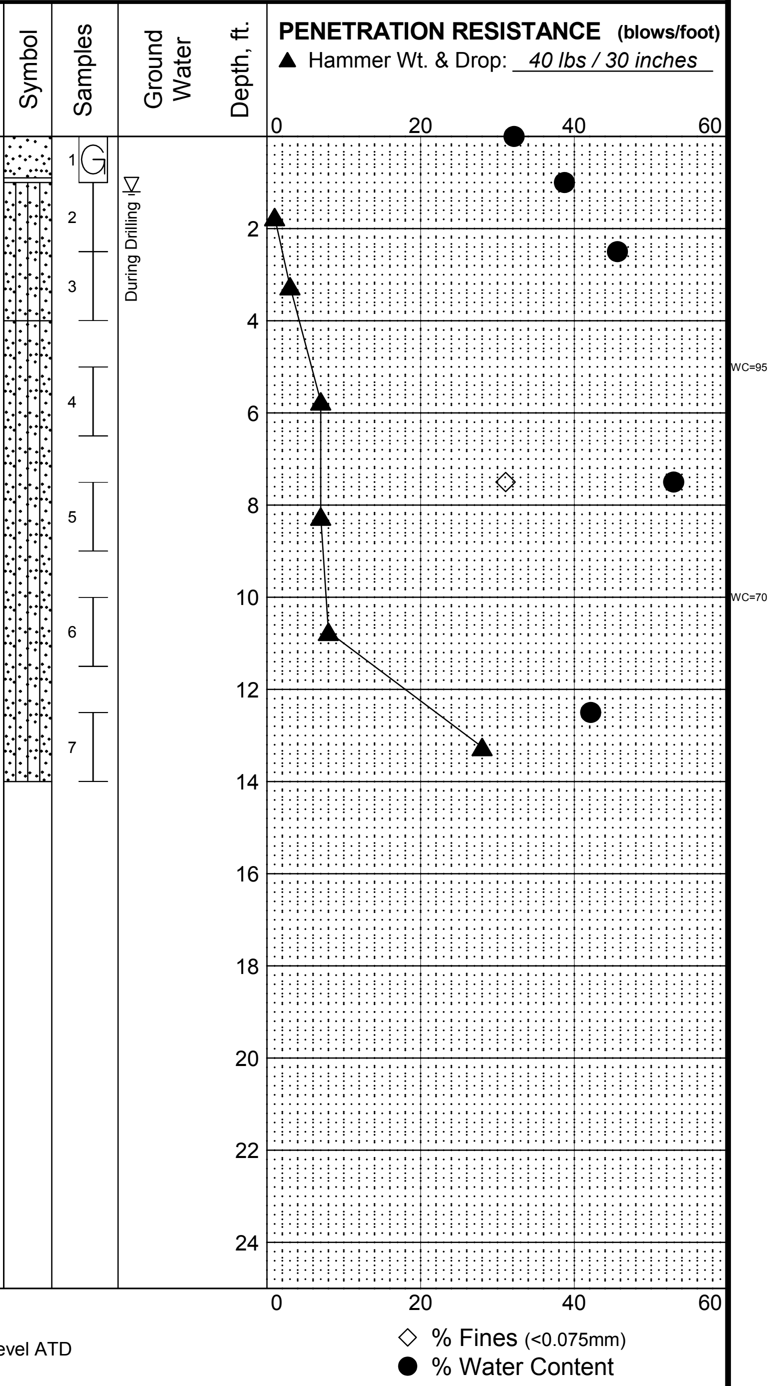
SOIL DESCRIPTION

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

SOIL DESCRIPTION	Depth, ft.
Brown, *Poorly Graded Sand (SP)*; moist; fine to medium sand. Recent Alluvium (Ha)	0.9
	1.0
Olive brown, *Sandy Organic Soil (OL)*; moist; some fine to medium sand; little silt; 50% organics. Peat (Hp)	4.0
Very loose to medium dense, brown to gray, *Silty Sand (SM)* to *Poorly Graded Sand with Silt (SP-SM)*; wet; fine to medium sand; few to little lenses of roots, stems and wood. Recent Alluvium (Ha).	
Interbedded, medium dense, *Silty Sand (SM)* and *Sandy Organic Soil (OL)*; wet; fine sand; few organics in sand beds; mostly organics locally. Recent Alluvium (Ha)/Peat (Hp)	14.0
- Significant heave and sloughing prevented further excavation.	

BOTTOM OF BORING
COMPLETED 6/13/2017

Notes:
(a) We collected non-standard split-spoon samples using a 1.5-inch-outside-diameter, 1.0-inch-inside-diameter split-spoon sampler. We drove the sampler using a 40-pound hammer, falling freely from a height of 30 inches.
(b) The plotted blow counts are estimated equivalent Standard Penetration Test N-values derived from non-standard penetration test values.



LEGEND

* Sample Not Recovered
G Grab Sample
⌶ Split Spoon
⊻ Ground Water Level ATD

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

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

LOG OF BORING HA-2-17

September 2017 21-1-22406-003

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FIG. A-14

REV 3 - Approved for Submittal

Appendix B

Laboratory Test Results

CONTENTS

We performed geotechnical laboratory testing on selected soil samples retrieved from the 11 borings completed for the City of Marysville State Avenue Corridor Widening Project. The laboratory testing program included tests to classify the soil and provide data for engineering studies. We performed visual classification on all retrieved samples. Our laboratory testing program included water content determinations, organic content determinations, grain size distribution analyses, and Atterberg Limits determinations. The following sections describe the laboratory test procedures.

B.1 VISUAL CLASSIFICATION

We visually classified soil samples retrieved from the borings using a system based on ASTM D2487-11, Standard Test Method for Classification of Soil for Engineering Purposes, and ASTM D2488-09a, Standard Recommended Practice for Description of Soils (Visual-Manual Procedure). We summarize our classification system in Appendix A. We assigned a Unified Soil Classification System (USCS) group name and symbol based on our visual classification of particles finer than 76.2 millimeters (3 inches). We revised visual classifications using results of the index tests discussed below.

B.2 WATER CONTENT DETERMINATION

We tested the water content of selected samples in accordance with ASTM D2216-10, Standard Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures. Comparison of the water content of a soil with its index properties can be useful in characterizing soil unit weight, consistency, compressibility, and strength. We present water content test results in the Laboratory Test Summary table in this appendix and graphically on Appendix A exploration logs.

B.3 ORGANIC CONTENT DETERMINATION

We determined the organic content of selected soil samples in accordance with ASTM D2974-14, Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils, Test Method C (440 degrees Celsius). We present organic content test results in the Lab Summary Table in this appendix.

B.4 GRAIN SIZE DISTRIBUTION ANALYSIS

Grain size distribution analyses separate soil particles through mechanical or sedimentation processes. Grain size distributions are used to classify the granular component of soils and can correlate with soil properties, including frost susceptibility, permeability, shear strength, liquefaction potential, capillary action, and sensitivity to moisture. We plot grain size distribution analysis results in this appendix. Grain size distribution plots provide tabular information about each specimen, including USCS group symbol and group name; water content; constituent (i.e., cobble, gravel, sand, and fines) percentages; coefficients of uniformity and curvature, if applicable; personnel initials; ASTM standard designation; and testing remarks. Constituent percentages are presented in the Lab Summary Table in this appendix and fines contents are plotted as data points on Appendix A exploration logs.

B.5 SIEVE ANALYSIS

We performed mechanical sieve analyses on selected soil specimens to determine the grain size distribution of coarse-grained soil particles, in accordance with ASTM C136/C136M-14, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.

B.6 FINES CONTENT DETERMINATION

We determined the percent of fine-grained soil particles (fines content) of selected soil specimens in accordance with ASTM D1140-14, Standard Test Methods for Determining the Amount of Material Finer Than 0.075 mm (No. 200) Sieve in Soils by Washing.

B.7 COMBINED ANALYSIS

We performed combined analyses (mechanical and sedimentation) on selected soil specimens to determine the grain size distribution of coarse- and fine-grained soil particles in accordance with ASTM D422-63 (2007)e2, Standard Test Method for Particle-Size Analysis of Soils. We assumed a specific gravity of 2.7 for hydrometer calculations unless otherwise indicated on grain size distribution plots.

B.8 ATTERBERG LIMITS DETERMINATION

We determined soil plasticity by performing Atterberg Limits tests on selected samples in accordance with ASTM D4318-10e1, Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils, Method A (Multi-Point Liquid Limit). The Atterberg Limits include liquid limit (LL), plastic limit (PL), and plasticity index (PI=LL-PL). These limits can assist soil classification, indicate soil consistency (when compared to natural water content), provide correlation to soil properties, evaluate clogging potential, and estimate liquefaction potential.

We present soil plasticity test results in the Lab Summary Table and on plasticity charts in this appendix. Plasticity charts provide the liquid limit, plastic limit, plasticity index, USCS group symbol, the sample description, water content, and percent passing the No. 200 sieve (if a grain size distribution analysis was performed). Soil plasticity test results are also shown graphically on Appendix A exploration logs.

B.9 CONSIDERATIONS

Drilling and sampling methodologies may affect the outcome of prescribed geotechnical laboratory tests. Refer to the field exploration discussion in this report for a discussion of these potential effects. Instances of limited recovery may have resulted in test samples not meeting specified minimum mass requirements, per ASTM standards. Test plots show which samples do not meet ASTM-specified minimum mass requirements.

LABORATORY TERMS

Abbreviations, Symbols, and Terms	Descriptions
%	Percent
*	Sample specimen weight did not meet required minimum mass for the test method
"	Inch
$^{\#}$	Test not performed by Shannon & Wilson, Inc. laboratory
ASTM Std.	ASTM International Standard
C_c	Coefficient of curvature
Clay size	Soil particles finer than 0.002 mm
cm	Centimeter
cm^2	Square centimeter
Coarse-grained	Soil particles coarser than 0.075 mm (cobble-, gravel- and sand-sized particles)
Cobbles	Soil particles finer than 305 mm and coarser than 76.2 mm
C_u	Coefficient of uniformity
CU	Consolidated-Undrained
ε	Axial strain
Fine-grained	Soil particles finer than 0.075 mm (silt- and clay-sized particles)
ft	Feet
γm	Wet unit weight
Gravel	Soil particles finer than 76.2 mm and coarser than 4.75 mm
G_s	Specific gravity of soil solids
H_o	Initial height
ΔH	Change in height
ΔH_{load}	End of load increment deformation
in	Inch
in^3	Cubic inch
LL	Liquid Limit
min	Minute
mm	Millimeter
μ_m	Micrometer
MC	Moisture content
MPa	Mega-Pascal
NP	Non-plastic
OC	Organic content
p	Total stress
p'	Effective stress
Pa	Pascal
pcf	Pounds per cubic foot
PI	Plasticity Index
PL	Plastic Limit
psf	Pounds per square foot
psi	Pounds per square inch
q	Deviatoric stress
Sand	Soil particles finer than 4.75 mm and coarser than 0.075 mm
sec	Second
Silt	Soil particles finer than 0.075 mm and coarser than 0.002 mm
t_n	Time to n% primary consolidation
t_{load}	Duration of load increment
tsf	Short tons per square foot
USCS	Unified Soil Classification System
UU	Unconsolidated-Undrained
WC	Water content

SAMPLE TYPES

Abbreviations, Symbols, and Terms	Descriptions
2SS	2.5-inch Outside Diameter Split-Spoon Sample
2ST	2-inch Outside Diameter Thin-Walled Tube
3HSA	3-inch CME Hollow-Stem Auger Sampler
3SS	3-inch Outside Diameter Split-Spoon Sample
4SS	4-inch Inside Diameter Split-Spoon Sample
6SS	6-inch Inside Diameter Split-Spoon Sample
CA_MC	Modified California Sampler
CA_SPT	Standard Penetration Test (SPT)
CORE	Rock Core
DM	+3.25-inch Outside Diameter Split-Spoon Sample
DMR	3.25-inch Sampler with Internal Rings
GRAB	Grab Sample
GUS	3-inch Outside Diameter Gregory Undisturbed Sampler (GUS) Sample
OSTER	3-inch Outside Diameter Osterberg Sample
PITCHER	3-inch Outside Diameter Pitcher Sample
PMT	Pressuremeter Test (f=failed)
PO	Porter Penetration Test Sample
PT	2.5-inch Outside Diameter Thin-Walled Tube
ROCK	Rock Core Sample
SCORE	Soil Core (as in Sonic Core Borings)
SH1	1-inch Plastic Sheath
SH2	2-inch Plastic Sheath with Soil Recovery
SH3	2-inch Plastic Sheath with no Soil Recovery
SPT	2-inch Outside Diameter Split-Spoon Sample
SS	Split-Spoon
ST	3-inch Outside Diameter Thin-Walled Tube
STW	3-inch Outside Diameter Thin-Walled Tube
TEST	Sample Test Interval
TW	Thin Wall Sample
UNDIST	Undisturbed Sample
VANE	Vane Shear
WATER	Water Sample for Probe Logs
XCORE	Core Sample

LABORATORY TEST SUMMARY

Boring	Top Depth (ft)	Sample Number	Sample Type	Blow Count	USCS	WC (%)	OC (%)	% Gravel	% Sand	% Fines	% Clay-size	C_u	C_c	LL	PL	NP	Soil Description
B-1-17	2.5	S-1	SPT	12		4.2											
B-1-17	5	S-2	SPT	9	SP	2.6		8*	89*	2.7*		3.1	0.9				Poorly Graded Sand
B-1-17	7.5	S-3	SPT	9		3.3											
B-1-17	10	S-4	SPT	21	SP	2.5		17*	78*	4.5*		4.3	0.9				Poorly Graded Sand with Gravel
B-1-17	12.5	S-5	SPT	21	SP	20.5		1*	95*	3.9*		2.4	1.2				Poorly Graded Sand
B-1-17	15	S-6	SPT	22		23.7											
B-1-17	17.5	S-7	SPT	27		17.3											
B-1-17	20	S-8	SPT	20		19.8											
B-1-17	21	S-8	SPT	20		27.2											
B-2-17	2.5	S-1	SPT	9		2.9											
B-2-17	5	S-2	SPT	11	SP	2.9		0*	97*	2.7*		2.2	0.9				Poorly Graded Sand
B-2-17	7.5	S-3	SPT	16	SM	6.5		2*	85*	13*							Silty Sand
B-2-17	10	S-4	SPT	19	SP-SM	8.0		0*	91*	9*							Poorly Graded Sand with Silt
B-2-17	12.5	S-5	SPT	19		6.5											
B-2-17	15	S-6	SPT	9		9.9											
B-2-17	17.5	S-7	SPT	18		7.4											
B-2-17	20	S-8	SPT	11		5.3											
B-3-17	2.5	S-1	SPT	11		5.0											
B-3-17	5	S-2	SPT	12		3.7											
B-3-17	7.5	S-3	SPT	17	SP	5.4		1*	95*	4.1*		1.3	0.6				Poorly Graded Sand
B-3-17	10	S-4	SPT	13		5.5											
B-3-17	12.5	S-5	SPT	21		10.0											
B-3-17	15	S-6	SPT	15		14.9											
B-3-17	17.5	S-7	SPT	17		20.2											
B-3-17	20	S-8	SPT	20		6.3											
B-4-17	2.5	S-1	SPT	18		4.5											
B-4-17	5	S-2	SPT	14	SP-SM	5.5			94	6.1		3.2	1.3				Poorly Graded Sand with Silt
B-4-17	7.5	S-3	SPT	14	SM	9.8			87	13							Silty Sand
B-4-17	10	S-4	SPT	14	SP-SM	7.5			90*	10*							Poorly Graded Sand with Silt
B-4-17	12.5	S-5	SPT	17		7.7											
B-4-17	15	S-6	SPT	20		6.7											
B-4-17	17.5	S-7	SPT	15		7.6											

LABORATORY TEST SUMMARY

Boring	Top Depth (ft)	Sample Number	Sample Type	Blow Count	USCS	WC (%)	OC (%)	% Gravel	% Sand	% Fines	% Clay-size	C_u	C_c	LL	PL	NP	Soil Description
B-4-17	20	S-8	SPT	22		6.2											
B-5-17	2.5	S-1	SPT	4		16.9											
B-5-17	5	S-2	SPT	17		13.8											
B-5-17	7.5	S-3	SPT	16		17.4											
B-5-17	10	S-4	SPT	19	SP-SM	16.4		0*	93*	7.3*		2.3	0.8				Poorly Graded Sand with Silt
B-5-17	12.5	S-5	SPT	18		17.5											
B-5-17	15	S-6	SPT	19		19.7											
B-5-17	17.5	S-7	SPT	18		12.6											
B-5-17	18.3	S-7	SPT	18		25.1											
B-5-17	20	S-8	SPT	19		18.8											
B-5-17	25	S-9	SPT	9		30.6											
B-5-17	25.5	S-9B	SPT	9	CL	37.9								42	23		Lean Clay
B-5-17	30	S-10	SPT	28	SP-SM	22.1				6.5							Poorly Graded Sand with Silt
B-5-17	35	S-11	SPT	19		23.2											
B-5-17	36.3	S-11	SPT	19		25.2											
B-5-17	40	S-12	SPT	24		27.5											
B-5-17	45.4	S-13	SPT	27		30.9											
B-5-17	50	S-14	SPT	18		35.3											
B-5-17	55	S-15	SPT	34	SM	23.4			74	26	4						Silty Sand
B-5-17	60	S-16	SPT	39		23.0											
B-5-17	65	S-17	SPT	21	CL	30.3								39	24		Lean Clay
B-5-17	70	S-18	SPT	27		28.2											
B-5-17	75	S-19	SPT	28		28.8											
B-5-17	80	S-20	SPT	31	ML	29.5				55							Sandy Silt
B-5-17	85	S-21	SPT	34		25.5											
B-5-17	90	S-22	SPT	30		25.5											
B-5-17	90.6	S-22	SPT	30		22.7											
B-5-17	95	S-23	SPT	30		28.0											
B-5-17	100	S-24	SPT	30		22.5											
B-5-17	105	S-25	SPT	30		24.9											
B-5-17	110	S-26	SPT	38		23.7											
B-6-17	7.5	S-1	SPT	18		23.0											

LABORATORY TEST SUMMARY

Boring	Top Depth (ft)	Sample Number	Sample Type	Blow Count	USCS	WC (%)	OC (%)	% Gravel	% Sand	% Fines	% Clay-size	C_u	C_c	LL	PL	NP	Soil Description
B-6-17	10	S-2	SPT	18		12.3											
B-6-17	12.5	S-3	SPT	22		15.4											
B-6-17	15	S-4	SPT	11	SP-SM	9.5			93	7.0							Poorly Graded Sand with Silt
B-6-17	17.5	S-5	SPT	12		12.7											
B-6-17	20	S-6	SPT	13		11.0											
B-6-17	25	S-7	SPT	27		10.1											
B-6-17	30	S-8	SPT	14	SM	23.3			80	20							Silty Sand
B-6-17	35	S-9	SPT	24		28.1											
B-6-17	40	S-10	SPT	27		22.9											
B-6-17	45	S-11	SPT	28	SM	22.0			77	23							Silty Sand
B-6-17	50	S-12	SPT	15		29.2											
B-6-17	55	S-13	SPT	24	ML	28.1				58							Sandy Silt
B-6-17	60	S-14	SPT	32		26.9											
B-6-17	65	S-15	SPT	30		25.6											
B-6-17	70	S-16	SPT	15	CL	30.9								34	23		Lean Clay
B-6-17	75	S-17	SPT	22	SM	23.9			71	29							Silty Sand
B-6-17	80	S-18	SPT	13		34.8											
B-6-17	85	S-19	SPT	17		29.2											
B-6-17	90	S-20	SPT	23		23.4											
B-6-17	95	S-21	SPT	36	SM	22.5			65	35							Silty Sand
B-6-17	100	S-22	SPT	13		34.0											
B-6-17	105	S-23	SPT	35		30.3											
B-7-17	7.5	S-1	SPT	2		26.1											
B-7-17	10	S-2	SPT	2	SP-SM	23.6				6.8							Poorly Graded Sand with Silt
B-7-17	12.5	S-3	SPT	2		25.0											
B-7-17	13	S-3	SPT	2		26.7											
B-7-17	15	S-4	SPT	4	SP-SM			3	86	10		4.7	1.2				Poorly Graded Sand with Silt
B-7-17	17.5	S-5	SPT	8		18.4											
B-7-17	20	S-6	SPT	4	SP-SM	25.8				7.0							Poorly Graded Sand with Silt
B-7-17	25	S-7	SPT	5		23.2											
B-7-17	30	S-8	SPT	7	SM	23.8		1	88	12							Silty Sand
B-7-17	35	S-9	SPT	6		20.1											

LABORATORY TEST SUMMARY

Boring	Top Depth (ft)	Sample Number	Sample Type	Blow Count	USCS	WC (%)	OC (%)	% Gravel	% Sand	% Fines	% Clay-size	C_u	C_c	LL	PL	NP	Soil Description
B-7-17	40	S-10	SPT	10		69.8	15.6										
B-7-17	45	S-11	SPT	14		25.1											
B-7-17	50	S-12	SPT	17	SM	26.3			61	39	6						Silty Sand
B-7-17	55	S-13	SPT	24	SM	25.9				37							Silty Sand
B-7-17	60	S-14A	SPT	21	ML	28.5				85							Silt with Sand
B-7-17	60.7	S-14	SPT	21		23.7											
B-7-17	61.2	S-14	SPT	21		26.9											
B-7-17	65	S-15	SPT	19		29.5											
B-7-17	70	S-16	SPT	18	CL	30.7								37	23		Lean Clay
B-7-17	75	S-17	SPT	23	SM	25.0			81	19							Silty Sand
B-7-17	80	S-18	SPT	28		25.4											
B-7-17	85	S-19	SPT	25		27.0											
B-7-17	86	S-19	SPT	25		30.0											
B-7-17	90	S-20	SPT	33	SM	23.9				20							Silty Sand
B-8-17	7.5	S-1	SPT	3		21.7											
B-8-17	10	S-2	SPT	2	SP-SM	23.8				7.2							Poorly Graded Sand with Silt
B-8-17	12.5	S-3	SPT	2		17.1											
B-8-17	15	S-4	SPT	3		17.3											
B-8-17	17.5	S-5	SPT	9		15.7											
B-8-17	20	S-6	SPT	4	SP-SM	17.4		1*	89*	9.8*		4.4	1.3				Poorly Graded Sand with Silt
B-8-17	25	S-7	SPT	6		12.9											
B-8-17	30	S-8	SPT	5	SP-SM	16.9				8.8							Poorly Graded Sand with Silt
B-8-17	35	S-9	SPT	8		14.4											
B-8-17	40	S-10	SPT	5		24.4											
B-8-17	45	S-11	SPT	17	SM	27.8		1*	82*	17*							Silty Sand
B-8-17	50	S-12	SPT	11		36.0											
B-8-17	55	S-13	SPT	18	SP-SM	33.3				8.5							Poorly Graded Sand with Silt
B-8-17	60	S-14	SPT	8		27.3											
B-8-17	60.5	S-14	SPT	8		52.2											
B-8-17	70	S-16	SPT	28	SW-SM	19.1		3	89	7.6		11.8	1.1				Well-Graded Sand with Silt
B-8-17	75	S-17	SPT	32		21.1											
B-8-17	80	S-18	SPT	25		22.6											

LABORATORY TEST SUMMARY

Boring	Top Depth (ft)	Sample Number	Sample Type	Blow Count	USCS	WC (%)	OC (%)	% Gravel	% Sand	% Fines	% Clay-size	C_u	C_c	LL	PL	NP	Soil Description
B-8-17	85	S-19	SPT	20		22.6											
B-8-17	85.4	S-19B	SPT	20	CL	25.5								34	21		Lean Clay with Sand
B-8-17	90	S-20	SPT	46	SM	25.9			64	36	4						Silty Sand
B-9-17	7.5	S-1	SPT	3		22.2											
B-9-17	10	S-2	SPT	3		18.6											
B-9-17	12.5	S-3	SPT	3		17.9											
B-9-17	15	S-4	SPT	5	SP-SM	16.4		1	88	11		4.5	1.3				Poorly Graded Sand with Silt
B-9-17	17.5	S-5	SPT	4		14.3											
B-9-17	20	S-6	SPT	4		17.5											
B-9-17	25	S-7	SPT	5		20.4											
B-9-17	30	S-8	SPT	8	SP-SM	15.2				8.5							Poorly Graded Sand with Silt
B-9-17	35	S-9	SPT	8		19.5											
B-9-17	40	S-10	SPT	15		29.6											
B-9-17	40.5	S-10	SPT	15		39.0											
B-9-17	41.3	S-10	SPT	15		30.5											
B-9-17	45	S-11	SPT	18	SM	23.2		1	68	31							Silty Sand
B-9-17	50	S-12A/B	SPT	15	SM	24.5				40							Silty Sand
B-9-17	55	S-13	SPT	17		27.4											
B-9-17	55.5	S-13	SPT	17		30.4											
B-9-17	60	S-14	SPT	6	CL	32.0								33	23		Lean Clay with Sand
B-9-17	65	S-15	SPT	23	ML	26.2			27	73	5						Silt with Sand
B-9-17	70	S-16	SPT	15		29.0											
B-9-17	75	S-17	SPT	10		30.3											
B-9-17	80	S-18	SPT	24	SM	24.1				34							Silty Sand
B-9-17	85	S-19	SPT	23		25.1											
B-9-17	90	S-20	SPT	11		22.9											
B-9-17	90.4	S-20	SPT	11		27.5											
B-9-17	95	S-21	SPT	23		25.8											
B-9-17	100	S-22	SPT	53		28.7											
B-9-17	105	S-23	SPT	31		22.3											
B-10-18	30	S-1	SPT	6		11.8											
B-10-18	35	S-2	SPT	6	SP-SM	19.5				10							Poorly Graded Sand with Silt

LABORATORY TEST SUMMARY

Boring	Top Depth (ft)	Sample Number	Sample Type	Blow Count	USCS	WC (%)	OC (%)	% Gravel	% Sand	% Fines	% Clay-size	C_u	C_c	LL	PL	NP	Soil Description
B-10-18	40	S-3	SPT	5		23.2											
B-10-18	45	S-4	SPT	6		26.5											
B-10-18	50	S-5	SPT	10		22.5											
B-10-18	55	S-6	SPT	8		184.7											
B-10-18	60	S-7	SPT	19		149.4											
B-10-18	65	S-8	SPT	15	MH	69.2								84	58.3		Elastic Silt with Sand
B-10-18	70	S-9	SPT	41		19.0											
B-10-18	75	S-10	SPT	13		23.4											
B-10-18	80	S-11	SPT	32	ML	24.0								0	0	NP	Sandy Silt
B-10-18	85	S-12	SPT	15		23.1											
B-10-18	90	S-13	SPT	16		26.9											
B-10-18	95	S-14	SPT	24		20.9											
B-10-18	100	S-15	SPT	12		31.5											
B-10-18	105	S-16	SPT	38		24.0											
B-10-18	110	S-17	SPT	27	SM	24.5				46							Silty Sand
B-10-18	115	S-18	SPT	20		21.1											
B-10-18	120	S-19	SPT	16		28.9											
B-10-18	125	S-20	SPT	10		29.8											
B-10-18	130	S-21	SPT	12		31.3											
B-10-18	135	S-22	SPT	8	CL-ML	22.5								21.6	17.8		Silty Clay
B-10-18	140	S-23	SPT	18		26.1											
B-10-18	145	S-24	SPT	18		27.5											
B-10-18	150	S-25	SPT	20	ML	24.1								22.5	19.3		Silt
B-10-18	155	S-26	SPT	20		31.7											
B-10-18	160	S-27	SPT	8		34.4											
B-10-18	165	S-28	SPT	9	ML	34.4								30.9	24.1		Silt
B-10-18	170	S-29	SPT	13		23.2											
B-10-18	175	S-30	SPT	35		25.7											
B-10-18	180	S-31	SPT	28	ML	26.1			17	83							Silt with Sand
B-10-18	185	S-32	SPT	20		32.9											
B-10-18	190	S-33	SPT	26	ML	33.9			3	97							Silt
B-10-18	195	S-34	SPT	38		24.9											

LABORATORY TEST SUMMARY

Boring	Top Depth (ft)	Sample Number	Sample Type	Blow Count	USCS	WC (%)	OC (%)	% Gravel	% Sand	% Fines	% Clay-size	C_u	C_c	LL	PL	NP	Soil Description
B-10-18	200	S-35	SPT	17		28.5											
B-11-18	30	S-1	SPT	7		15.0											
B-11-18	35	S-2	SPT	7		18.8											
B-11-18	40	S-3	SPT	5		25.9											
B-11-18	45	S-4	SPT	6	SM	26.1				18							Silty Sand
B-11-18	50	S-5	SPT	7		29.4											
B-11-18	56	S-6	SPT	55		204.4											
B-11-18	60	S-7	SPT	8		113.8											
B-11-18	65	S-8	SPT	13		20.9											
B-11-18	70	S-9	SPT	20	SM	20.1				27							Silty Sand
B-11-18	75	S-10	SPT	18		22.0											
B-11-18	80	S-11	SPT	4		29.4											
B-11-18	85	S-12	SPT	13	ML	30.7								32.2	23.6		Silt
B-11-18	90	S-13	SPT	30	SM	22.3				24							Silty Sand
B-11-18	95	S-14	SPT	39		23.0											
B-11-18	100	S-15	SPT	8	CL	32.8								33.2	21.9		Lean Clay
B-11-18	105	S-16	SPT	17		29.8											
B-11-18	110	S-17	SPT	43		22.9											
B-11-18	115	S-18	SPT	22		27.0											
B-11-18	120	S-19	SPT	29		28.7											
B-11-18	125	S-20	SPT	13	CL	27.5								28	20.3		Lean Clay
B-11-18	130	S-21	SPT	36		28.3											
B-11-18	135	S-22	SPT	14		26.5											
B-11-18	140	S-23	SPT	32		27.5											
B-11-18	145	S-24	SPT	16		28.5											
B-11-18	150	S-25	SPT	8	CL	34.0								34.2	22.1		Lean Clay
B-11-18	155	S-26	SPT	11		27.8											
B-11-18	160	S-27	SPT	8		22.4											
B-11-18	170	S-29	SPT	31		30.8											
B-11-18	175	S-30	SPT	20		27.9											
B-11-18	180	S-31	SPT	36	ML	24.7			19*	81*							Silt with Sand
B-11-18	185	S-32	SPT	30		26.0											

LABORATORY TEST SUMMARY

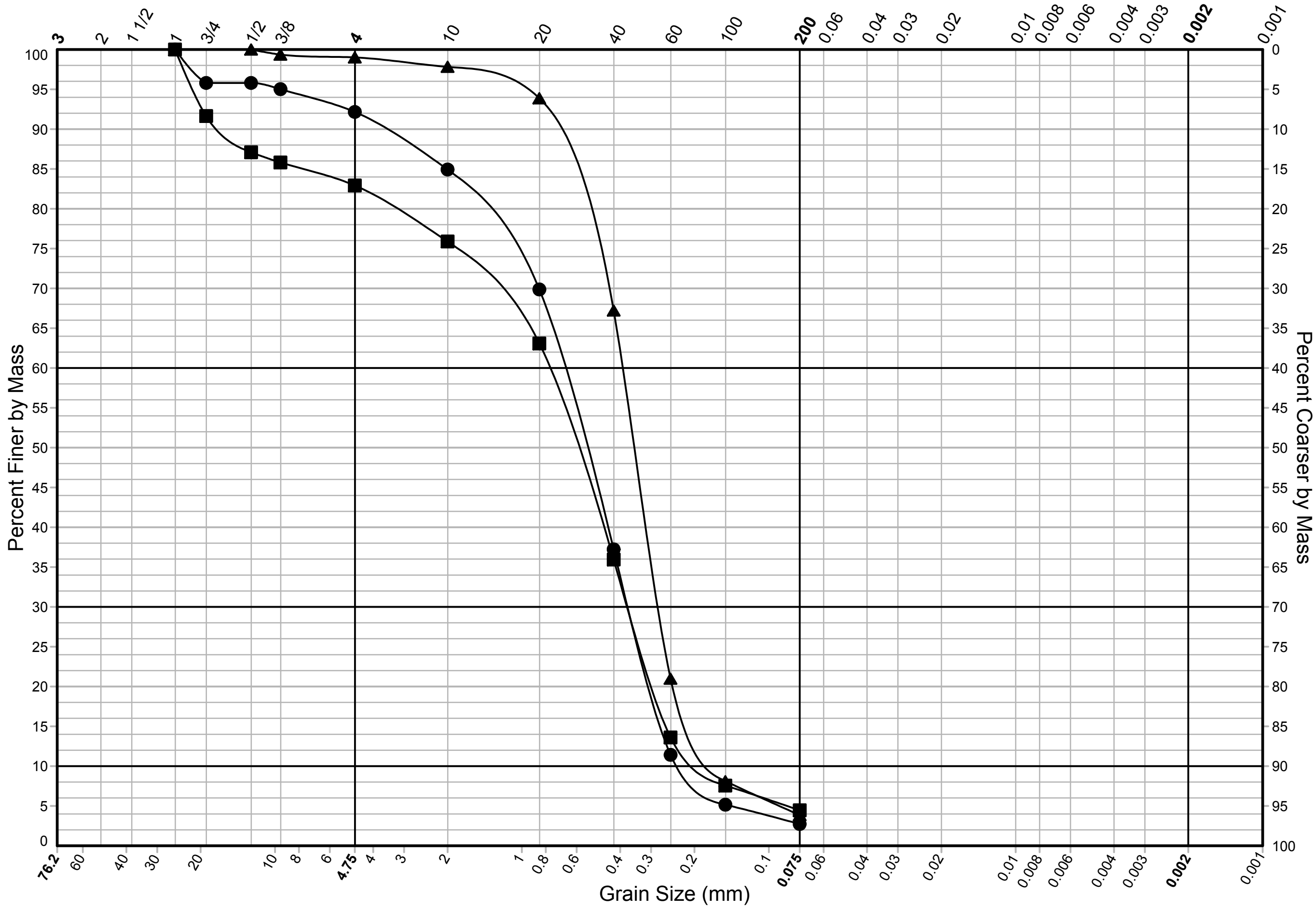
Boring	Top Depth (ft)	Sample Number	Sample Type	Blow Count	USCS	WC (%)	OC (%)	% Gravel	% Sand	% Fines	% Clay-size	C_u	C_c	LL	PL	NP	Soil Description
B-11-18	190	S-33	SPT	9		29.9											
B-11-18	195	S-34	SPT	23		29.3											
B-11-18	200	S-35	SPT	11	CL	32.9								34.4	19.9		Lean Clay
B-11-18	210	S-36	SPT	27		27.6											
B-11-18	230	S-38	SPT	35		31.5											
HA-1-17	0	S-1	GRAB			72.6											
HA-1-17	1	S-2	SS	1		92.5	8.5										
HA-1-17	2.5	S-3	SS	1		57.2											
HA-1-17	5	S-4	SS	3	SP	31.8		1	96	2.9		5.2	0.7				Poorly Graded Sand
HA-1-17	6	S-4	SS	3		136.1											
HA-1-17	6	S-5	SS	28/8"		136.1											
HA-2-17	0	S-1	GRAB			32.2											
HA-2-17	1	S-2	SS	1		38.7											
HA-2-17	2.5	S-3	SS	3		45.6											
HA-2-17	5	S-4	SS	7		94.9	9.7										
HA-2-17	7.5	S-5	SS	7	SM	52.9			69*	31*	3*						Silty Sand
HA-2-17	10	S-6	SS	8		69.7	7.2										
HA-2-17	12.5	S-7	SS	28		42.1											

