INTERURBAN TRAIL EXTENSION

Surface Water Technical Information Report

Draft Submittal

Prepared for:

City of Pacific
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June 2018

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1. Project Overview

1.1 Project Description

The Interurban Trail Extension project will construct a 12-foot wide paved multipurpose trail between 3rd Avenue SW and Stewart Road SW in the City of Pacific, filling in gaps between previously completed trail segments. The project location is shown on Figure 1 – Vicinity Map.

The project also includes trail connections from adjacent streets at County Line Road and 4th Avenue SW. At County Line Road, a 5-stall parking lot and picnic area will also be constructed. An 11-stall parking lot will be constructed at the north end of the trail improvements at 3rd Avenue SW.

Stormwater management for the new trail will be accomplished using a Flow Control BMP equivalent to permeable pavement, whereby runoff from conventional pavement is collected by permeable shoulder materials, directed into a subsurface reservoir, and infiltrated into native soils below the trail.

1.2 Design Standards

This project is subject to the requirements of the *2016 King County Surface Water Design Manual* (KCSWDM), which is adopted as the City's surface water design manual by Chapter 24.08.100 of the Pacific Municipal Code (PMC), in addition to Minimum Requirements 1 - 9 as described in PMC Sections 24.08.200 – 24.08.280.

1.3 Threshold Discharge Areas

Threshold discharge areas (TDAs) are defined for projects with multiple storm drainage discharge points. A TDA is defined as an onsite area that drains to a single natural discharge location, or multiple natural discharge locations that combine within one-quarter mile downstream (as determined by the shortest flow path). The TDA is used to determine the applicability of the core and special requirements of the 2016 KCSWDM.

The Interurban Trail Extension project is comprised of a single TDA, referred to as TDA A, since all project and upstream area runoff is collected by Milwaukee Creek, a tributary of the White River, which runs parallel to the trail for the length of the project. Storm drainage features within and immediately adjacent to the project areas are shown on Figure 2. The downstream drainage system is described in Section 3.3 and shown on Figure 3.

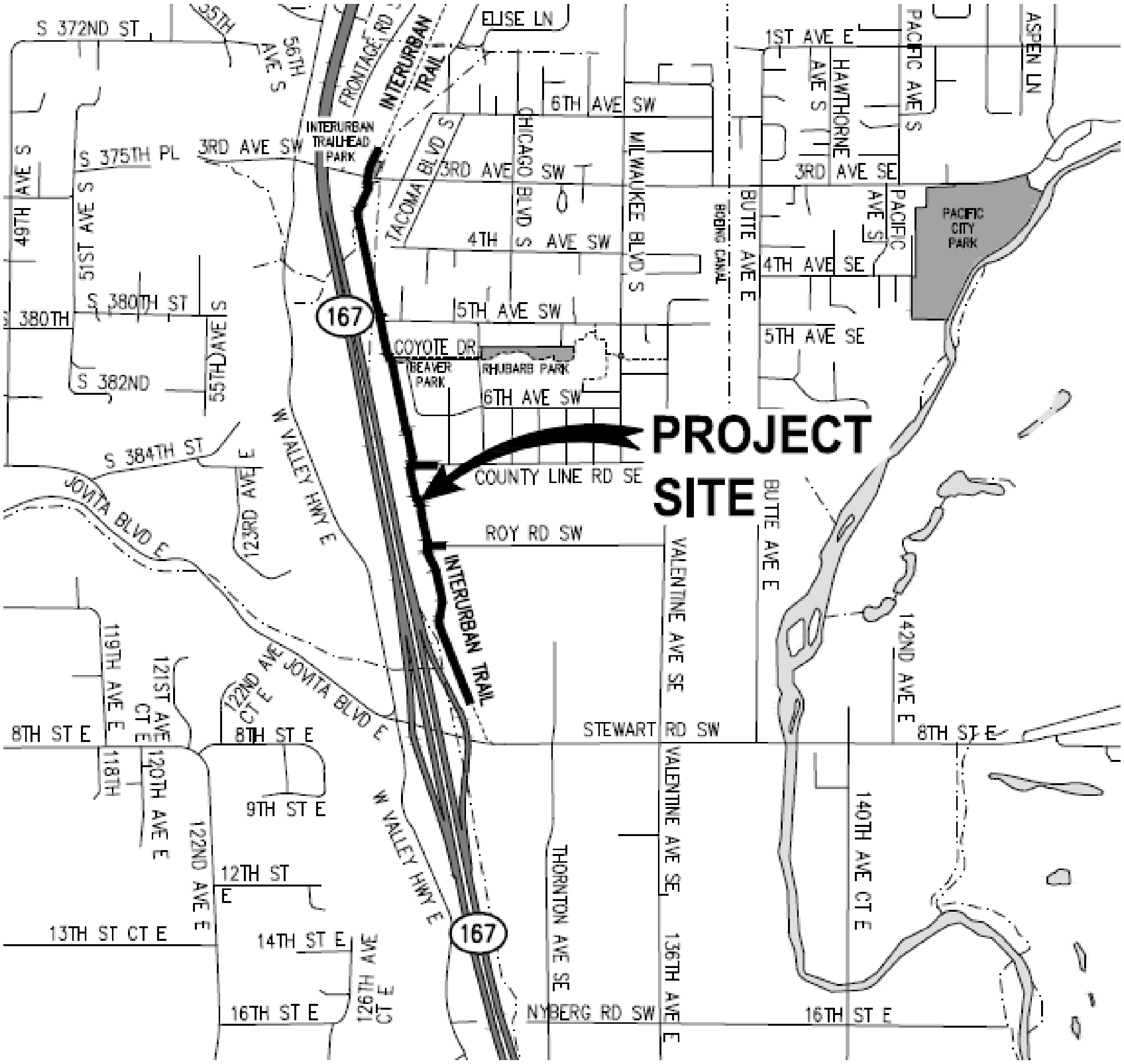

Figure 1 – Vicinity Map

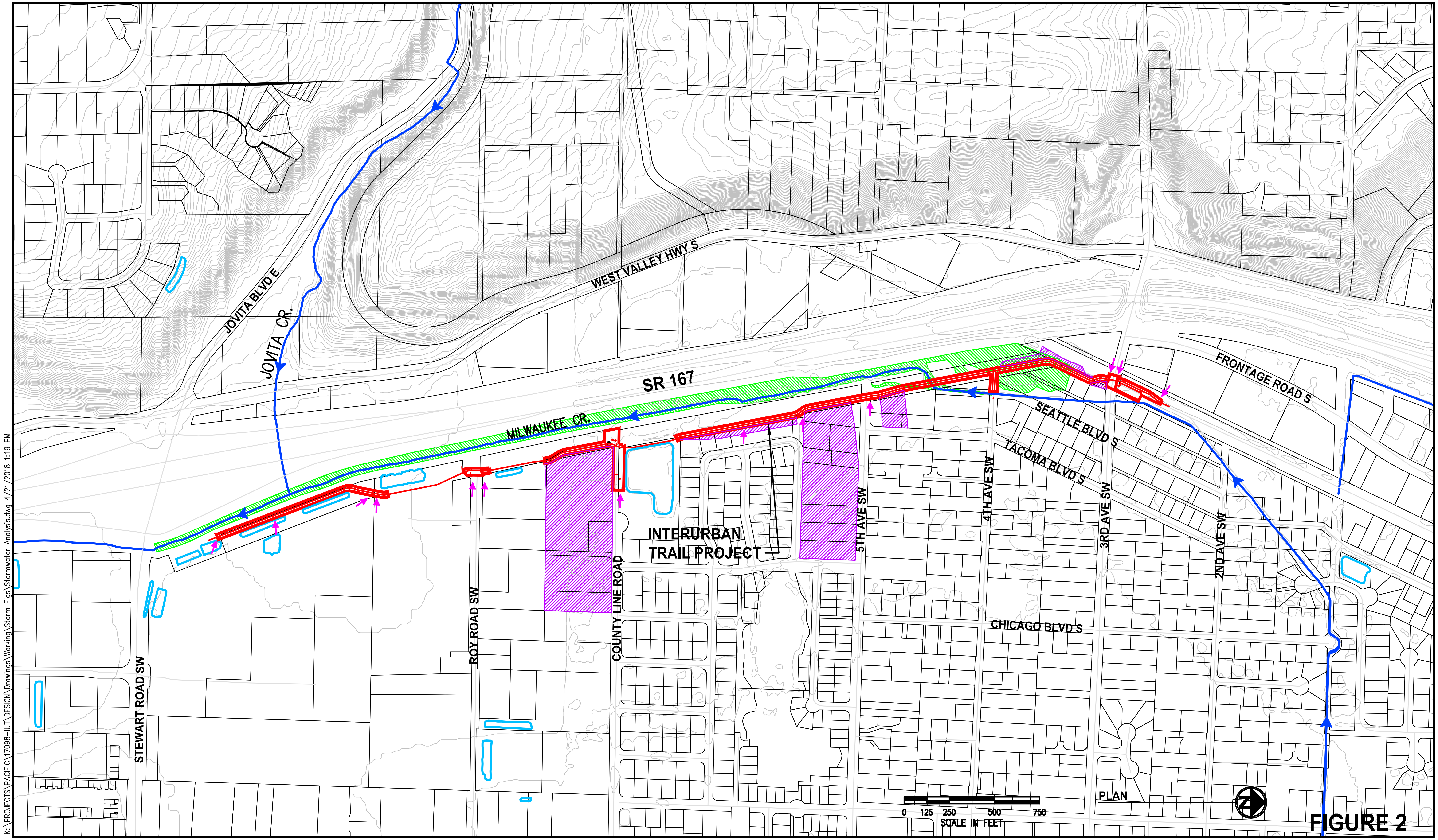

FIGURE 2

K:\PROJECTS\PACIFIC\17098-IUT\DESIGN\Drawings\Working\Storm Figs\Stormwater Analysis.dwg 4/21/2018 1:19 PM

→	EXISTING UPSTREAM DITCH OR PIPE CONVEYANCE
▨	UPSTREAM TRIBUTARY AREA – UNCONCENTRATED RUNOFF
🟩	APPROX. WETLAND AREA
▭	EXISTING STORMWATER POND

SITE VICINITY STORM DRAINAGE MAP

INTERURBAN TRAIL EXTENSION

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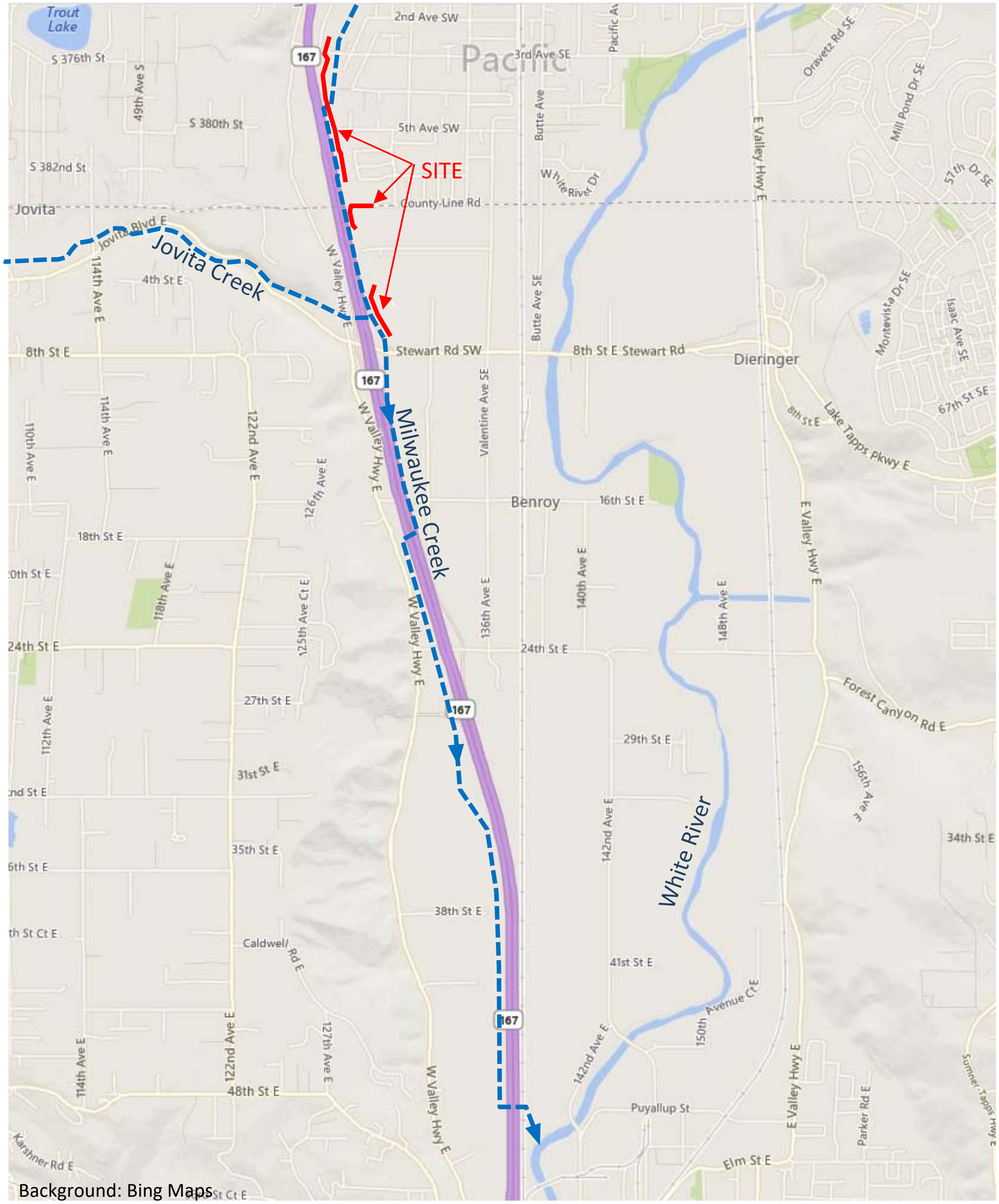


Background: Bing Maps

Figure 3 – Downstream Map

2. Conditions and Requirements Summary

2.1 Applicability of Drainage Requirements

The type of drainage review and the applicability of the Core and Special Requirements of the 2016 KCSWDM is dependent on the size and type of project. Per Figure 1.1.2.A of the KCSWDM, Flow Chart For Determining Type of Drainage Review Required, the project is subject to Full Drainage Review because it will result in greater than 2,000 square feet of new and/or replaced impervious surface, yet is not a single family residence, agricultural, or urban planned development project. Full Drainage Review, requires compliance with Core Requirements #1 - 9 and Special Requirements #1 – 5 of the KCSWDM.

Table 1 below contains project-specific TDA information used to determine the applicability of drainage requirements specified above.

Table 1 – Project Area Summary

	TDA A
Site Area[1]	3.84 ac
Existing Impervious Surface	0.54 ac
New and Replaced Impervious Surfaces	1.86 ac
New and Replaced Non-Pollution Generating Surfaces to be fully infiltrated	1.67 ac
New and Replaced Pollution Generating Impervious Surface (PGIS)	0.19 ac
PGIS draining to Regional Stormwater Pond (County Line Road Parking Lot)	0.06 ac
PGIS draining to Milwaukee Creek (3rd Ave SW Parking Lot)	0.13 ac

2.2 Core and Special Requirements

Following is a description of how each of the Core and Special Requirements of the 2016 KCSWDM is being addressed for this project.

2.2.1 Core Requirement 1 – Discharge at the Natural Location

The project is located within the White River Drainage Basin. The project will maintain existing drainage patterns, with all runoff from the project and upstream areas discharging into Milwaukee Creek and adjacent wetlands, which drain to the south parallel to the Interurban Trail alignment.