GRAIN SIZE DISTRIBUTION PLOT

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

BORING B-1-17

Gravel		Sand			Fines	
Coarse	Fine	Coarse	Medium	Fine	Silt	Clay-Size
Mesh Opening in Inches		Mesh Openings per Inch, U.S. Standard			Grain Size in Millimeters	



Sample Identification	Depth (ft)	USCS Group Symbol	USCS Group Name	Gravel %	Sand %	Fines %	< 20μm %	< 2μm %	WC %	Tested By	Review By	ASTM Std.
● B-1-17, S-2*	5.0	SP	Poorly Graded Sand	8	89	2.7			2.6	CRM	AKV	C136
■ B-1-17, S-4*	10.0	SP	Poorly Graded Sand with Gravel	17	78	4.5			2.5	CRM	AKV	C136
▲ B-1-17, S-5*	12.5	SP	Poorly Graded Sand	1	95	3.9			20.5	CRM	AKV	C136

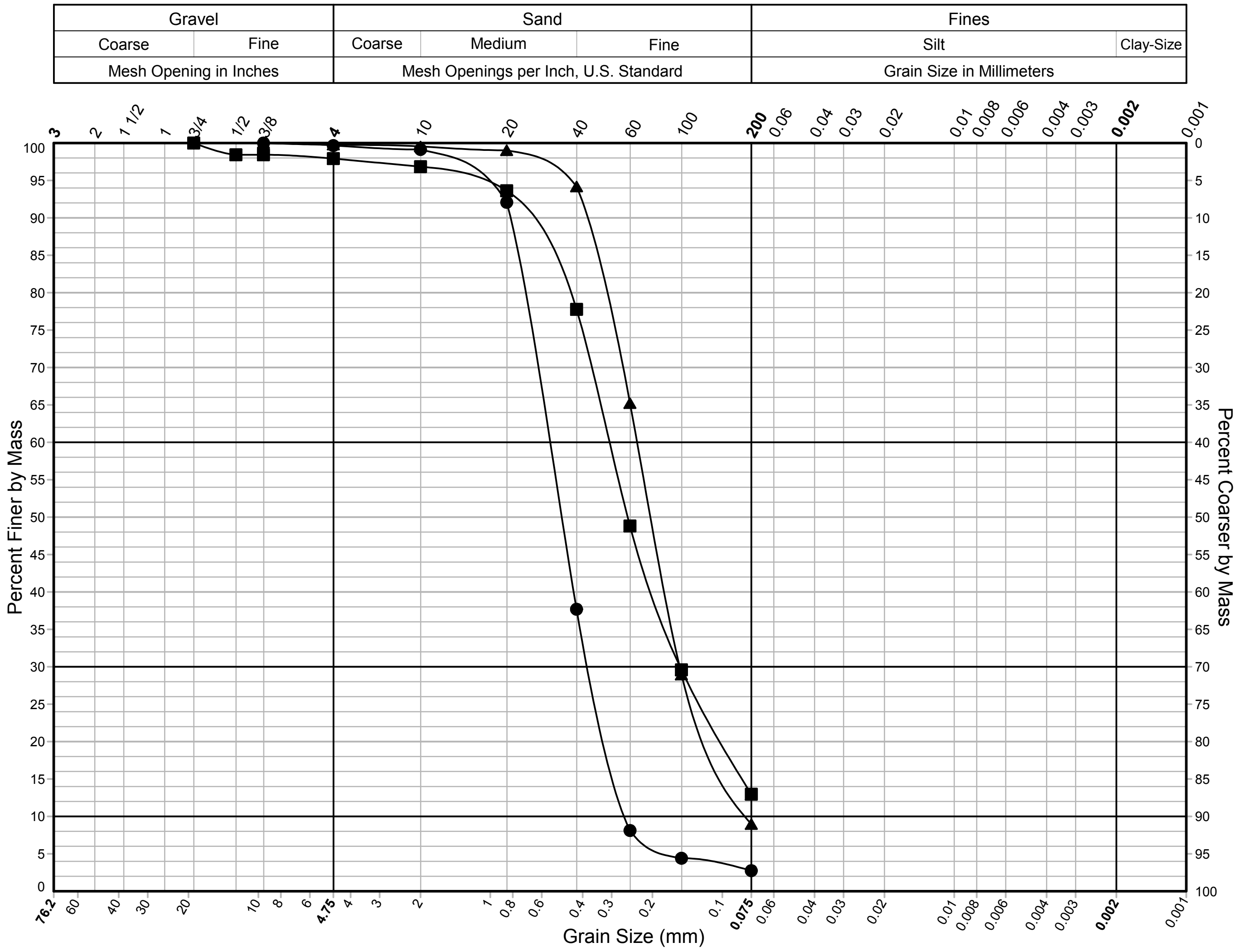
* *Test specimen did not meet minimum mass recommendations.*

21-1-22406-003 A_GSA_MAIN 21-22406.GPJ SHAN_WIL.GDT 8/30/18

GRAIN SIZE DISTRIBUTION PLOT

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

BORING B-2-17



Sample Identification	Depth (ft)	USCS Group Symbol	USCS Group Name	Gravel %	Sand %	Fines %	< 20µm %	< 2µm %	WC %	Tested By	Review By	ASTM Std.
● B-2-17, S-2*	5.0	SP	Poorly Graded Sand	0	97	2.7			2.9	CRM	AKV	C136
■ B-2-17, S-3*	7.5	SM	Silty Sand	2	85	13			6.5	CRM	AKV	C136
▲ B-2-17, S-4*	10.0	SP-SM	Poorly Graded Sand with Silt	0	91	9.0			8.0	CRM	AKV	C136

* *Test specimen did not meet minimum mass recommendations.*

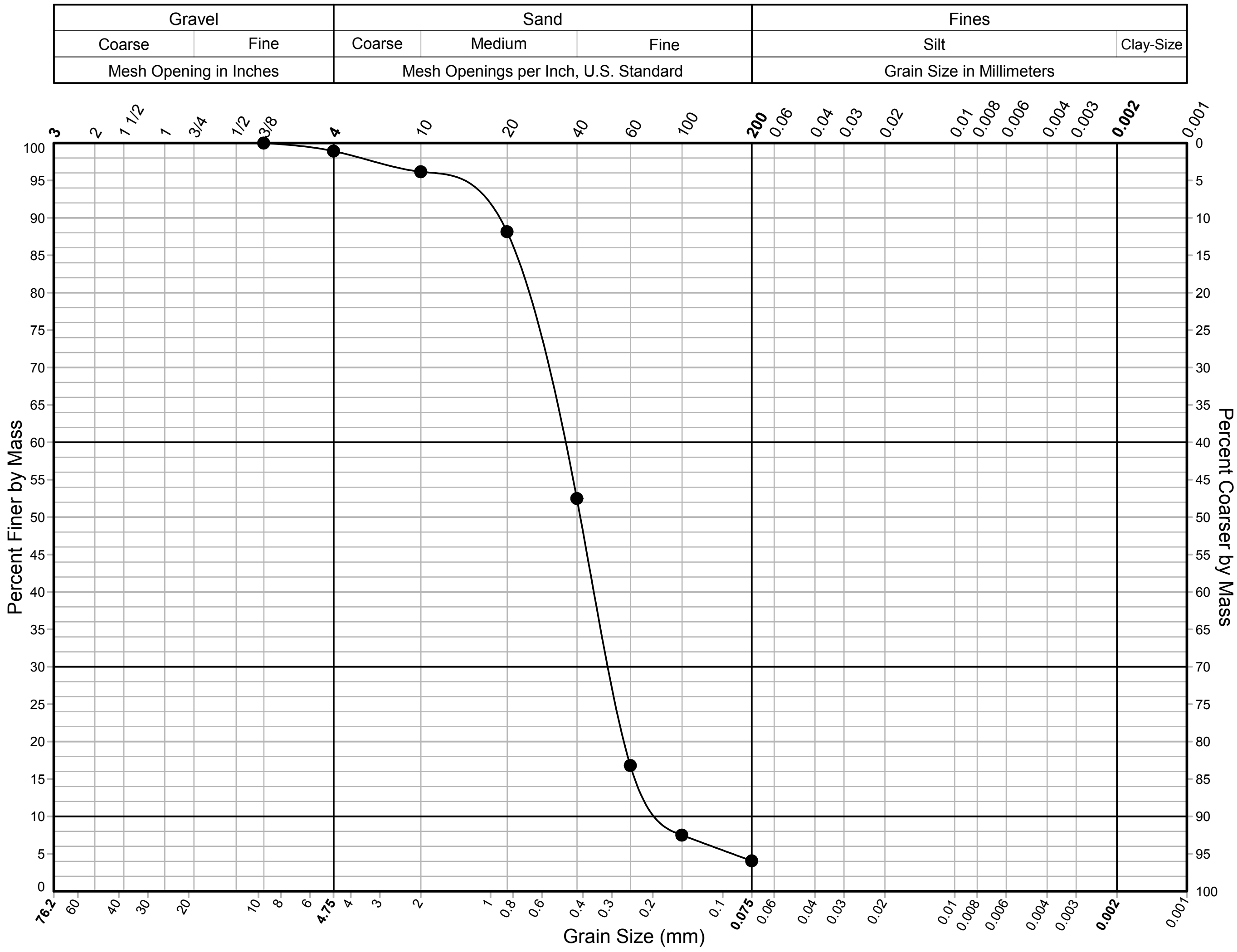
21-1-22406-003 A_GSA_MAIN 21-22406.GPJ SHAN_WIL.GDT 8/30/18

SHANNON & WILSON, INC.

GRAIN SIZE DISTRIBUTION PLOT

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

BORING B-3-17



Sample Identification	Depth (ft)	USCS Group Symbol	USCS Group Name	Gravel %	Sand %	Fines %	< 20µm %	< 2µm %	WC %	Tested By	Review By	ASTM Std.
● B-3-17, S-3*	7.5	SP	Poorly Graded Sand	1	95	4.1			5.4	CRM	AKV	C136

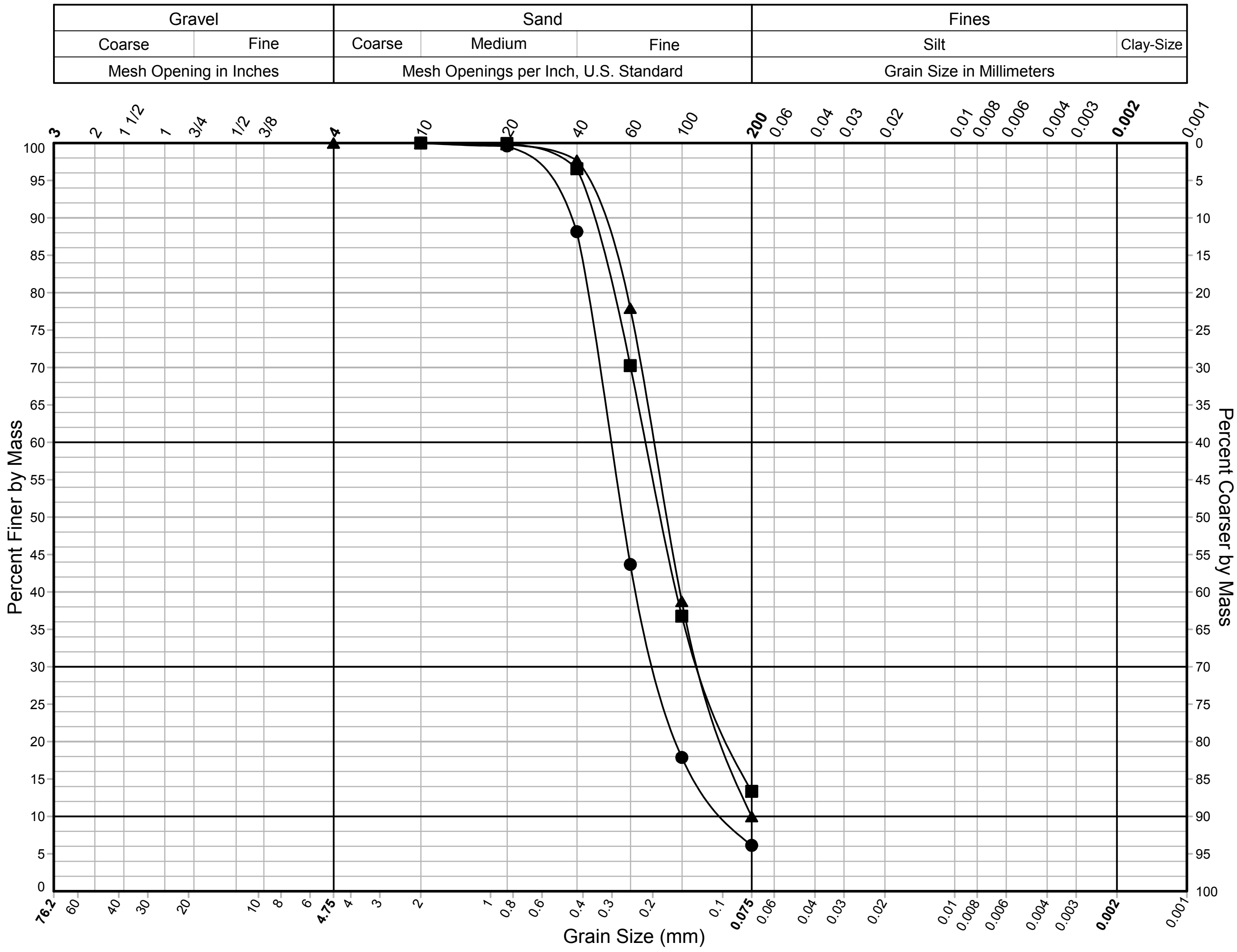
* *Test specimen did not meet minimum mass recommendations.*

21-1-22406-003 A_GSA_MAIN 21-22406.GPJ SHAN_WIL.GDT 8/30/18

GRAIN SIZE DISTRIBUTION PLOT

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

BORING B-4-17



Sample Identification	Depth (ft)	USCS Group Symbol	USCS Group Name	Gravel %	Sand %	Fines %	< 20µm %	< 2µm %	WC %	Tested By	Review By	ASTM Std.
● B-4-17, S-2	5.0	SP-SM	Poorly Graded Sand with Silt		94	6.1			5.5	CRM	AKV	C136
■ B-4-17, S-3	7.5	SM	Silty Sand		87	13			9.8	CRM	AKV	C136
▲ B-4-17, S-4*	10.0	SP-SM	Poorly Graded Sand with Silt		90	10			7.5	CRM	AKV	C136

* *Test specimen did not meet minimum mass recommendations.*

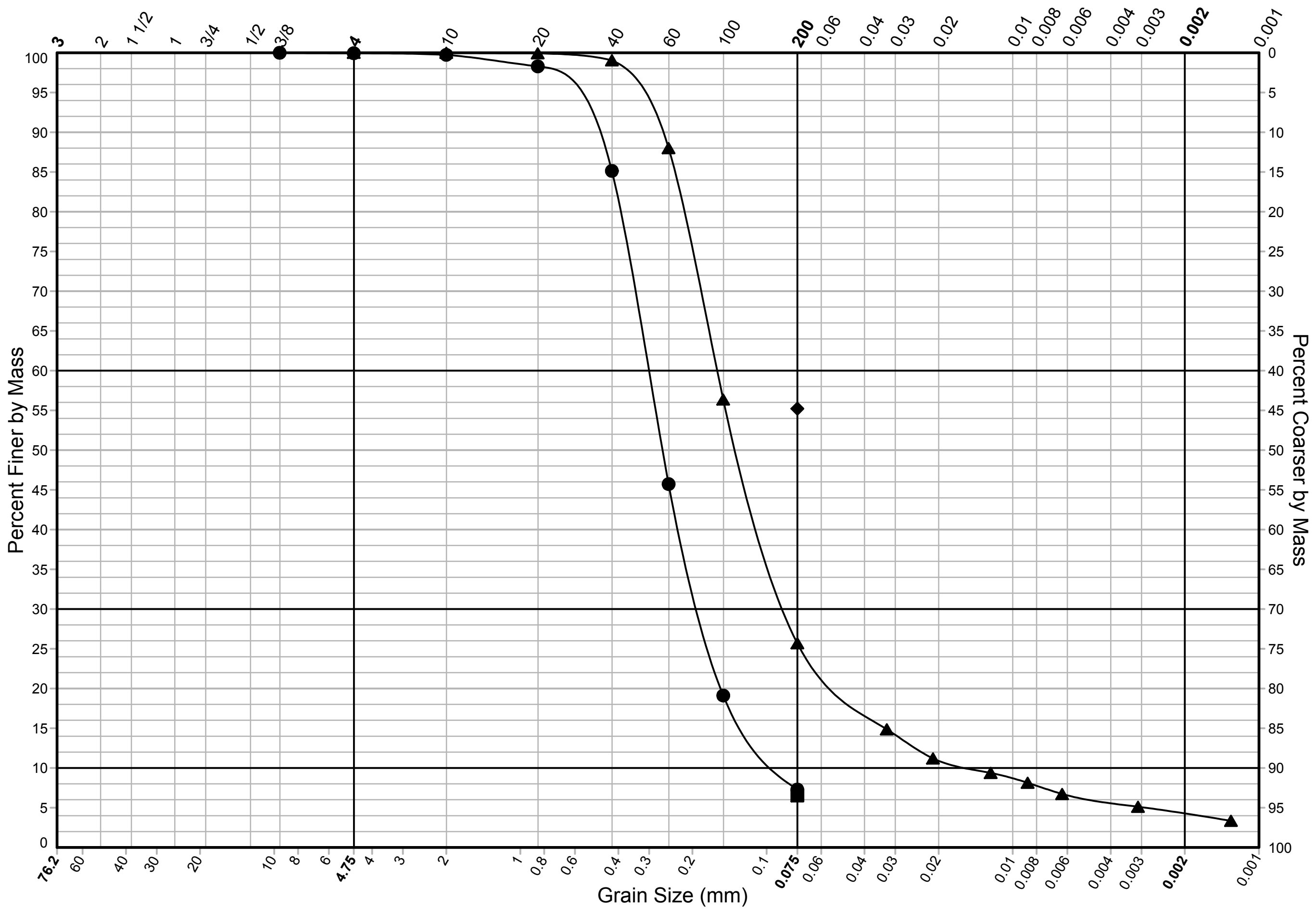
SHANNON & WILSON, INC.

GRAIN SIZE DISTRIBUTION PLOT

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

BORING B-5-17

Gravel		Sand			Fines	
Coarse	Fine	Coarse	Medium	Fine	Silt	Clay-Size
Mesh Opening in Inches		Mesh Openings per Inch, U.S. Standard			Grain Size in Millimeters	



Sample Identification	Depth (ft)	USCS Group Symbol	USCS Group Name	Gravel %	Sand %	Fines %	< 20µm %	< 2µm %	WC %	Tested By	Review By	ASTM Std.
● B-5-17, S-4*	10.0	SP-SM	Poorly Graded Sand with Silt	0	93	7.3			16.4	BMC	AKV	C136
■ B-5-17, S-10	30.0	SP-SM	Poorly Graded Sand with Silt			6.5			22.1	CRM	AKV	D1140
▲ B-5-17, S-15	55.0	SM	Silty Sand		74	26	11	4	23.4	AKV	AKV	D422
◆ B-5-17, S-20	80.0	ML	Sandy Silt			55			29.5	BMC	AKV	D1140

* *Test specimen did not meet minimum mass recommendations.*

21-1-22406-003 A_GSA_MAIN 21-22406.GPJ SHAN_WIL.GDT 8/30/18

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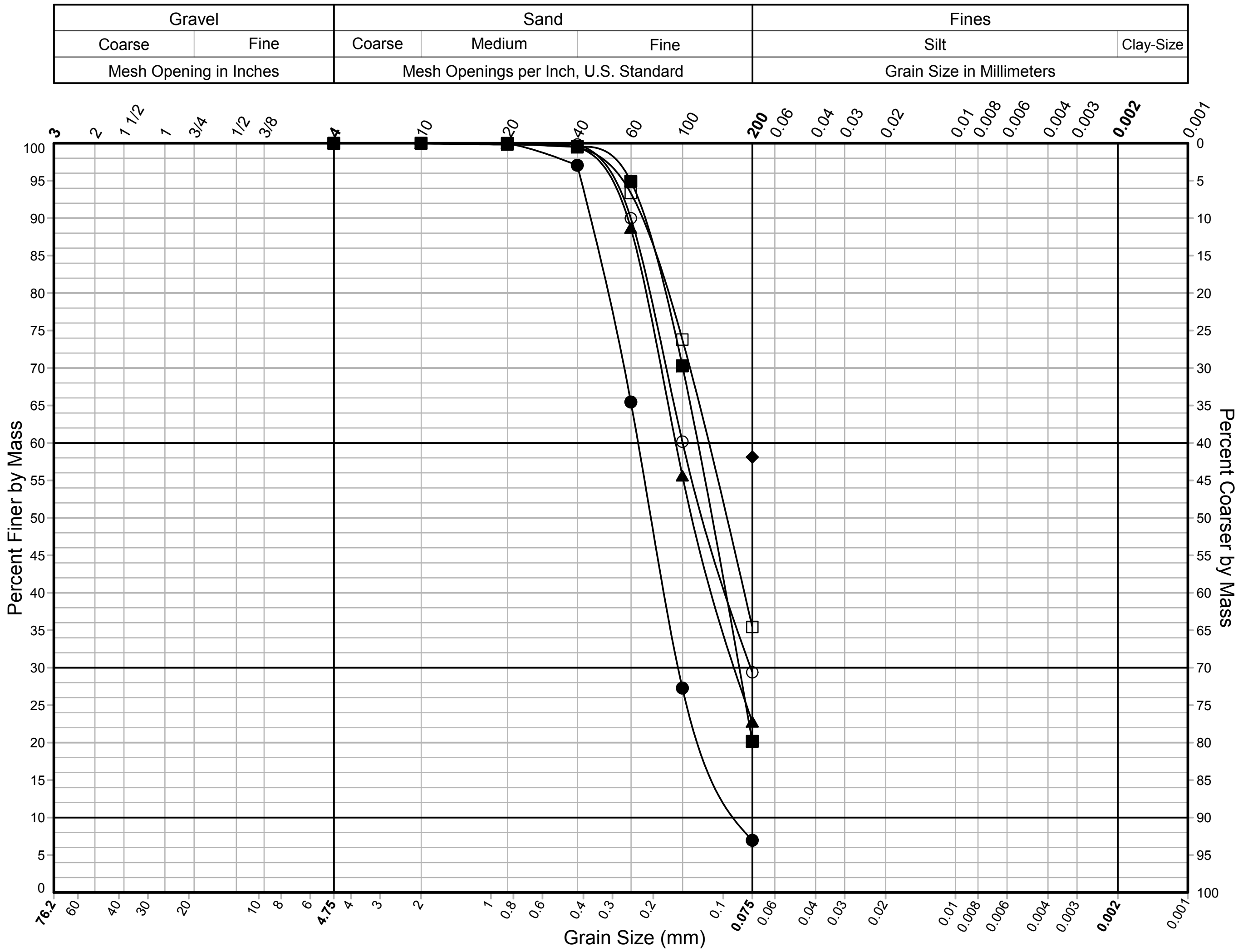
GRAIN SIZE DISTRIBUTION PLOT

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

BORING B-6-17



Sample Identification	Depth (ft)	USCS Group Symbol	USCS Group Name	Gravel %	Sand %	Fines %	< 20µm %	< 2µm %	WC %	Tested By	Review By	ASTM Std.
● B-6-17, S-4	15.0	SP-SM	Poorly Graded Sand with Silt		93	7.0			9.5	BMC	AKV	C136
■ B-6-17, S-8	30.0	SM	Silty Sand		80	20			23.3	BMC	AKV	C136
▲ B-6-17, S-11	45.0	SM	Silty Sand		77	23			22.0	BMC	AKV	C136
◆ B-6-17, S-13	55.0	ML	Sandy Silt			58			28.1	BMC	AKV	D1140
○ B-6-17, S-17	75.0	SM	Silty Sand		71	29			23.9	BMC	AKV	C136
□ B-6-17, S-21	95.0	SM	Silty Sand		65	35			22.5	BMC	AKV	C136

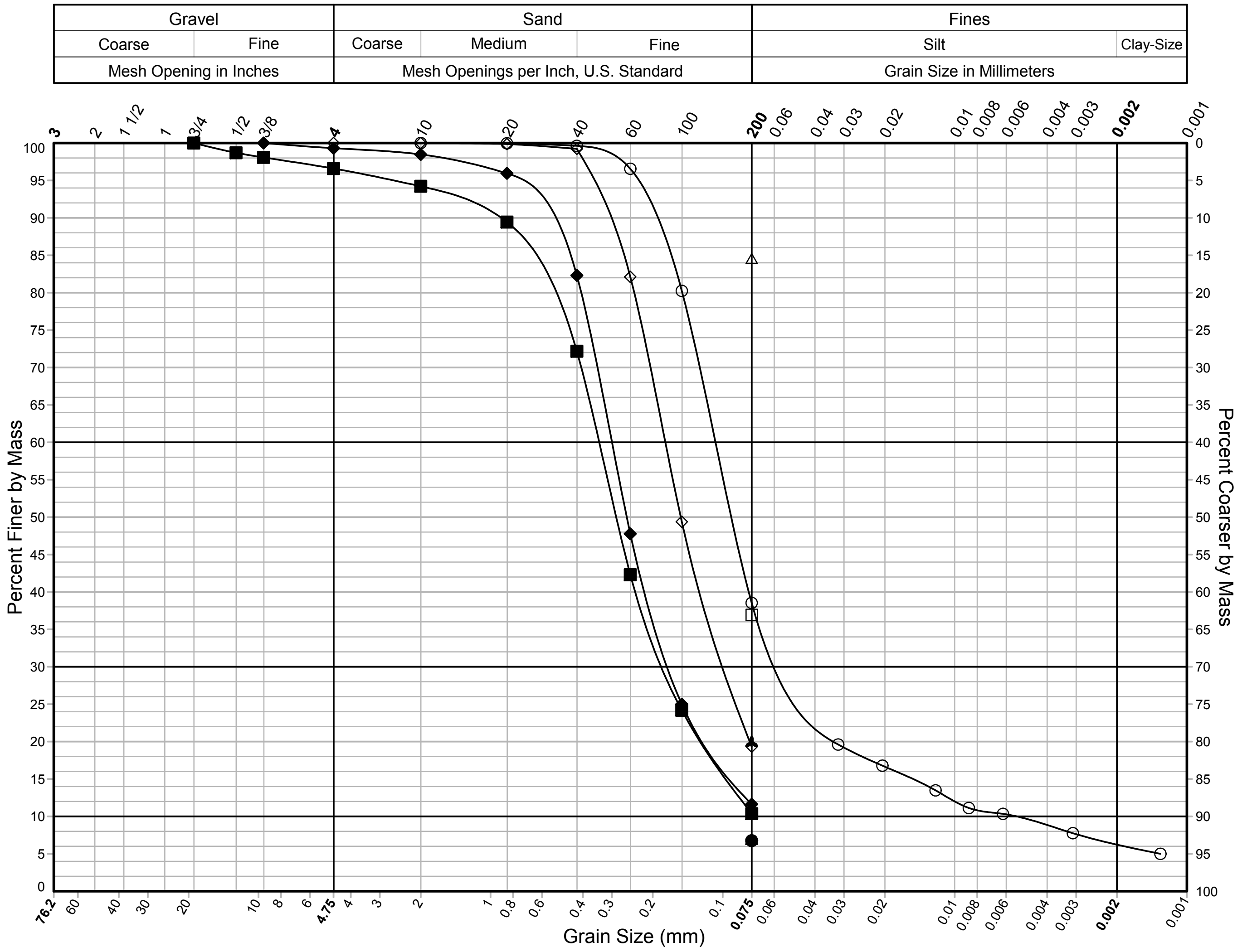
21-1-22406-003

A_GSA_MAIN 21-22406.GPJ SHAN_WIL.GDT 8/30/18

GRAIN SIZE DISTRIBUTION PLOT

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

BORING B-7-17



Sample Identification	Depth (ft)	USCS Group Symbol	USCS Group Name	Gravel %	Sand %	Fines %	< 20µm %	< 2µm %	WC %	Tested By	Review By	ASTM Std.
● B-7-17, S-2	10.0	SP-SM	Poorly Graded Sand with Silt			6.8			23.6	BMC	AKV	D1140
■ B-7-17, S-4*	15.0	SP-SM	Poorly Graded Sand with Silt	3	86	10				BMC	AKV	C136
▲ B-7-17, S-6*	20.0	SP-SM	Poorly Graded Sand with Silt			7.0			25.8	BMC	AKV	D1140
◆ B-7-17, S-8	30.0	SM	Silty Sand	1	88	12			23.8	BMC	AKV	C136
○ B-7-17, S-12	50.0	SM	Silty Sand		61	39	17	6	26.3	AKV	AKV	D422
□ B-7-17, S-13	55.0	SM	Silty Sand			37			25.9	BMC	AKV	D1140
△ B-7-17, S-14A	60.0	ML	Silt with Sand			85			28.5	BMC	AKV	D1140
◇ B-7-17, S-17	75.0	SM	Silty Sand		81	19			25.0	BMC	AKV	C136
⅄ B-7-17, S-20	90.0	SM	Silty Sand			20			23.9	BMC	AKV	D1140

* *Test specimen did not meet minimum mass recommendations.*

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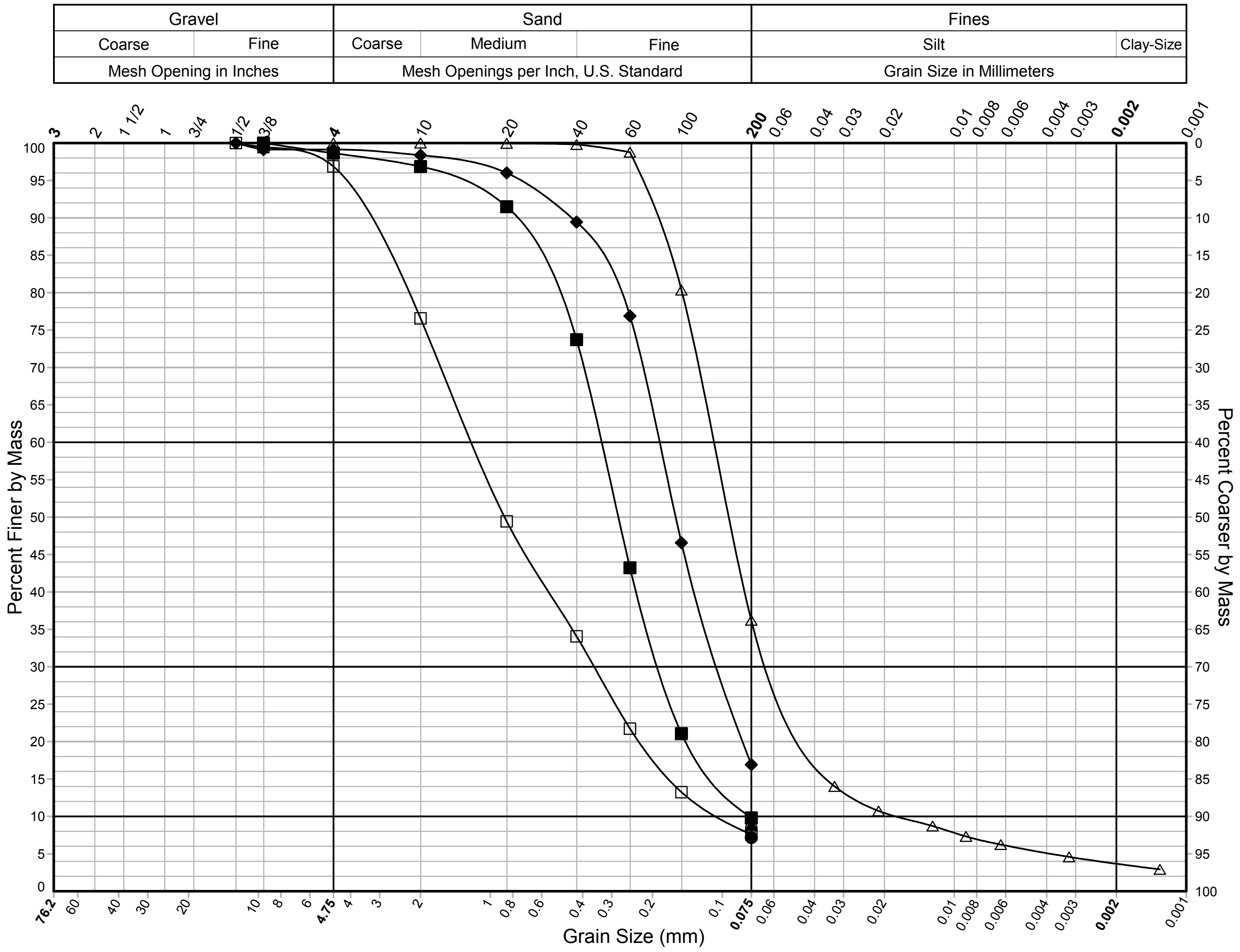
GRAIN SIZE DISTRIBUTION PLOT

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

BORING B-8-17



Sample Identification	Depth (ft)	USCS Group Symbol	USCS Group Name	Gravel %	Sand %	Fines %	< 20µm %	< 2µm %	WC %	Tested By	Review By	ASTM Std.
● B-8-17, S-2	10.0	SP-SM	Poorly Graded Sand with Silt			7.2			23.8	BMC	AKV	D1140
■ B-8-17, S-6*	20.0	SP-SM	Poorly Graded Sand with Silt	1	89	9.8			17.4	BMC	AKV	C136
▲ B-8-17, S-8	30.0	SP-SM	Poorly Graded Sand with Silt			8.8			16.9	BMC	AKV	D1140
◆ B-8-17, S-11*	45.0	SM	Silty Sand	1	82	17			27.8	BMC	AKV	C136
○ B-8-17, S-13	55.0	SP-SM	Poorly Graded Sand with Silt			8.5			33.3	BMC	AKV	D1140
□ B-8-17, S-16*	70.0	SW-SM	Well-Graded Sand with Silt	3	89	7.6			19.1	BMC	AKV	C136
△ B-8-17, S-20	90.0	SM	Silty Sand		64	36	11	4	25.9	AKV	AKV	D422

* *Test specimen did not meet minimum mass recommendations.*

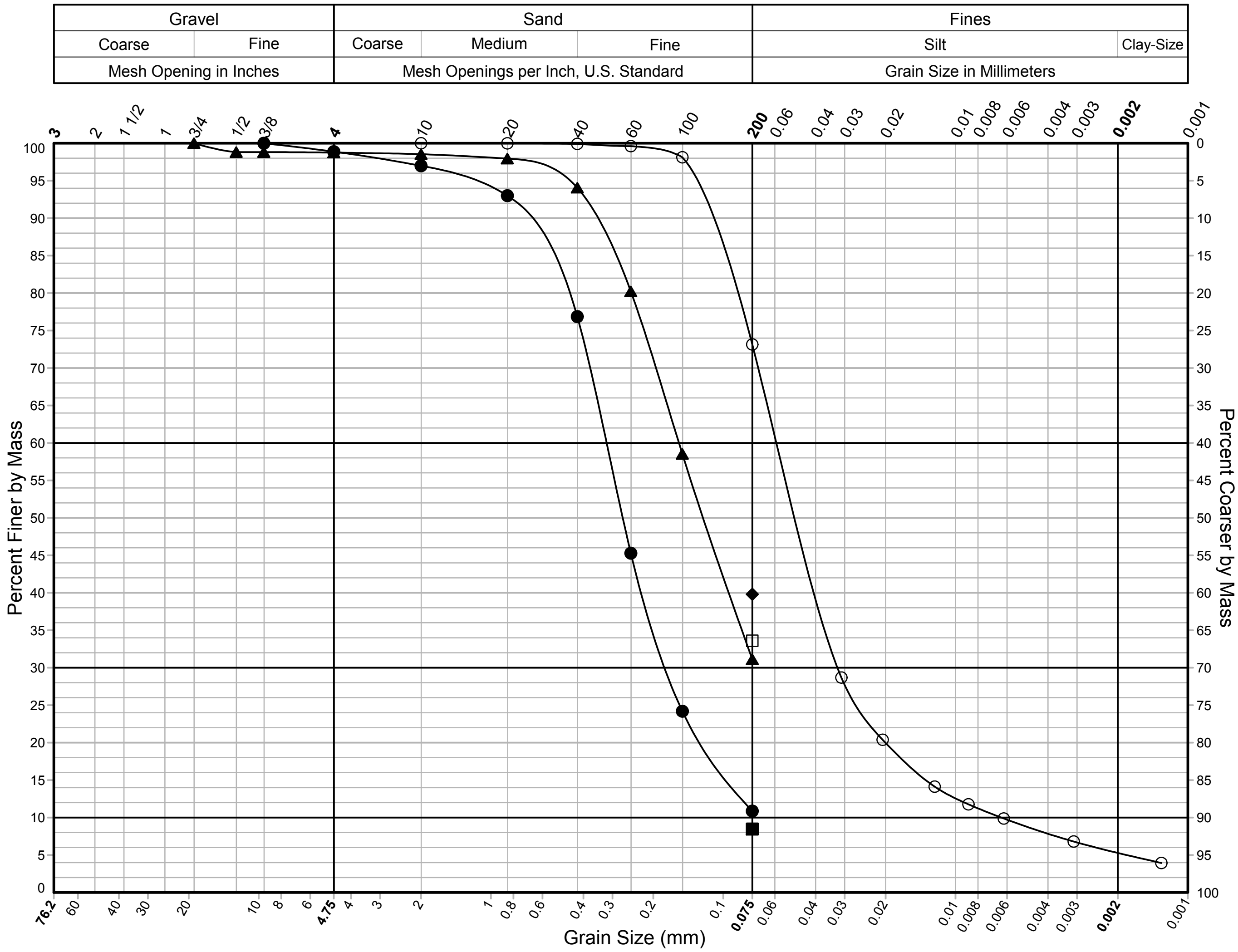
21-1-22406-003 A_GSA_MAIN 21-22406.GPJ SHAN_WIL.GDT 8/30/18

SHANNON & WILSON, INC.

GRAIN SIZE DISTRIBUTION PLOT

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

BORING B-9-17



Sample Identification	Depth (ft)	USCS Group Symbol	USCS Group Name	Gravel %	Sand %	Fines %	< 20µm %	< 2µm %	WC %	Tested By	Review By	ASTM Std.
● B-9-17, S-4*	15.0	SP-SM	Poorly Graded Sand with Silt	1	88	11			16.4	AKV	AKV	C136
■ B-9-17, S-8	30.0	SP-SM	Poorly Graded Sand with Silt			8.5			15.2	AKV	AKV	D1140
▲ B-9-17, S-11*	45.0	SM	Silty Sand	1	68	31			23.2	AKV	AKV	C136
◆ B-9-17, S-12A/B	50.0	SM	Silty Sand			40			24.5	AKV	AKV	D1140
○ B-9-17, S-15	65.0	ML	Silt with Sand		27	73	20	5	26.2	AKV	AKV	D422
☐ B-9-17, S-18	80.0	SM	Silty Sand			34			24.1	AKV	AKV	D1140

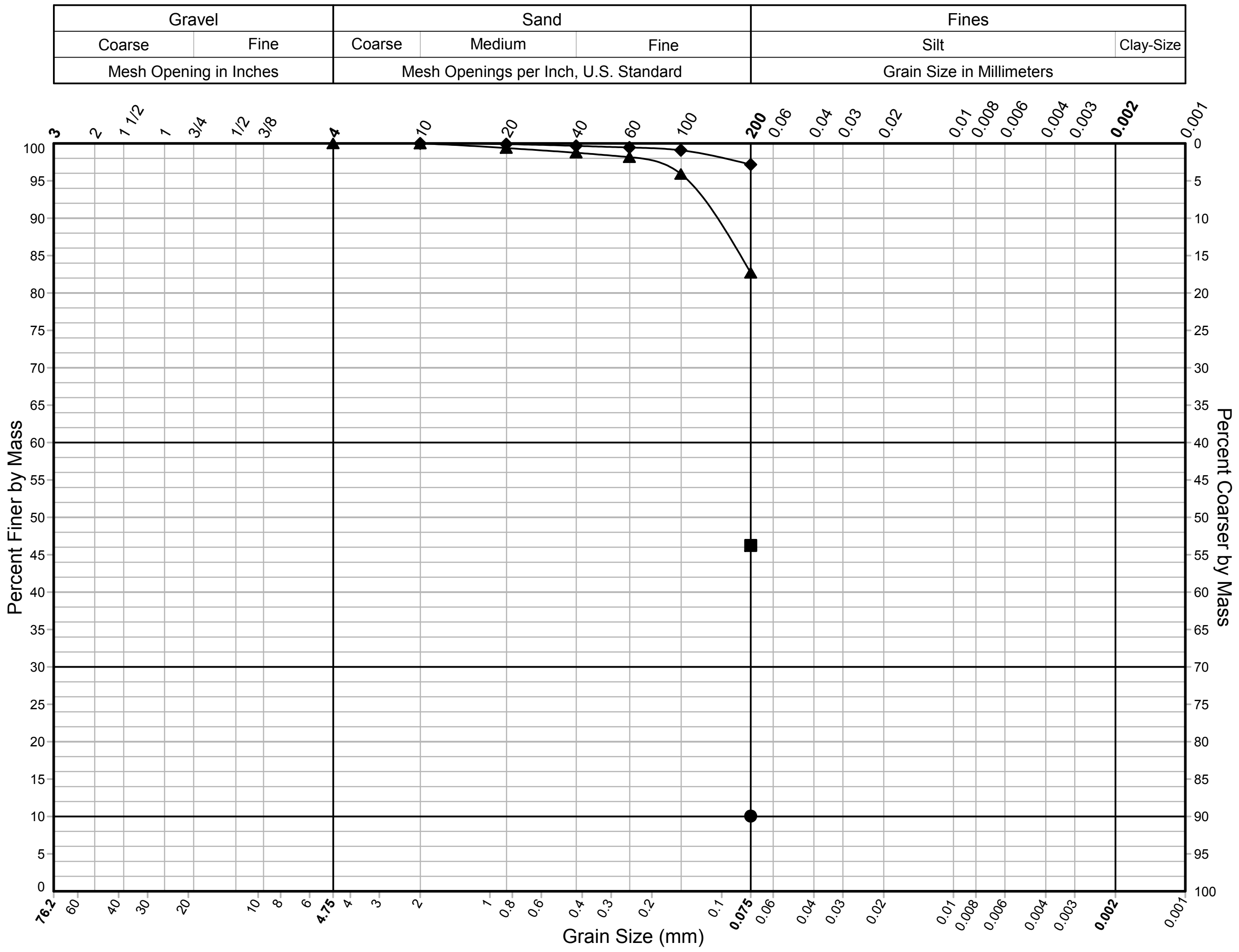
* *Test specimen did not meet minimum mass recommendations.*

21-1-22406-003 A_GSA_MAIN 21-22406.GPJ SHAN_WIL.GDT 8/30/18

GRAIN SIZE DISTRIBUTION PLOT

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

BORING B-10-18



Sample Identification	Depth (ft)	USCS Group Symbol	USCS Group Name	Gravel %	Sand %	Fines %	< 20µm %	< 2µm %	WC %	Tested By	Review By	ASTM Std.
● B-10-18, S-2*	35.0	SP-SM	Poorly Graded Sand with Silt			10			19.5	AKV	AKV	D1140
■ B-10-18, S-17	110.0	SM	Silty Sand			46			24.5	AKV	AKV	D1140
▲ B-10-18, S-31*	180.0	ML	Silt with Sand		17	83			26.1	AKV	AKV	C136
◆ B-10-18, S-33*	190.0	ML	Silt		3	97			33.9	AKV	AKV	C136

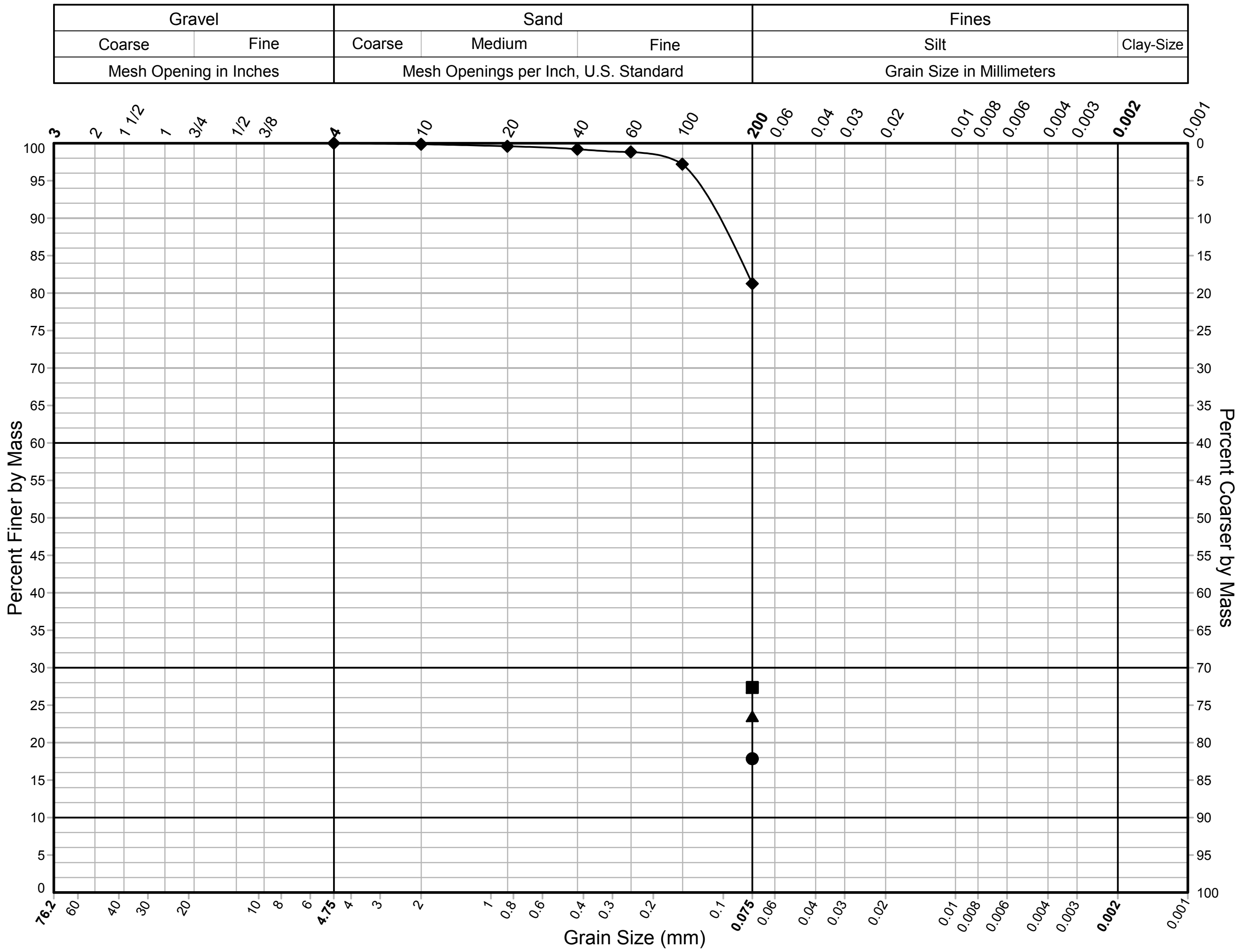
* *Test specimen did not meet minimum mass recommendations.*

21-1-22406-003 A_GSA_MAIN 21-22406.GPJ SHAN_WIL.GDT 8/30/18

GRAIN SIZE DISTRIBUTION PLOT

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

BORING B-11-18



Sample Identification	Depth (ft)	USCS Group Symbol	USCS Group Name	Gravel %	Sand %	Fines %	< 20µm %	< 2µm %	WC %	Tested By	Review By	ASTM Std.
● B-11-18, S-4	45.0	SM	Silty Sand			18			26.1	AKV	AKV	D1140
■ B-11-18, S-9*	70.0	SM	Silty Sand			27			20.1	AKV	AKV	D1140
▲ B-11-18, S-13	90.0	SM	Silty Sand			24			22.3	AKV	AKV	D1140
◆ B-11-18, S-31*	180.0	ML	Silt with Sand		19	81			24.7	AKV	AKV	C136

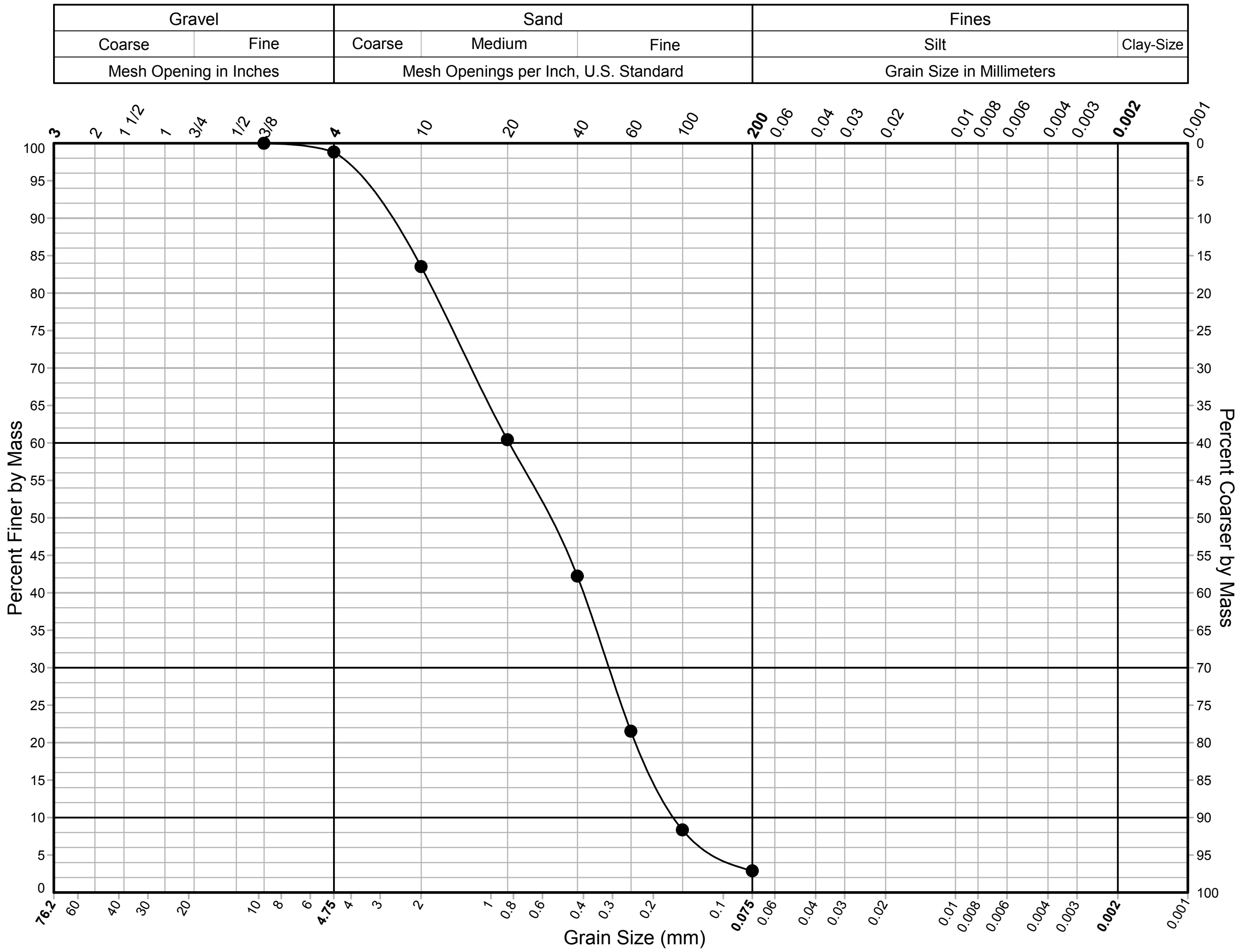
* *Test specimen did not meet minimum mass recommendations.*

21-1-22406-003 A_GSA_MAIN 21-22406.GPJ SHAN_WIL.GDT 8/30/18

GRAIN SIZE DISTRIBUTION PLOT

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

BORING HA-1-17



Sample Identification	Depth (ft)	USCS Group Symbol	USCS Group Name	Gravel %	Sand %	Fines %	< 20µm %	< 2µm %	WC %	Tested By	Review By	ASTM Std.
● HA-1-17, S-4*	5.0	SP	Poorly Graded Sand	1	96	2.9			31.8	BMC	AKV	C136

* *Test specimen did not meet minimum mass recommendations.*

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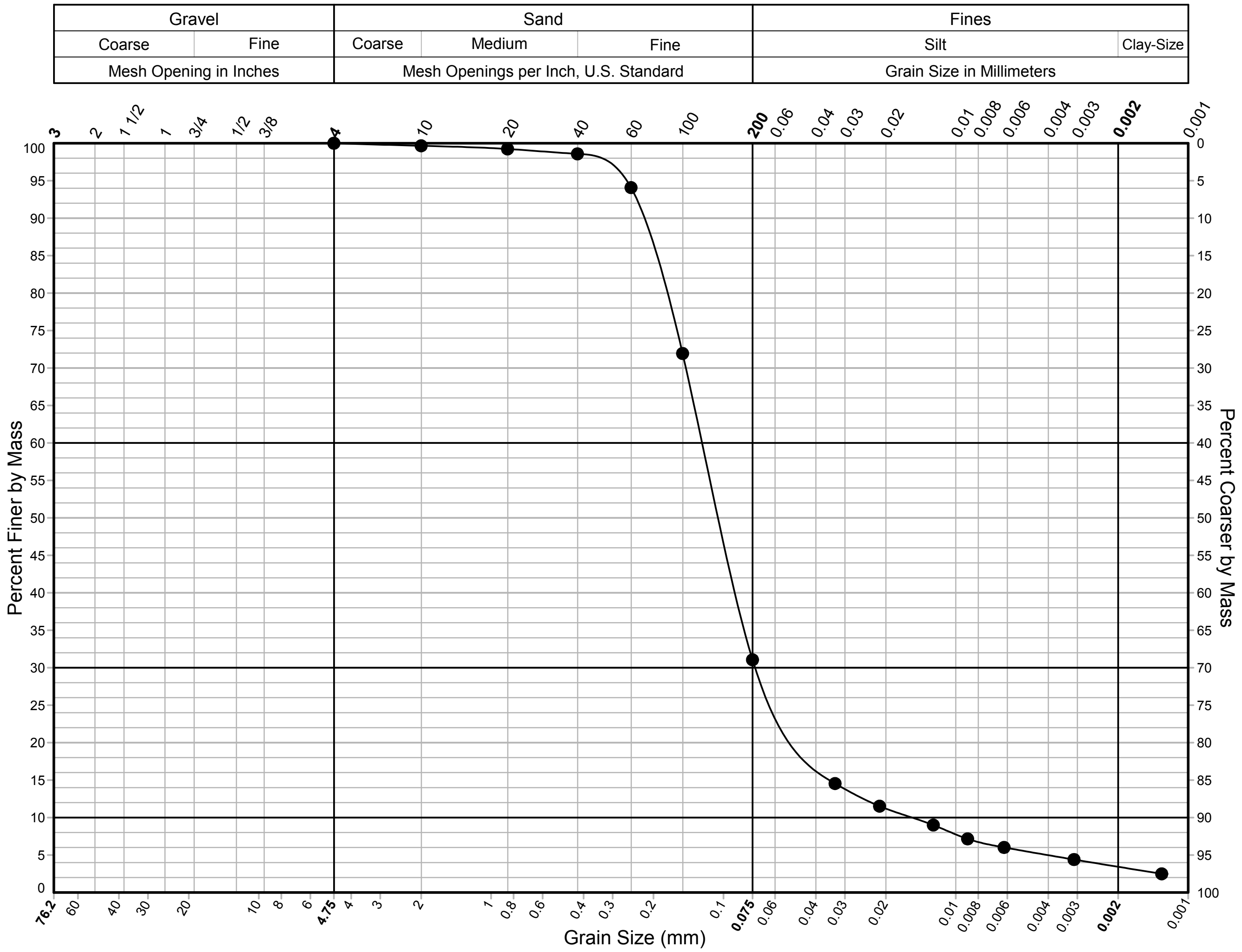
GRAIN SIZE DISTRIBUTION PLOT

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

BORING HA-2-17



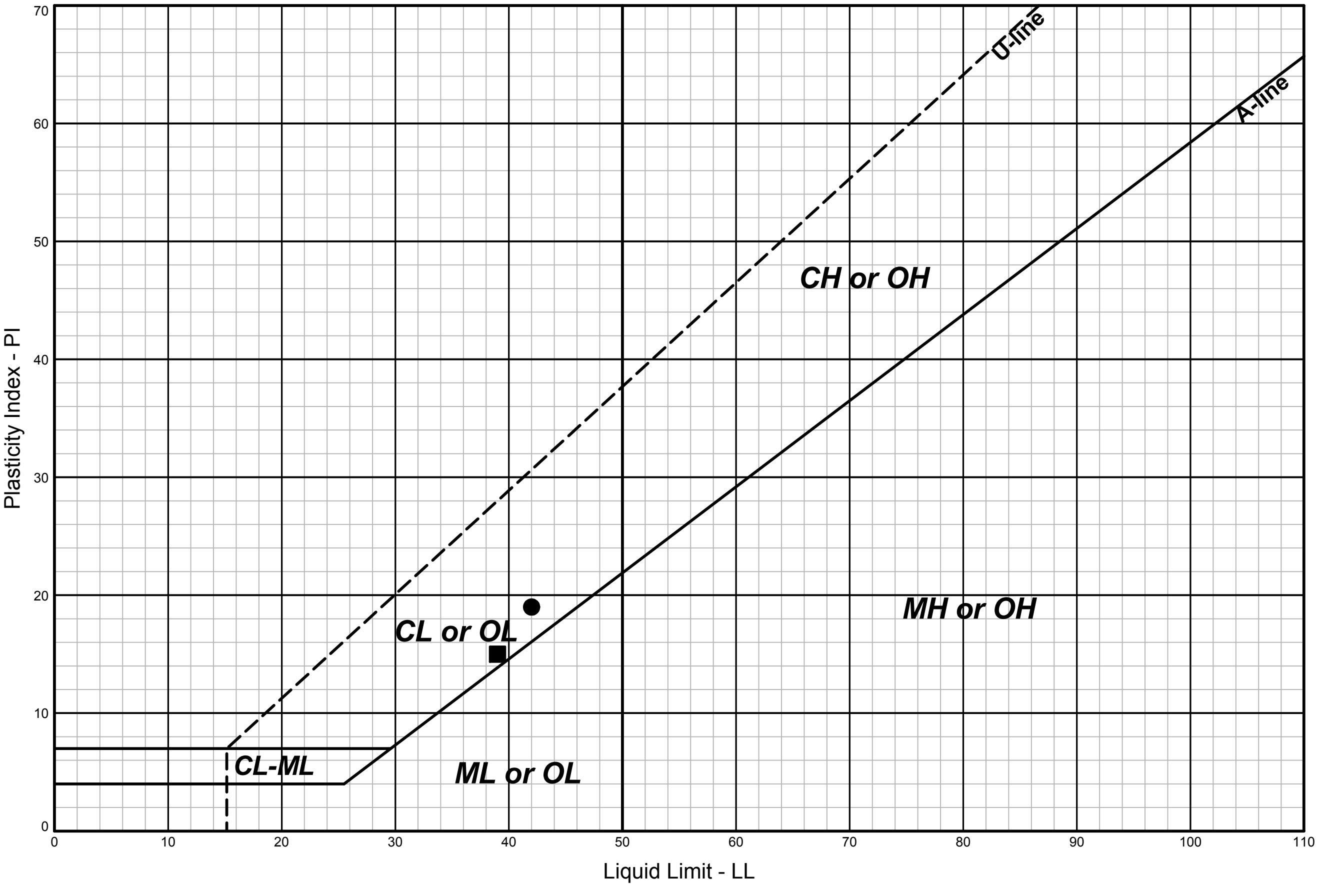
Sample Identification	Depth (ft)	USCS Group Symbol	USCS Group Name	Gravel %	Sand %	Fines %	< 20µm %	< 2µm %	WC %	Tested By	Review By	ASTM Std.
● HA-2-17, S-5	7.5	SM	Silty Sand		69	31	11	3	52.9	AKV	AKV	D422

21-1-22406-003 A_GSA_MAIN 21-22406.GPJ SHAN_WIL.GDT 8/30/18

PLASTICITY CHART

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

BORING B-5-17



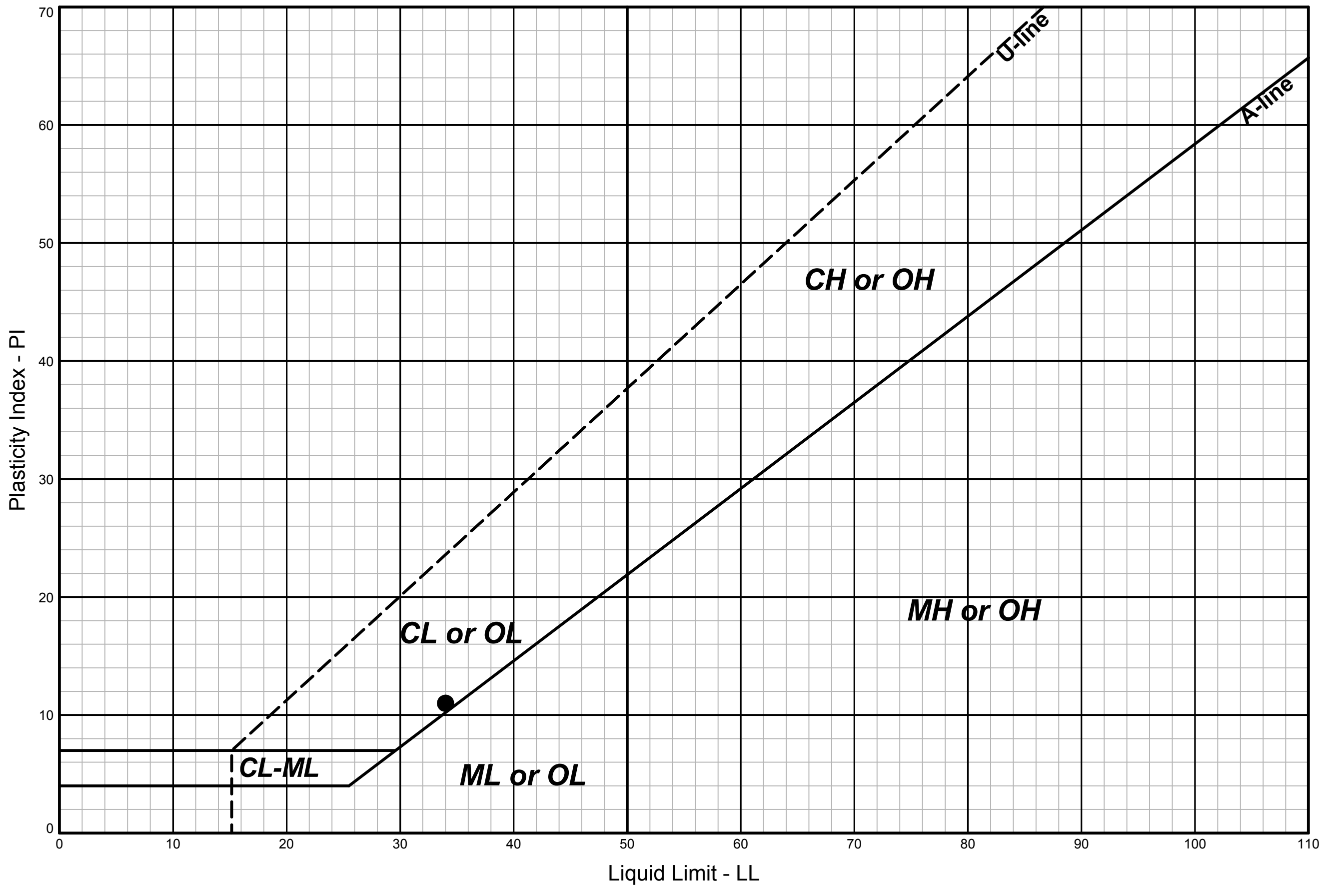
Sample Identification	Depth (ft)	USCS Group Symbol	USCS Group Name	LL	PL	PI	WC %	Gravel %	Sand %	Fines %	< 2µm %	Tested By	Review By	ASTM Std.
● B-5-17, S-9B	25.5	CL	Lean Clay	42	23	19	37.9					AKV	AKV	D4318
■ B-5-17, S-17	65.0	CL	Lean Clay	39	24	15	30.3					AKV	AKV	D4318