2.2.2 Core Requirement 2 – Offsite Analysis

An analysis of upstream drainage areas and downstream conditions is included in Chapter 3 of this report.

2.2.3 Core Requirement 3 – Flow Control

Core Requirement #3 is required to be addressed for projects that add 5,000 square feet or more of new plus replaced impervious surfaces.

Although areas within the City of Pacific and other incorporated areas are not mapped on King County's current Flow Control Applications map, the project site is subject to Conservation Flow Control standards consistent with Department of Ecology requirements for flow control for projects that drain to streams not included on the list of Flow Control Exempt surface waters.

Per Section 1.2.3.1 B of the 2016 KCSWDM, the target surfaces for Conservation Flow Control areas applicable to this project consist of new and replaced impervious surfaces that are not fully dispersed. For this project, this amounts to 1.86 acre of impervious surface targeted for flow control, as shown in Table 1.

However, as discussed in Section 2.2.9 for Core Requirement 9, most new and replaced impervious surfaces for this project will be fully infiltrated utilizing a BMP equivalent to permeable pavement, consisting of conventional pavement with infiltrating shoulders (clean fractured rock) that directs trail runoff into a reservoir course beneath the pavement.

Although Table 1.2.9.A of the 2016 KCSWDM (Flow Control BMP Facility Sizing Credits) requires permeable pavements to be modeled as ½ impervious surface and ½ grass surface, the City of Pacific allows the full infiltration credit to be used for permeable pavement, consistent with the requirements of the Department of Ecology's 2014 surface Water Management Manual for Western Washington (SWMMWW). The full infiltration credit allows fully-infiltrated surfaces to be subtracted from the area of new impervious surface when performing facility sizing calculations. The 2014 SWMMW defines impervious surfaces as "ineffective" and not subject to flow control requirements if approved continuous runoff modeling methods indicate that the entire runoff file is infiltrated.

As documented in Section 4.1 of this report, by implementing the flow control BMP sizing credit for full infiltration, the project is eligible for Exception #2, which waives the facility requirement of Core Requirement 3 when there is no more than a 0.15-cfs difference in the sum of developed 100-year peak flows and the sum of historic site conditions 100-year peak flows.

2.2.4 Core Requirement 4 – Conveyance System

In accordance with the 2016 KCSWDM, new pipe systems are required to be designed with sufficient capacity to convey and contain the 25-year peak flow. In addition, overflows resulting from the 100-year runoff event will be analyzed to verify that any such overflows will not create or aggravate a severe flooding problem or severe erosion problem. The only piped drainage systems within the project area are extensions of existing culverts, which will match the size and capacity of the existing culverts.

2.2.5 Core Requirement 5 – Erosion and Sediment Control

Erosion and sediment control measures proposed for this project are described in Section 7 of this report. The construction contractor will designate an erosion and sediment control supervisor and will be responsible for modifying the plan to accommodate changing site conditions and to ensure site discharges are in accordance with the State of Washington Construction Stormwater General Permit. A Construction Stormwater Pollution Prevention Plan (CSWPPP) has been prepared for this project using the Department of Ecology's template and is bound separately.

2.2.6 Core Requirement 6 – Maintenance and Operations

Since this is a public project, all drainage facilities will be maintained by the City of Pacific in accordance with the City's operation and maintenance procedures.

2.2.7 Core Requirement 7 – Financial Guarantees and Liability

As a public project, financial guarantee and liability requirements are not applicable.

2.2.8 Core Requirement 8 – Water Quality

Water quality treatment is required for the project's new and replaced pollution-generating surfaces, consisting of the parking lots at County Line Road and 3rd Avenue SW, which exceed 5,000 square feet.

Water quality treatment for the parking lot at County Line Road will be provided by the existing City of Pacific regional stormwater pond located adjacent to the parking lot.

Water quality treatment for the parking lot at 3rd Street SW will be provided utilizing a filter strip prior to sheet flow discharge to Milwaukee Creek.

2.2.9 Core Requirement 9 – Flow Control BMPs

All proposed projects, including redevelopment projects, must provide onsite flow control BMPs when more than 2,000 square feet of new plus replaced impervious surfaces are generated. Target surfaces for application of Core Requirement #9 include new impervious surfaces, new pervious surfaces, replaced impervious surfaces, and any existing impervious surfaces added on or after January 8, 2001 not already mitigated with an approved flow control BMP or flow control facility.

An evaluation of the feasibility of onsite flow control BMPs has been included in Section 4.3 of this report.

All new and replaced impervious surfaces for the trail will be fully infiltrated utilizing a BMP equivalent to permeable pavement, consisting of conventional pavement with infiltrating shoulders (clean fractured rock) that directs trail runoff into a reservoir course beneath the pavement.

2.2.10 Special Requirement 1 – Other Adopted Area-Specific Requirements

There are no adopted area-specific requirements that apply to this project beyond what is required by the 2016 KCSWDM.

2.2.11 Special Requirement 2 – Flood Hazard Area Delineation

The project area is not located within a FEMA-mapped floodplain.

2.2.12 Special Requirement 3 – Flood Protection Facilities

Special Requirement 3 does not apply to this project because the project will not rely on or modify an existing flood protection facility.

2.2.13 Special Requirement 4 – Source Control

Special Requirement 4 does not apply to this project because the project does not require a commercial building or site development permit.

2.2.14 Special Requirement 5 – Oil Control

No portion of the project meets the definition of a high use site; therefore no additional BMPs will be installed for oil control.

3. Off-Site Analysis

An off-site analysis was performed for this project to comply with Core Requirement #3, to analyze drainage conditions downstream and upstream of the site. The purpose of the off-site analysis is to determine if there are existing drainage problems downstream from the site that could be aggravated by the proposed project. This section also includes a description of on-site drainage basins.

3.1 Existing Site Drainage Conditions and TDAs

The project area consists of a single TDA because, as shown on Figure 2, all site runoff recombines at Milwaukee Creek within ¼ mile from the project area as measured by the shortest flowpath.

Existing drainage features within the project area consist of the following:

- Storm drainage outfalls from stormwater ponds at the Gordon Trucking site
- Drainage ditch crossing the project area immediately north of the Gordon Trucking site
- Drainage ditch along south side of Roy Road SW
- Piped drainage system along north side of Roy Road SW
- Drainage ditch along north side of County Line Road
- Piped drainage conveyance under trail aligned with Otter Drive SW
- Drainage ditch immediately north of Beaver Meadows subdivision
- Drainage ditch on north side of 5th Avenue SW
- Milwaukee Creek and side channel crossings between 4th and 5th Avenues SW
- Wetlands between 3rd and 4th Avenues SW
- Piped drainage systems at 3rd Avenue SW
- Culvert under trail north of 3rd Avenue SW.

3.2 Upstream Tributary Areas

Since the project will not impact flows within Milwaukee Creek or any of the tributary ditches and conveyance systems listed above, the upstream tributary areas for these drainage systems have not been delineated. However, areas that appears to drain towards the project area with un-concentrated runoff have been shown on Figure 2, because the trail embankment could potentially prevent runoff from these areas from reaching Milwaukee Creek and adjacent wetlands. Culverts will be installed beneath the trail embankment in these areas to convey any intercepted sheet flow runoff.

3.3 Downstream Analysis

All runoff from the project area and upstream areas is conveyed downstream by Milwaukee Creek, a constructed, fish bearing drainage channel with a nearly flat longitudinal slope that flows south from the project area on the east side of SR 167 (see Figure 3). Jovita Creek discharges into Milwaukee Creek near the south end of the project area, opposite the Gordon Trucking site. Approximately 380 feet downstream from the site, Milwaukee Creek crosses under Stewart Road in an approximate 20-foot wide box culvert, then continues another 3,500 feet south before crossing under SR 167 and continuing south on the west side of the freeway. Another 10,000 feet further south, the creek turns east, crossing back under SR 167 before discharging into the White River near Puyallup Street in Sumner.

Within the project area, the channel at the water surface elevation was observed to be approximately 8 feet in width.

3.4 Existing and Predicted Drainage Problems

No existing drainage problems within downstream systems have been identified by City staff or KPG during on-site investigations within the project vicinity or within ¼ mile downstream. Since the new trail will be constructed to infiltrate runoff, the project will not result in any increase of flows within Milwaukee Creek that could aggravate any drainage problems that may exist.

4. Flow Control and Water Quality Facility Analysis and Design; and Flow Control BMP Evaluation

The applicability of flow control and water quality treatment requirements for this project are described in Sections 2.2.3, 2.2.8, and 2.2.9. The following sections document the analysis and design of the required facilities.

4.1 Flow Control Analysis and Design

To determine if the project meets the criteria of Exception #2 to Core Requirements #3 for Conservation Flow Control Areas, the peak runoff rate from flow control target surface for the project was modeled for both the historic (forested) and proposed site conditions.

Although the total flow control target surface for this project is 1.86 acres, the 1.67 acres of fully infiltrating areas can be subtracted per the Flow Control BMP Facility Sizing Credit for full infiltration documented in Table 1.2.9.A of the KCSWM. Therefore, the area to be modeled to evaluate Exception #2 is 1.86 – 1.67 = 0.19 acres.

WWHM 2012 with 15-minutes time steps was used to model the runoff, resulting in the following (see Appendix A for WWHM screenshots):

Table 2 – Flow Control Threshold Calculation

Q_{100} - Developed	0.1473 cfs
Q_{100} – Historic (forested)	0.0147 cfs
ΔQ_{100}	0.133 cfs

Since, as demonstrated above, the increase in peak flow rates resulting from the project is less than 0.15 cfs, the flow control facility requirement is waived.

4.2 Water Quality Treatment Analysis and Design

As discussed in Section 2.2.8, a filter strip will be utilized to provide the required water quality treatment prior to discharge from pollution-generating impervious surfaces at the 3rd Avenue SW trailhead parking lot. Based on the size of the parking lot and slope of the filter strip, a 5-foot wide strip will be used. See sizing calculations in Appendix B.

4.3 Flow Control BMPs

Flow control BMPs (FCBMPs) are required to be installed to the maximum extent feasible on projects within the Urban Growth Area per Section 1.2.9.1 of the 2016 KCSWDM. A FCBMP feasibility analysis has been prepared using the Small Road Improvement and Urban Road Improvement Project BMP Requirement lists outlined in Section 1.2.9.3.2 of the 2016 KCSWDM and the design and infeasibility criteria for each FCBMP provided in KCSWDM Section C2.

Target surfaces for this analysis include new impervious surfaces, new pervious surfaces, replaced impervious surfaces, and any existing impervious surfaces added on or after January 8, 2001. For this project, the following surfaces must be evaluated for implementation of FCBMPs:

- New & replaced trail impervious surfaces – 1.67 acres
- New & replaced parking lot impervious surfaces – 0.19 acres

4.3.1 Full Dispersion BMPs

Full dispersion is required where feasible. Full Dispersion is not feasible for this project because the area between the trail and Milwaukee Creek does not contain native vegetation. In addition, in many areas the required 100-foot flowpath length does not exist.

4.3.2 Infiltration and Bioretention BMPs

All target impervious surfaces not mitigated by Full Dispersion are required to be mitigated to the maximum extent feasible using one or more of the following BMPs: Full Infiltration, Limited Infiltration, Bioretention, or Permeable Pavement.

For the trail surface, a BMP equivalent to permeable pavement will be used to achieve full infiltration. Runoff from dense HMA surfacing will be collected by 2-foot wide shoulders constructed of 12-inch thick 5/8” clean crushed rock and infiltrated into a minimum 12-inch thickness of gravel borrow underlying the entire trail width. The gravel borrow will serve as a reservoir to allow infiltration into native soils.

Based on input from the geotechnical engineer, the facilities have been modeled using a long-term infiltration rate of 1 inch per hour for the gravel borrow layer beneath the trail, and 0.2 inch per hour for the native soils. The WWHM calculations included in Appendix A show that runoff from trail surfaces will be fully infiltrated.

Other infiltration BMPs are not feasible for this project due to shallow groundwater conditions. Infiltration trenches and bioretention both require a 3-foot separation from groundwater, which cannot be achieved because the groundwater elevation was observed to be only one foot below the surface in most of the project area.

In the two small trailhead parking lots, it is not known if the existing soils meet the soil suitability criteria for providing treatment. Further, since a portion of these areas consists of replaced impervious surfaces, Infeasibility Criteria #26 in C.2.7 applies because the existing surface being replaced is not a non-pollution generating surface over outwash soils.

4.3.3 Basic Dispersion BMPs

Basic Dispersion is required for target impervious surfaces not mitigated by Full Dispersion, Infiltration, or Bioretention BMPs. Basic dispersion will be utilized for the two small trailhead parking areas. The trailhead parking lot at County Line Road will be graded to sheet flow into the adjacent City of Pacific regional stormwater pond. The trailhead parking lot at 3rd Avenue SW will be graded to sheet flow through a filter strip and towards Milwaukee Creek.

4.3.4 Soil Quality Preservation

New pervious surfaces are required to comply with soil moisture holding requirements, requiring all pervious areas to have an 8-inch thickness of topsoil with 10% organic content in planting beds and 5% organic content in turf areas, and a pH from 6.8 to 8.0 or matching the pH of the undisturbed soil. Planting beds require a 2-inch mulch layer of organic material.

5. Special Reports and Studies

Draft Report of Geotechnical Engineering Services, prepared by GeoDesign, Inc., dated 1/22/18 (see Appendix C).

6. Other Permits

A list of permits required for this project will be included in the next submittal of this report.

7. CSWPPP Analysis and Design

A Construction Stormwater Pollution Prevention Plan (CSWPPP) consists of two parts: an Erosion and Sediment Control (ESC) plan and a Stormwater Pollution Prevention and Spill (CWPPS) plan. Following is a summary of the CSWPPP elements relevant to this project. A draft CSWPPP has been prepared for this project using the Department of Ecology's template, and is bound separately.

7.1 Erosion and Sediment Control

Temporary erosion and sediment control plans have been prepared for this project and incorporated into the contract plans. In accordance with Section 8-01.3 of the 2016 *WSDOT Standard Specifications for Road, Bridge, and Municipal Construction (Standard Specification)*, the contractor will have the option to adopt the ESC plans included in the Contract Plans, or submit modified ESC plans for approval. In addition, the contractor is required to designate an ESC Lead/ Supervisor who has a current Certificate of Training in Construction Site Erosion and Sediment Control from a course approved by the Washington State Department of Ecology. The

ESC Lead/Supervisor is responsible for installing, inspecting, and maintaining BMPs included in the ESC Plan, and updating the ESC plan to reflect current field conditions.

The ESC Lead/Supervisor is also responsible for turbidity monitoring of discharges from the project site to comply with the State of Washington NPDES Construction Stormwater General Permit and the ESC Standard in Appendix D of the 2016 *KCSWDM*.

Although ESC plans have been prepared for this project, due to the variability in construction conditions and weather, it will be necessary to supplement and modify the BMPs shown on the plans over the course of construction. In general, the linear nature of the construction site, flat grades, heavy vegetation, and dispersed drainage will result in a decreased risk of erosion impacts to nearby Milwaukee Creek. However, erosion and sedimentation risks still exist, particularly where the trail alignment passes through wetlands and at the crossing of Milwaukee Creek. Maintaining perimeter silt fences, grading to disperse runoff, and keeping bare soils covered, particularly along the trail's fill slopes, will be critical for successful ESC implementation.

7.2 Stormwater Pollution Prevention and Spill Plan

The stormwater pollution prevention and spill plan must identify all activities that could contribute pollutants to surface and storm water during construction and apply BMPs applicable to these activities. Per Section 1-07.15(1) of the WSDOT Standard Specification, the contractor will be required to prepare and submit a project-specific spill prevention, control and countermeasures plan.

Activities that could contribute pollutants to surface and storm water for this project include:

- Equipment fuel and hydraulic leaks
- Equipment refueling
- Hot mix asphalt for trail construction
- Concrete placement for curb and sidewalk

8. Bond Quantities, Facility Summaries, and Declaration of Covenant

All storm drainage facilities will be publicly-maintained, therefore bond quantities, facility summaries, and declarations of covenant are not required.

9. Operations and Maintenance Manual

Operation and maintenance instructions have been included for the following site stormwater components: trail permeable shoulders and filter strip, as follows:

9.1 Infiltrating Trail Shoulder Maintenance

Preventive Maintenance:

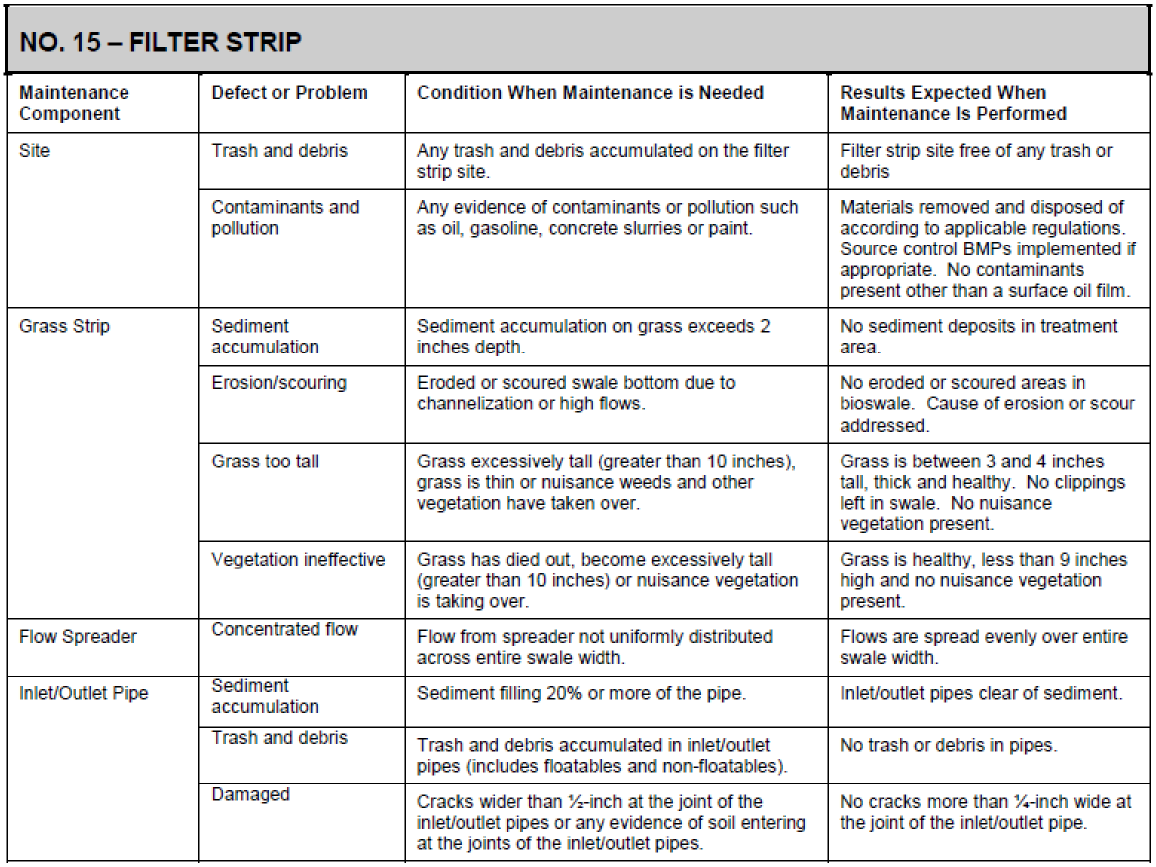
Perform annual surface cleaning of the trail and shoulders to prevent buildup of organic materials or soils that could plug the gravel shoulder surface, preventing infiltration.

Corrective Maintenance:

If surface of infiltrating shoulder becomes plugged by organic materials, soil, or vegetation growth, rake the surface to remove debris and restore infiltration. If plugging materials have migrated into the gravel, it will be necessary to remove and replace the crushed rock.

9.2 Filter Strip Maintenance

The following Filter Strip maintenance guidelines are from Appendix A of the 2016 KCSWDM.



NO. 15 – FILTER STRIP

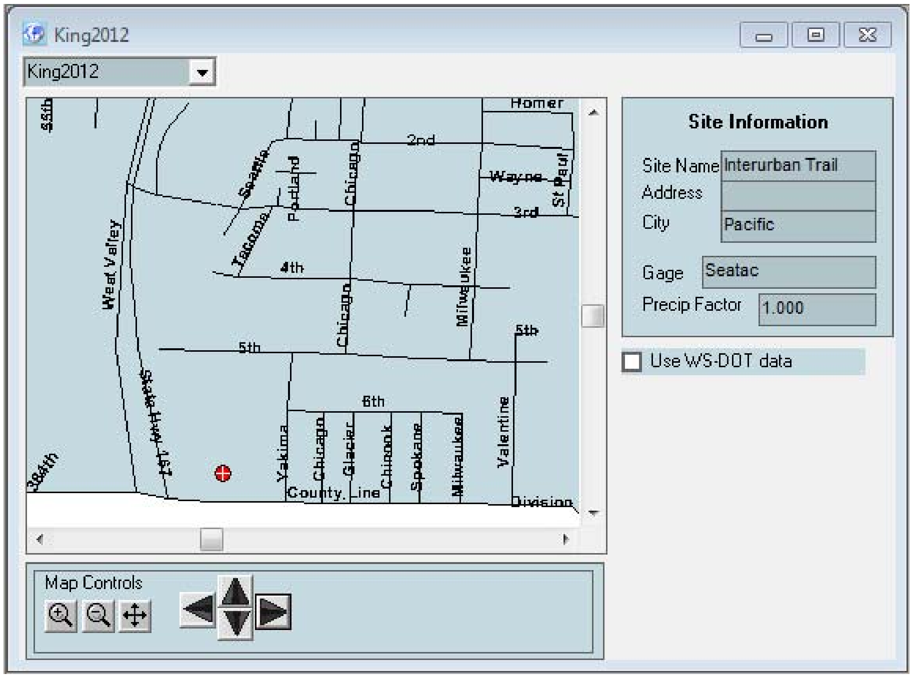
Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Results Expected When Maintenance Is Performed
Site	Trash and debris	Any trash and debris accumulated on the filter strip site.	Filter strip site free of any trash or debris
	Contaminants and pollution	Any evidence of contaminants or pollution such as oil, gasoline, concrete slurries or paint.	Materials removed and disposed of according to applicable regulations. Source control BMPs implemented if appropriate. No contaminants present other than a surface oil film.
Grass Strip	Sediment accumulation	Sediment accumulation on grass exceeds 2 inches depth.	No sediment deposits in treatment area.
	Erosion/scouring	Eroded or scoured swale bottom due to channelization or high flows.	No eroded or scoured areas in bioswale. Cause of erosion or scour addressed.
	Grass too tall	Grass excessively tall (greater than 10 inches), grass is thin or nuisance weeds and other vegetation have taken over.	Grass is between 3 and 4 inches tall, thick and healthy. No clippings left in swale. No nuisance vegetation present.
	Vegetation ineffective	Grass has died out, become excessively tall (greater than 10 inches) or nuisance vegetation is taking over.	Grass is healthy, less than 9 inches high and no nuisance vegetation present.
Flow Spreader	Concentrated flow	Flow from spreader not uniformly distributed across entire swale width.	Flows are spread evenly over entire swale width.
Inlet/Outlet Pipe	Sediment accumulation	Sediment filling 20% or more of the pipe.	Inlet/outlet pipes clear of sediment.
	Trash and debris	Trash and debris accumulated in inlet/outlet pipes (includes floatables and non-floatables).	No trash or debris in pipes.
	Damaged	Cracks wider than ½-inch at the joint of the inlet/outlet pipes or any evidence of soil entering at the joints of the inlet/outlet pipes.	No cracks more than ¼-inch wide at the joint of the inlet/outlet pipe.

APPENDIX A

Flow Control Calculations

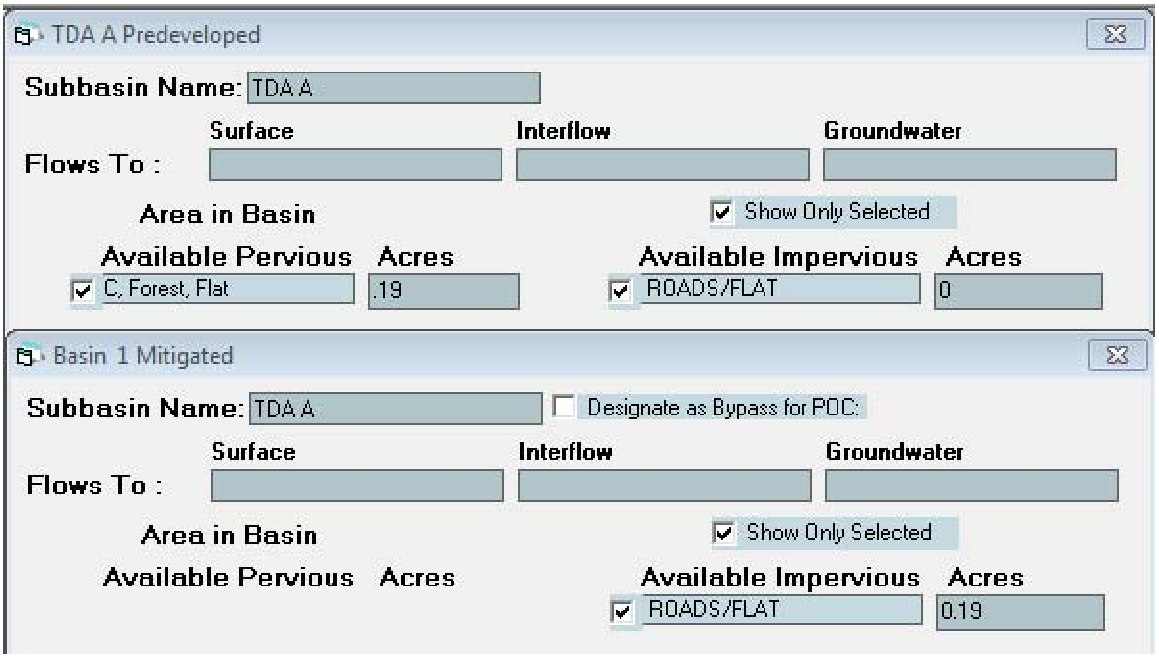
- Flow Control Exception Calculations
- Trail Infiltration Calculations

WWHM 2012 Flow Control Exception Calculations:



Site Information

Site Name: Interurban Trail
Address:
City: Pacific
Gage: Seatac
Precip Factor: 1.000
☐ Use WS-DOT data



TDA A Predeveloped

Subbasin Name: TDA A

Flows To : Surface: Interflow: Groundwater:

Area in Basin ☑ Show Only Selected

Available Pervious	Acres	Available Impervious	Acres
☑ C, Forest, Flat	.19	☑ ROADS/FLAT	0

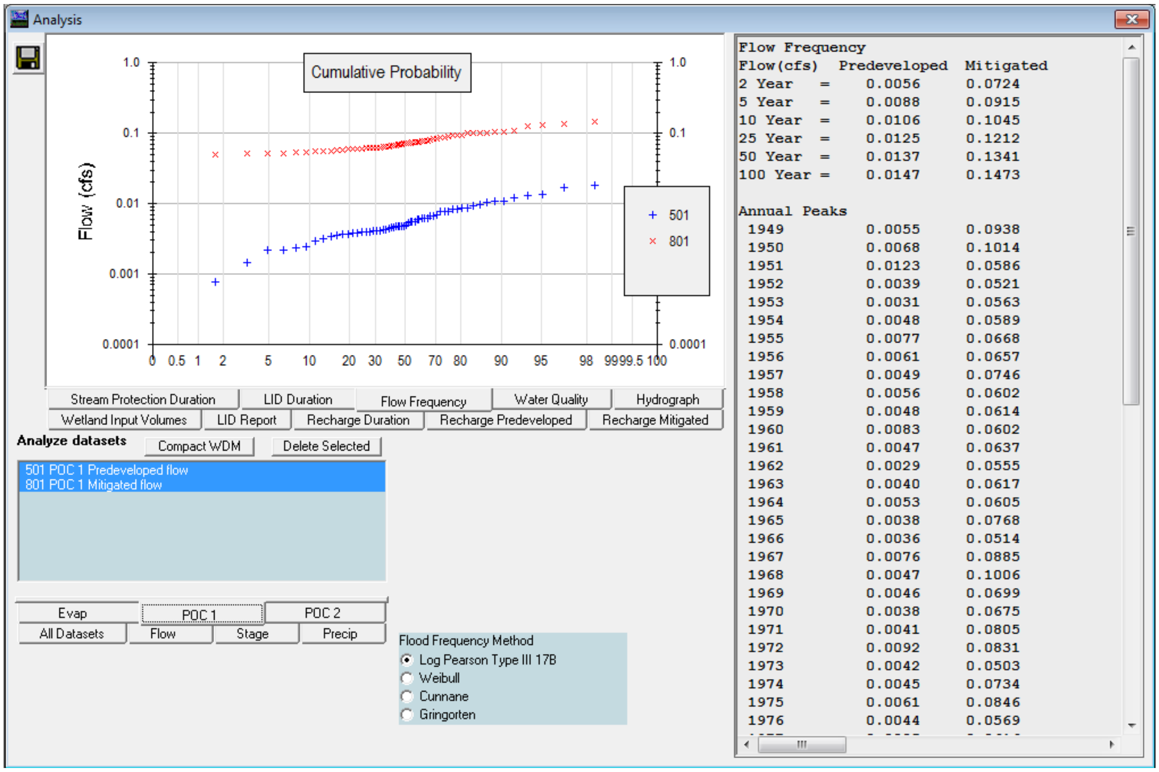
Basin 1 Mitigated

Subbasin Name: TDA A ☐ Designate as Bypass for POC:

Flows To : Surface: Interflow: Groundwater:

Area in Basin ☑ Show Only Selected

Available Pervious	Acres	Available Impervious	Acres
		☑ ROADS/FLAT	0.19



Analyze datasets

501 POC 1 Predeveloped flow
801 POC 1 Mitigated flow

Flood Frequency Method
● Log Pearson Type III 17B
○ Weibull
○ Cunnane
○ Gringorten

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Flow Frequency
Flow(cfs)   Predeveloped   Mitigated
2 Year   =      0.0056      0.0724
5 Year   =      0.0088      0.0915
10 Year  =      0.0106      0.1045
25 Year  =      0.0125      0.1212
50 Year  =      0.0137      0.1341
100 Year =      0.0147      0.1473