21-1-22406-003 A_ATT_MAIN 21-22406.GPJ SHAN_WIL.GDT 8/30/18

PLASTICITY CHART

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

BORING B-6-17



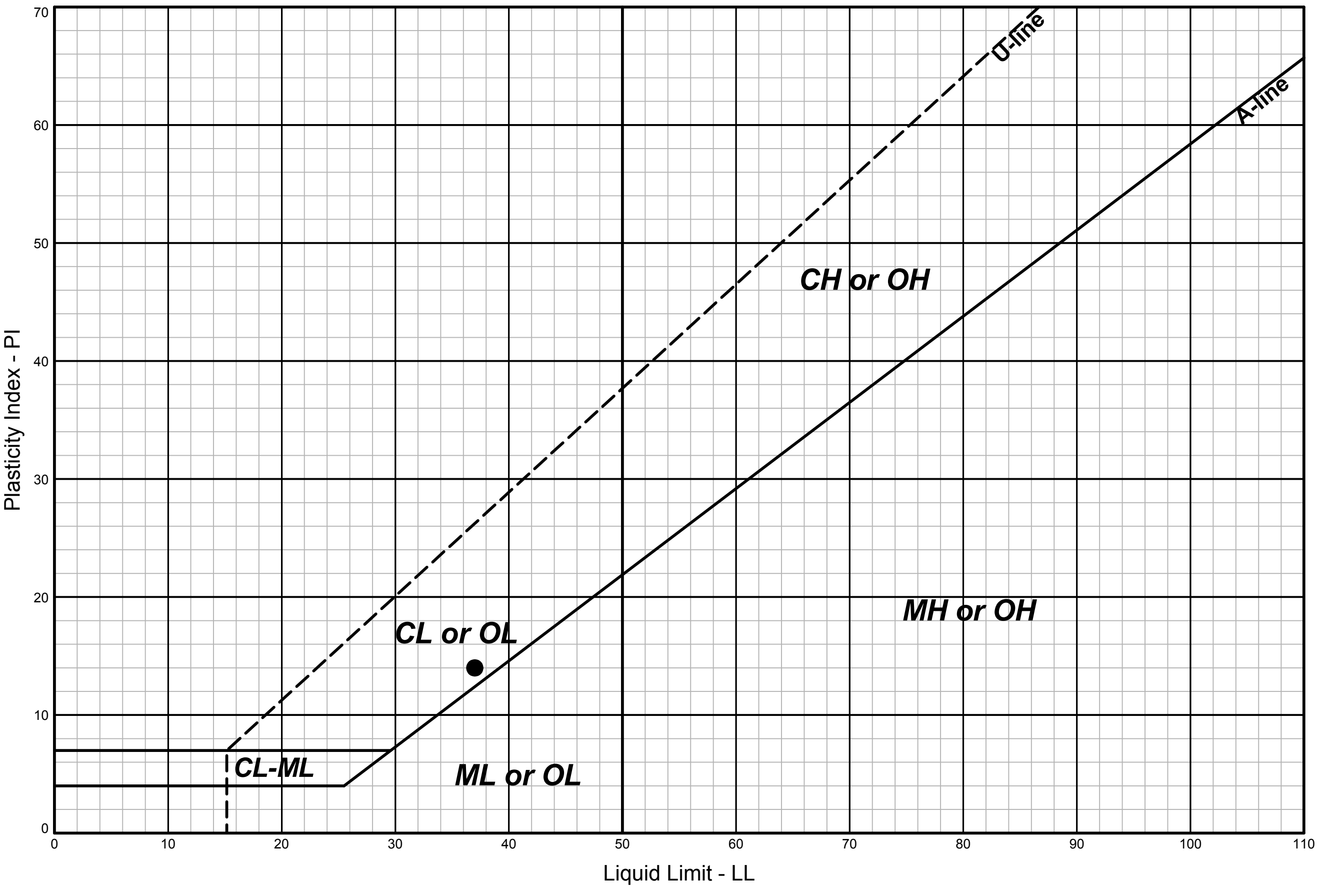
Sample Identification	Depth (ft)	USCS Group Symbol	USCS Group Name	LL	PL	PI	WC %	Gravel %	Sand %	Fines %	< 2μm %	Tested By	Review By	ASTM Std.
● B-6-17, S-16	70.0	CL	Lean Clay	34	23	11	30.9					AKV	AKV	D4318

21-1-22406-003 A_ATT_MAIN 21-22406.GPJ SHAN_WIL.GDT 8/30/18

PLASTICITY CHART

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

BORING B-7-17

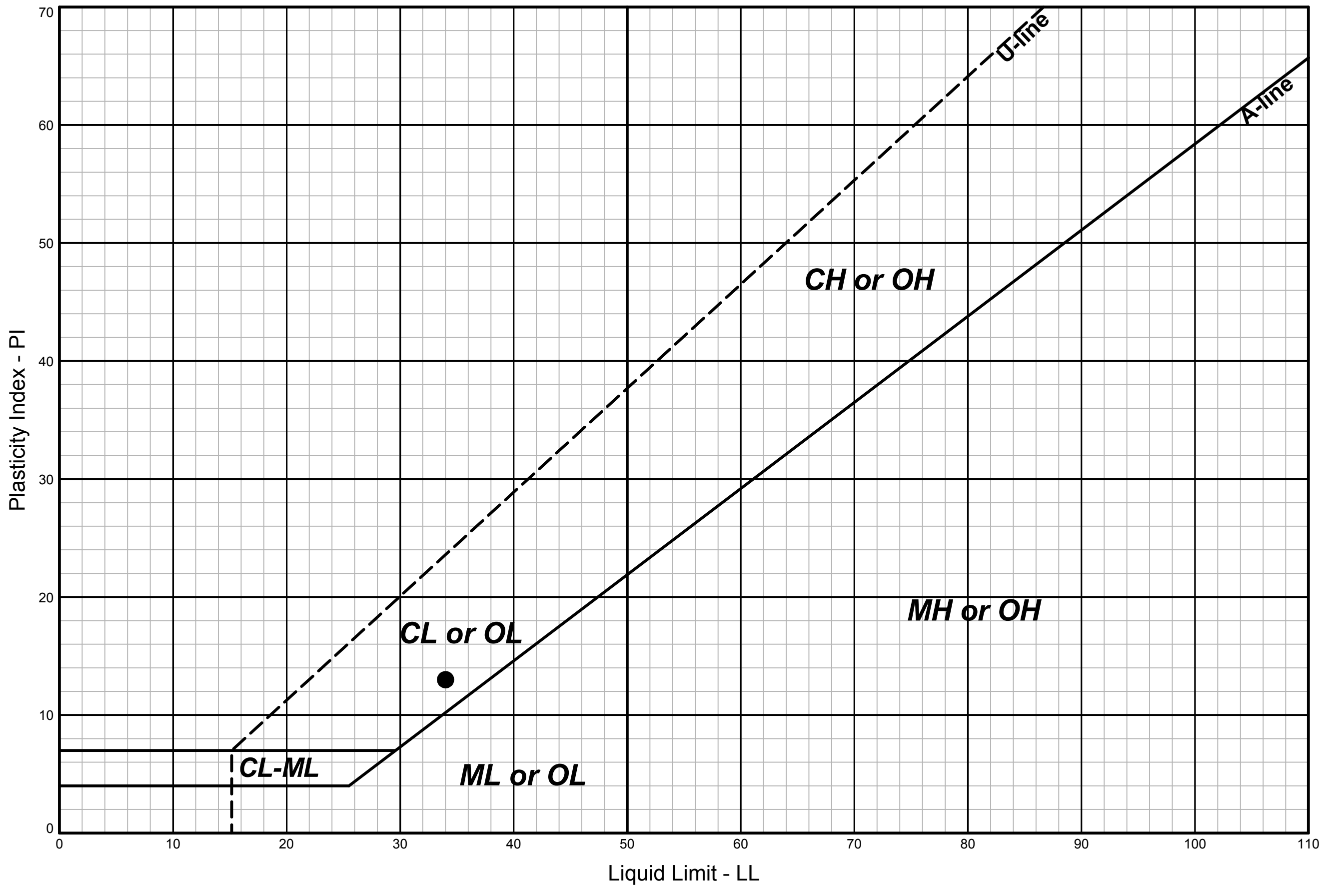


Sample Identification	Depth (ft)	USCS Group Symbol	USCS Group Name	LL	PL	PI	WC %	Gravel %	Sand %	Fines %	< 2µm %	Tested By	Review By	ASTM Std.
● B-7-17, S-16	70.0	CL	Lean Clay	37	23	14	30.7					AKV	AKV	D4318

PLASTICITY CHART

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

BORING B-8-17

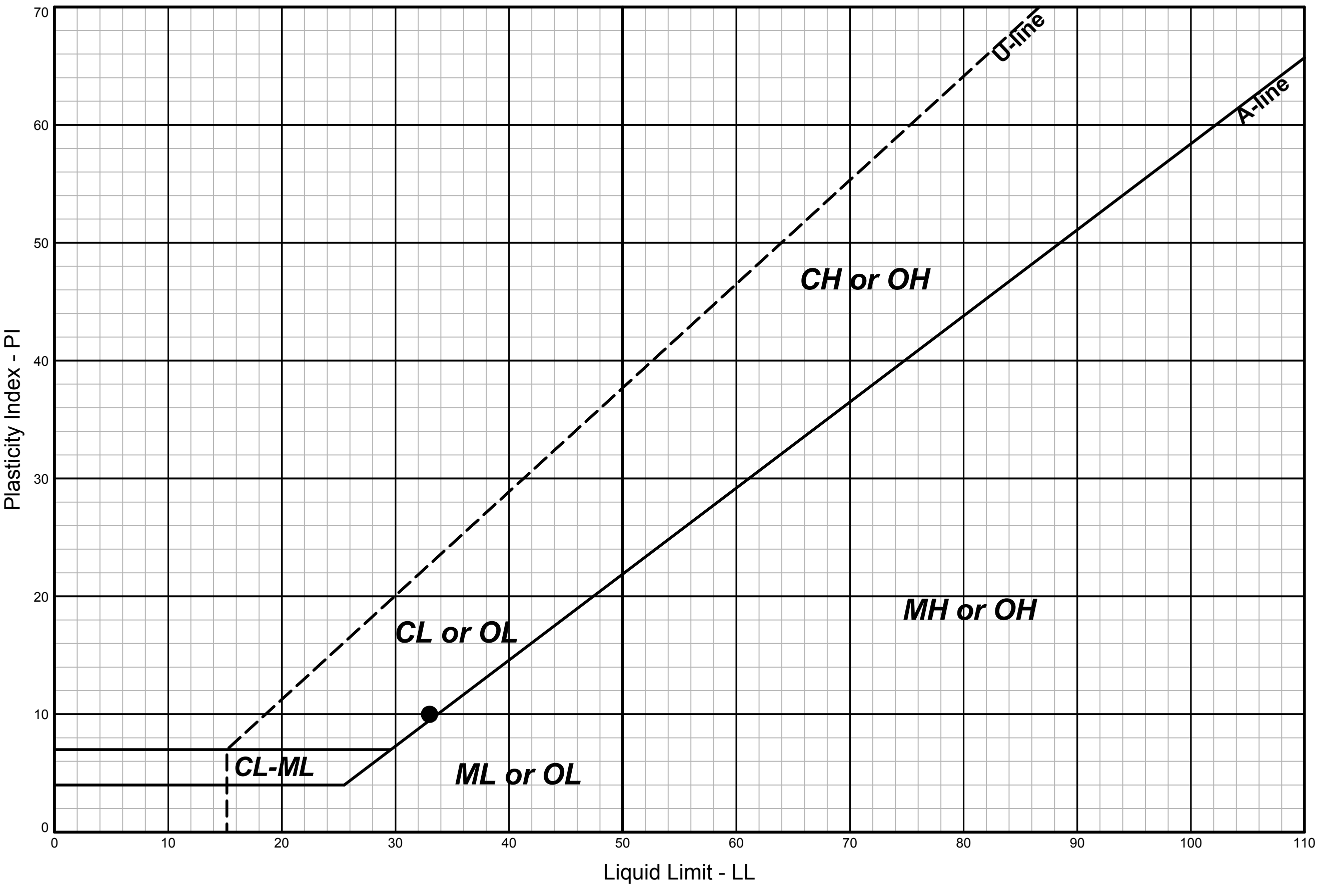


Sample Identification	Depth (ft)	USCS Group Symbol	USCS Group Name	LL	PL	PI	WC %	Gravel %	Sand %	Fines %	< 2μm %	Tested By	Review By	ASTM Std.
● B-8-17, S-19B	85.4	CL	Lean Clay with Sand	34	21	13	25.5					AKV	AKV	D4318

PLASTICITY CHART

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

BORING B-9-17

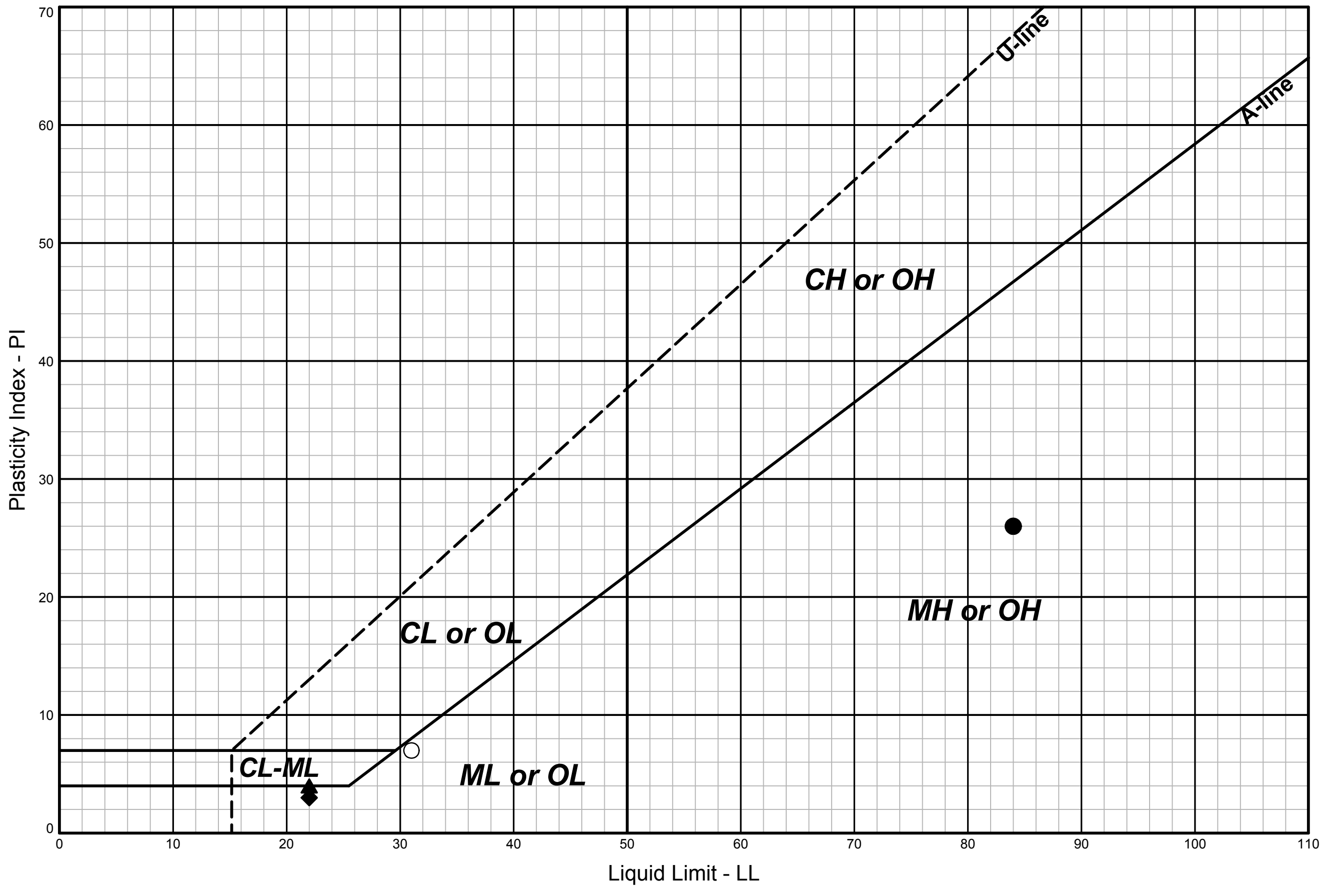


Sample Identification	Depth (ft)	USCS Group Symbol	USCS Group Name	LL	PL	PI	WC %	Gravel %	Sand %	Fines %	< 2µm %	Tested By	Review By	ASTM Std.
● B-9-17, S-14	60.0	CL	Lean Clay with Sand	33	23	10	32.0					AKV	AKV	D4318

PLASTICITY CHART

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

BORING B-10-18

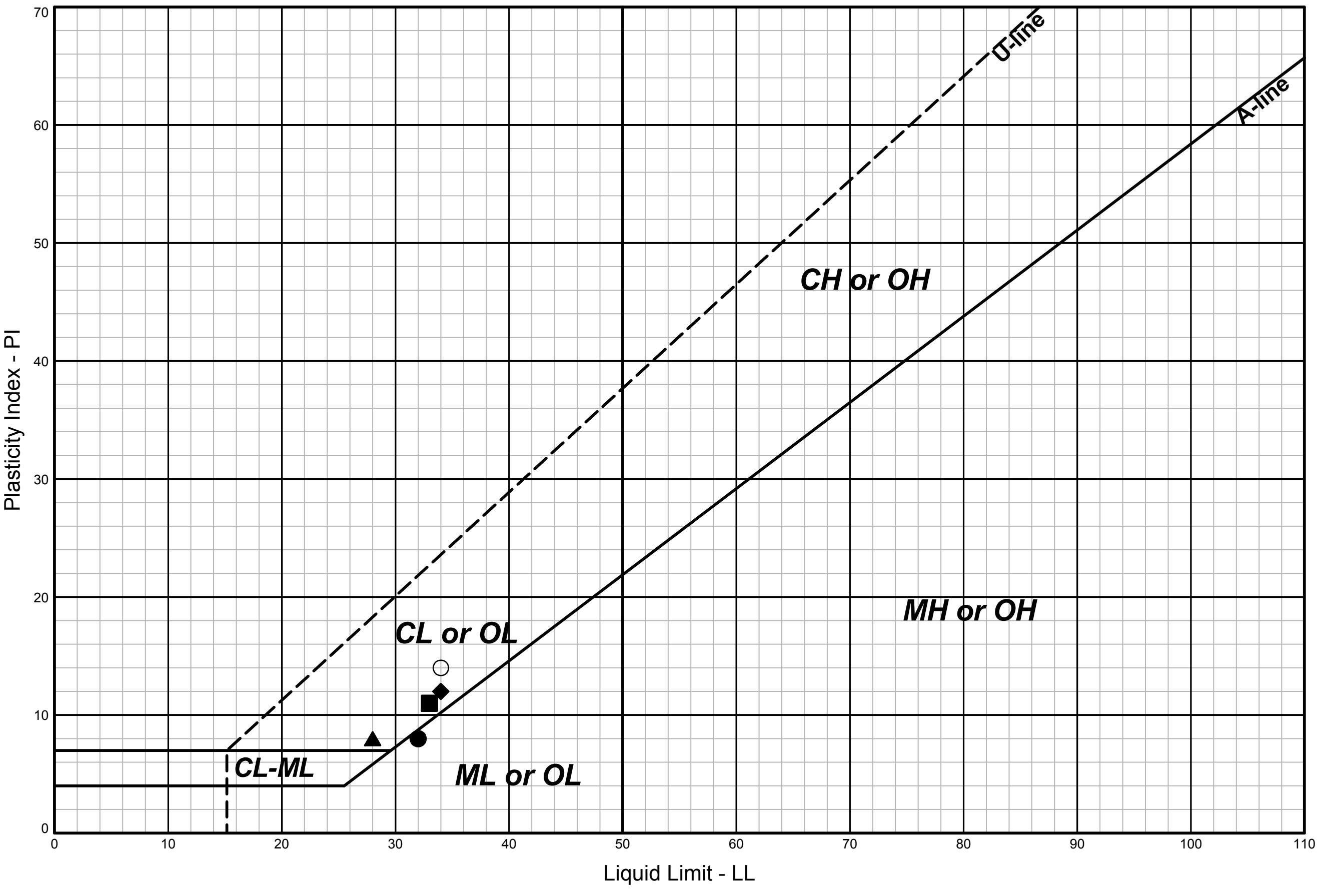


Sample Identification	Depth (ft)	USCS Group Symbol	USCS Group Name	LL	PL	PI	WC %	Gravel %	Sand %	Fines %	< 2μm %	Tested By	Review By	ASTM Std.
● B-10-18, S-8	65.0	MH	Elastic Silt with Sand	84	58	26	69.2					AKV	AKV	D4318
B-10-18, S-11	80.0	ML	Sandy Silt	**NP**	**NP**	**NP**	24.0					AKV	AKV	D4318
▲ B-10-18, S-22	135.0	CL-ML	Silty Clay	22	18	4	22.5					AKV	AKV	D4318
◆ B-10-18, S-25	150.0	ML	Silt	22	19	3	24.1					AKV	AKV	D4318
○ B-10-18, S-28	165.0	ML	Silt	31	24	7	34.4					AKV	AKV	D4318

PLASTICITY CHART

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

BORING B-11-18



Sample Identification	Depth (ft)	USCS Group Symbol	USCS Group Name	LL	PL	PI	WC %	Gravel %	Sand %	Fines %	< 2µm %	Tested By	Review By	ASTM Std.
● B-11-18, S-12	85.0	ML	Silt	32	24	8	30.7					AKV	AKV	D4318
■ B-11-18, S-15	100.0	CL	Lean Clay	33	22	11	32.8					AKV	AKV	D4318
▲ B-11-18, S-20	125.0	CL	Lean Clay	28	20	8	27.5					AKV	AKV	D4318
◆ B-11-18, S-25	150.0	CL	Lean Clay	34	22	12	34.0					AKV	AKV	D4318
○ B-11-18, S-35	200.0	CL	Lean Clay	34	20	14	32.9					AKV	AKV	D4318

21-1-22406-003 A_ATT_MAIN 21-22406.GPJ SHAN_WIL.GDT 8/30/18

APPENDIX C: GLOBAL STABILITY RESULTS

Appendix C

Global Stability Analyses and Results

CONTENTS

Exhibits

Tables

Figures

C.1 GENERAL

We performed global stability analyses of numerous embankment and retaining wall sections along the roadway alignment considering both the existing and proposed conditions. Results of these analyses are discussed in their respective sections in the Main Text of the report and are presented in this appendix.

Global stability analyses were performed using the limit equilibrium stability program GeoStudio 2016 SLOPE/W by Geo-Slope International. The Morgenstern-Price method, which satisfies both force and moment equilibrium, was used to estimate FS values.

Our global stability analyses account for static, seismic, and post-seismic conditions, as applicable. In accordance with the GDM, global stability analyses target the following minimum FS values:

Exhibit C-1: Geotechnical Design Manual (GDM) Minimum Factor of Safety (FS) Values for Embankments and Retaining Walls Supporting a Roadway

	Minimum Factor of Safety Values		
	Static	Seismic	Post-Seismic
Embankment	1.3	Not Applicable	Not Applicable
Retaining Walls (General)	1.3	1.1	1.1
Abutments and Retaining Wall Supporting a Bridge	1.5	1.1	1.1

The seismic condition evaluates the embankment and walls with an applied horizontal acceleration coefficient equal to one-half of the PGA, defined for the Project in Exhibit 3-1 in the Main Text of the report. Post-seismic analysis pertains to the embankment and wall stability under liquefied conditions using residual soil shear strength properties and no horizontal seismic acceleration coefficient. As described in Section 3.2.2, liquefiable soils are present under the embankment extending to a maximum depth corresponding to elevation -35 feet.

We estimated soil properties used in the stability analysis based on results of the subsurface explorations and laboratory testing and our experience in similar subsurface conditions. Post-seismic residual soil strength properties were estimated using empirical strength correlations that are a function of normalized corrected SPT blow count and effective overburden stress.

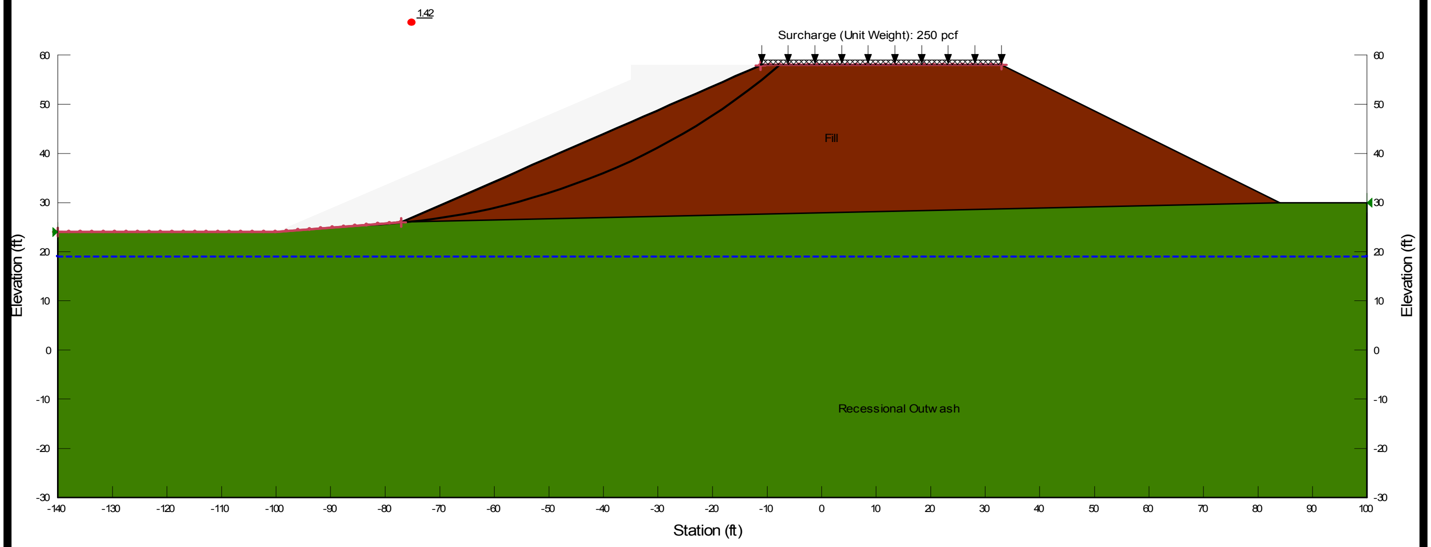
Our engineering studies utilize the existing embankment cross sections provided by HDR on October 16, 2017. The cross sections are cut at 25-foot intervals from centerline station 101+00 to 108+25.

Our retaining wall stability analyses utilize abutment and retaining wall cross sections provided by HDR on June 1, 2018. The retaining wall cross sections are cut at 10-foot intervals along the wall lengths. The retaining wall stability analyses were based on a previous wall plan, where Geofoam Walls 1 and 2 were soldier pile and lagging walls referred to as Retaining Walls 1 and 2. Due to the symmetry of the walls on the east and west sides of the alignment, stability analyses were performed at Retaining Walls 1 and 2 and were considered applicable to Retaining Walls 3 and 4. In the current design, Retaining Walls 1 and 2 have been changed to Geofoam Walls 1 and 2. However, the analysis of the walls based on June 1, 2018 HDR cross sections remains applicable to Retaining Walls 3 and 4.

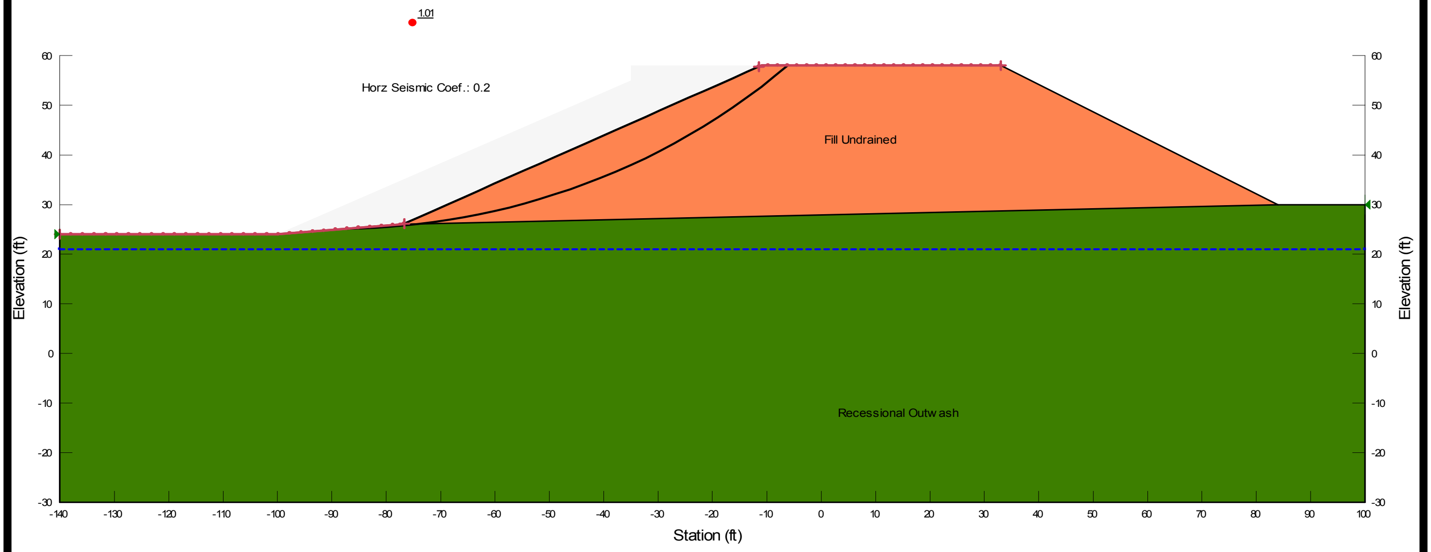
Table C-1. Estimated Soil Properties for Global Stability Analyses.