Annual Peaks
 1949           0.0055      0.0938
 1950           0.0068      0.1014
 1951           0.0123      0.0586
 1952           0.0039      0.0521
 1953           0.0031      0.0563
 1954           0.0048      0.0589
 1955           0.0077      0.0668
 1956           0.0061      0.0657
 1957           0.0049      0.0746
 1958           0.0056      0.0602
 1959           0.0048      0.0614
 1960           0.0083      0.0602
 1961           0.0047      0.0637
 1962           0.0029      0.0555
 1963           0.0040      0.0617
 1964           0.0053      0.0605
 1965           0.0038      0.0768
 1966           0.0036      0.0514
 1967           0.0076      0.0885
 1968           0.0047      0.1006
 1969           0.0046      0.0699
 1970           0.0038      0.0675
 1971           0.0041      0.0805
 1972           0.0092      0.0831
 1973           0.0042      0.0503
 1974           0.0045      0.0734
 1975           0.0061      0.0846
 1976           0.0044      0.0569
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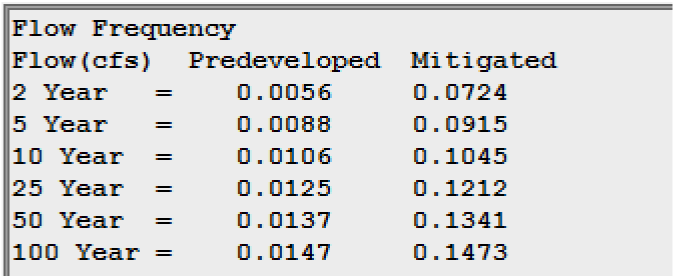

```
Flow Frequency
Flow(cfs)  Predeveloped  Mitigated
2 Year   =     0.0056      0.0724
5 Year   =     0.0088      0.0915
10 Year  =     0.0106      0.1045
25 Year  =     0.0125      0.1212
50 Year  =     0.0137      0.1341
100 Year =     0.0147      0.1473
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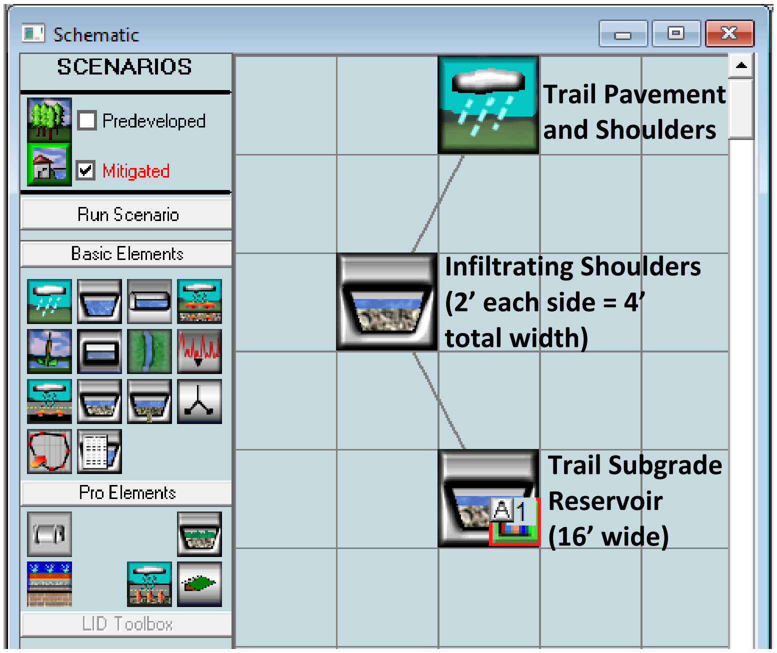
WWHM 2012 Permeable Pavement Calculations:



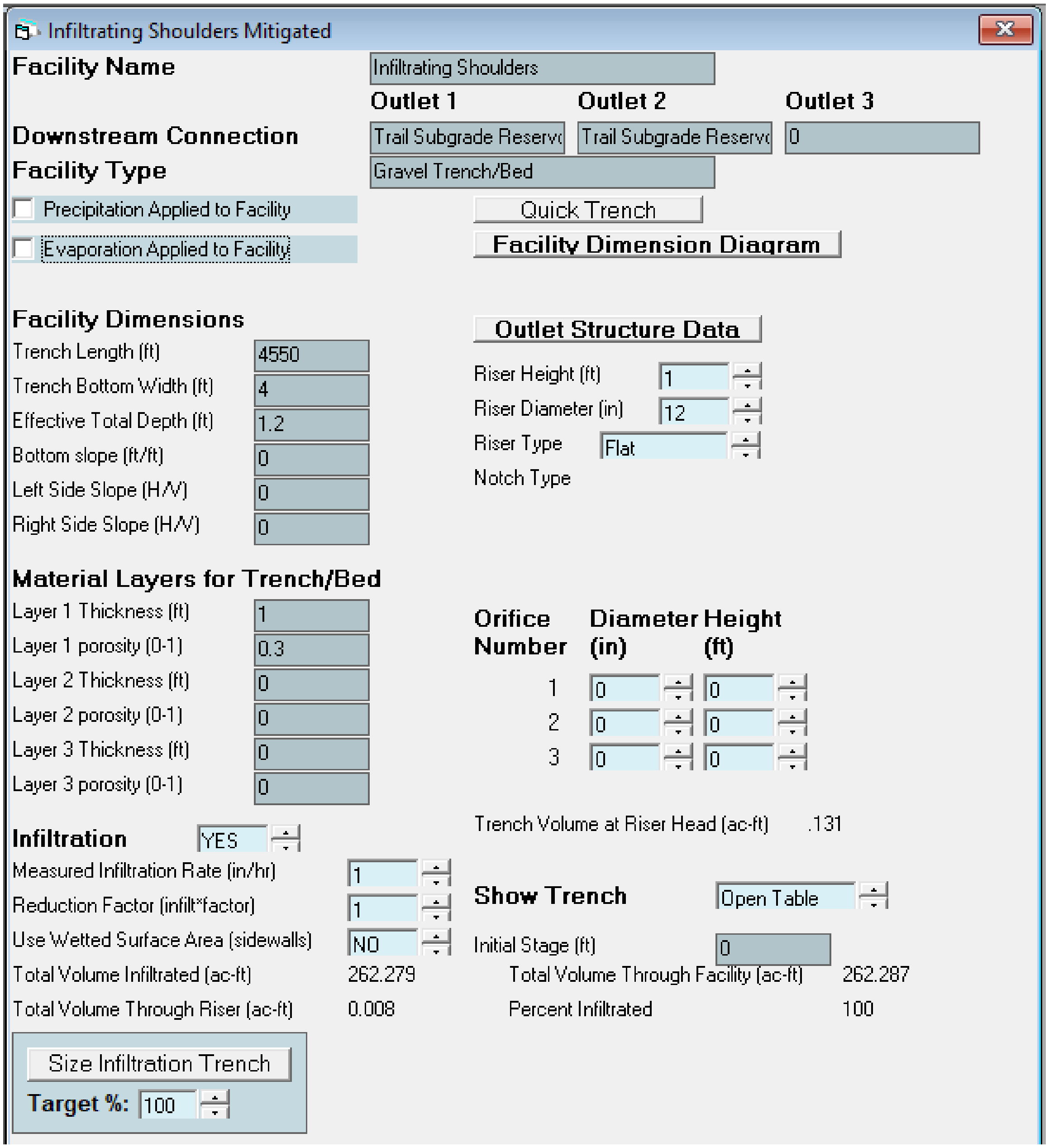
Subbasin Name: Trail Pavement and Shoulders ☐ Designate as Bypass for POC:

	Surface	Interflow	Groundwater
Flows To :	Infiltrating Shoulders	Infiltrating Shoulders	

Area in Basin

☑ Show Only Selected

Available Pervious	Acres	Available Impervious	Acres
		☑ ROADS/FLAT	1.67



Infiltrating Shoulders Mitigated

Facility Name Infiltrating Shoulders

	Outlet 1	Outlet 2	Outlet 3
Downstream Connection	Trail Subgrade Reservo	Trail Subgrade Reservo	0

Facility Type Gravel Trench/Bed

☐ Precipitation Applied to Facility
☐ Evaporation Applied to Facility

Facility Dimensions
Trench Length (ft) 4550
Trench Bottom Width (ft) 4
Effective Total Depth (ft) 1.2
Bottom slope (ft/ft) 0
Left Side Slope (H/V) 0
Right Side Slope (H/V) 0

Material Layers for Trench/Bed
Layer 1 Thickness (ft) 1
Layer 1 porosity (0-1) 0.3
Layer 2 Thickness (ft) 0
Layer 2 porosity (0-1) 0
Layer 3 Thickness (ft) 0
Layer 3 porosity (0-1) 0

Infiltration YES
Measured Infiltration Rate (in/hr) 1
Reduction Factor (infilt*factor) 1
Use Wetted Surface Area (sidewalls) NO
Total Volume Infiltrated (ac-ft) 262.279
Total Volume Through Riser (ac-ft) 0.008

Target %: 100

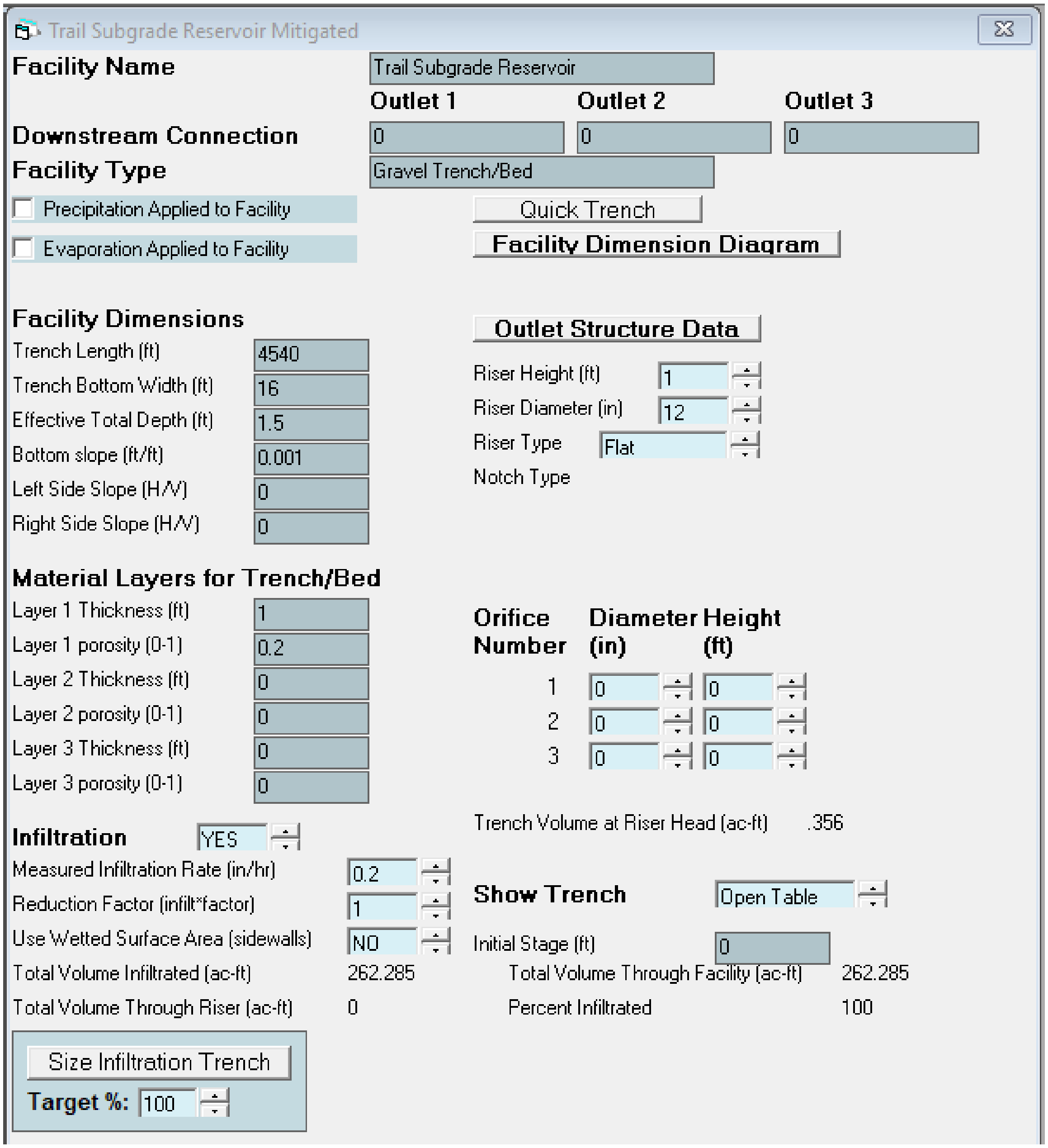
Riser Height (ft) 1
Riser Diameter (in) 12
Riser Type Flat
Notch Type

Orifice Number	Diameter (in)	Height (ft)
1	0	0
2	0	0
3	0	0

Trench Volume at Riser Head (ac-ft) .131

Show Trench Open Table

Initial Stage (ft) 0
Total Volume Through Facility (ac-ft) 262.287
Percent Infiltrated 100



Trail Subgrade Reservoir Mitigated

Facility Name: Trail Subgrade Reservoir

	Outlet 1	Outlet 2	Outlet 3
Downstream Connection	0	0	0

Facility Type: Gravel Trench/Bed

☐ Precipitation Applied to Facility
☐ Evaporation Applied to Facility

Facility Dimensions

Trench Length (ft)	4540
Trench Bottom Width (ft)	16
Effective Total Depth (ft)	1.5
Bottom slope (ft/ft)	0.001
Left Side Slope (H/V)	0
Right Side Slope (H/V)	0

Outlet Structure Data

Riser Height (ft)	1
Riser Diameter (in)	12
Riser Type	Flat
Notch Type	

Material Layers for Trench/Bed

Layer 1 Thickness (ft)	1
Layer 1 porosity (0-1)	0.2
Layer 2 Thickness (ft)	0
Layer 2 porosity (0-1)	0
Layer 3 Thickness (ft)	0
Layer 3 porosity (0-1)	0

Orifice Number	Diameter (in)	Height (ft)
1	0	0
2	0	0
3	0	0

Trench Volume at Riser Head (ac-ft) .356

Infiltration: YES

Measured Infiltration Rate (in/hr)	0.2
Reduction Factor (infilt*factor)	1
Use Wetted Surface Area (sidewalls)	NO
Total Volume Infiltrated (ac-ft)	262.285
Total Volume Through Riser (ac-ft)	0

Show Trench: Open Table

Initial Stage (ft)	0
Total Volume Through Facility (ac-ft)	262.285
Percent Infiltrated	100

Target %: 100

APPENDIX B

Water Quality Design Calculations

- Filter Strip Sizing Calculation

Filter Strip Sizing Calculation:
(per KCSWDM Section 6.3.4.1)

Step 1: Calculate design flow

$Q_{WQ,\ ON\text{-}LINE}$ = 0.211 cfs (see attached WWHM calculation)

Applying the modification described in CKWSEM Table 6.2.1.A:

$P_{2\ yr}$ = 2.0 inches
$P_{6\ mo}$ = 0.72 (2.0 inches) 1.44 inches
K = 1.98 (from Table 6.2.1A, see attached)
Q_{wq} = 0.0211 x 1.98 = 0.0418 cfs

Step 2: Calculate design flow depth

$d_f = ((Q_{wq}n_{wq}) / (1.49Ws^{0.5}))^{0.6}$

Where:

d_f = design depth of flow
Q_{wq} = 0.0418 cfs (see Step 1)
n_{wq} = 0.35
W (filter strip width perpendicular to direction of flow) = 130 ft
s (longitudinal slope of filter strip parallel to direction of flow) = 0.02

d_f = ((0.0418 cfs x 0.35) / (1.49 x 130 ft x $0.02^{0.5}$))$^{0.6}$ = 0.0433 ft

Step 3: Calculate design flow through filter strip

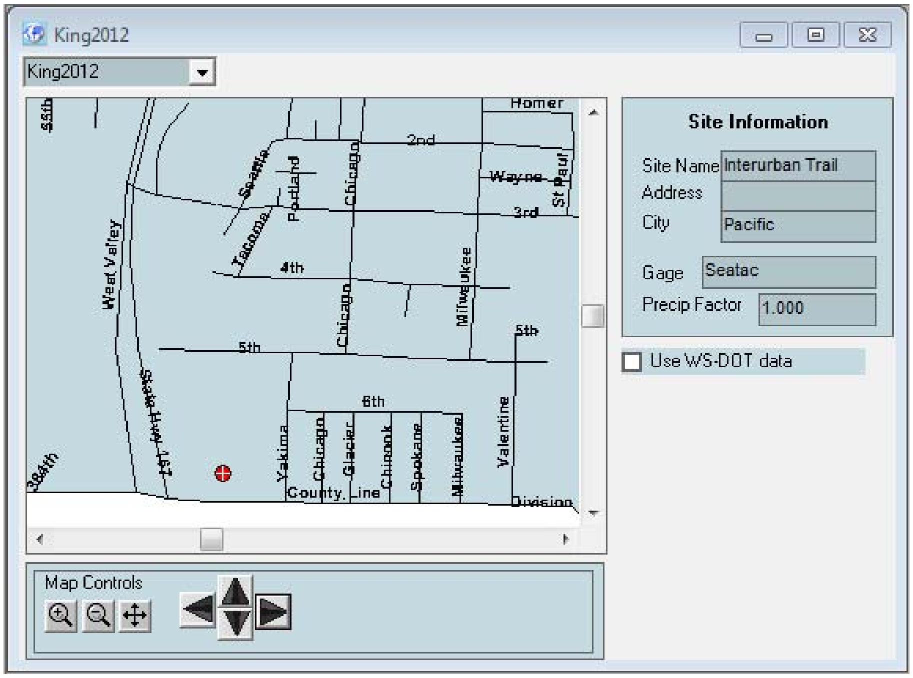
$V_{wq} = Q_{wq} / Wd_f$ = 0.0481 cfs / (130 ft x 0.0433 ft) = 0.0085 fps

Step 4: Calculate required length of filter strip

L = 540 V_{wq} = 540 x 0.0085 fps = 4.59 ft

Use 5’ filter strip length

WWHM 2012 Water Quality Flow Rate Calculation:



Site Information

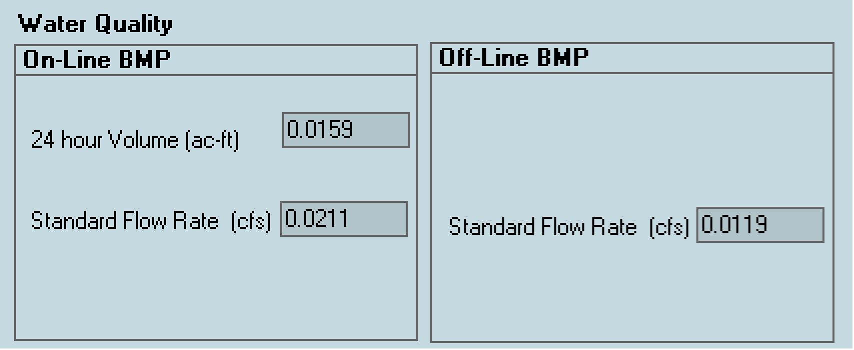
Site Name: Interurban Trail
Address:
City: Pacific
Gage: Seatac
Precip Factor: 1.000
☐ Use WS-DOT data

Subbasin Name: 3rd SW Trailhead Parking
☐ Designate as Bypass for POC:

Flows To: Surface / Interflow / Groundwater

Area in Basin
☑ Show Only Selected

Available Pervious	Acres	Available Impervious	Acres
		☑ ROADS/FLAT	0.13



Water Quality

On-Line BMP

24 hour Volume (ac-ft): 0.0159
Standard Flow Rate (cfs): 0.0211

Off-Line BMP

Standard Flow Rate (cfs): 0.0119

APPENDIX C

Geotechnical Report

REPORT OF GEOTECHNICAL ENGINEERING SERVICES

Interurban Trail Improvements
City of Pacific
Pacific, Washington

For
KPG, P.S.
January 22, 2018

GeoDesign Project: KPG-80-01

January 22, 2018

KPG, P.S.2502 Jefferson Avenue
Tacoma, WA 98402

Attention: Nate Mozer, P.E.

Report of Geotechnical Engineering Services
Interurban Trail Improvements
City of Pacific
Pacific, Washington
GeoDesign Project: KPG-80-01

GeoDesign, Inc. is pleased to submit this report of geotechnical engineering services to support the final design efforts for the Interurban Trail segment between Roy Road SW and 3rd Avenue SW. This report has been prepared in accordance with our proposal dated August 8, 2017.

We appreciate the opportunity to be of service to you. Please contact us if you have questions regarding this report.

Sincerely,

GeoDesign, Inc.

DRAFT

Kevin J. Lamb, P.E.
Principal Engineer

cc: Terry Wright, KPG, P.S. (via email only)

BJW:KJL:kt
Attachments
One copy submitted (via email only)
Document ID: KPG 80-01-012218-geor-DRAFT.docx

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1.0 INTRODUCTION

This report presents the results of GeoDesign's geotechnical engineering services to support final design efforts for the Interurban Trail Segment between Roy Road SW and 3rd Avenue SW in Pacific, Washington.

The proposed project includes the design of approximately 2,500 lineal feet of the Interurban Trail located between Roy Road SW and 3rd Avenue SW. The Interurban Trail extension project will construct new trail segments and rehabilitate existing segments to establish the trail from 3rd Avenue SW to Roy Road SW. It will include a new bridge structure to extend the trail across the Milwaukee Ditch at the northern end of the project alignment. The proposed trail alignment is within or adjacent to a PSE powerline easement.

We understand that the trail is primarily intended for non-motorized use but will likely be accessed by City of Pacific Police, maintenance crews on a weekly basis, and occasionally by PSE vehicles that are not anticipated to exceed an H-20 wheel loading.

Landau Associates completed a geotechnical report to support preparation of the 50% design plans (Landau, 2011). Shallow explorations completed along the alignment encountered peat at shallow depth throughout the trail alignment. The explorations generally did not extend to sufficient depth to penetrate the peat or to evaluate subsurface conditions at the proposed Milwaukee Ditch crossing. The 50% design plans indicate that fill embankments for the trail would be supported with CMU block retaining walls up to approximately 4 feet in height. CMU block walls generally do not tolerate significant settlement and preloading was recommended to decrease post-construction settlement.

2.0 PURPOSE AND SCOPE OF SERVICES

The purpose of this study was to gather and review available subsurface information, conduct field explorations to evaluate subsurface conditions at the site, and provide geotechnical conclusions and engineering recommendations for the new connector trail sections and the bridge over the Milwaukee Ditch. Our scope of services included the following:

- Reviewed preliminary plans and existing geotechnical report for the project.
- Performed a field investigation to explore subsurface conditions.
- Completed geotechnical laboratory analyses.
- Prepared this report summarizing our findings, conclusions, and recommendations related to the following:
    - Subsurface soil and groundwater conditions and results of laboratory testing
    - Preload requirements and settlement monitoring
    - Embankment construction
    - Applicable wall types to support embankment fills that can tolerate settlement
    - Subgrade preparation outside of embankment areas
    - Foundation support for the Milwaukee Ditch bridge
    - Permeable and non-permeable pavement sections
    - Earth anchor design criteria to support relocation of guy wire anchors

3.0 SITE CONDITIONS

3.1 GENERAL

The proposed trail will extend between the existing access at 3rd Avenue SW (Station 100+00) and the end of the trail located approximately 350 feet north of the access point at Roy Road SW (Station 132+49) (Figure 2 through 6). The proposed trail alignment is along or within the eastern edge of the PSE utility easement and is bordered on the east most typically by residential housing developments and on the west by State Route 167. The proposed trail alignment includes crossing of the Milwaukie Ditch and road crossings at 5th Avenue SW and at County Line Road SE.

Surficial conditions were determined from observations during several visits to the site, and subsurface conditions were evaluated by reviewing existing geologic/geotechnical information and completing eight borings. A description of the field explorations is presented in Appendix A.

3.2 SURFACE CONDITIONS

The proposed project includes constructing new trail segments and rehabilitating or reconstructing existing substandard sections. The surface conditions along the undeveloped portions of the proposed trail alignment and adjacent to the developed sections generally consist of tall grass with deciduous trees and blackberry bushes. The topography along the proposed trail alignment is generally flat and ranges in elevation from 58.7 to 62.6 feet.

New trail sections are planned between the following Stations:

- 100+00 and 118+20
- 128+50 and 132+50

Currently, the trail alignment in these areas consists of tall grass and Himalayan Blackberry brush and the ground surface is approximately 4 feet below the required trail grade. Surface conditions in these areas will require construction of a fill embankment to support the trail.

An existing trail section exists between Stations118+20 and 125+00.

This section of trail was constructed as part of the development of the adjacent residential community. Trees have been planted along the edge of the private property that borders the trail alignment and the trail is surfaced with AC pavement. The pavement appears to be thin, and throughout this trail section the pavement has been heaved up by shallow tree roots that extend under the pavement. The existing trail width is substandard, and the pavement is in poor condition.

Existing trail sections are also present between the following Stations:

- 125+00 and 128+50
- 132+50 and 136+64

Additional improvements were not planned in these areas as indicated on the 50% design plans. The trail sections are paved with AC in generally good condition and are sufficiently wide enough to accommodate the trail.

3.3 SUBSURFACE CONDITIONS

The surficial geology in the area is mapped as alluvium. These deposits generally consist of unconsolidated, interbedded deposits of silt, sandy silt, silty sand, and fine sand. Wetland deposits consisting of lenses to layers of peat with interbeds of silt and silty sand are also present throughout the area overlying the alluvium. Development adjacent to the area and construction of existing trail segments within the project area has resulted in the disturbance of surficial soil placement of fill over the peat and alluvium deposits.

Subsurface conditions during this investigation were explored by drilling eight borings (B-1 through B-8) to depths ranging between 11.5 and 41.5 feet BGS at the locations shown on Figures 2 through 6. The borings were generally completed in areas that have not been impacted by previous development or trail construction activities. A description of the field explorations and the exploration logs are presented in Appendix A.

We also reviewed the summary logs of explorations completed during the previous geotechnical investigation by Landau Associates (2011). The locations of these explorations are also shown on Figures 2 through 6, and summary logs are presented in Appendix B.

Borings completed along the proposed project alignment generally encountered subsurface conditions consistent with our understanding of the area. Within areas not impacted by development and recently placed fill explorations generally encountered peat deposits underlain by fine-grained alluvium. Explorations completed within or near existing trail sections encountered a surficial layer of fill overlying the peat and alluvium. Materials encountered in the explorations are described below.

3.3.1 Fill

Fill was encountered in Landau borings B-6p and B-8p in the southern portion of the project alignment. The borings were completed in areas where existing trail sections are present. The fill at both locations is approximately 1 foot in thickness. Boring B-6p encountered fill composed of sandy silt, similar in composition to the underlying alluvium deposits. Boring B-8p encountered fill composed of silty sand with gravel that was likely imported to the area.

3.3.2 Peat

Peat is present at all the explorations locations. The peat is present just below the vegetation root mat at all of GeoDesign's exploration locations and at exploration B-1 completed by Landau. At the remaining Landau locations peat is present beneath a layer of fill or a thin layer of alluvium. The peat is characterized as very soft to soft and highly compressible. Interbedded lenses to thin layers of silty sand and sandy silt are occasionally present within the peat deposits.

3.3.3 Alluvium

GeoDesign borings were completed within alluvium deposits that are present beneath the peat. Alluvium is also present above the peat as encountered in Landau borings B-1 through B-5, B-7, and B-8. The alluvium consists of an upper layer of silt to sandy silt underlain by sand and isolated layers of silt or sandy silt. The alluvium is typically loose and grades to medium dense below a depth of approximately 15 feet BGS.

3.4 GROUNDWATER

Groundwater was encountered during drilling of all borings along the project alignment at depths ranging between 0.1 foot and 3.5 feet BGS. Groundwater monitoring wells were installed in borings B-3 and B-8. The wells were installed in mid-October when groundwater levels and the nearby White River are typically at their lowest. Table 1 summarizes groundwater data collected for this project.

Table 1. Summary of Groundwater Data

Boring Location	Depth to Groundwater (feet BGS)			
	10/16/17 During Drilling	10/19/17	11/7/17	12/19/17
B-1	1.0	--	--	
B-2	3.5	--	--	
B-3 (well)	0.5	0.1	0.05	Ground surface under water
B-4	0.3	--	--	
B-5	1.5	--	--	
B-6	1.0	--	--	
B-7	1.0	--	--	
B-8 (well)	0.5	0.8	0.76	Ground surface under water

3.5 SEISMICITY

The State of Washington is situated at a convergent continental margin and is susceptible to subduction zone, intraplate, and shallow crustal source earthquakes. We reviewed published geologic maps for the site vicinity (Johnson et al., 1999; Sherrod et al., 2004) to evaluate seismic hazards. Based on our subsurface explorations, literature review, and experience, a summary of the seismic hazards in the area and their associated impact at the site are as follows:

- **Amplification:** Areas subject to amplification are typically underlain by a thick sequence of soft or loose soil overlying stiff soil or bedrock. Based on our explorations and available geologic maps, the site is underlain by thick sequence of alluvium deposits that vary from soft to stiff peat and silt with variable sand content and loose to medium dense sand with variable silt content. In our opinion, this material has a moderate potential for site amplification.
- **Liquefaction/Settlement:** The site is underlain by alluvium that is composed of lenses to layers of loose sand and silty sand deposits with a shallow water table. The site has a high potential for seismically induced liquefaction.

- **Lateral Spreading:** Areas subject to lateral spreading are typically gently sloping or flat sites underlain by liquefiable sediments adjacent to an open face (such as riverbanks or bay fronts). Liquefied soil adjacent to open faces may "flow" in that direction, resulting in lateral displacement and surface cracking. In our opinion, there is a low to moderate risk of lateral spreading occurring at this site during a design-level event considering that the trail alignment is generally flat.
- **Fault Surface Rupture:** We did not find evidence of faults through the site or on maps of the area. We conclude that the potential for fault surface rupture at the site is low.

4.0 LABORATORY TESTING

Laboratory testing was conducted on specific soil samples selected from the explorations to assist in the characterization of certain physical parameters of the soil. Index tests that were performed included the determination of natural water content, grain-size distribution analysis, percent fines, and one-dimensional consolidation. A one-dimensional consolidation test was conducted to estimate primary and secondary settlement to evaluate settlement potential of the near-surface peat that was encountered in the borings. All tests were conducted in general accordance with appropriate ASTM standards (ASTM, 2012). A discussion of laboratory test methodology and the test results are presented in Appendix A. Test results are also displayed where appropriate on the exploration logs presented in Appendix A.

5.0 DESIGN RECOMMENDATIONS

5.1 GENERAL

Based on our review of available information; the development history of the site; and the results of our explorations, laboratory testing, and analyses, it is our opinion that construction of the trail is feasible provided the following recommendations are incorporated:

- It will be necessary to limit earthwork construction activities to the dry season due to shallow groundwater throughout the alignment. Low ground pressure equipment will be necessary during the initial subgrade preparation phases of construction.

- Peat encountered along the alignment is highly compressible and placement of fills or foundation loads will result in significant settlement. We anticipate post-construction primary consolidation settlement of the proposed embankment on the order of 3 to 12 inches and secondary consolidation settlement up to 4 inches. Secondary consolidation will take place over a long period of time and can typically be ignored for long linear structures.

- Depending on the City of Pacific's tolerance for post-construction settlement of the trail, consolidation of the peat can be managed by placing additional fill material to account for the anticipated post-construction settlement and accepting some amount of undulations in the trail surface or through the placement of a rolling preload approximately 2 feet thick. The duration of the preload would be up to approximately three months.

- Embankment subgrade preparation for the new sections of the trail will require geosynthetic reinforcement below and within the fill to create a stable subgrade. This reinforcement can be incorporated into the design of the embankment so that the face of the embankment can be constructed near vertical to minimize impact on the adjacent wetland.

- A settlement-tolerant retaining structure consisting of a vegetated or non-vegetated face MSE embankment is recommended. The recommended structure can be constructed with an MSE structure consisting of the Tensar Sierrascape retaining wall system or alternatively with geocell geosynthetic material incorporated during filling. Both systems are highly flexible and can accommodate the anticipated settlement. The Tensar system uses a geotextile-wrapped face supported with welded-wire forms that will support the embankment face at near-vertical inclinations. Geocells consists of a geosynthetic material composed of an accordion-like network of high-strength interconnected cells.

- The embankment should be constructed after clearing of vegetation, mowing the vegetation, and filling of any large depressions along the alignment. After preparation of the alignment area, a geosynthetic material (geogrid and filter material or high-strength woven geotextile) should be placed at the base of the embankment before placing in initial lift of fill shot rock or crushed rock material to construct a stable subgrade to support the embankment construction.

- Clearing and subgrade preparation for the embankment should extend at least 2 to 4 feet horizontally beyond the planned trail/embankment width.

- Embankment construction may impact adjacent poles within the PSE right-of-way. Loading and consolidation of the peat may result in lateral deflection of nearby poles. Mitigation of the lateral deformation may require installation of new poles or guy wires to anchor the pole in place.

- The thickness of the peat appears to be limited in depth to approximately 2.5 to 3 feet at the proposed bridge location across Milwaukie Ditch. Subgrade improvement through over-excavation and replacement/displacement of the peat at the proposed bridge abutments is feasible to provide shallow foundation support.

- Structures supported on shallow foundations will be susceptible to liquefaction-induced settlement. Liquefaction-induced settlement of up to 3 inches is estimated. Ground improvement methods such as compaction grouting or placing stone columns beneath the bridge abutment are an option to help reduce the amount of liquefaction-induced settlement; however, the project cost of these alternatives is typically prohibitive for a pedestrian trail project of this size. Dewatering of the bridge abutment excavations may be necessary for preparation of the abutment subgrade.

- Pavement for the proposed trail alignment can consist of dense or permeable HMA pavement. Due to the long-term settlement potential, rigid PCC pavement is not recommended.

- Support for power pole guy wire anchors should be achieved through installation of helical anchors that extend through the very soft to soft peat deposits and into the underlying medium dense sand with variable silt content.

5.2 EMBANKMENT CONSTRUCTION

The existing peat and loose alluvial soils along the alignment will need to be stabilized for the construction of embankments to support new trail sections or the widening of existing sections. We understand embankment heights up to approximately 4 feet are planned. Recommendations to address embankment construction are provided below.

5.2.1 Subgrade Preparation

Subgrade preparation for the embankment should extend at least 3 feet horizontally beyond the planed trail/embankment width. This will provide sufficient space for temporary erosion and sediment control elements, fill placement, and construction of the embankment.

Subgrade preparation beneath the trail embankment should consist of clearing of vegetation, mowing the vegetation as close to the ground as possible, and filling of any large depressions along the alignment. The root mat at the ground surface should be left intact and will help support earthwork equipment.

5.2.2 Placement of Stabilization Geotextile

After preparation of the trail alignment area, a geosynthetic material (geogrid and filter material or high-strength woven geotextile) should be placed over the mowed surface beneath the extent of the embankment area and extending 3 feet beyond the face of the embankment before placing the initial lift of fill. Appropriate geosynthetic subgrade reinforcement should consist of the following materials or their equivalents:

- Tensar TX-160 geogrid underlain by a filter geotextile similar to Mirafi 160N, or
- Tencate Mirafi 380 RSi

The geosynthetic shall be laid smooth without excessive wrinkles across the prepared subgrade and unrolled immediately ahead of the covering operation. Additional requirements for subgrade reinforcement geosynthetics can be found in the "Geosynthetics" section of this report.

5.2.3 Embankment Fill

After placement of the subgrade reinforcement the initial lift of fill should consist of stabilization material consisting of shot rock or crushed rock material. Appropriate stabilization materials for the initial lift of embankment fill include the following:

- WSS 9-03.9(3) – Crushed Surfacing, have less than 5 percent by dry weight passing the U.S. Standard No. 200 sieve and have at least two mechanically fractured faces, or
- WSS 9-03.9(2) – Permeable Ballast, or
- WSS 9-13.7(2) - Backfill for Rock Wall

Additional requirements for stabilization material are presented in the "Stabilization Material" section.

The initial lift should be placed in one lift with a thickness between 12 and 18 inches. The entire thickness should be placed prior to equipment traveling over the surface. Turning of construction equipment should be avoided during placement of fill material to avoid folding or wrinkling of the geosynthetic. Under no circumstances should construction equipment be allowed on uncovered geotextiles.

After placement of the initial lift of fill construction of the embankment can proceed.

5.2.4 Reinforced Soil Slope