Soil Layer	Total Unit Weight (pcf)	Static		Seismic		Post Seismic	
		Friction Angle (°)	Cohesion (psf)	Friction Angle (°)	Cohesion (psf)	Friction Angle (°)	Cohesion (psf)
Embankment Fill	110	31	0	31	0	8	0
Lightweight Fill	10	N/A	N/A	N/A	N/A	N/A	N/A
Common Borrow	125	34	0	34	0	34	0
Alluvium	115	32	0	32	50	10	0
Peat Under Embankment	95	0	550	0	550	0	550
Peat Outside Embankment	95	0	400	0	400	0	400
Elastic Silt	110	0	1000	0	1000	0	1000
Recessional Outwash	120	33	0	33	0	33	0

STATIC CONDITION



SEISMIC CONDITION



City of Marysville
State Avenue Corridor Widening
Marysville, Washington

GLOBAL STABILITY RESULTS
EXISTING CONDITIONS
STATION 101+75

September 2019 21-1-22406-003

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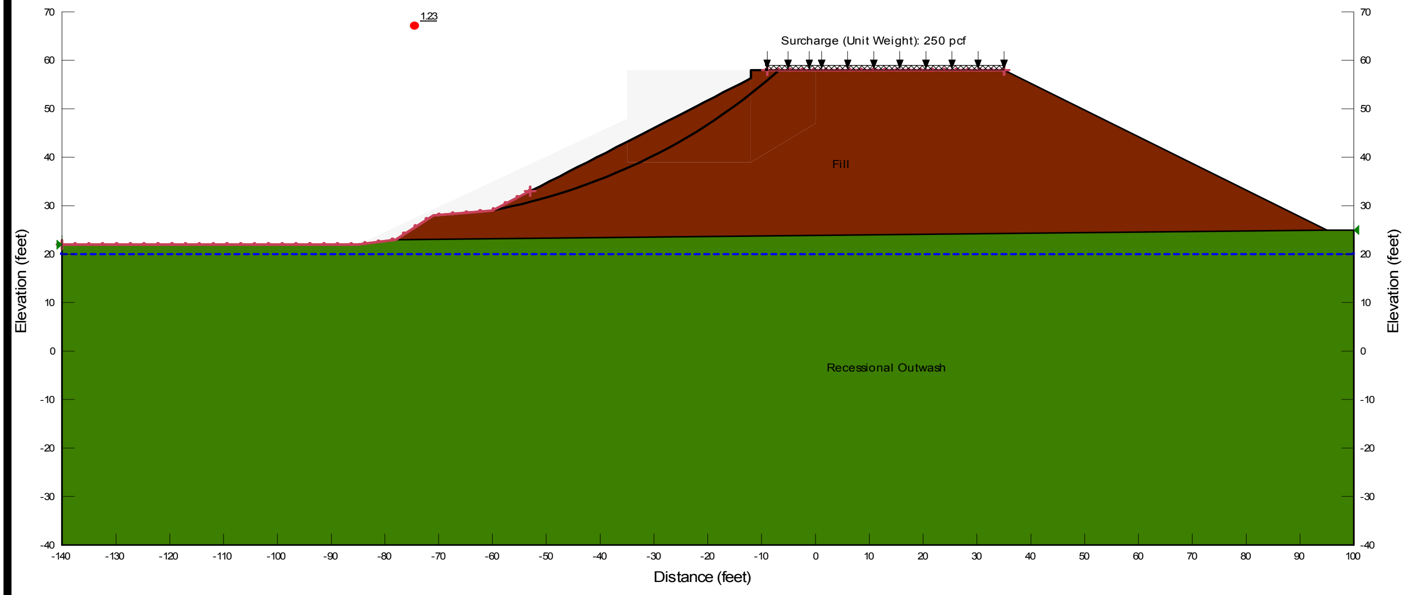
Geotechnical and Environmental Consultants

FIG. C-1

STATIC CONDITION



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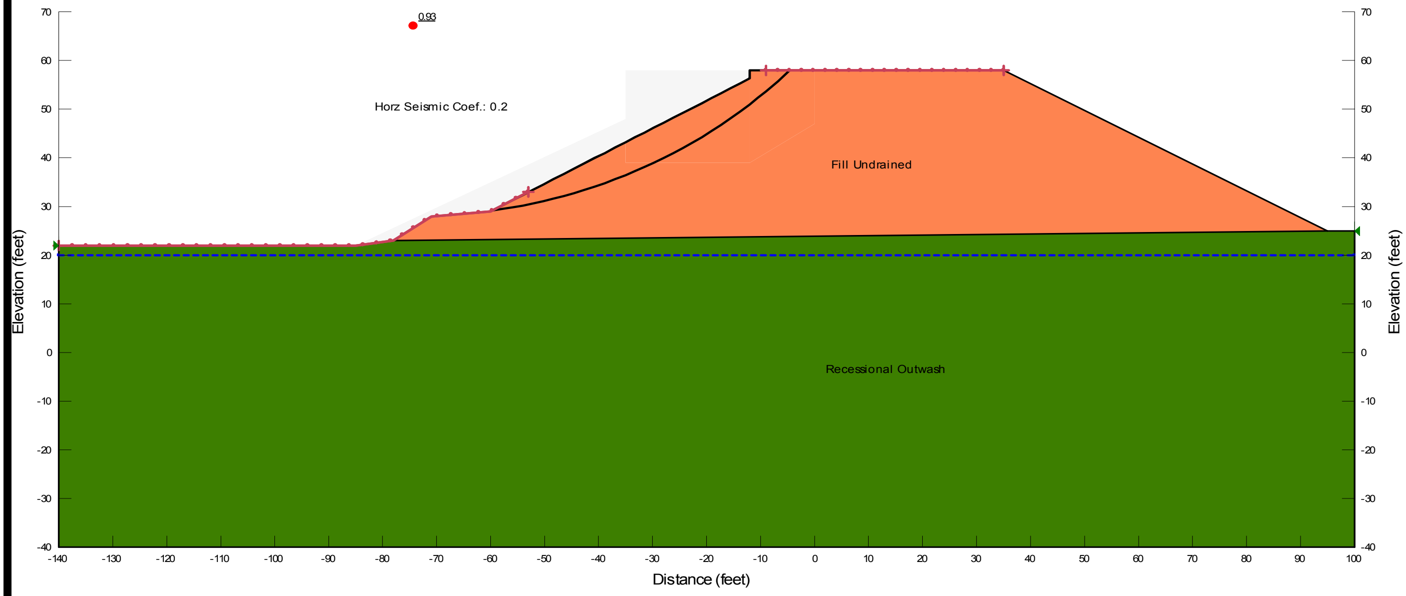

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

GLOBAL STABILITY RESULTS
EXISTING CONDITIONS
STATION 102+00

September 2018 21-1-22406-003

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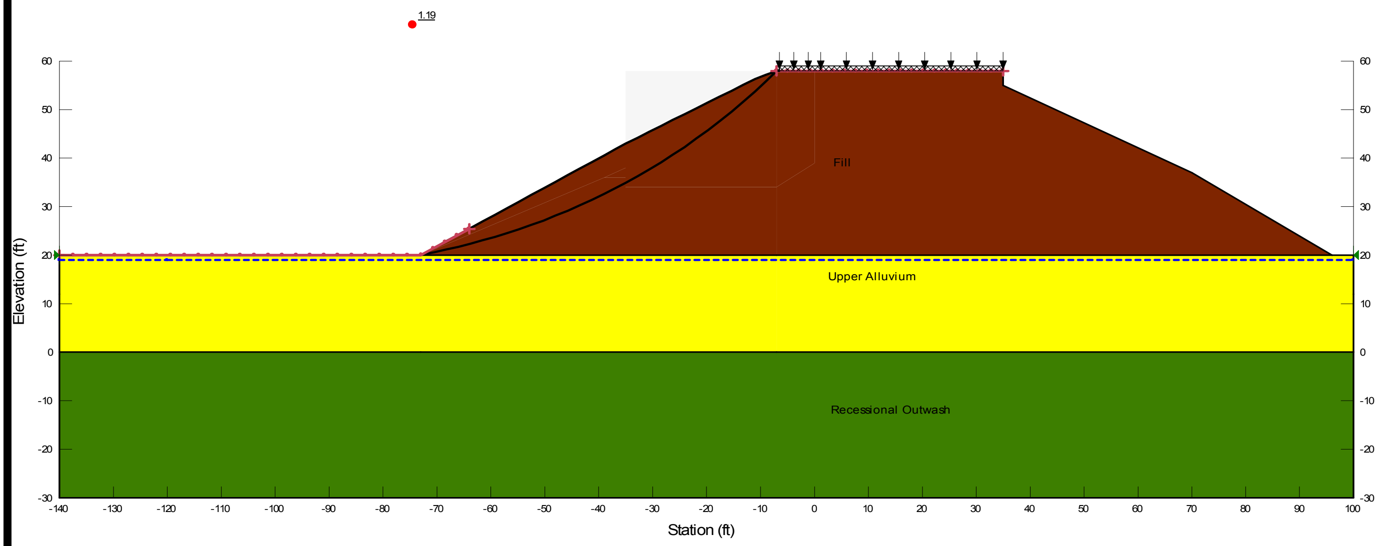
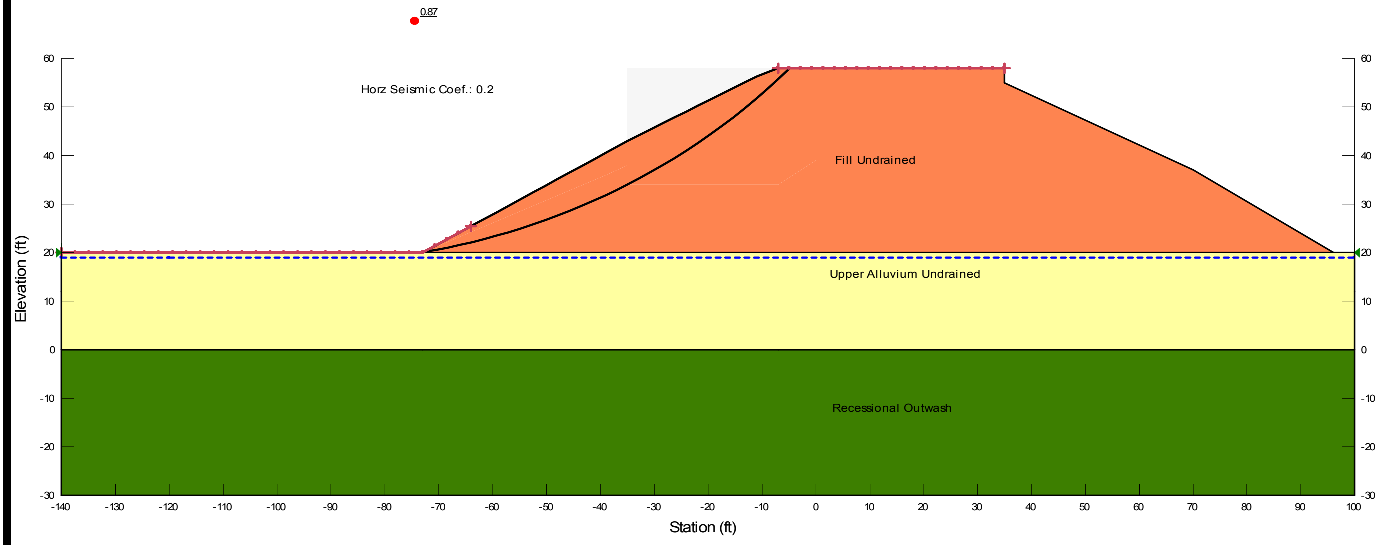
FIG. C-2

STATIC CONDITION



SEISMIC CONDITION



City of Marysville
State Avenue Corridor Widening
Marysville, Washington

GLOBAL STABILITY RESULTS
EXISTING CONDITIONS
STATION 102+25

September 2018 21-1-22406-003

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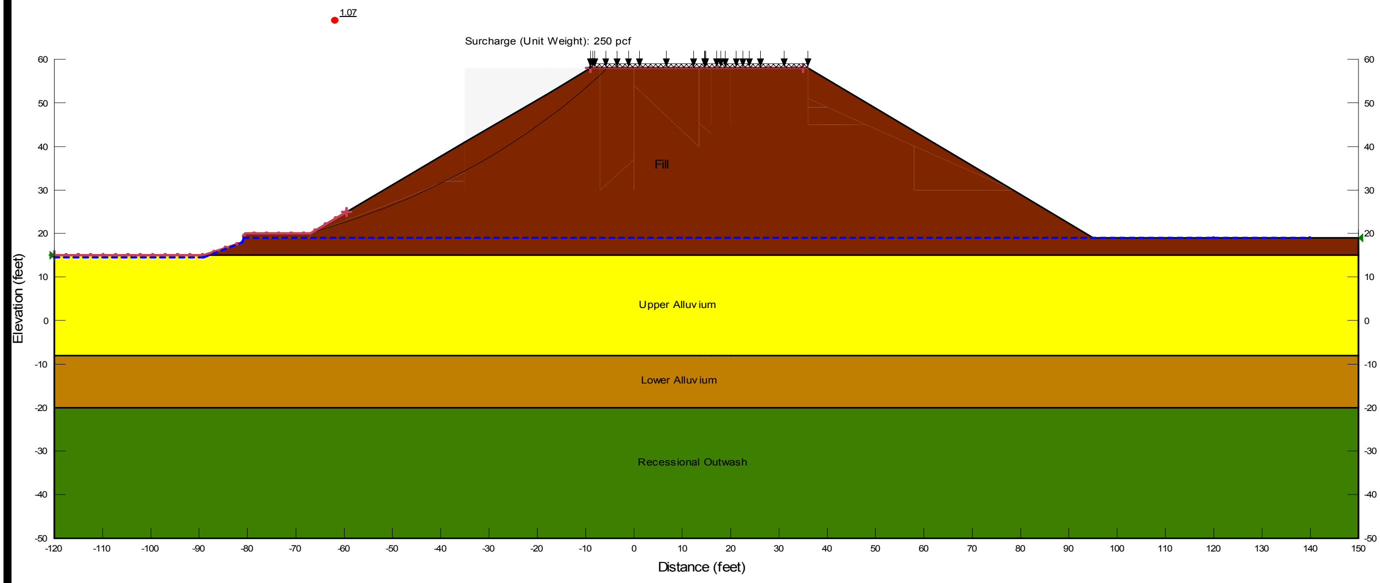
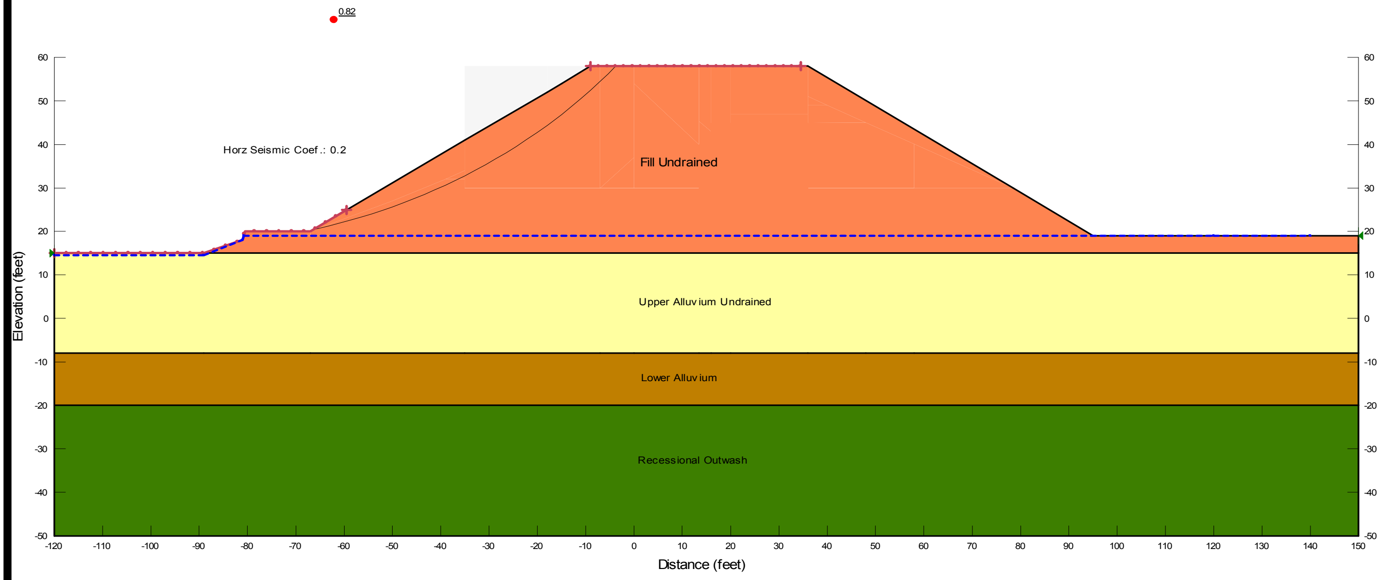
FIG. C-3

STATIC CONDITION



SEISMIC CONDITION



City of Marysville
State Avenue Corridor Widening
Marysville, Washington

GLOBAL STABILITY RESULTS
EXISTING CONDITIONS
STATION 102+50

9/56/2018 21-1-22406-003

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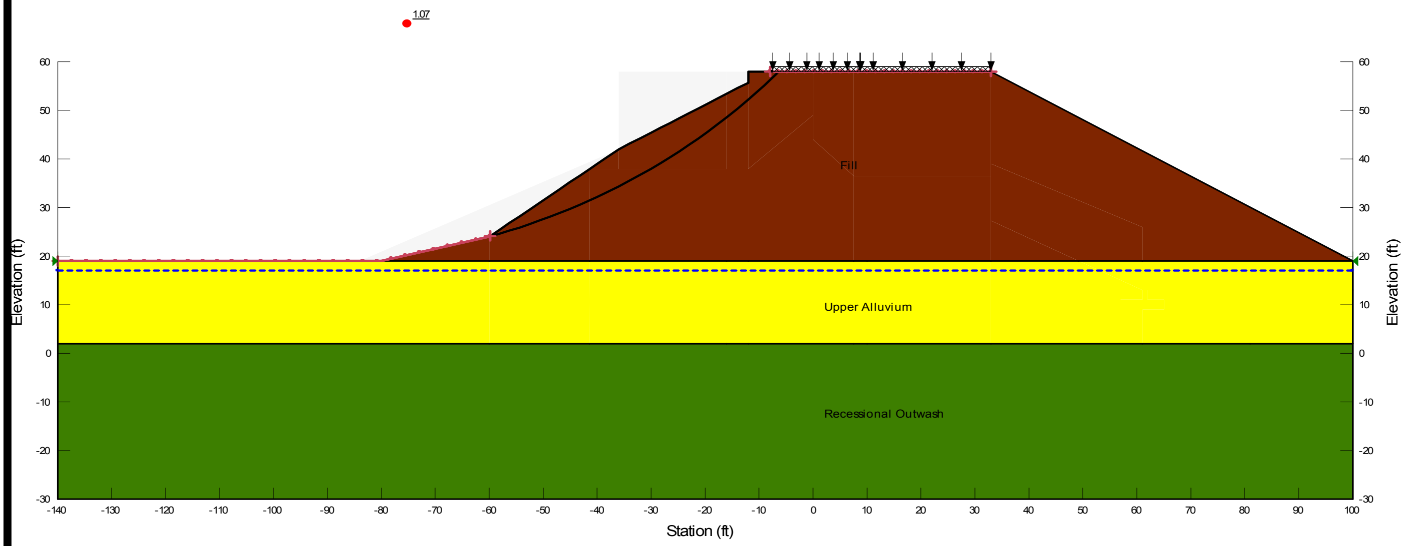
FIG. C-4

STATIC CONDITION



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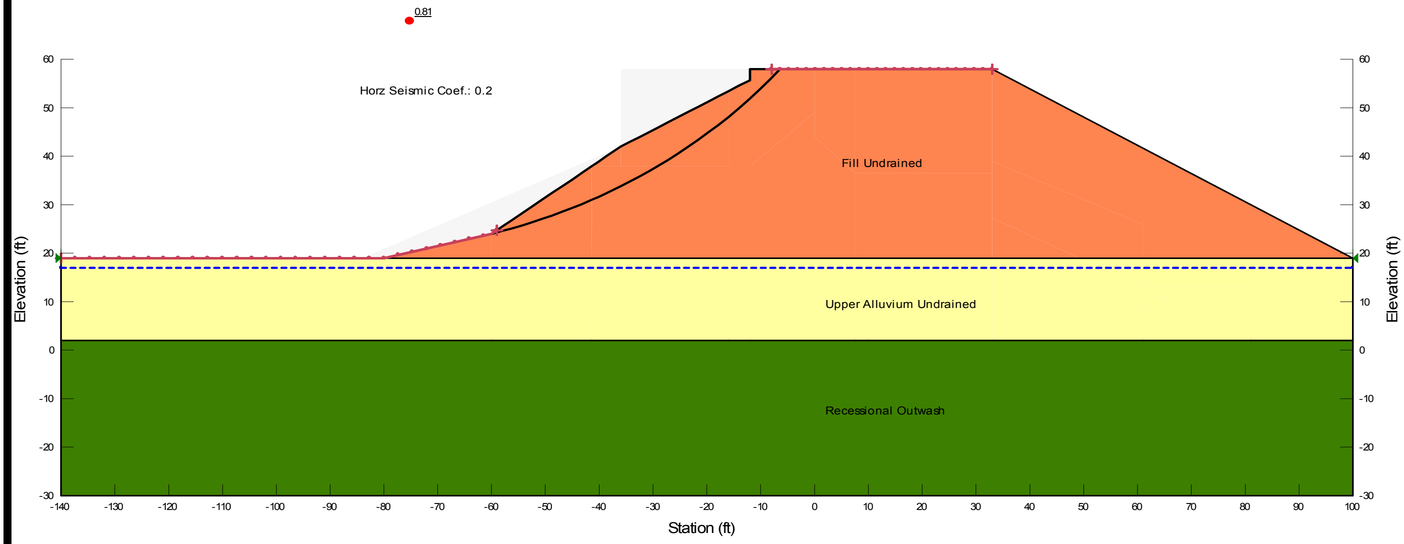

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

GLOBAL STABILITY RESULTS
EXISTING CONDITIONS
STATION 103+75

September 2018 21-1-22406-003

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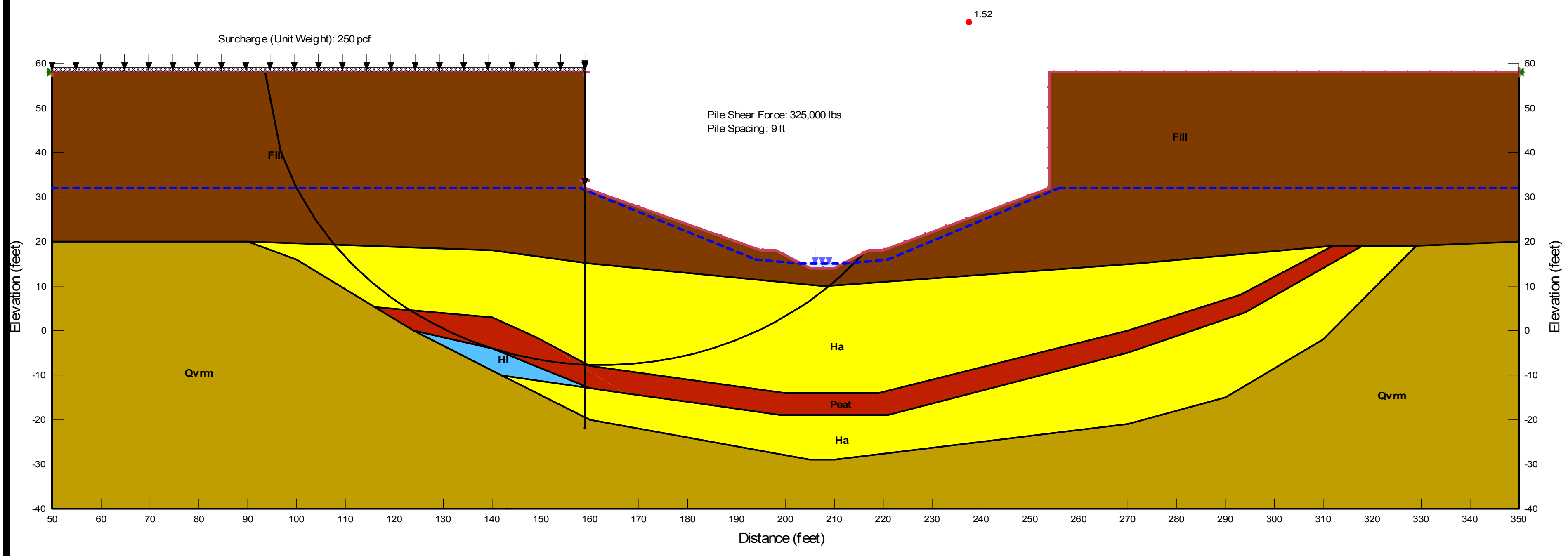
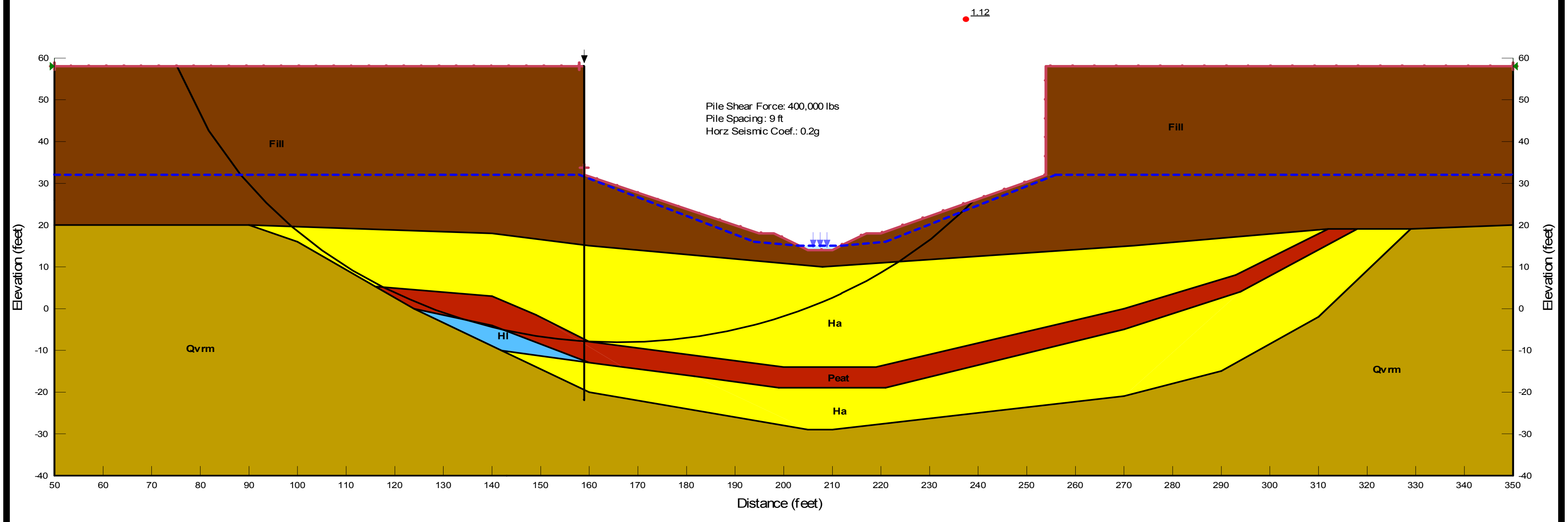
FIG. C-5

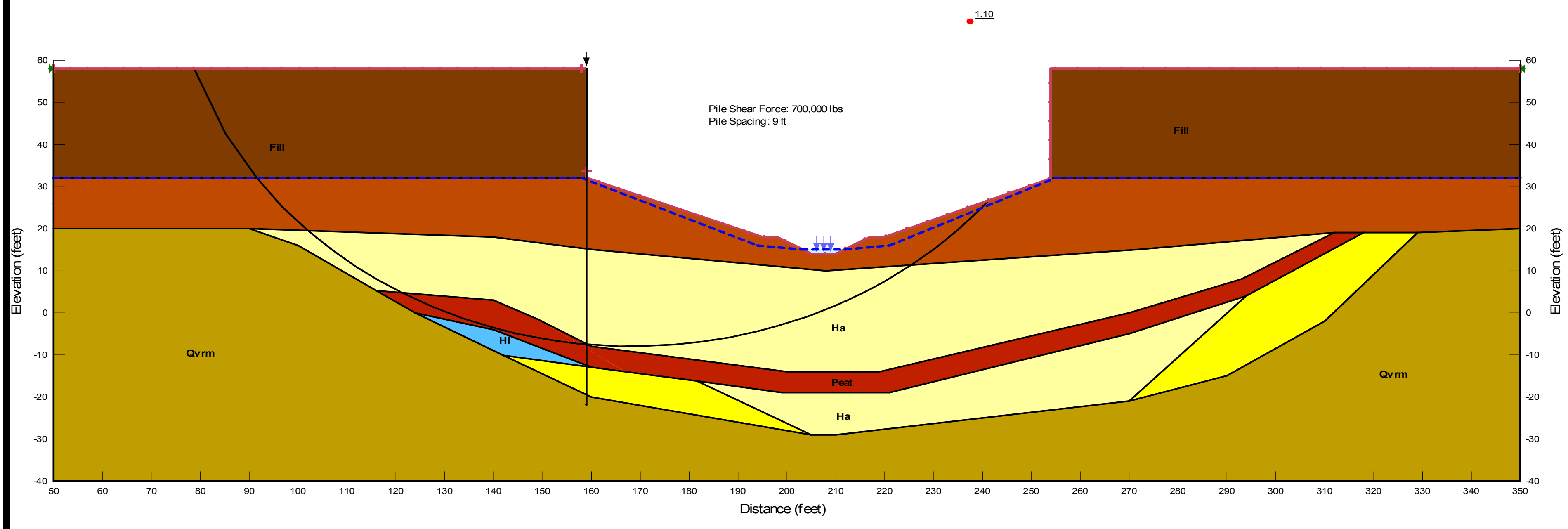
STATIC CONDITION



SEISMIC CONDITION



POST SEISMIC CONDITION



City of Marysville
State Avenue Corridor Widening
Marysville, Washington

GLOBAL STABILITY RESULTS
SOUTH ABUTMENT
CENTER LINE

September 2018
21-1-22406-003

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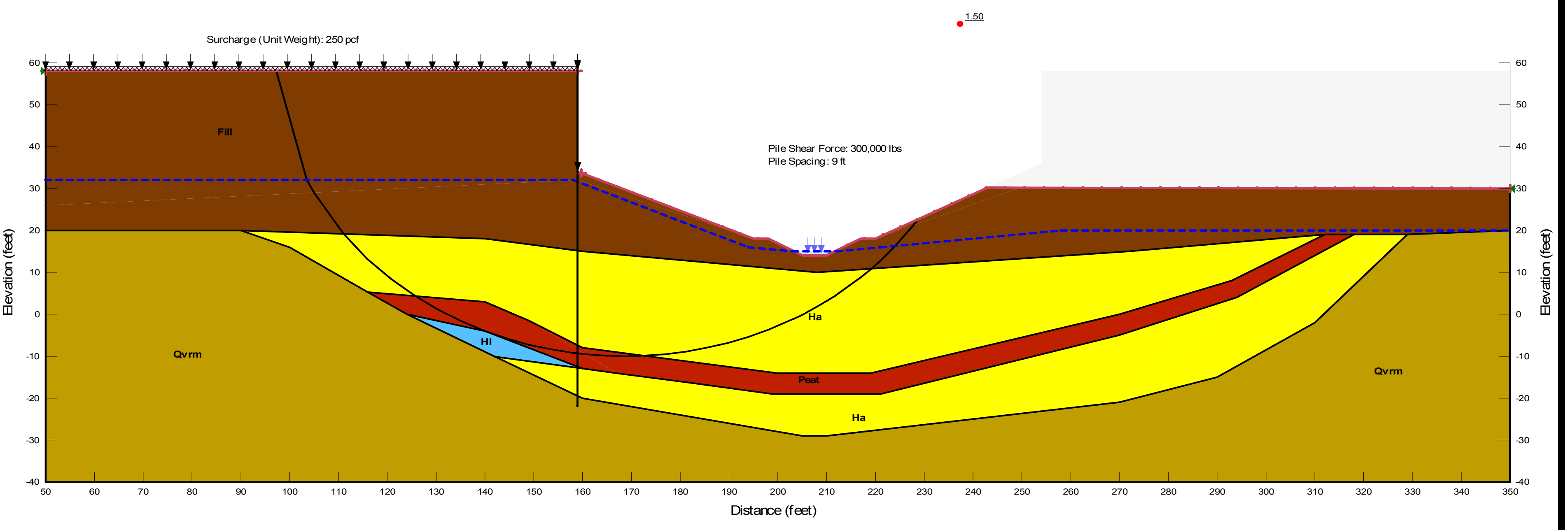
FIG. C-6

FIG. C-6

STATIC CONDITION



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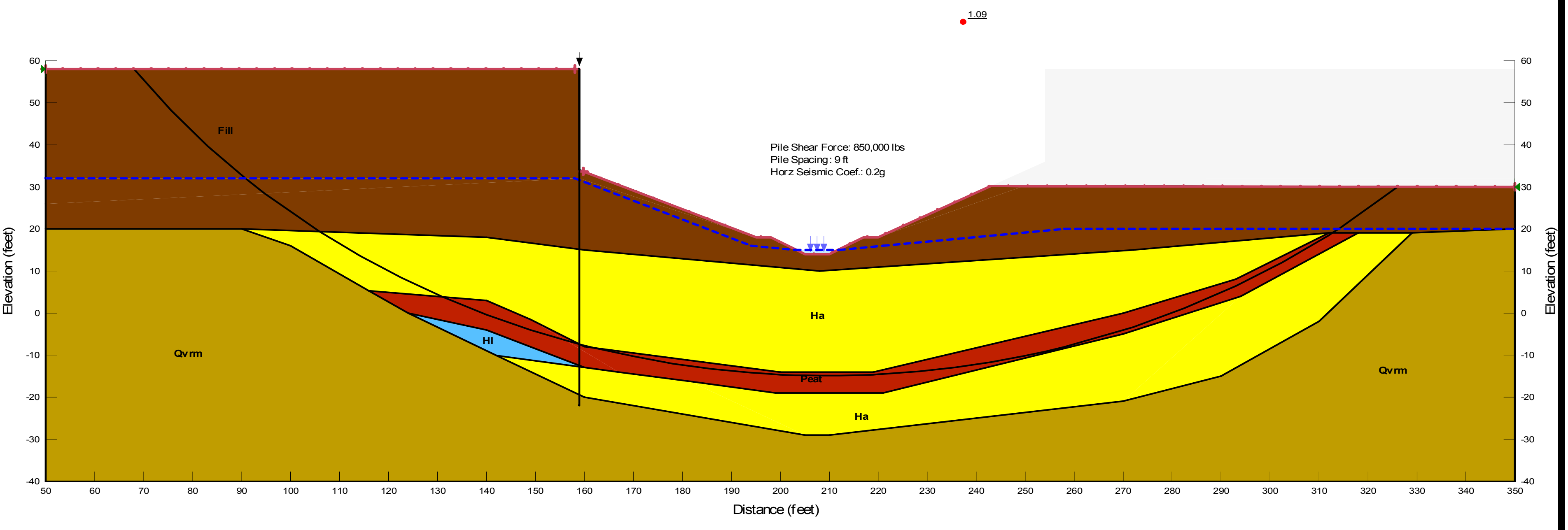

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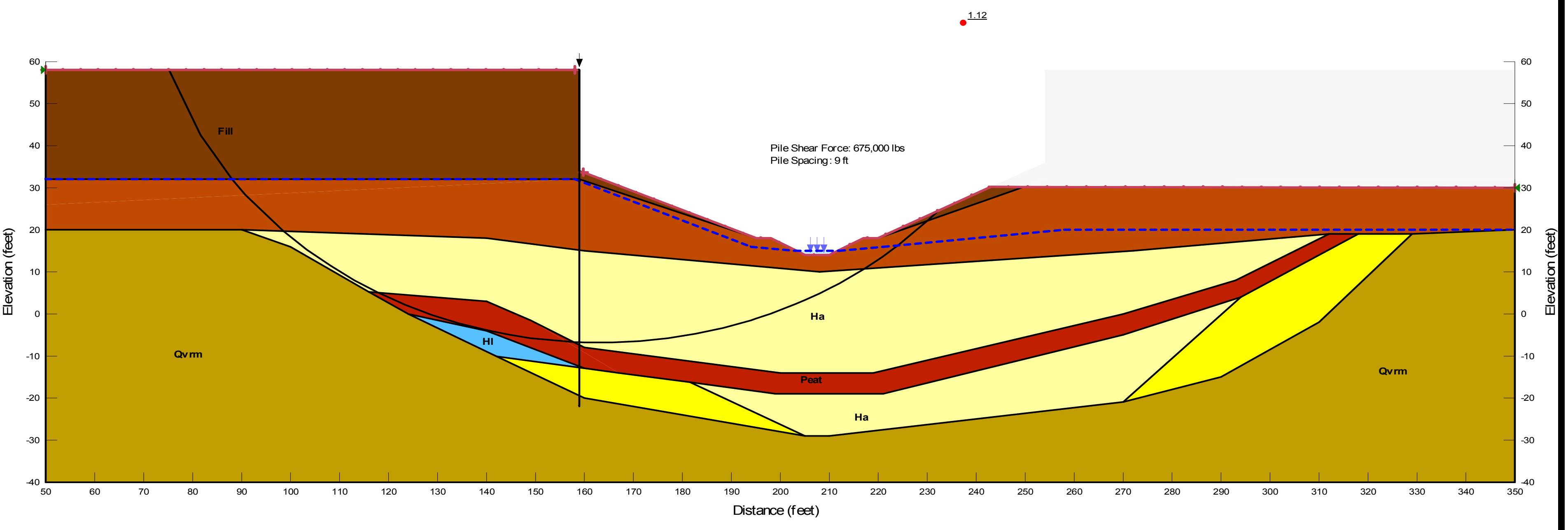