If side slopes of the embankment greater than 2H:1V are required, we recommend constructing the embankment as an RSS structure. RSS' are similar to MSE walls; however, they do not incorporate interlocking hard facing elements, such as CMU blocks, on the face of the embankment. For embankments with sideslopes greater than 2H:1V, we recommend constructing the fill embankment as an RSS rather than the hard-faced MSE wall previously indicated on the 50% design plans. Hard-faced MSE walls do not tolerate significant amounts of settlement. Construction of the MSE structure would also require placement of the embankment fill, a preload to speed consolidation, removal of the preload, and then construction of the wall.

RSS structures will tolerate a significant amount of settlement and can be constructed as the fill is placed. Depending on the tolerance for encroachment into the wetland area, the face of the fill embankment to support the trail can either be sloped or near vertical. RSS' can be constructed with face inclinations up to near vertical. RSS' are constructed using geosynthetic reinforcing placed at specific intervals within the fill that reinforces the soil and allows for steeper slope inclinations than unreinforced soil. RSS' with inclinations above 1H:1V require that the face be supported by wrapping with geotextile with long-term support provided with L-shaped, welded-wire forms or, alternatively, a geocell or geoweb product can be used.

A design for an appropriate RSS structure for the trail was not included in our scope of services. We can provide a design for the RSS if desired. If the desired slope face is in excess of 1H:1V, we recommend using welded-wire forms or geocell material to support the face. Recommendations are provided in Table 2 for appropriate soil parameters to be used in the design of an RSS.

Table 2. Recommended Design Parameters for RSS

Soil Properties	**Reinforced Zone Soil**	**Retained Soil**	**Foundation Bearing Soil**
	Gravel Borrow WSS 9-03.14(1)	**Fill Embankment WSS 9-03.14(1)**	**Stabilized Subgrade**
Unit Weight (pcf)	135	125	125
Friction Angle (degrees)	36	36	34
Cohesion (psf)	0	0	
Allowable Bearing Pressure on Improved Subgrade as Recommended (psf)	not applicable	not applicable	1,500

5.2.5 Widening of Existing Embankments

Where existing embankments will be widened to support the trail, the new embankment fill should be keyed into the existing embankment. This can be accomplished by stair stepping it into the existing embankment slope such that it is keyed into it a minimum horizontal distance of approximately 2 feet for each 1-foot lift beginning at the toe of the existing embankment slope. The subgrade below the area where additional embankment fill is required should be prepared in accordance with the recommendations provided above.

Depending on how much the existing embankment will be widened, additional excavation into the existing embankment may be required in order to install the geogrid reinforcement for constructing the RSS. For an embankment height of up to 5 feet, we anticipate the length of the required geogrid reinforcing will be approximately 4 feet long.

5.2.6 Embankment Settlement

Construction of the embankment to support the new trail sections will result in settlement and consolidation of the underlying peat and loose alluvial soils. We understand embankment heights up to approximately 4 feet are planned. We estimate total primary consolidation settlement is on the order to 3 to 10 inches, some of which will occur during construction and the remainder within approximately two months after the full height of the embankment is achieved. Post-construction settlement is estimated to be on the order of 2 to 6 inches and secondary consolidation settlement up to 4 inches. The variation of the anticipated settlement is related to the variable thickness of peat encountered along the alignment. We anticipate differential settlement of the trail alignment will be greatest in the area immediately south of the Milwaukee Ditch bridge and could be up to approximately 3 inches over a distance of 100 feet.

Primary consolidation will begin as the fill is applied and is expected to take approximately two months for approximately 90 percent of the anticipated consolidation to take place. Secondary consolidation will take place over a long period of time and can be ignored for long linear structures.

Roads or trails surfaced with HMA can generally tolerate a significant amount of differential settlement where the subsurface conditions are consistent. Post-construction settlement can be addressed by accounting for the average settlement and increasing the surface elevation of the trail to accommodate some of the anticipated settlement. If post-construction settlement cannot be tolerated then a preload, in the form of additional fill, can be applied along the new embankment sections to help mitigate post-construction settlement.

We anticipate that construction access will be limited to using the unpaved trail surface as the embankment is constructed, which will result in significant traffic loads and allow most of the primary consolidation to take place during construction.

5.2.6.1 Preloading

If the anticipated post-construction settlement is not tolerable, preloading the embankment area is recommended. The purpose of the preload fill is to pre-induce a large portion of the settlement that would otherwise occur below newly filled areas or structures. A preload program will significantly reduce post-construction settlement and the potential differential settlement due to variability in areal loading and thickness of compressible soil. The thickness of preload surcharge fill and the area covered by the fill are typically determined based on soil properties, the height of new fill, the weight and size of the new loads, the time available to accomplish the preload program, and the allowable post-construction settlement that the site improvements can tolerate. The adjacent wetlands limit the extent of a preload to the embankment footprint.

Other methods are available to help reduce the amount of settlement, such as ground improvement with compaction grouting or placing stone columns beneath the trail embankment; however, the expense of these alternatives is typically not justifiable for trail/road projects.

We evaluated the preload program for this site considering new fill thickness of up to 4 feet. We recommend using a minimum height of 12 inches of surcharge fill to shorten the settlement period and decrease post-construction settlement. The thickness of the surcharge fill is measured above the design finished pavement level at the completion of the preloading program. Therefore, the total surcharge fill thickness at the beginning of the preloading program must compensate for the expected settlement. In our opinion, the surcharge fill should measure 16 to 18 inches above the design pavement level.

We evaluated the potential settlement of the fill for these conditions. We estimate that the settlement will be in the range of 4 to 12 inches.

Based on our analysis, we anticipate that 90 percent of primary consolidation will be achieved within approximately two months. This assumes that long-term secondary settlement of the trail alignment on the order of 3 to 4 inches is acceptable.

Placement of the permeable pavement should not occur until after removal of the preload and 90 percent of primary settlement has occurred. The surcharge fill should consist of permeable ballast material so that paving can begin after the end of the preload program and final grading.

5.2.7 Settlement Monitoring

The embankment should be monitored during construction to determine the magnitude and rate of settlement. The data will be used to determine whether consolidation of the underlying soil has slowed sufficiently to allow removal of the preload. We estimate that the preload program may take six to eight weeks to complete.

To monitor the settlement, we recommend placing settlement plates at approximately 300-foot intervals along the east edge of newly constructed trail sections to avoid construction traffic impacts. The plates should be placed on the subgrade reinforcement geotextile prior to placement of the stabilization material. Recommendations for settlement plates and their installation are shown on Figure 7.

The elevations of the plates and measurement rods should be surveyed prior to any filling, twice a week during filling, and once a week thereafter. If a measurement rod is bent by construction equipment, it should be straightened and resurveyed as soon as possible. The elevations should be referenced to a benchmark located at least 100 feet away from the preload fill.

The settlement data should be provided to GeoDesign immediately after the readings are taken so that we may evaluate the data. If the settlement plates are not surveyed prior to placement of any fill, the initial settlement behavior of the fill pad will not be recorded, and the value of the observations will be diminished because the total magnitudes of settlement will be unknown. This may result in a longer preload period than would otherwise be necessary.

5.2.8 Embankment Impacts

Timber power poles support the PSE utility lines that parallel the trail alignment. Embankment construction may impact the existing power poles. Loading and consolidation of the peat may result in some lateral deflection of nearby poles, especially if they have shallow embedment. It is difficult to estimate the amount deflection that could occur. The poles should be monitored during fill placement and consolidation to determine if mitigation measures to address the pole deflection are necessary. Mitigation of the lateral deformation may require installation of new poles or guy wires to anchor the pole in place.

5.3 MILWAUKEE DITCH BRIDGE

The soft, compressible peat appears to be limited in depth to approximately 2.5 to 3 feet at the proposed bridge location across the Milwaukee Ditch. The peat is highly compressible under the influence of new loads and is not suitable for supporting shallow foundations. Over-excavation and replacement of the peat is recommended and will be required if shallow foundations are preferred. During the dry season the groundwater level is expected to decrease, minimizing the dewatering required to complete over-excavation.

Deep foundations to support the proposed bridge are likely cost-prohibitive based on the type of proposed structure and intended use. Post-construction settlement up to approximately 4 inches over the life of the structure is anticipated. It is anticipated that this degree of settlement can be tolerated by the selected bridge system or that structural adjustments can be made to the bridge deck to compensate for foundation settlement.

5.3.1 Foundation Support - Spread Footings

The pedestrian bridge abutments can be supported on spread footings placed over an improved subgrade. We anticipate that an abutment on spread footings will consist of a conventional cast-in-place wall abutment or large modular gravity block-type units stacked from the competent bearing stratum to the top of abutment elevation to support the bridge structure. The following recommendations should be incorporated into design and implemented during construction.

The peat encountered near the proposed Milwaukee Ditch bridge abutments is highly compressible and is not suitable for supporting foundations and should be removed. Based on borings B-2 through B-4, the peat extends to depth of approximately 4 feet BGS near the proposed bridge abutments. The very soft to soft peat should be removed from the base of the proposed abutments to expose the underlying sand alluvium. Excavation depth should be a minimum such that the foundation will be underlain by a minimum 2-foot thickness of stabilized subgrade. The over-excavation should extend outwards 1 foot for every 1 foot of depth.

Stabilization material should be placed at the base of over-excavations where the subgrade remains soft and saturated. The material should be pushed and kneaded into the subgrade using the back of the excavator bucket until firm. The subgrade should then be prepared similar to the subgrade beneath the fill embankment. A heavy-duty geotextile similar to Mirafi® Tencate RS380i/RS580i or geogrid similar to Tensar TX-160 underlain by a non-woven filtration geotextile should be placed over the stabilization material after it has been backfilled to above existing groundwater levels.

After placement of the initial lift of stabilization material, the excavation should then be backfilled with stabilization material or imported granular material compacted to 95 percent of the maximum dry density, as determined by ASTM D1557. Additional layers of geosynthetic subgrade reinforcing material, at a spacing of approximately 10 inches, should be incorporated into the backfill to provide additional stability.

GeoDesign did not evaluate scour or horizontal erosion of the ditch channel and the effect of such erosion on the foundations for the proposed bridge foundation. If required, we recommend that a stream hydrologist evaluate the scour and erosion potential at this crossing and provide measures to protect the bridge foundations, if necessary. Such measures might include abutment wing walls and/or slope armoring using riprap.

5.3.2 Bearing Capacity

The proposed abutment may be supported by continuous spread footings founded on the improved subgrade provided it is constructed as recommended described above. If located above a sloped area, the bottom of foundations should be embedded sufficiently to provide a minimum 5-foot horizontal bench in front of the abutment. Considering the depth required to penetrate the underlying layer of peat, we anticipate a sufficient bench will be provided.