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

GLOBAL STABILITY RESULTS
SOUTH ABUTMENT
STATION 10+10

September 2018 21-1-22406-003

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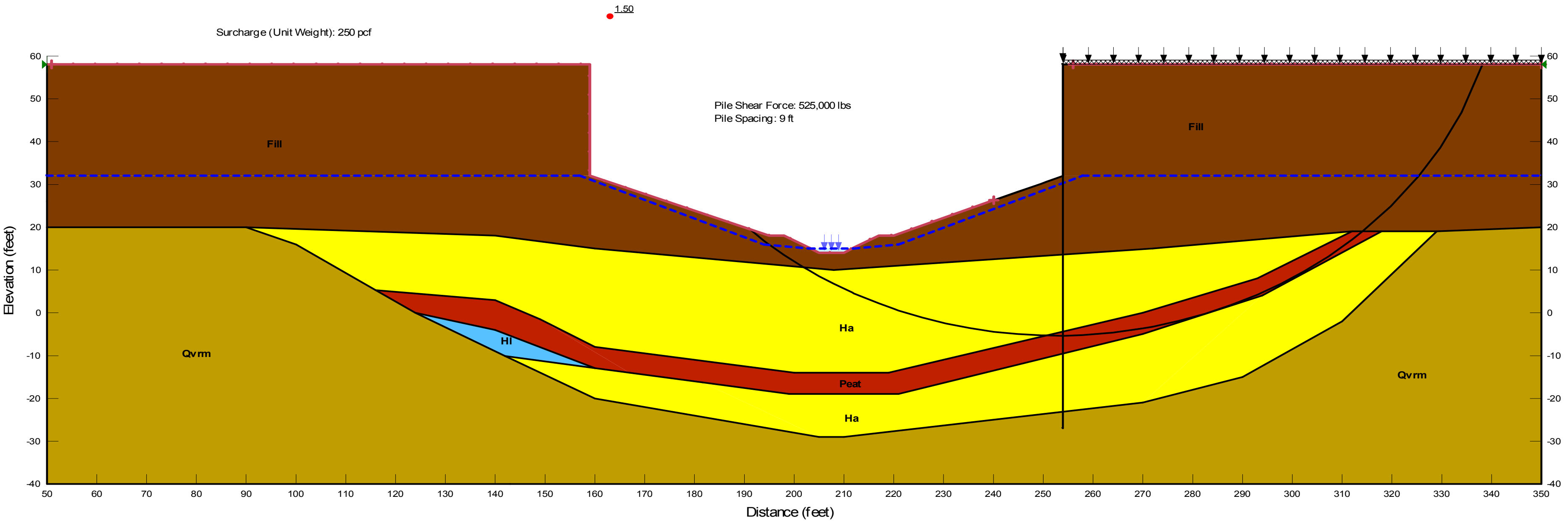
Geotechnical and Environmental Consultants

FIG. C-7

FIG. C-7

STATIC CONDITION



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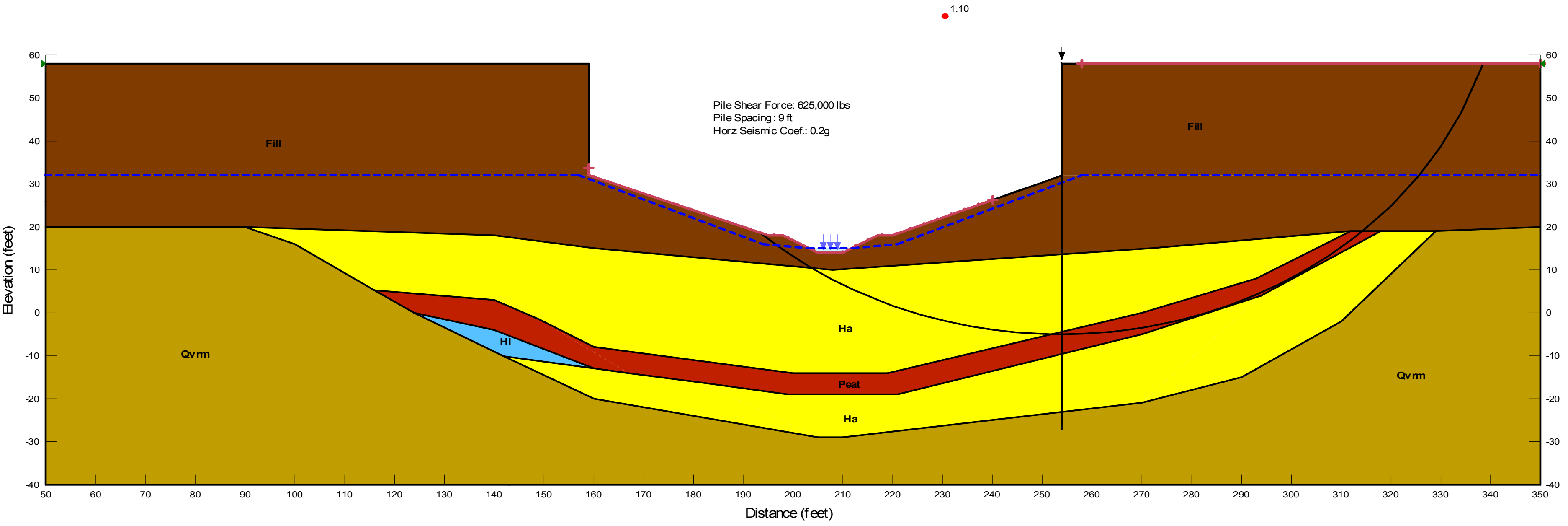

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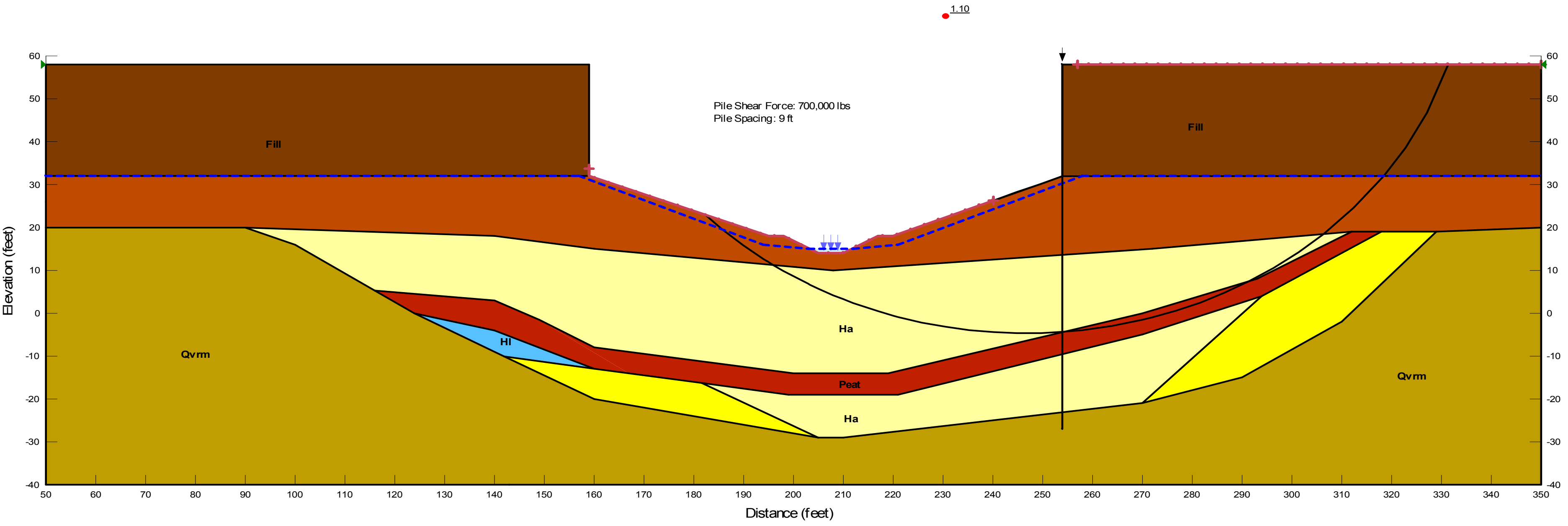

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

GLOBAL STABILITY RESULTS
NORTH ABUTMENT
CENTER LINE

September 2018
21-1-22406-003

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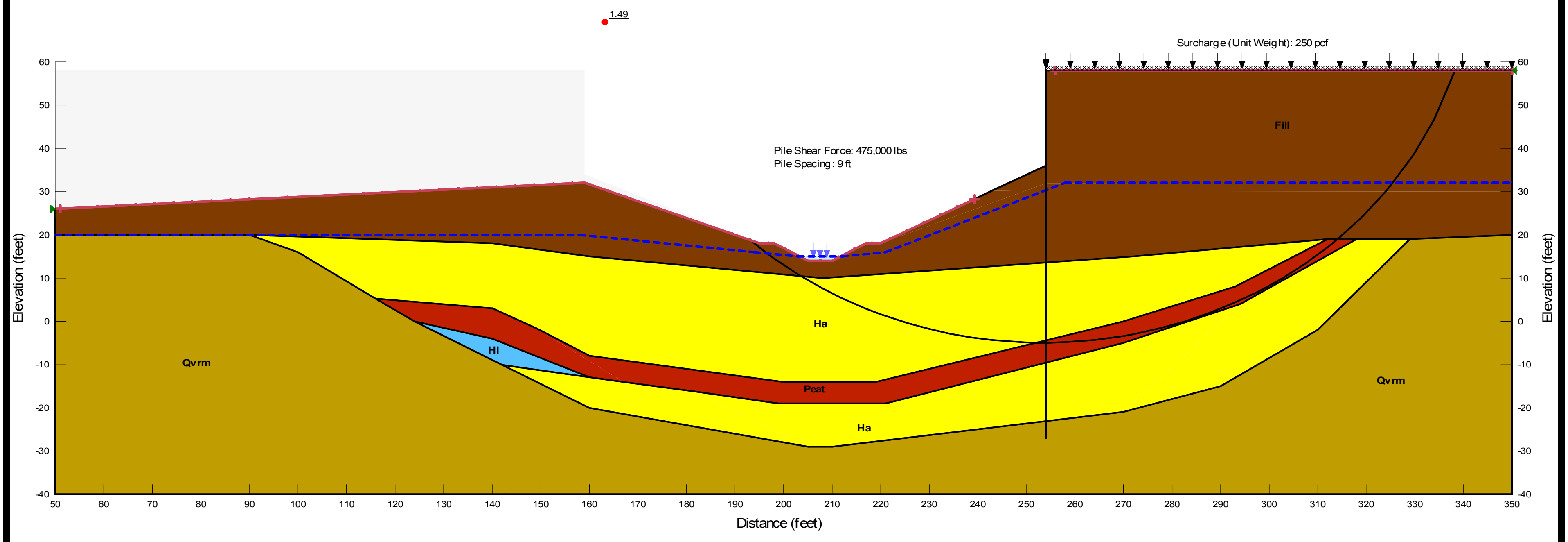
Geotechnical and Environmental Consultants

FIG. C-8

FIG. C-8

STATIC CONDITION



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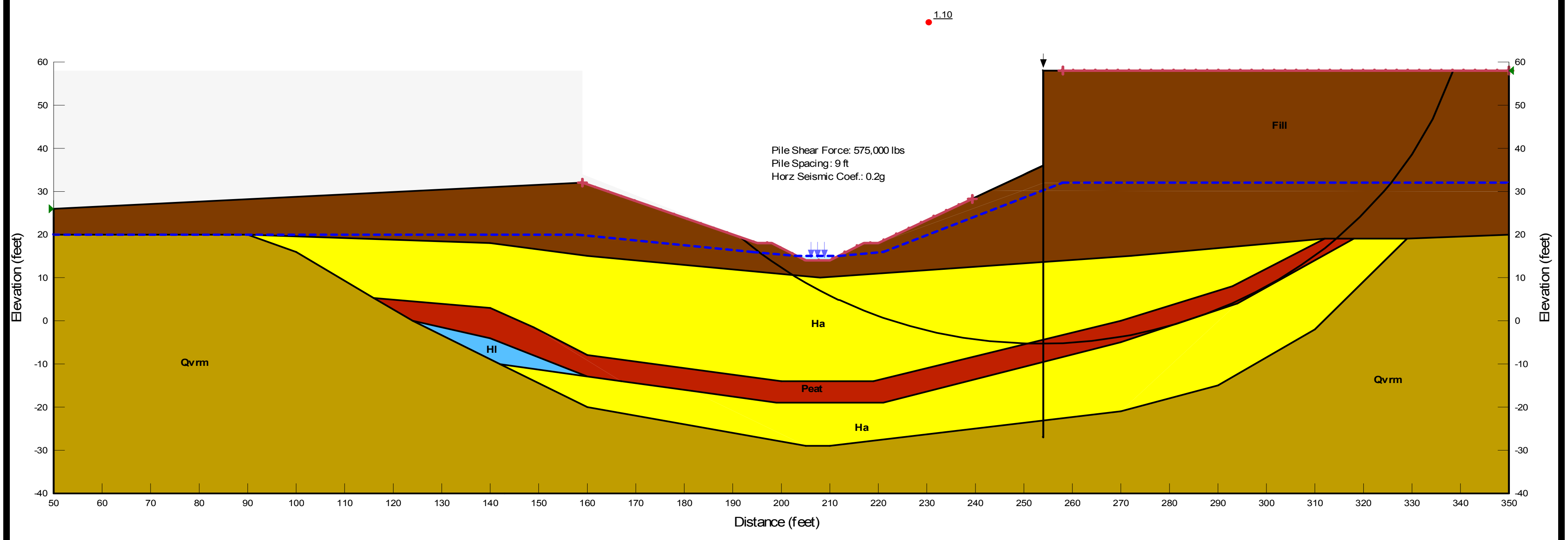

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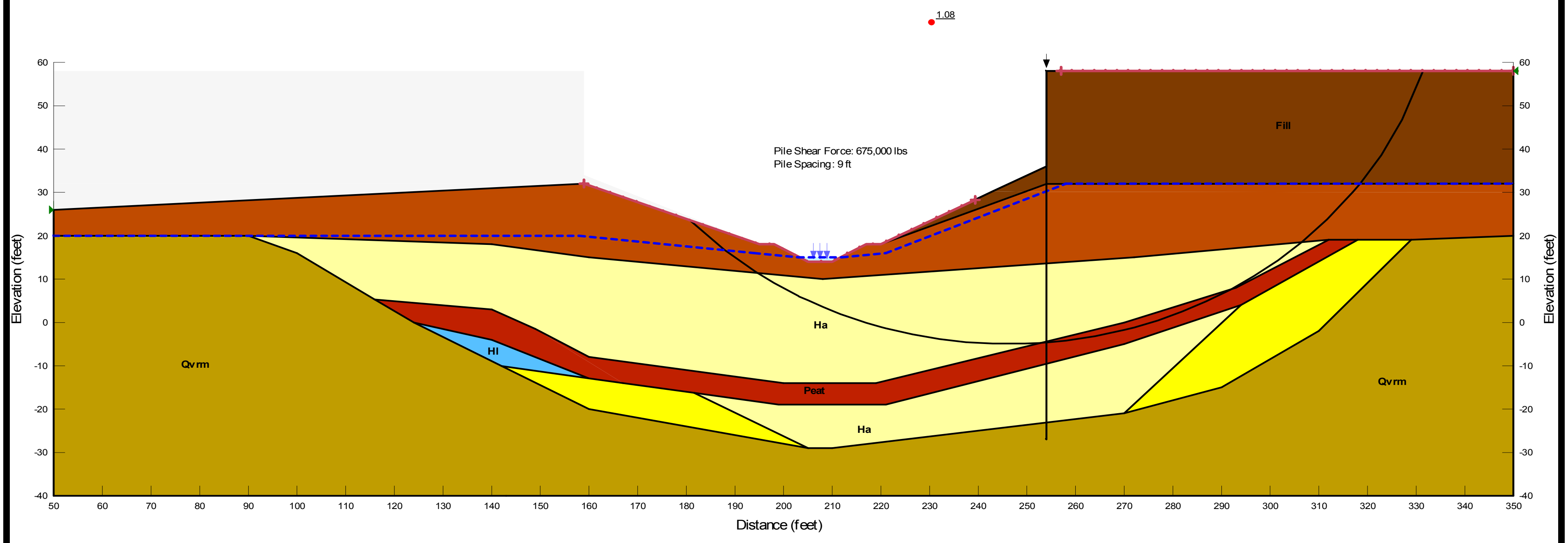

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

GLOBAL STABILITY RESULTS
NORTH ABUTMENT
STATION 10+80

September 2018 21-1-22406-003

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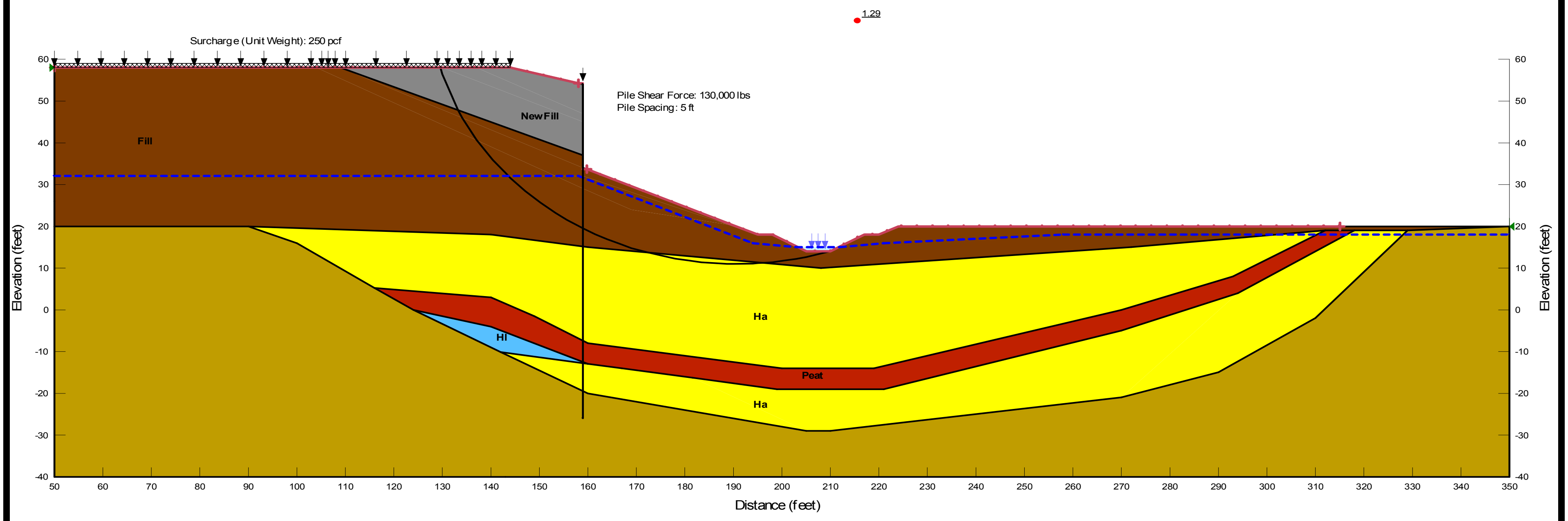
Geotechnical and Environmental Consultants

FIG. C-9

FIG. C-9

STATIC CONDITION



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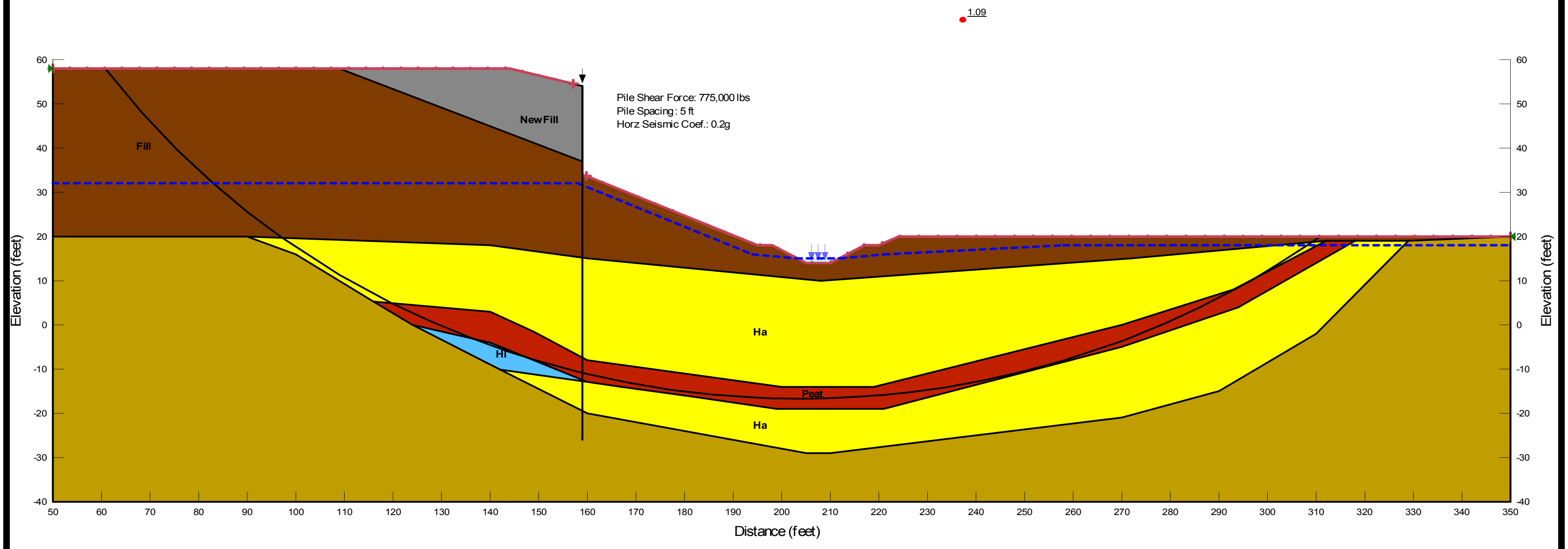

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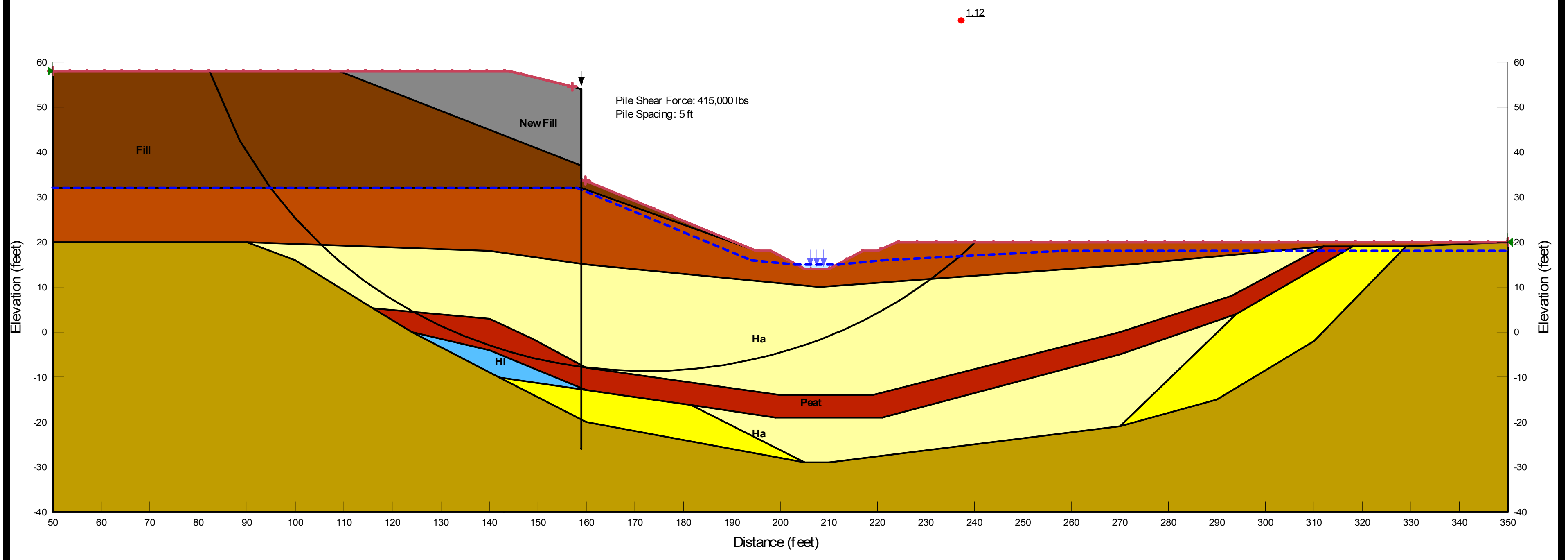

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

GLOBAL STABILITY RESULTS
WALL 1 STATION 10+20
H = 20 FEET

September 2018 21-1-22406-003

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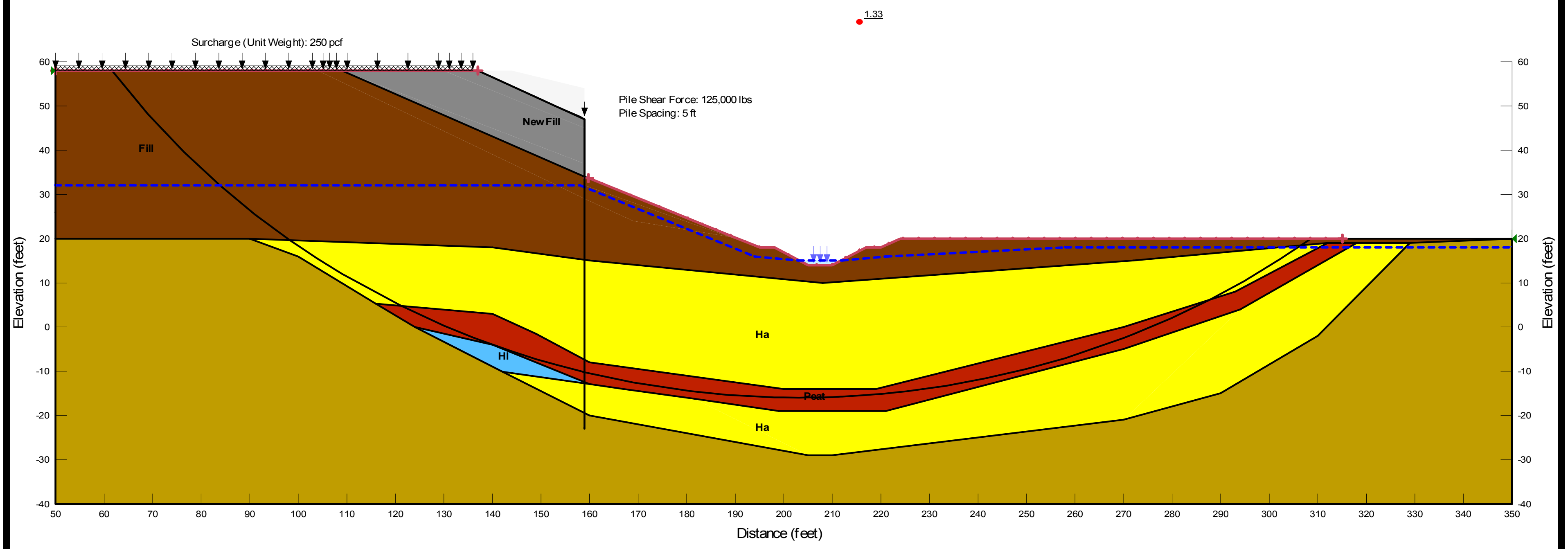
FIG. C-10

FIG. C-10

STATIC CONDITION



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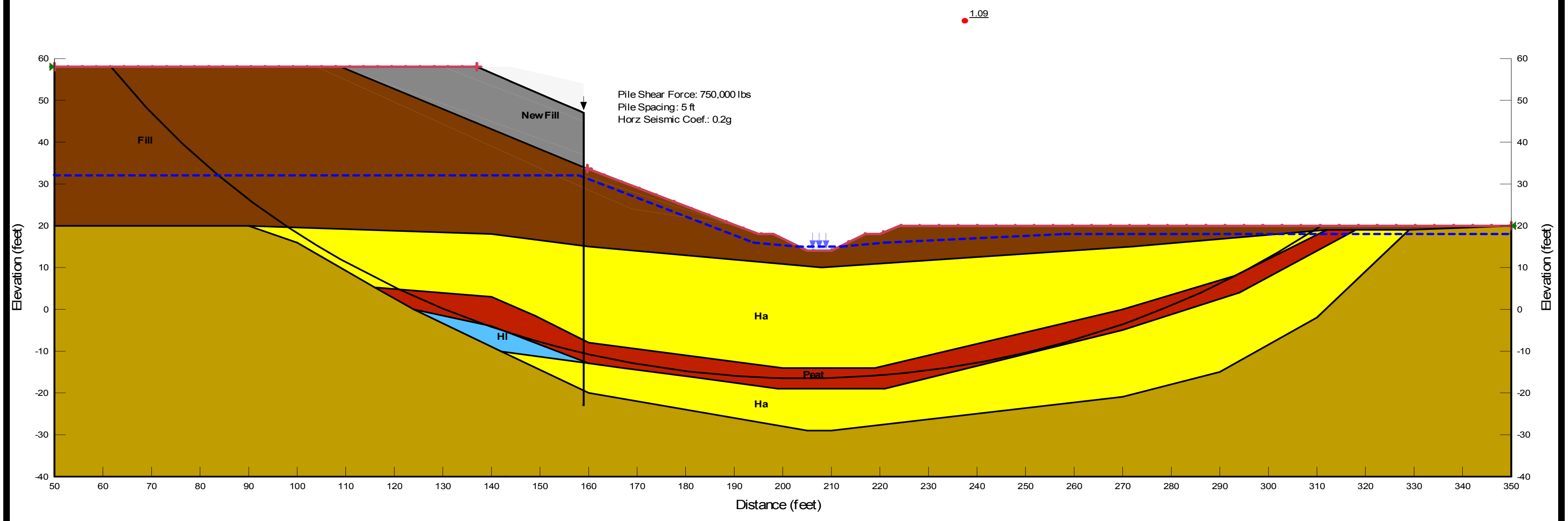
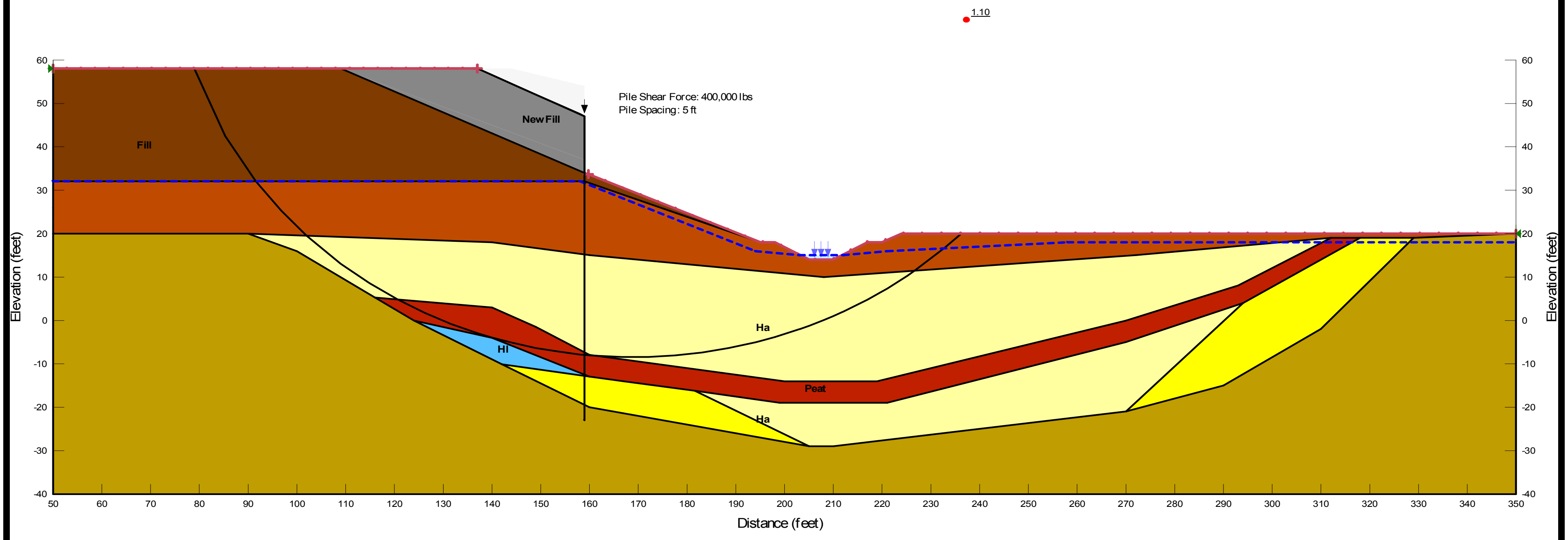