All footings on the improved subgrade should be proportioned for a maximum allowable soil bearing pressure of 2,000 psf. This bearing pressure is a net bearing pressure and applies to the total of dead and long-term live loads and may be increased by one-third when considering seismic or wind loads. The weight of the base footing and any overlying backfill can be ignored in calculating footing loads.

The reinforced structural fill material should extend at least 12 inches beyond the edges of the proposed footings for every foot of over-excavation required to expose competent native soil beneath the plan footing elevation.

5.3.3 Post-Construction Bridge Foundation Settlement

For structural elements founded as described above, we estimate that total post-construction foundation settlement for footings will be up to approximately 2 inches. This settlement estimate assumes foundations are supported on a subgrade constructed as recommended above. We assume that the bridge deck can accommodate settlement and can be adjusted as necessary. The trail approach to the bridge should not be structurally connected to the bridge deck, making re-leveling possible.

To decrease post-construction settlement, the fill area beneath the bridge abutments should be monitored during construction to verify settlement has dissipated for at least two weeks before placement of the bridge deck. A surcharge fill can also be placed on the approaches to the bridge and should extend approximately 100 feet in either direction to further reduce post-construction settlement between the bridge and the adjacent approaches.

5.3.4 Lateral Resistance

Lateral loads can be resisted by passive earth pressure on the sides of footings and by friction on the base of the footings. We recommend that a friction coefficient of 0.35 be used to compute the frictional resistance for footings bearing on crushed rock backfill of 6 inches or more.

An equivalent fluid unit weight of 100 pcf is recommended to compute passive earth pressure acting on footings constructed in direct contact with compacted structural fill. This value is based on the assumptions that the adjacent confining structural fill or native soil is level. The top 1 foot of soil should be neglected when calculating lateral earth pressures unless the foundation area is covered with pavement.

5.3.5 Approach Embankments

We anticipate the bridge approach embankments will be up to approximately 4 feet above the existing ground surface. Differential settlement between the bridge and the approach embankment can be reduced by either removing the shallow peat layer beneath the approach embankment or through surcharging the area as discussed in the “Preloading” section. If the peat is left in place, long-term differential settlement at the transition from the bridge to the approach embankment should be expected. The settlement will continue over the life of the structure and require periodic maintenance.

Preloading the approach area will significantly decrease post-construction settlement. Removal of the peat at the transition and then decreasing the excavation depth as the distance from the bridge increases will also provide for a smooth transition between the bridge and the approach. The excavation subgrade should be reinforced similar that recommended above for the bridge foundation. The fill area beneath the approach embankment should be monitored during construction to verify settlement has dissipated for at least two weeks before placement of the bridge deck.

5.4 PAVEMENT

Dense AC or porous asphalt pavement is suitable for constructing the trail surface. Infiltration of water through the pavement surface will not impact the RSS structure.

5.4.1 Recommended Pavement Sections

A dense AC pavement section consisting of 2.5 inches of AC over 6 inches of base course rock (WSS 9-03.9(3) – Crushed Surfacing) is appropriate for the trail and providing support for the anticipated maintenance vehicles.

Appropriate permeable pavement sections as based on assumed light vehicle loads consisting of a maintenance truck are provided in Table 3.

Table 3. Permeable Pavement Sections

Layer	Recommended Porous Asphalt Section (inches)	Alternative Porous Asphalt Section (inches)
Porous Asphalt Wearing Layer	2	3
Asphalt-Treated Porous Base	3	--
Choker	--	2 maximum
Storage Aggregate	5 minimum	6 minimum

The choker course in Table 3 is replaced with asphalt-treated porous base, which will provide a stable surface for placing the porous asphalt wearing layer. This has been shown to be beneficial on previous projects due to the rutting susceptibility of the storage aggregate and choker course materials. The use of a choker course can facilitate grading and decrease construction traffic disturbance of the underlying storage aggregate during paving operations. The thickness of the storage aggregate layer is a minimum thickness required for structural support of the pavement. The thickness may need to be increased based on hydraulic storage requirements.

5.4.2 Subgrade Preparation

The subgrade should consist of the compacted embankment material. If constructed in accordance with our recommendations, the new trail embankment surface should not require additional preparation prior to construction of the pavement section. In areas where existing trail sections are present and will be reconstructed or overlain, the trail surface should be proof rolled to verify that it is ready for paving.

5.4.3 Pavement Materials

5.4.3.1 Dense AC

AC for nonporous pavement should be dense HMA Class ½" according to WSS 5-04 – Hot Mix Asphalt. The AC should be thoroughly and uniformly compacted to at least 91 percent of the maximum density of the mixture, as determined by AASHTO T 209. We recommend minimum and maximum lift thicknesses of 2.0 and 3.0 inches, respectively, for HMA Class ½". Asphalt binder should be performance graded and conform to PG 64-22. Aside from the lift thickness recommendations identified herein, the AC should be constructed per the requirements presented in WSS 5.04 – Hot Mix Asphalt.

5.4.3.2 Porous Asphalt

AC used for porous asphalt pavement should be designed as a ½- to ¾-inch, nominal, open-graded HMA. Selection of the preferred aggregate size should be based on the desired surface texture and the required layer thickness limitations. Approximate "broad band" gradations for recommended aggregate gradation for porous asphalt are provided in Table 4.

Table 4. Porous Asphalt Gradation (3/8 inch)

Sieve Size	3/8 inch Percent Passing	½ inch Percent Passing	¾ inch Percent Passing
1 inch	--	--	99 - 100
¾ inch	--	100	85 - 96
½ inch	99 - 100	90 – 98	55 - 71
3/8 inch	90 – 100	55 - 90	--
#4	22 – 40	10 – 40	10 - 24
#8	5 – 15	0 – 13	6 - 16
#200	0 - 3	0 - 3	0 - 3
Recommended Maximum Layer Thickness (inches)	2.5	3	4

The actual mix design should be completed under the direction of a competent mix design technician familiar with the WSDOT mix design procedures. The asphalt binders to construct porous asphalt pavement should be PG 70-22ER.

The preferred and recommended asphalt binder is PG 70-22ER (polymer modified); however, its availability can be limited because some of the local asphalt suppliers limit their on-hand binder to PG 64-22. PG 70-22ER is available but is typically stocked by asphalt suppliers for a specific project, which requires pre-ordering it so that it is available when needed. Suppliers prefer a project size of approximately 600 tons of AC to use a complete tanker volume of the binder. Its availability and use are further restricted to the warm months of the year because of its stiffness, so it is not readily available between October and May. Projects specifying PG 70-22ER should be scheduled accordingly and specifications should address supplier availability.

The binder should be between 6.0 and 6.5 percent of the pavement section by weight of total (dry aggregate) mix.

Warm-mix asphalt technology with a proper mix design and appropriate additives can be used to construct the porous asphalt. Use of the warm-mix additives may require a longer "curing" time for the asphalt prior to allowing cars to traffic over the surface.

Compaction of the porous asphalt should consist of approximately two to four complete passes by an 8-ton, dual-steel roller compactor working in static mode only. Compaction of the porous asphalt should be to a target air voids content of 15 to 18 percent (82 to 85 percent of maximum theoretical [Rice] density). A nuclear density gage should be used to monitor compaction.

We recommended that porous asphalt specifications are prepared in conformance with those approved by the APWA-Washington Construction Materials Committee. The specifications have now been integrated into the WSDOT Local Agency GSPs and are now available at: http://www.wsdot.wa.gov/partners/apwa/Division_5_Page.htm.

5.4.3.3 Choker Aggregate

Imported granular material used as choker aggregate beneath permeable pavements should be clean crushed rock that meets a No. 57 size gradation according to AASHTO M 43, as provided in Table 5.

Table 5. Permeable Pavement Choker Aggregate (AASHTO No. 57)

Sieve Size	Percent Passing
1½ inches	100
1 inch	95 - 100
½ inch	25 - 60
No. 4	0 - 10
No. 8	0 - 5

The percent fracture should be a minimum of 75 percent and a minimum of two fracture faces.

Alternatively, aggregate for bituminous surface treatment [WSS 9-03.4(2) – Grading and Quality], 5/8-inch or 3/4-inch washed crushed rock, which is available from local suppliers, will also be suitable. The aggregate should have at least two mechanically fractured faces.

As indicated in Table 3, a 3-inch-thick layer of ATPB can be used in place of the choker course and 1-inch of the storage aggregate. This layer of ATPB will accommodate the uneven surface of the storage aggregate and will provide a uniform surface over which to place the porous asphalt pavement.

5.4.3.4 Storage Aggregate

Imported granular material used as storage aggregate beneath permeable pavements should be clean crushed rock or crushed gravel and sand that meets a No. 2 or No. 3 size gradation according to AASHTO M 43 or clean crushed rock that conforms to WSS 9-03.9(2) – Permeable Ballast. Recommended gradations for acceptable storage aggregate are provided in Table 6.

Table 6. Storage Aggregate

Sieve Size	AASHTO No. 2 Percent Passing	AASHTO No. 3 Percent Passing	WSS 9-03.9(2) - Permeable Ballast Percent Passing
2 ½ inches	100	100	90 - 100
2 inches	35 - 70	90 - 100	65 - 100
1 ½ inches	0 - 15	35 - 70	--
1 inch	--	0 - 15	40 - 80
¾ inch	0 - 5	--	--
½ inch	--	0 - 5	--
No. 4	--	--	0 - 5

"Rail ballast" or "clean ballast" products available from local quarries will typically meet the AASHTO gradation criteria. The percent fracture should be greater than 75 percent to improve interlocking between fragments, and the aggregate should have a minimum WSS degradation value of 30. We anticipate that the storage aggregate gradations specified above will have between 35 and 40 percent voids compaction in the field. The percent voids should be measured in accordance with ASTM C29 using the "jigging method."

The storage aggregate should be placed in one lift and compacted to a firm and unyielding condition. Over-compaction and construction traffic should be avoided.

5.4.4 Permeable Pavement Considerations

We recommend the following considerations for installation of permeable pavement:

- The long-term performance of permeable pavements is reliant upon proper design, installation, and long-term maintenance.
- The width of the trail should be sized to accommodate maintenance equipment that will be necessary to vacuum the pavement.
- Sediment, organic debris, and organic growth will reduce the permeability of permeable pavement. Regular, periodic maintenance is required to maintain the hydrologic performance of the pavement. Maintenance should consist of periodic cleaning by regentative air sweeping and/or vacuum sweeping and flushing with high volume water at low pressure. Based on available information, vacuum sweeping should be performed two to four times per year and flushing at least once per year.
- Sanding for snow and ice removal should be avoided on permeable pavement.
- Public awareness plans should be developed to educate residents on activities that should be avoided on or adjacent to permeable pavement.
- During and after construction, stockpiles of landscaping material (e.g., topsoil, bark dust, etc.) and construction material (e.g., sand, gravel, etc.) should not be placed on the permeable pavements. Extreme care should be taken to prevent trafficking of muddy construction equipment over permeable pavements.
- Landscaping areas that are adjacent to permeable pavements should be designed to prevent run-off from washing debris onto the pavement and designed such that leaf debris does not accumulate on the pavement.

5.5 EXISTING TRAIL SECTIONS

Three sections of existing dense AC-paved trail are present within the project area. The northernmost section, between Stations 118+20 and 125+00, will be widened and the AC surfacing is in poor condition. We recommend grinding the existing surface and incorporating it into the new trail. Through this area properties along the trail have planted trees along the property line and the tree roots have heaved the pavement, resulting in AC failure. We recommend incorporating a ditch or shallow swale between the trail and adjacent properties to help prevent root growth beneath the new trail surface.

5.6 GUY WIRE ANCHOR RECOMMENDATIONS