POST SEISMIC CONDITION



City of Marysville
State Avenue Corridor Widening
Marysville, Washington

GLOBAL STABILITY RESULTS
WALL 1 STATION 10+30
H = 14 FEET

September 2018 21-1-22406-003

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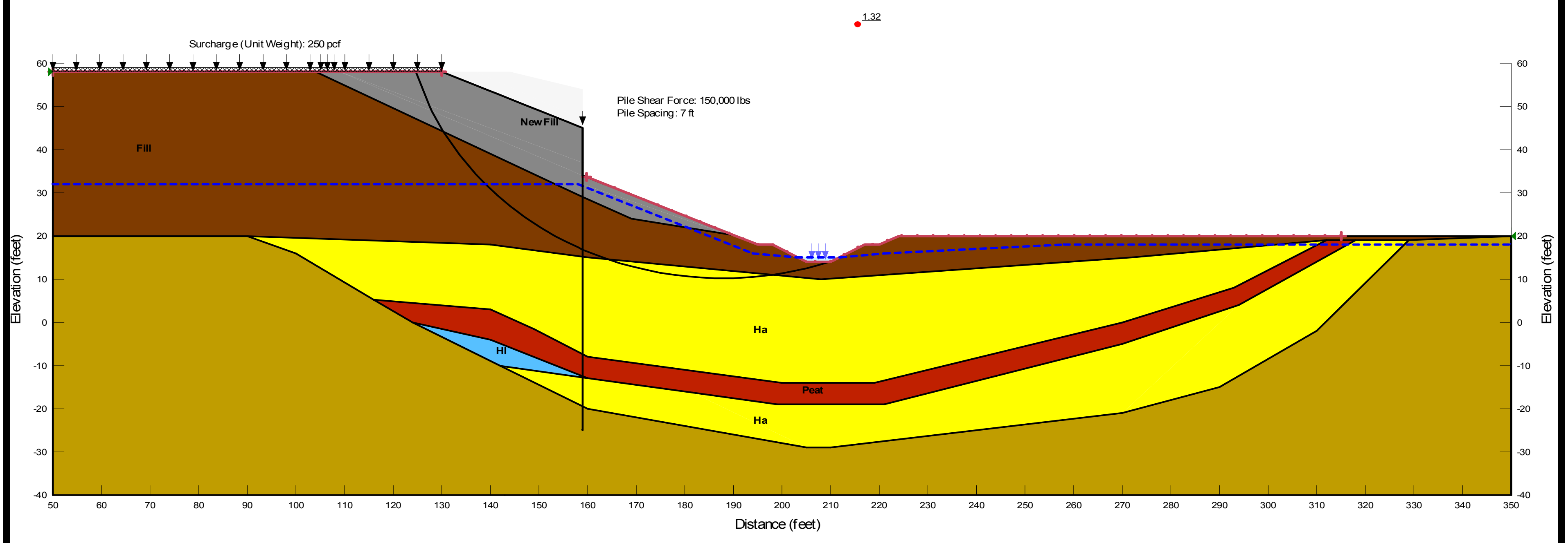
FIG. C-11

FIG. C-11

STATIC CONDITION



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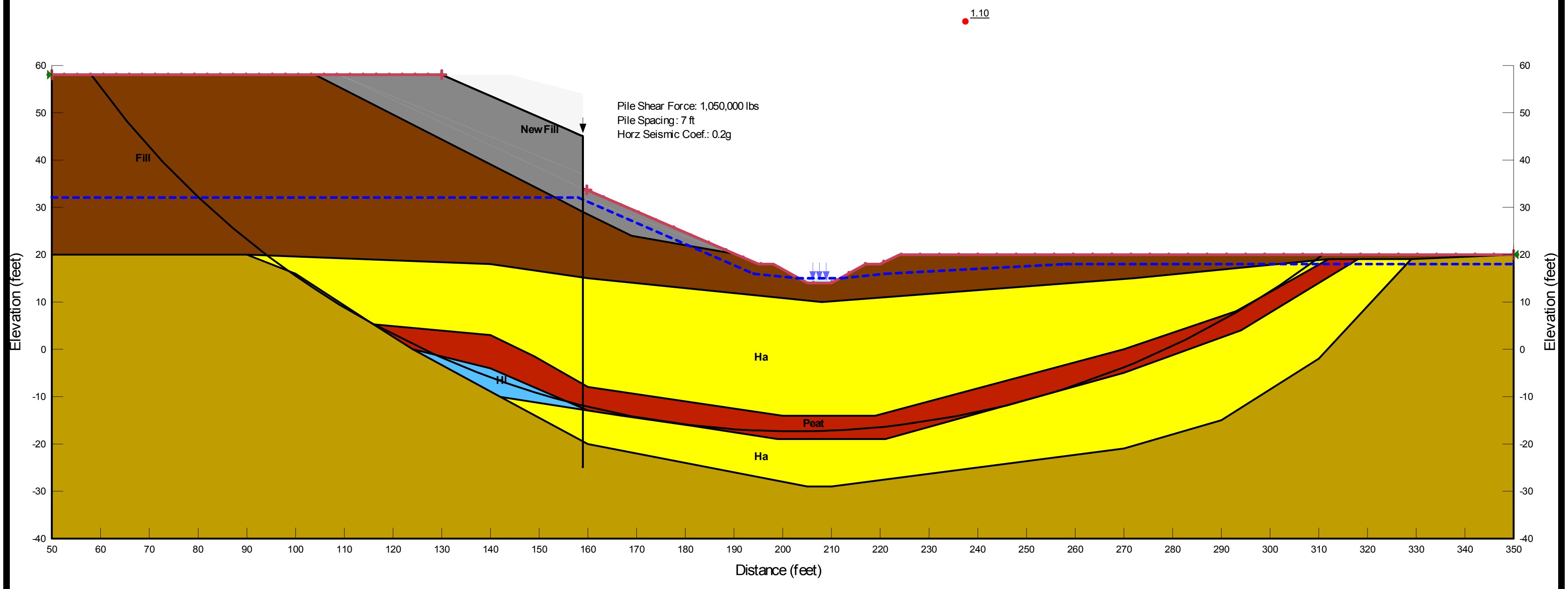

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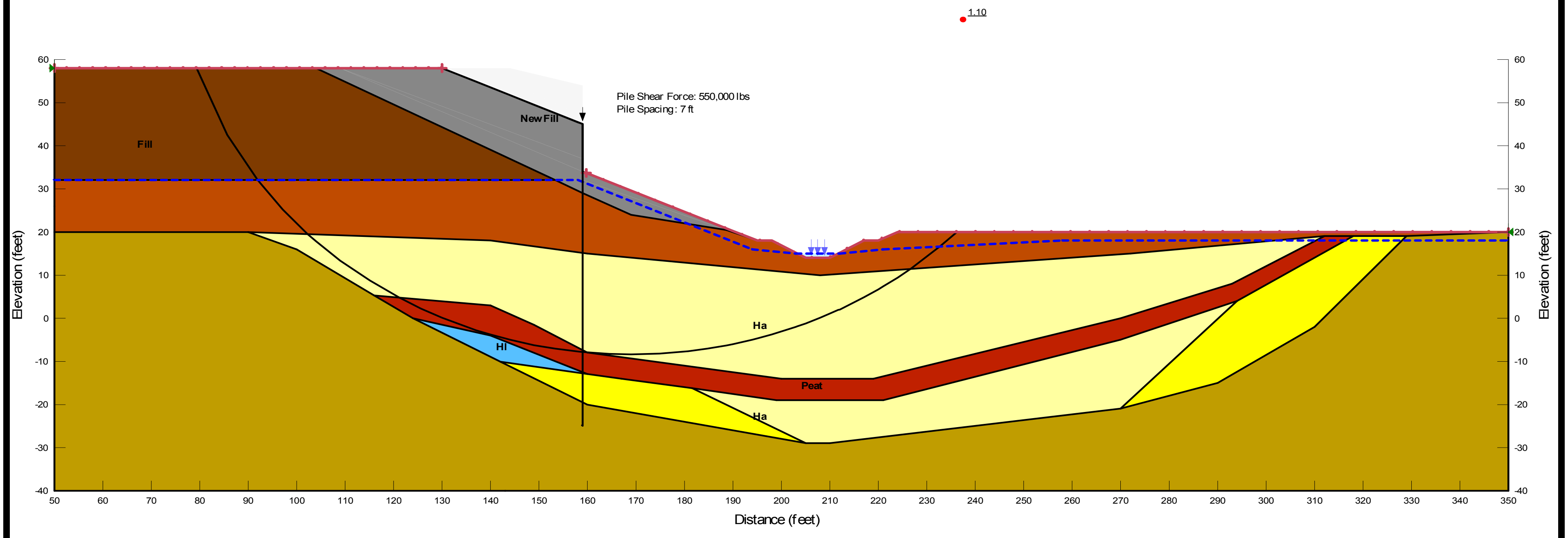

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

GLOBAL STABILITY RESULTS
WALL 1 STATION 10+40
H = 11 FEET

September 2018 21-1-22406-003

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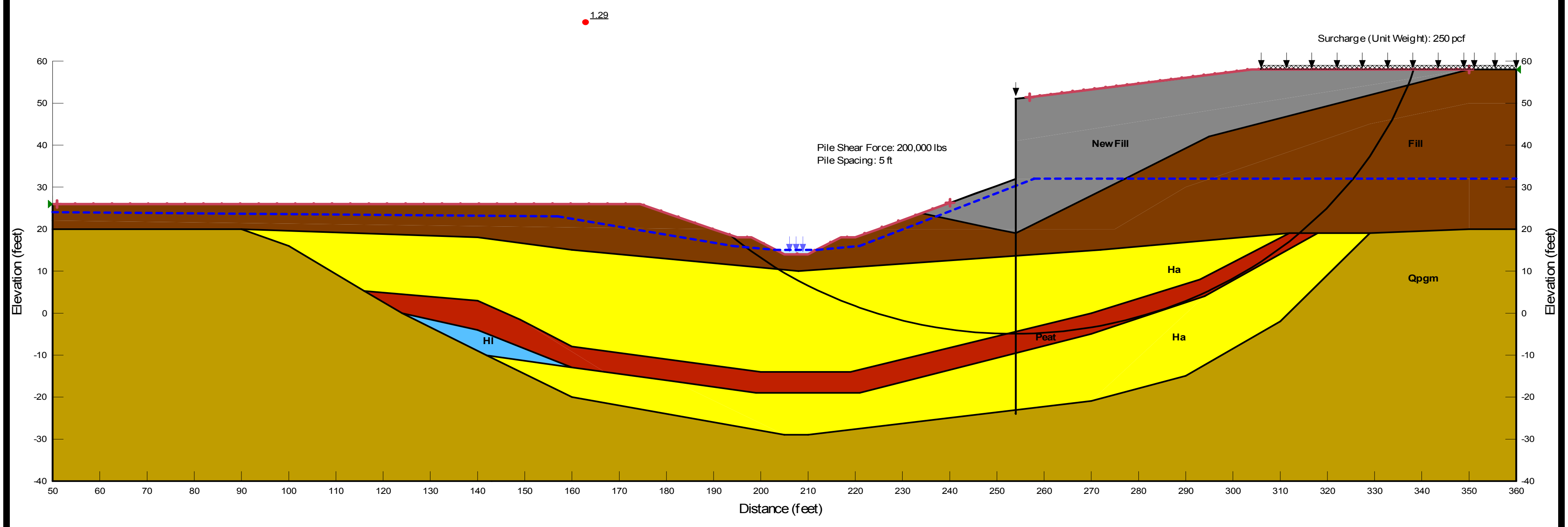
FIG. C-12

FIG. C-12

STATIC CONDITION



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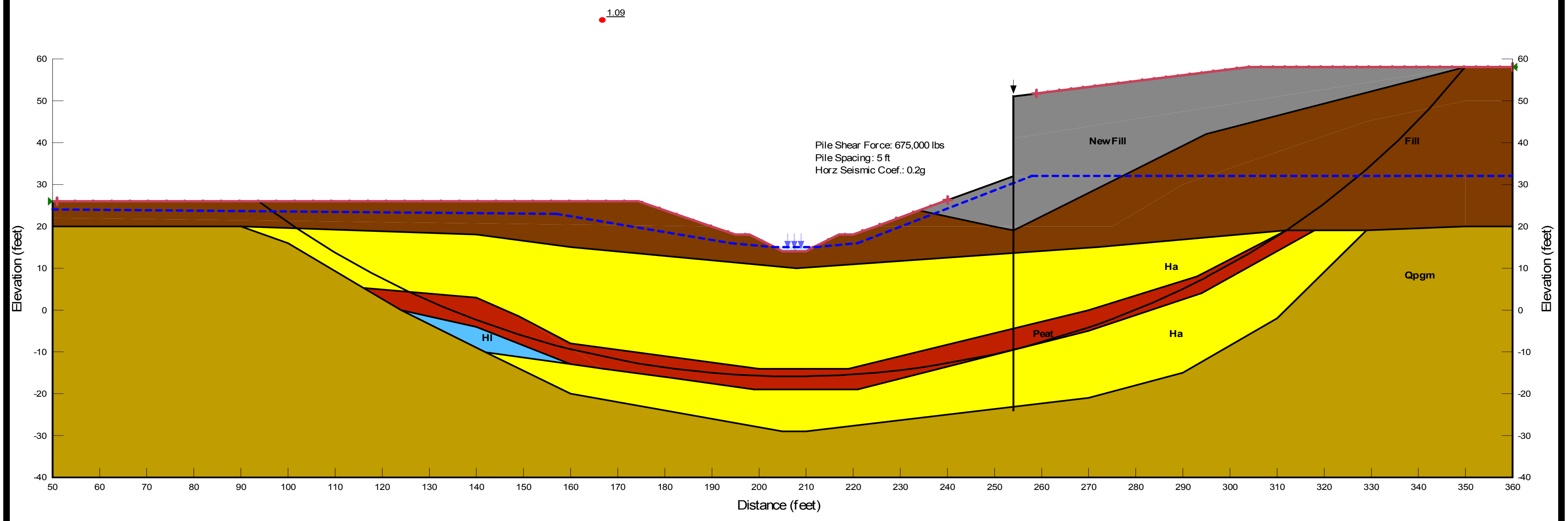

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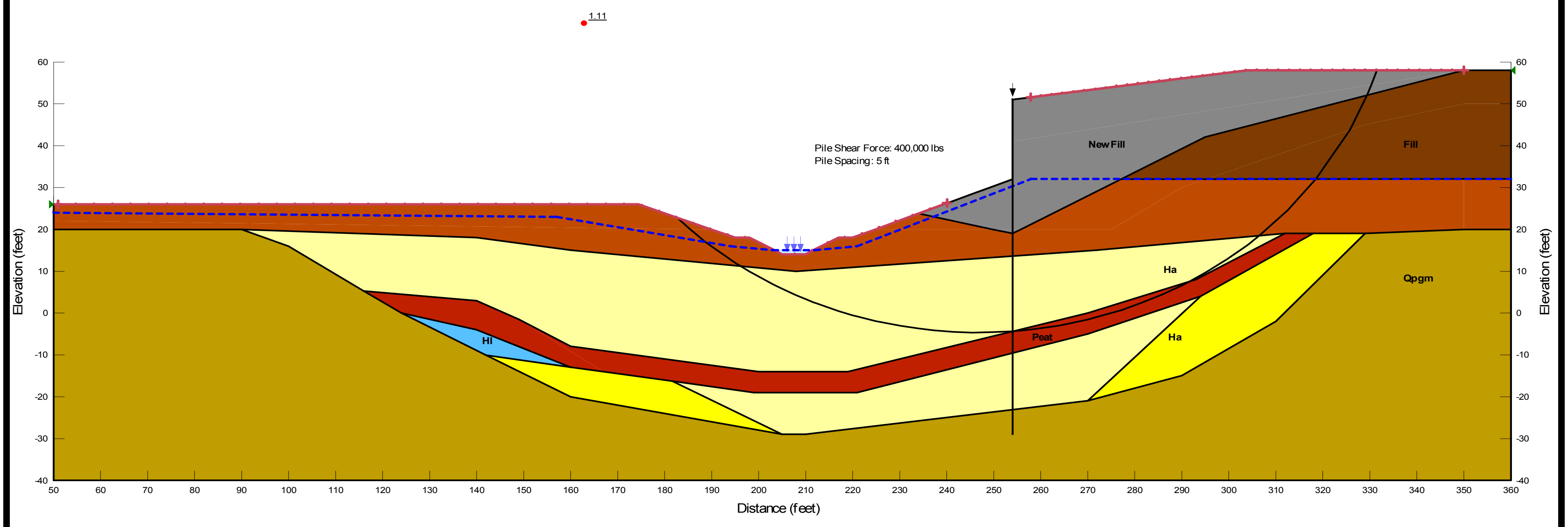

FIG. C-13

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

GLOBAL STABILITY RESULTS
WALL 2 STATION 10+20
H = 18 FEET

September 2018 21-1-22406-003

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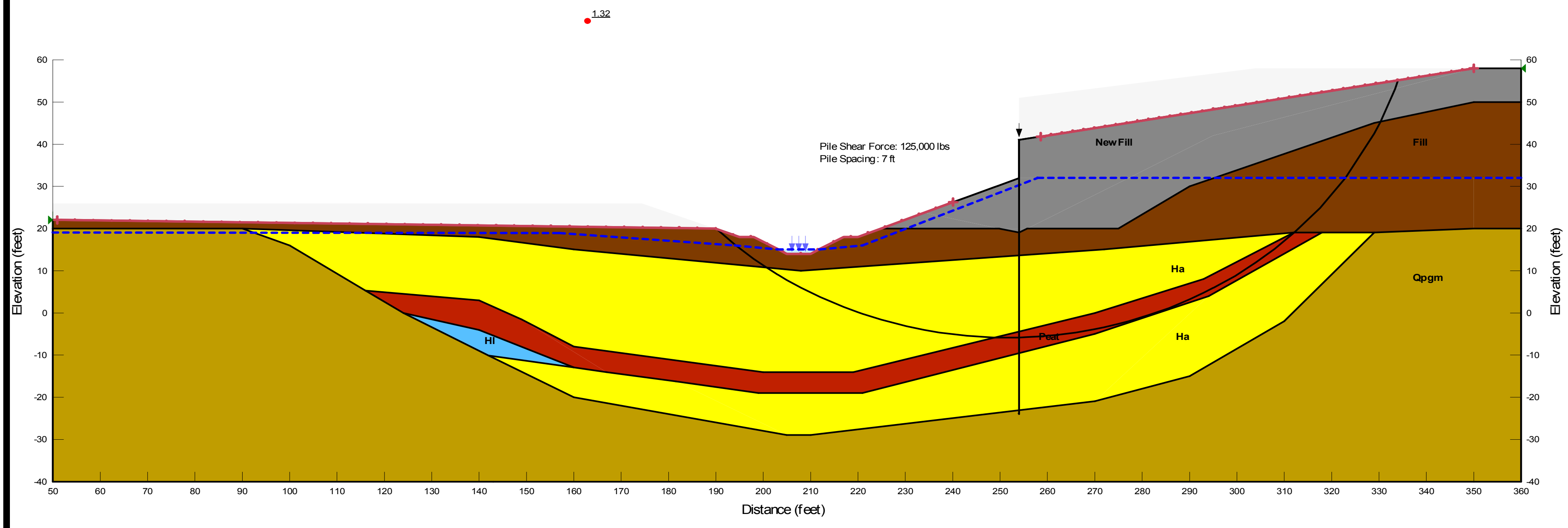
Geotechnical and Environmental Consultants

FIG. C-13

STATIC CONDITION



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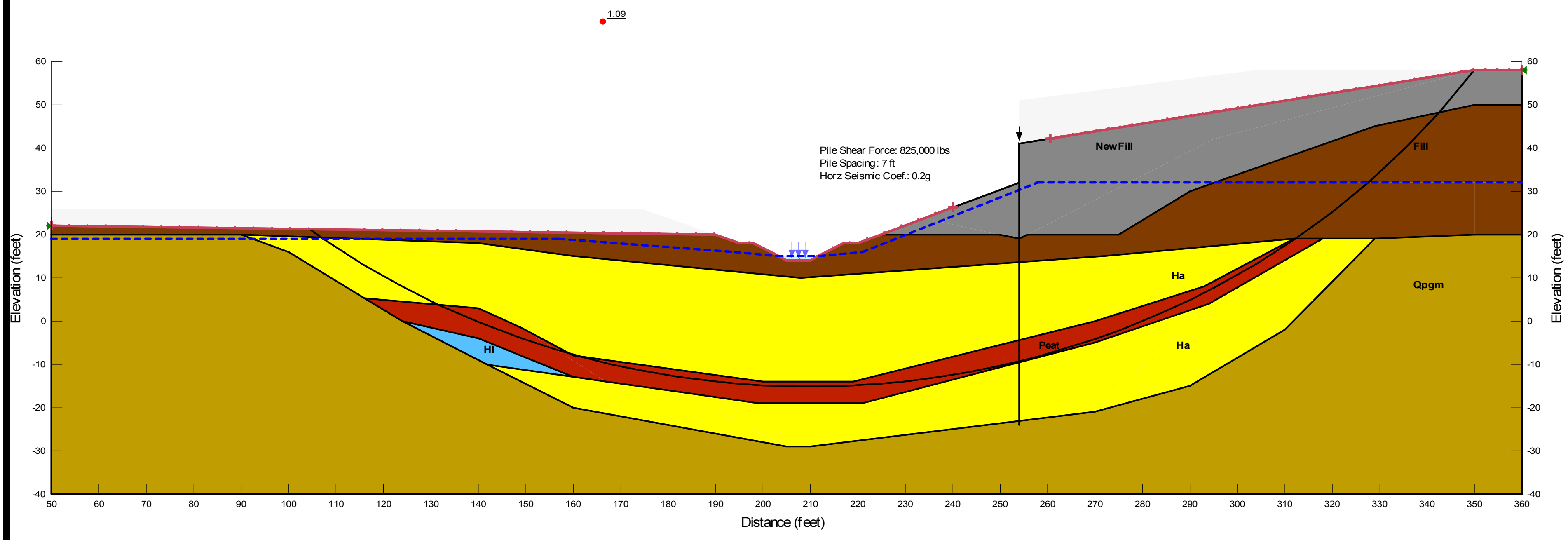

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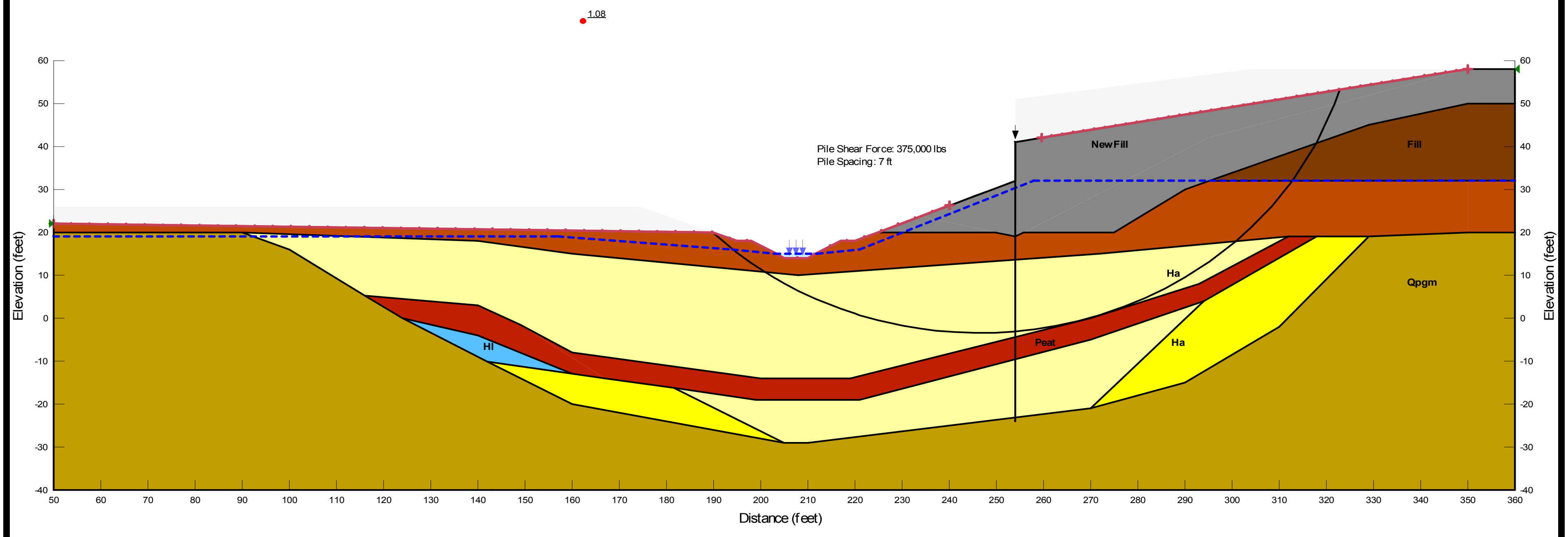

FIG. C-14

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

GLOBAL STABILITY RESULTS
WALL 2 STATION 10+40
H = 9 FEET

September 2018 21-1-22406-003

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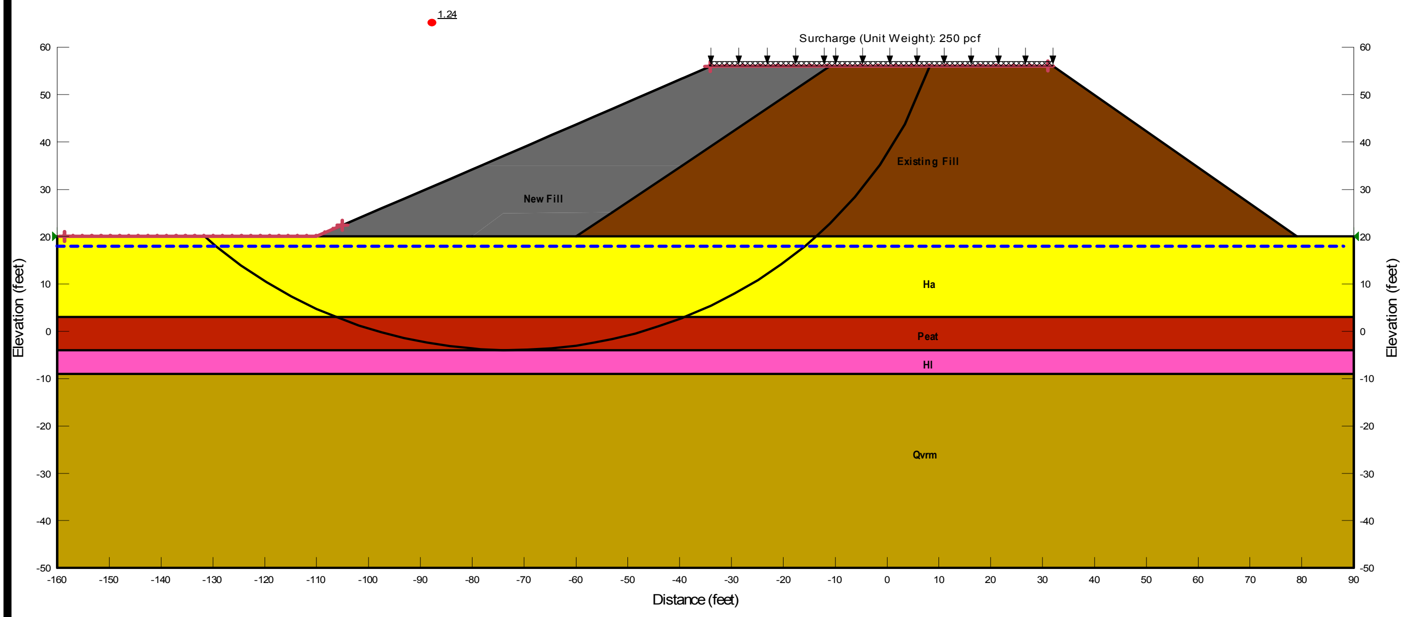
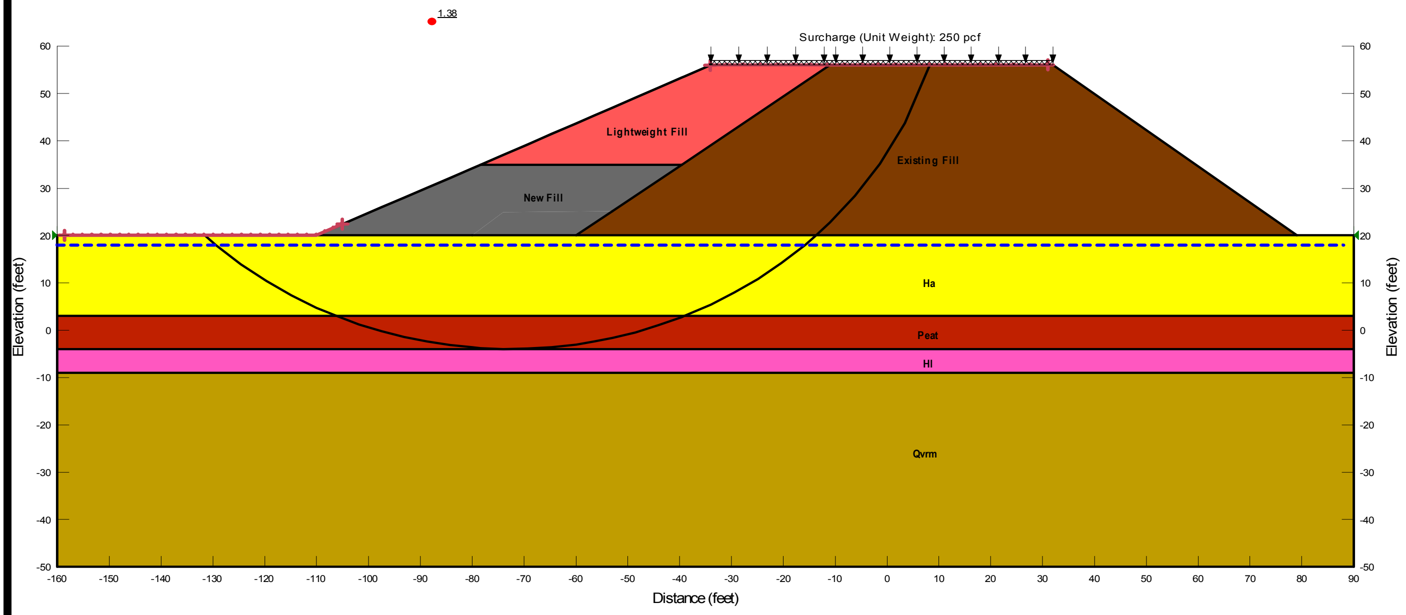
Geotechnical and Environmental Consultants

FIG. C-14

GRANULAR FILL



LIGHTWEIGHT FILL



City of Marysville
State Avenue Corridor Widening
Marysville, Washington

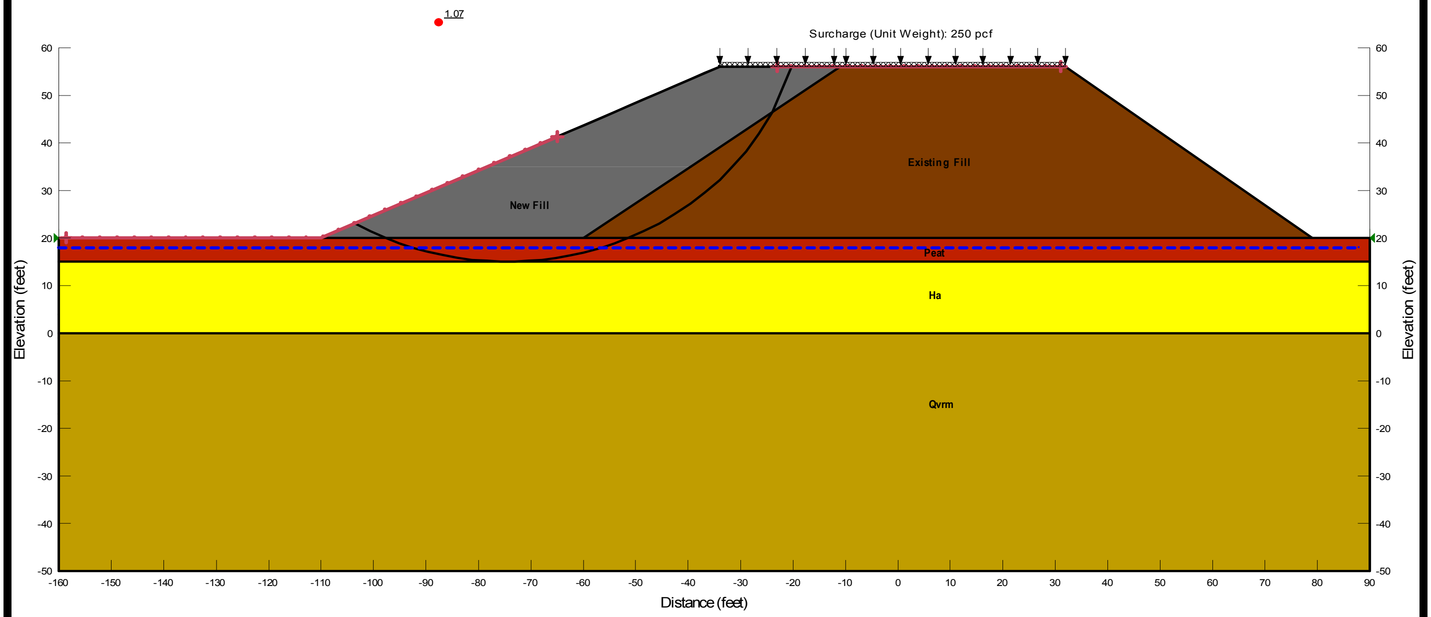
GLOBAL STABILITY RESULTS
PARTIAL HEIGHT LIGHTWEIGHT FILL
STATION 104+00

September 2019 21-1-22406-003

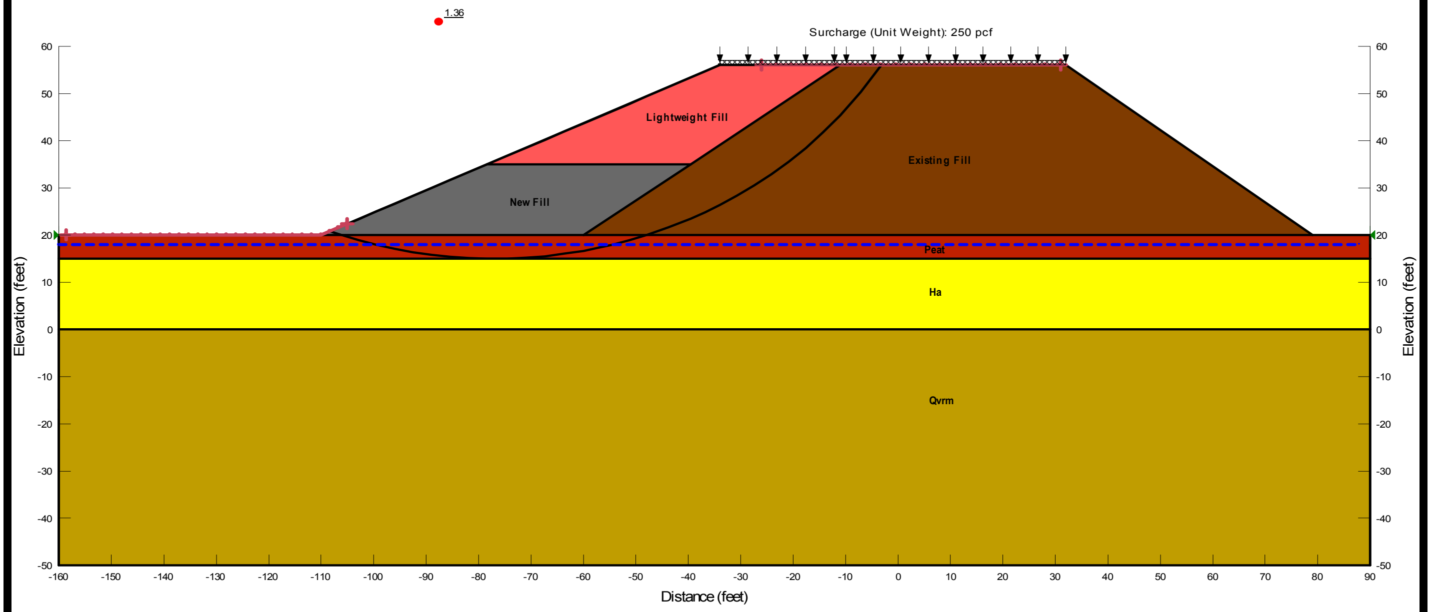
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-15

GRANULAR FILL



LIGHTWEIGHT FILL



City of Marysville
State Avenue Corridor Widening
Marysville, Washington

GLOBAL STABILITY RESULTS
PARTIAL HEIGHT LIGHTWEIGHT FILL
STATION 104+00

September 2019 21-1-22406-003

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FIG. C-16

Appendix D

Settlement Analysis Results

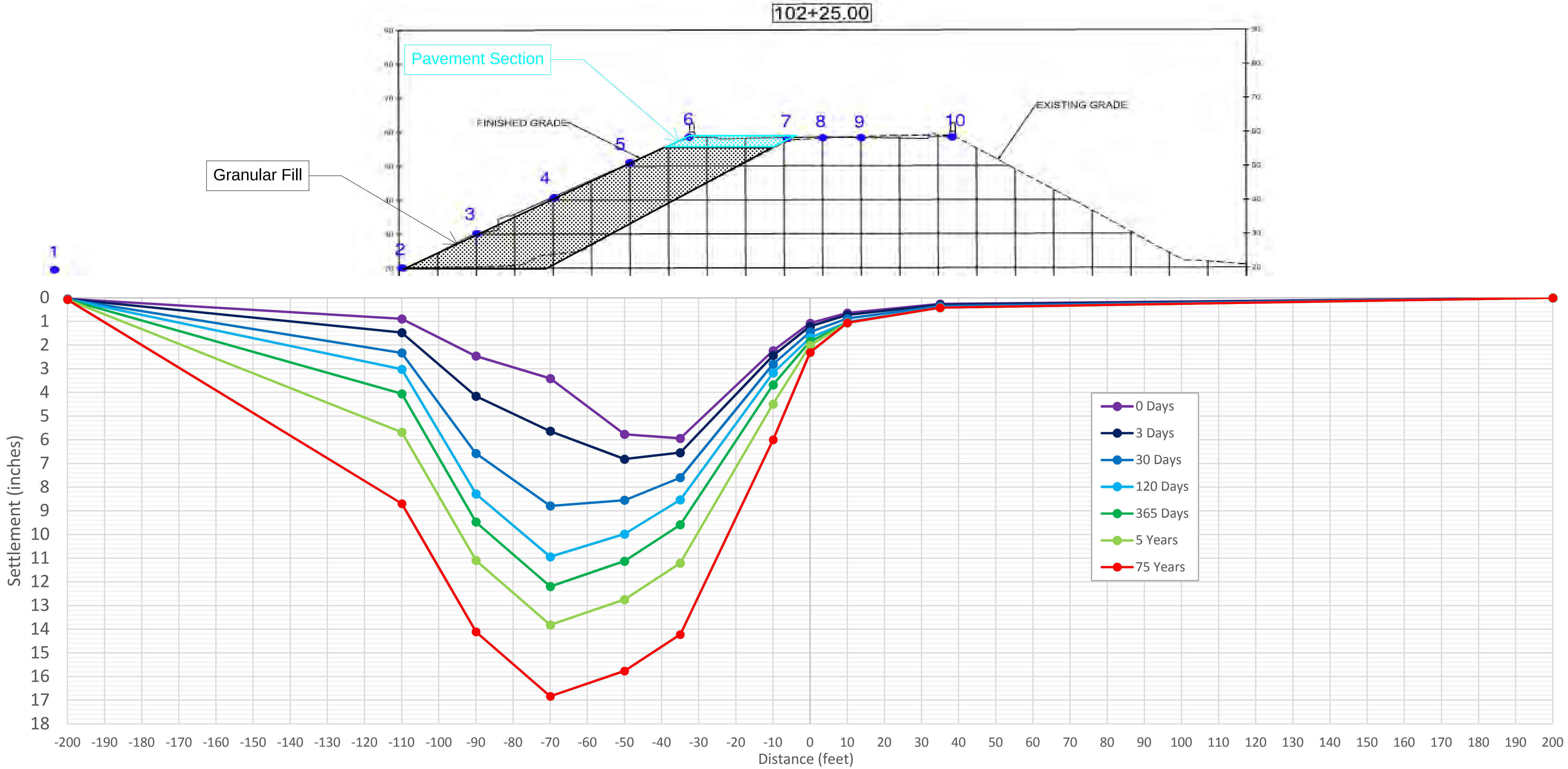
CONTENTS

Table

Figures

Table D-1. Estimated Soil Properties for Settlement Analyses

Soil Layer	Total Unit Weight (pcf)	Es (ksf)	Cc	OCR	Cv	Ca/Cc
Embankment Fill	110	100	N/A	N/A	N/A	N/A
Alluvium	115	250	N/A	N/A	N/A	N/A
Peat	95	N/A	0.46	1	0.088	0.06
Elastic Silt	110	300	N/A	N/A	N/A	N/A
Recessional Outwash	120	500	N/A	N/A	N/A	N/A



City of Marysville
State Avenue Corridor Widening
Marysville, Washington

ROADWAY SETTLEMENT
STATION 102+25 FULL HEIGHT
GRANULAR FILL (NO PRELOAD)

September 2018 21-1-22406-003

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FIG. D-1

Printed: 9-06-18 22:21 File: I:\EF\21-1 SEA\22400s\22406 Marysville State Avenue\Report\Revised Draft Report - September 2018\Appendix D\[Settlement Plots Station 102+25 Full Height Fill no Preload.xlsx]102+25 FH Fill no Preload-

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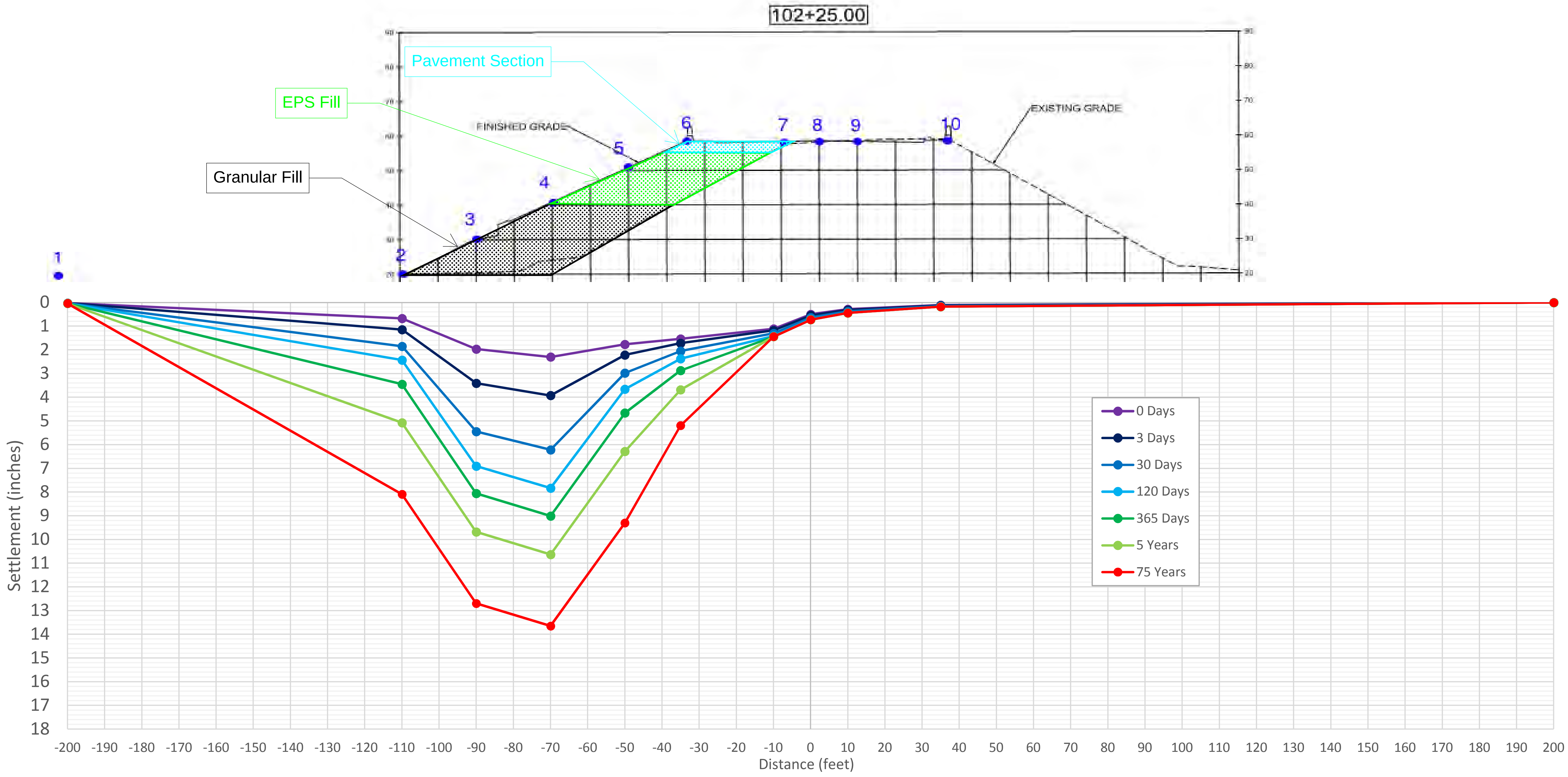

City of Marysville
State Avenue Corridor Widening
Marysville, Washington

ROADWAY SETTLEMENT
STATION 102+25 PARTIAL HEIGHT
LIGHTWEIGHT FILL (NO PRELOAD)

September 2018
21-1-22406-003

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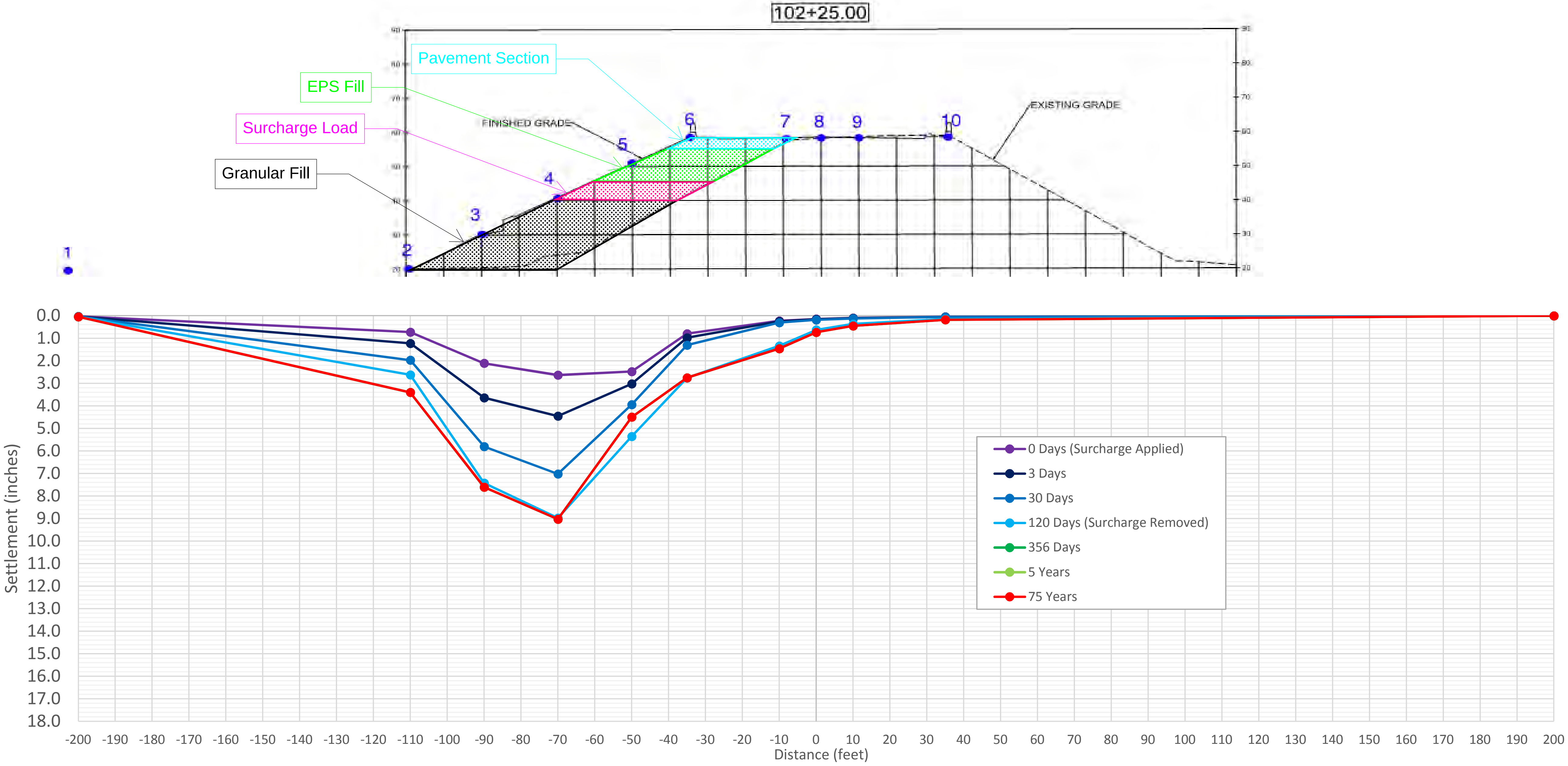
FIG. D-2

Printed: 9-06-18 22:28 File: I:\EF\21-1 SEA\22400s\22406 Marysville State Avenue\Report\Revised Draft Report - September 2018\Appendix D\[Settlement Plots Station 102+25 with Preload.xlsx]102+25 with Preload-



City of Marysville
State Avenue Corridor Widening
Marysville, Washington

**ROADWAY SETTLEMENT
STATION 102+25 PARTIAL HEIGHT
LIGHTWEIGHT FILL WITH 5-FOOT
PRELOAD**

September 2018
21-1-22406-003

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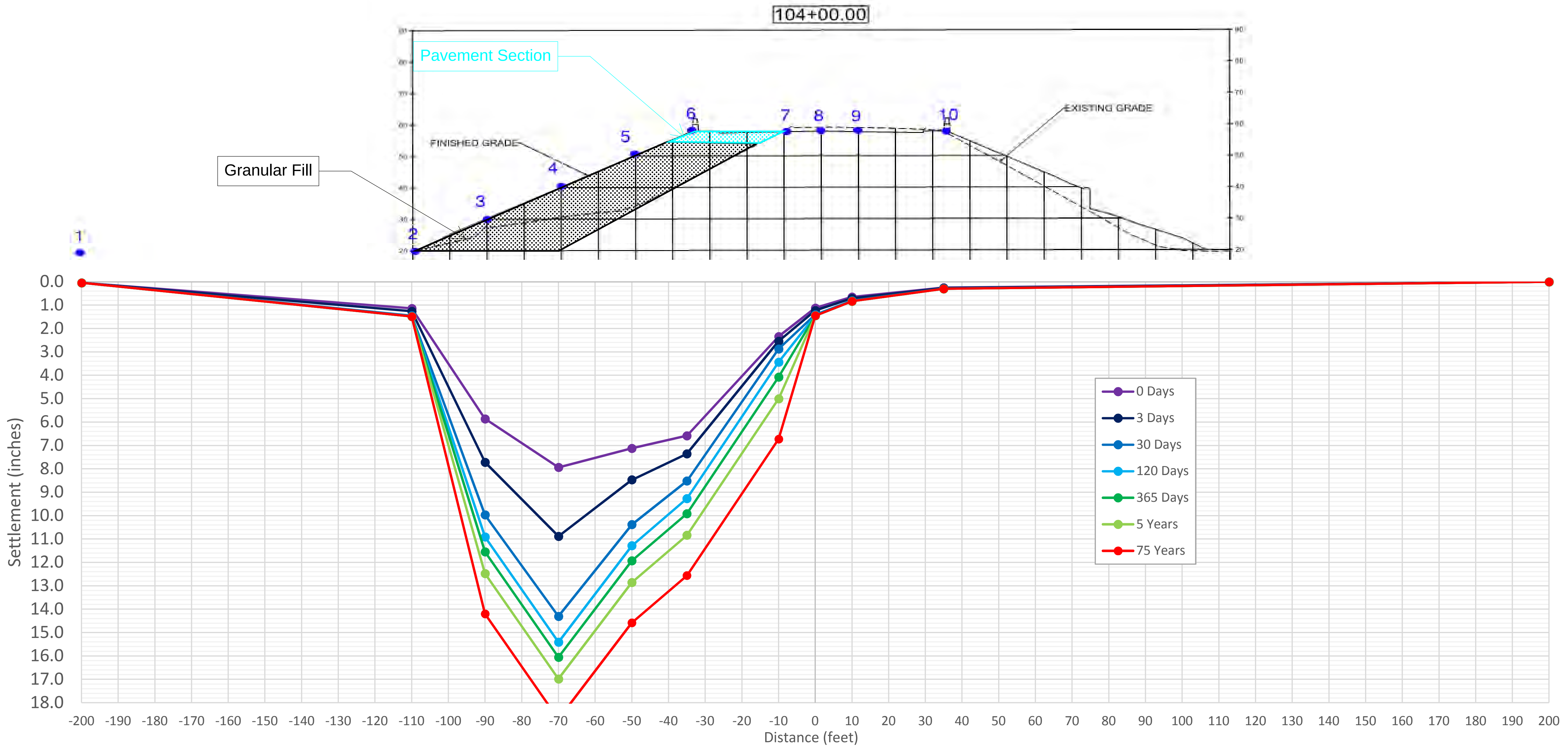
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. D-3

Printed: 9-06-18 22:30 File: I:\EF21-1 SEA\22400s\22406 Marysville State Avenue\Report\Revised Draft Report - September 2018\Appendix D\[Settlement Plots Station 104+00 Full Height Fill no Preload.xlsx]104+00 no Preload-



City of Marysville
State Avenue Corridor Widening
Marysville, Washington

ROADWAY SETTLEMENT
STATION 104+00 FULL HEIGHT
GRANULAR FILL (NO PRELOAD)

September 2018 21-1-22406-003

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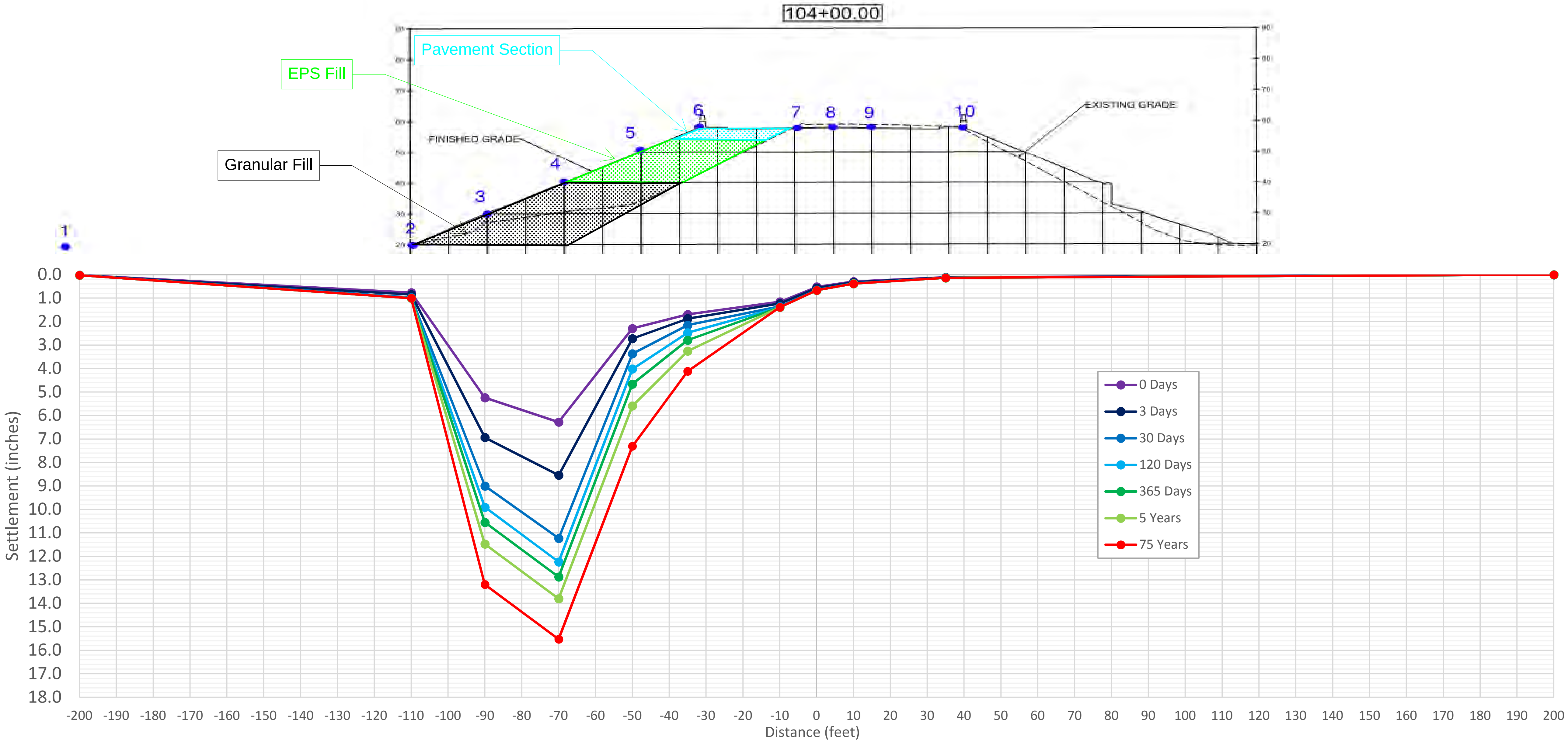
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. D-4

Printed: 9-06-18 22:35 File: I:\EF\21-1 SEA\22400s\22406 Marysville State Avenue\Report\Revised Draft Report - September 2018\Appendix D\[Settlement Plots Station 104+00 no Preload.xlsx]104+00 no Preload-



City of Marysville
State Avenue Corridor Widening
Marysville, Washington

**ROADWAY SETTLEMENT
STATION 104+00 PARTIAL HEIGHT
LIGHTWEIGHT FILL (NO PRELOAD)**

September 2018 21-1-22406-003

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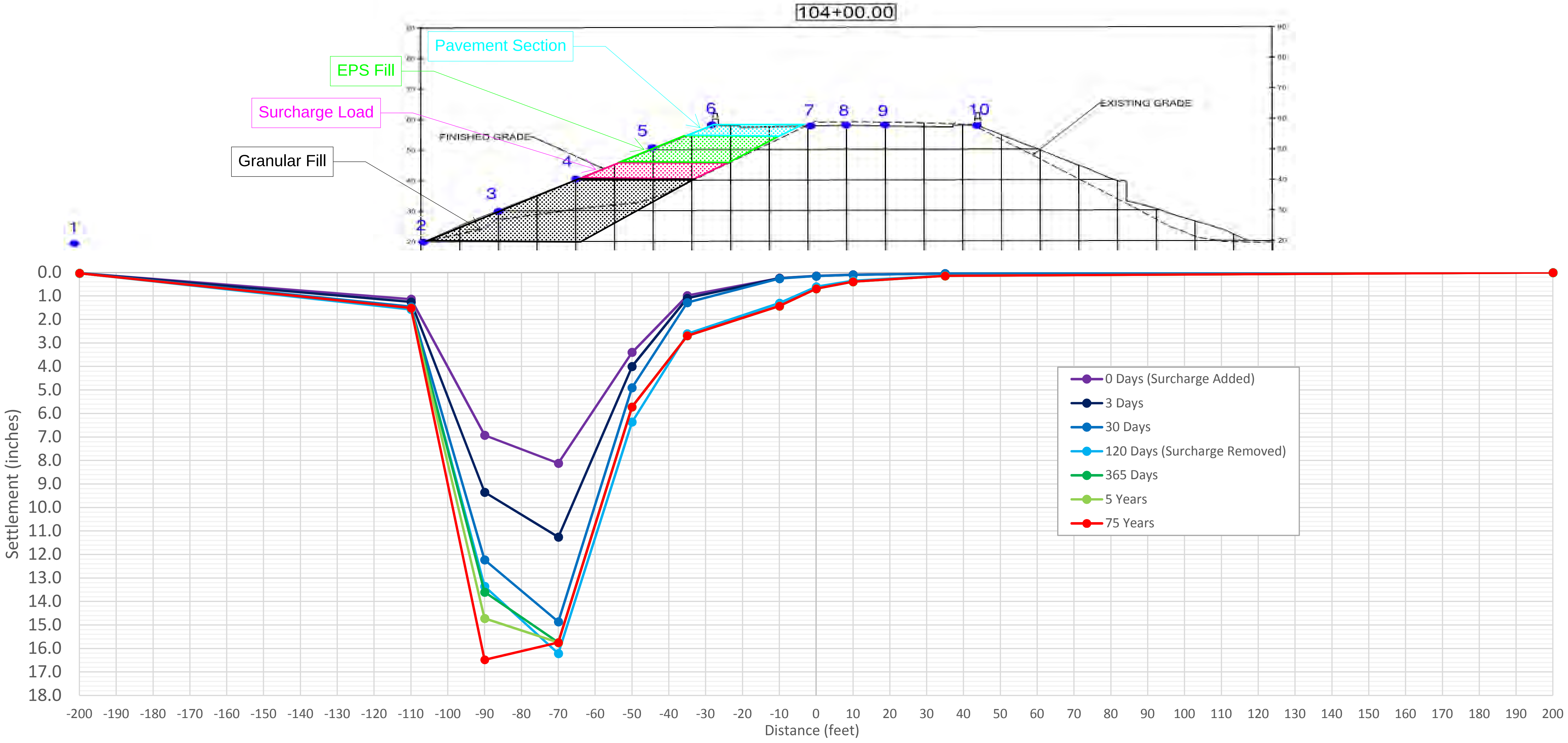
FIG. D-5

Printed: 9-06-18 22:41 File: I:\EF\21-1 SEA\22400s\22406 Marysville State Avenue\Report\Revised Draft Report - September 2018\Appendix D\[Settlement Plots Station 104+00 with Preload.xlsx]104+00 with Preload-



City of Marysville
State Avenue Corridor Widening
Marysville, Washington

**ROADWAY SETTLEMENT
STATION 104+00 PARTIAL HEIGHT
LIGHTWEIGHT FILL WITH 5-FOOT
PRELOAD**

September 2018 21-1-22406-003

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GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. D-6

IMPORTANT INFORMATION

Important Information

About Your Geotechnical Report

IMPORTANT INFORMATION

CONSULTING SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND FOR SPECIFIC CLIENTS.

Consultants prepare reports to meet the specific needs of specific individuals. A report prepared for a civil engineer may not be adequate for a construction contractor or even another civil engineer. Unless indicated otherwise, your consultant prepared your report expressly for you and expressly for the purposes you indicated. No one other than you should apply this report for its intended purpose without first conferring with the consultant. No party should apply this report for any purpose other than that originally contemplated without first conferring with the consultant.

THE CONSULTANT'S REPORT IS BASED ON PROJECT-SPECIFIC FACTORS.

A geotechnical/environmental report is based on a subsurface exploration plan designed to consider a unique set of project-specific factors. Depending on the project, these may include the general nature of the structure and property involved; its size and configuration; its historical use and practice; the location of the structure on the site and its orientation; other improvements such as access roads, parking lots, and underground utilities; and the additional risk created by scope-of-service limitations imposed by the client. To help avoid costly problems, ask the consultant to evaluate how any factors that change subsequent to the date of the report may affect the recommendations. Unless your consultant indicates otherwise, your report should not be used (1) when the nature of the proposed project is changed (for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one, or chemicals are discovered on or near the site); (2) when the size, elevation, or configuration of the proposed project is altered; (3) when the location or orientation of the proposed project is modified; (4) when there is a change of ownership; or (5) for application to an adjacent site. Consultants cannot accept responsibility for problems that may occur if they are not consulted after factors that were considered in the development of the report have changed.

SUBSURFACE CONDITIONS CAN CHANGE.

Subsurface conditions may be affected as a result of natural processes or human activity. Because a geotechnical/environmental report is based on conditions that existed at the time of subsurface exploration, construction decisions should not be based on a report whose adequacy may have been affected by time. Ask the consultant to advise if additional tests are desirable before construction starts; for example, groundwater conditions commonly vary seasonally.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes, or groundwater fluctuations may also affect subsurface conditions and, thus, the continuing adequacy of a geotechnical/environmental report. The consultant should be kept apprised of any such events and should be consulted to determine if additional tests are necessary.

MOST RECOMMENDATIONS ARE PROFESSIONAL JUDGMENTS.

Site exploration and testing identifies actual surface and subsurface conditions only at those points where samples are taken. The data were extrapolated by your consultant, who then applied judgment to render an opinion about overall subsurface conditions. The actual interface between materials may be far more gradual or abrupt than your report indicates. Actual conditions in areas not sampled may differ from those predicted in your report. While nothing can be done to prevent such situations, you and your consultant can work together to help reduce their impacts. Retaining your consultant to observe subsurface construction operations can be particularly beneficial in this respect.

A REPORT'S CONCLUSIONS ARE PRELIMINARY.

The conclusions contained in your consultant's report are preliminary, because they must be based on the assumption that conditions revealed through selective exploratory sampling are indicative of actual conditions throughout a site. Actual subsurface conditions can be discerned only during earthwork; therefore, you should retain your consultant to observe actual conditions and to provide conclusions. Only the consultant who prepared the report is fully familiar with the background information needed to determine whether or not the report's recommendations based on those conclusions are valid and whether or not the contractor is abiding by applicable recommendations. The consultant who developed your report cannot assume responsibility or liability for the adequacy of the report's recommendations if another party is retained to observe construction.

THE CONSULTANT'S REPORT IS SUBJECT TO MISINTERPRETATION.

Costly problems can occur when other design professionals develop their plans based on misinterpretation of a geotechnical/environmental report. To help avoid these problems, the consultant should be retained to work with other project design professionals to explain relevant geotechnical, geological, hydrogeological, and environmental findings, and to review the adequacy of their plans and specifications relative to these issues.

BORING LOGS AND/OR MONITORING WELL DATA SHOULD NOT BE SEPARATED FROM THE REPORT.

Final boring logs developed by the consultant are based upon interpretation of field logs (assembled by site personnel), field test results, and laboratory and/or office evaluation of field samples and data. Only final boring logs and data are customarily included in geotechnical/environmental reports. These final logs should not, under any circumstances, be redrawn for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process.

To reduce the likelihood of boring log or monitoring well misinterpretation, contractors should be given ready access to the complete geotechnical engineering/environmental report prepared or authorized for their use. If access is provided only to the report prepared for you, you should advise contractors of the report's limitations, assuming that a contractor was not one of the specific persons for whom the report was prepared, and that developing construction cost estimates was not one of the specific purposes for which it was prepared. While a contractor may gain important knowledge from a report prepared for another party, the contractor should discuss the report with your consultant and perform the additional or alternative work believed necessary to obtain the data specifically appropriate for construction cost estimating purposes. Some clients hold the mistaken impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes that aggravate them to a disproportionate scale.

READ RESPONSIBILITY CLAUSES CLOSELY.

Because geotechnical/environmental engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against consultants. To help prevent this problem, consultants have developed a number of clauses for use in their contracts, reports, and other documents. These responsibility clauses are not exculpatory clauses designed to transfer the consultant's liabilities to other parties; rather, they are definitive clauses that identify where the consultant's responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your report, and you are encouraged to read them closely. Your consultant will be pleased to give full and frank answers to your questions.

The preceding paragraphs are based on information provided by the ASFE/Association of Engineering Firms Practicing in the Geosciences, Silver Spring, Maryland