We anticipate PSE will be responsible for designing the anchors. We recommend that anchors extend through the peat deposits and into the underlying medium dense alluvium deposits. Peat extends to depths of up to 12 feet BGS at the exploration locations. We recommend a conservative minimum embedment depth of 20 feet for the anchors.

5.7 SEISMIC DESIGN CRITERIA

Moderate to high levels of earthquake shaking should be anticipated during the design life of the structure. The recommended seismic design parameters, based on the 2015 IBC, are presented in Table 7.

Table 7. IBC Seismic Design Parameters

Parameter	**Short Period (T_s = 0.2 second)**	**1 Second Period (T_1 = 1.0 second)**
MCE Spectral Acceleration, S	S_s = 1.257 g	S_1 = 0.482 g
Site Class	E	
Site Coefficient, F	F_a = 0.9	F_v = 2.40
Adjusted Spectral Acceleration, S_M	S_{MS} = 1.131 g	S_{M1} = 1.156 g
Design Spectral Response Acceleration Parameters, S_D	S_{DS} = 0.754 g	S_{D1} = 0.771 g
Design PGA, S_{aPGA}	0.45 g	

Liquefaction can be defined as the sudden loss of shear strength in a soil due to an excessive buildup of pore water pressure. Liquefied soil layers generally follow a path of least resistance to dissipate pore pressures, often resulting in sudden surface settlement, sand boils or ejections, and/or lateral spreading in extreme cases. Clean, loose, uniform or silty, fine-grained, saturated sand is particularly susceptible to liquefaction. Lateral spreading is a liquefaction-related seismic hazard. Areas subject to lateral spreading are typically gently sloping or flat sites underlain by liquefiable sediment adjacent to an open face, such as riverbanks. Liquefied soil adjacent to open faces may “flow” in that direction, resulting in lateral displacement and surface cracking.

The alluvium underlying the site is susceptible to liquefaction when subjected to an earthquake. Based on the results of the analysis, we estimate 1 into to 4 inches of liquefaction-induced settlement is possible at the site under the design-level event. We note that the soil at the site is interbedded with silty soil that will strain soften, and we expect actual settlement to be less than predicted. We anticipate differential settlement will be on the order of one-half of the total settlement.

6.0 CONSTRUCTION CONSIDERATIONS

6.1 SOFT GROUND

The on-site soil is unsuitable for support of heavy construction traffic. We anticipate low ground pressure equipment will need to be used during the initial stages of subgrade preparation along the trail alignment. The use of low ground pressure equipment during earthwork construction should be included in the project specifications. Once the initial lift of fill over the reinforced subgrade is placed, we anticipate construction traffic will not be limited to low ground pressure equipment.

6.2 EXCAVATION

Excavations into the native soil will be readily accomplished with conventional earthwork equipment. During the wet season the area along the alignment can be inundated with surface water. Groundwater was encountered in all our borings between 0.1 feet and 1 foot BGS and the area was underwater beginning in December 2017. Dewatering should be anticipated in all excavations. Some sloughing and caving should be expected in excavations because of the soft peat material. In cases where internal dewatering is not sufficient or where “running sand” is encountered, external wells may be required for deeper excavations. The walls of excavations greater than 4 feet deep should be no steeper than 1.5H1V unless adequate shoring is provided. Excavation walls should be sloped to 2H:1V or flatter if workers are required to enter.

Dewatering should be capable of maintaining groundwater levels at least 2 feet below the base of excavations. Flow rates for dewatering can likely vary depending on location, soil type, and the season in which the excavation occurs. The dewatering systems should be capable of adapting to variable flows. Pumped groundwater should be treated in accordance with local ordinances before flowing back into the ditch or the river.

All excavations should be made in accordance with applicable OSHA and state regulations. The contractor should be aware of and familiar with applicable local, state, and federal safety regulations, including current OSHA excavation and trench safety standards. While we have described certain approaches to the utility vault and trench excavations in the foregoing discussions, the contractor is responsible for selecting the excavation and dewatering methods, monitoring the trench excavations for safety, and providing shoring as required to protect personnel and adjacent slopes or improvements.

6.3 PERMANENT SLOPES

Permanent unreinforced fill slopes should not exceed 2H:1V. With the exception of surface landscape material, all fill for permanent slopes should be placed as recommended for structural fill. Slopes should be planted with appropriate vegetation as soon as possible after grading to provide protection against erosion.

If these permanent fill slope inclinations cannot be accommodated or reduction in wetland areas to be affected is necessary, steeper inclinations can be obtained using reinforced soil slopes as discussed in the “Reinforced Soil Slope” section.

6.4 MATERIALS

The near-surface soil throughout the alignment is anticipated to consist of peat, which is not suitable on site for use as fill. Recommended fill materials are described below.

6.4.1 Structural Fill – Embankment

Structural fill should be naturally occurring pit- or quarry-run rock, crushed rock, or crushed gravel and sand and should meet the specifications provided in WSS 9-03.14(1) – Gravel Borrow, with the exception that the percentage passing the U.S. Standard No. 200 sieve does not exceed 5 percent by dry weight. The reduced percentage passing the U.S. Standard No. 200 sieve results in a material less susceptible to deteriorating under wet weather conditions.

The WSDOT Aggregate Source Approval certificates should not be used as acceptance that the material coming from the pit meets gradation or performance requirements. Confirmation sampling and testing should be performed on all proposed aggregate.

The use of granular, free-draining material will increase the workability of the material during the wet season and the likelihood that the material can be placed and adequately compacted.

Structural fill should be placed in lifts with a maximum uncompacted thickness of 12 inches and compacted to not less than 95 percent of the maximum dry density, as determined by ASTM D1557. During the wet season or when wet subgrade conditions exists, the initial lift should be approximately 18 inches in uncompacted thickness and should be compacted by rolling with a smooth-drum roller without using vibratory action.

6.4.2 Stabilization Material

Stabilization material for use as the initial lift of embankment fill, to stabilize soft subgrade areas, or to backfill over-excavations should consist of the following:

- WSS 9-03.9(2) – Permeable Ballast, or
- WSS 9-13.7(2) - Backfill for Rock Wall

The material should have a maximum particle size of 4 inches, have less than 5 percent by dry weight passing the U.S. Standard No. 4 sieve, and have at least two mechanically fractured faces. The initial lift of stabilization material used to fill over-excavations should be 18 inches thick and compacted to a firm condition. Successive lifts should be 12 inches thick and compacted to a dense and unyielding condition.

6.5 GEOSYNTHETICS

Geotextiles are recommended for subgrade stabilization, reinforcement, and separation. The geotextiles should be installed in conformance with the specifications provided in WSS 2-12 – Construction Geosynthetic.

6.5.1 Stabilization Geotextile

A geosynthetic to provide subgrade stabilization, reinforcement, and separation is recommended below shallow foundations and fill embankments where soft subgrade conditions are present. This stabilization geotextile can consist of a two-layer system composed of a geogrid, such as

Tensar TX-160 (base course fill material), TX150L (permeable ballast), or TX190L (backfill for rock walls fill materials), and underlain by a non-woven geotextile filter fabric, such as Mirafi 160N. Alternatively, a layer of a heavy-duty geotextile for reinforcement, separation, and drainage, such as Mirafi® RS380i/RS580i or similar materials, can be used.

7.0 OBSERVATION OF CONSTRUCTION

Recommendations provided in this report assume that GeoDesign, Inc. will be retained to provide geotechnical consultation and observation services during construction. A member of our geotechnical staff should observe the exposed subgrade along the trail after mowing of the grass along the trail alignment and prior to the placement of stabilization geotextile. We should also observe the exposed subgrade for bridge areas after stripping, site cutting, and over-excavation have been completed to determine if there are areas of unsuitable or unstable soil.

Subsurface conditions observed during construction should be compared with those encountered during the subsurface explorations. Recognition of changed conditions often requires site-specific experience; therefore, GeoDesign personnel should visit the site with sufficient frequency to detect whether subsurface conditions change significantly from those anticipated and to verify that the work is completed in accordance with the construction drawings and specifications.

Observation and laboratory testing of the proposed fill materials should be completed to verify that proposed fill materials are in conformance with our recommendations. Observation of the placement and compaction of the fill should be performed to verify it meets the required compaction and will be capable of providing the structural support for the proposed infrastructure. A sufficient number of in-place density tests should be performed as the fill is placed to verify the required relative compaction is being achieved.

8.0 LIMITATIONS

We have prepared this report for use by the City of Pacific, KPG,P.S., and their consultants in design of this project. The data and report can be used for bidding or estimating purposes, but our report, conclusions, and interpretations should not be construed as warranty of the subsurface conditions and are not applicable to other nearby building sites.

Exploration observations indicate soil conditions only at specific locations and only to the depths penetrated. They do not necessarily reflect soil strata or water level variations that may exist between exploration locations. If subsurface conditions differing from those described are noted during the course of excavation and construction, re-evaluation will be necessary.

The site development plans and design details were preliminary at the time this report was prepared. If design changes are made, we request that we be retained to review our conclusions and recommendations and to provide a written modification or verification.

The scope of our services does not include services related to construction safety precautions and our recommendations are not intended to direct the contractor's methods, techniques, sequences, or procedures, except as specifically described in our report for consideration in design.

Within the limitations of scope, schedule, and budget, our services have been executed in accordance with generally accepted practices in this area at the time the report was prepared. No warranty, express or implied, should be understood.

◆ ◆ ◆

We appreciate the opportunity to be of continued service to you. Please call if you have questions concerning this report or if we can provide additional services.

Sincerely,

GeoDesign, Inc.

DRAFT

Ben Weinberg, E.I.T.
Geotechnical Staff

DRAFT

Kevin J. Lamb, P.E.
Principal Engineer

REFERENCES

ASTM, 2012. *Annual Book of ASTM Standards*, Vol. 4.08, Soil and Rock (1): D420-D4914, Philadelphia: American Society for Testing and Materials.

Booth, D.B., Waldron, H.H., Troost, K.G., 2004, Geologic Map of the Poverty Bay 7.5' Quadrangle, King and Pierce Counties, Washington: U.S. Geologic Survey Scientific Investigations Map SIM-2854, scales 1:24,000 (available at: https://pubs.usgs.gov/sim/2004/2854/)

Johnson, S.Y., S.V. Dadisman, J.R. Childs, and W.D. Stanley, 1999*, Active Tectonics of the Seattle Fault and Central Puget Sound, Washington: Implications for earthquake hazards,*: GSA Bulletin, v. 111, no. 7, p. 1042-1053.

Landau, 2011. *Draft Geotechnical Report of Interurban Trail Extension; Pacific, Washington,* dated June 3, 2011.

Sherrod, B.L., T.M. Brocher, C.S. Weaver, R.C. Bucknam, R.J. Blakely, H.M. Kelsey, A.R. Nelson, and R. Haugerud, 2004, *Holocene fault scarps near Tacoma, Washington*, *Geology*, 32, p. 9-12.

Washington State Department of Transportation, 2016. Standard Specifications for Road, Bridge, and Municipal Construction. M 41-10.

FIGURES

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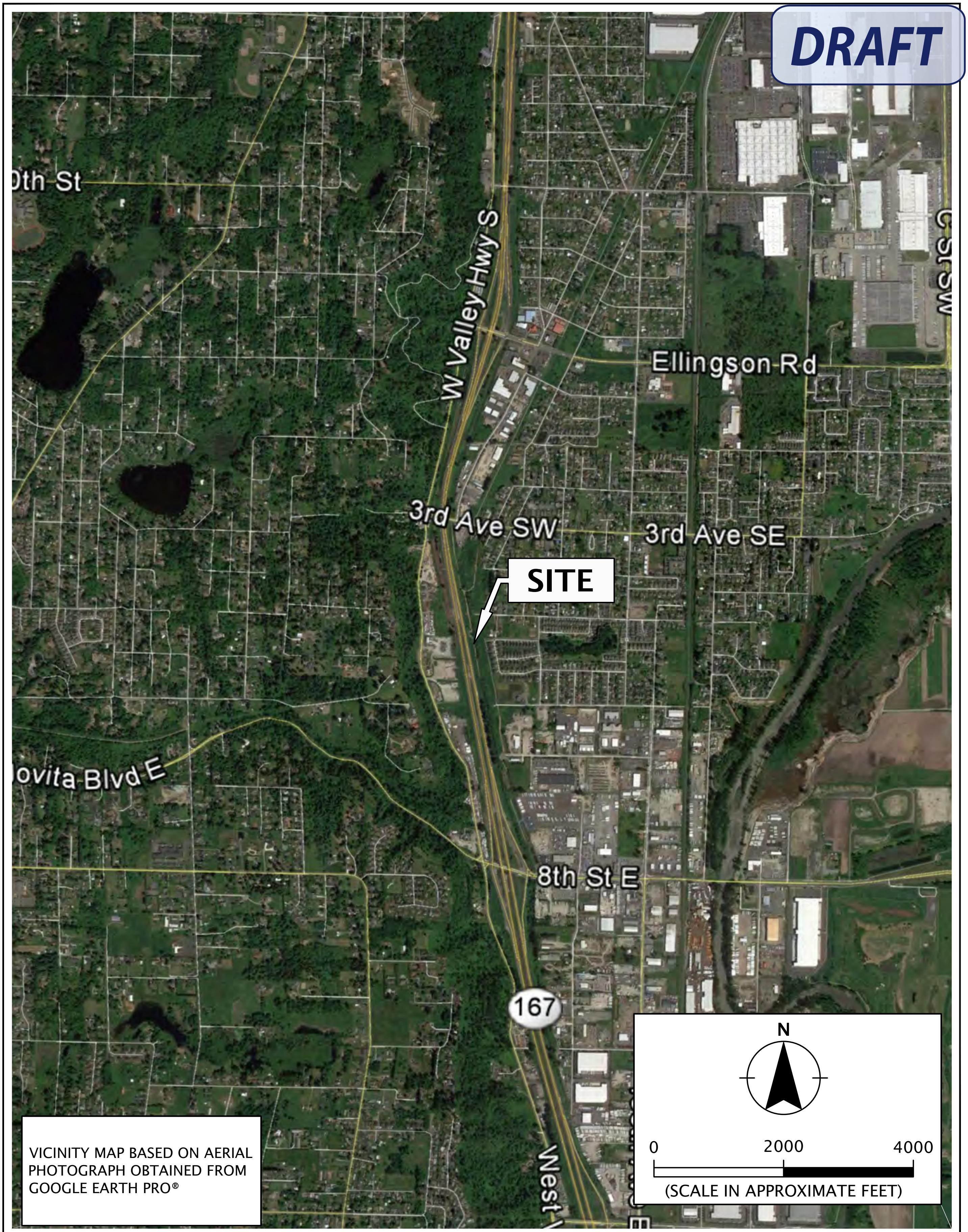

VICINITY MAP BASED ON AERIAL PHOTOGRAPH OBTAINED FROM GOOGLE EARTH PRO®

GEODESIGN INC 2502 Jefferson Avenue Tacoma WA 98402 253.203.0095 www.geodesigninc.com	KPG-80-01	**VICINITY MAP**	
	JANUARY 2018	INTERURBAN TRAIL IMPROVEMENTS PACIFIC, WA	**FIGURE 1**

Printed By: mmiller | Print Date: 1/22/2018 8:11:52 AM
File Name: J:\E-L\KPG\KPG-80\KPG-80-01\Figures\CAD\KPG-80-01-VM01.dwg | Layout: FIGURE 1

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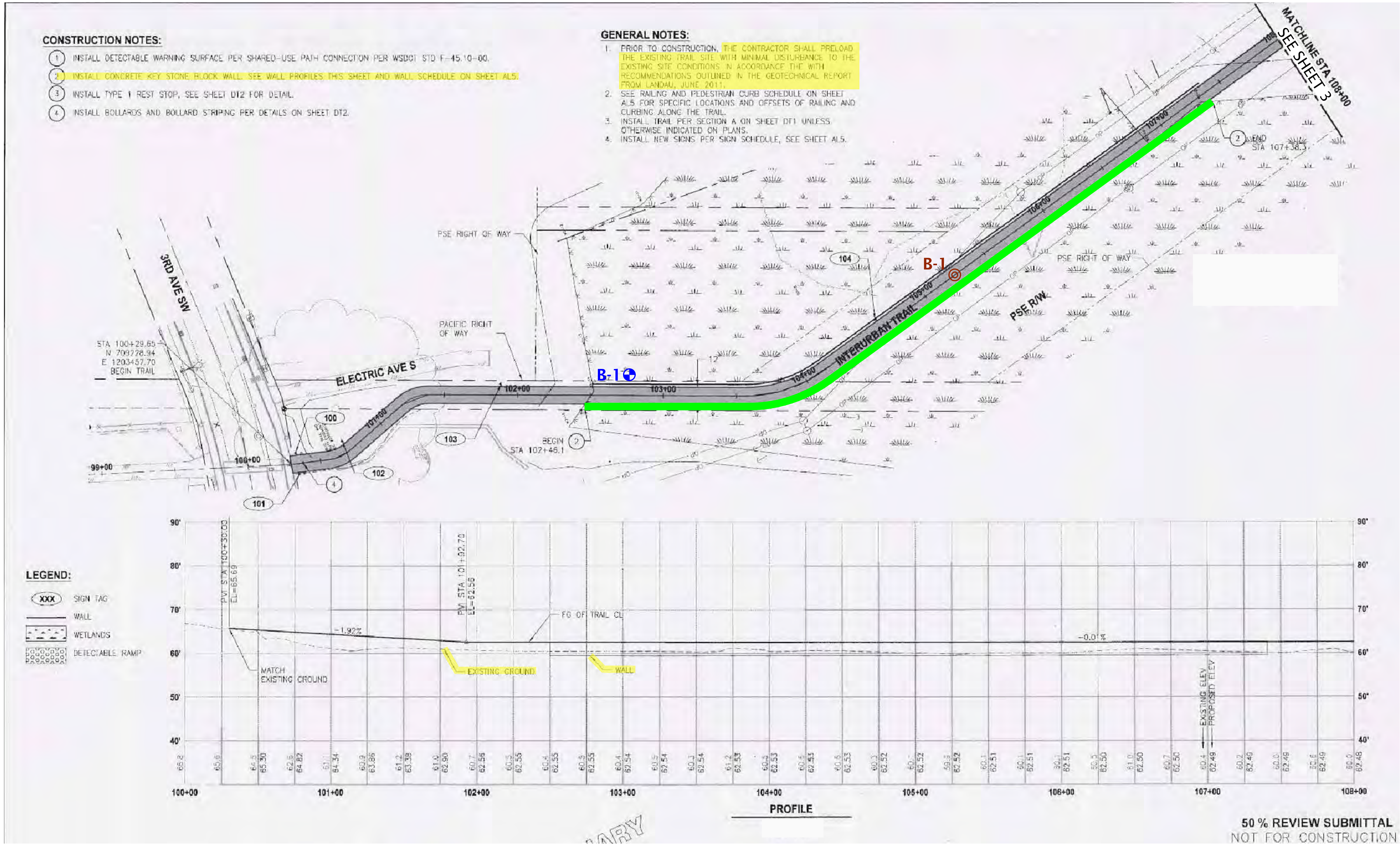

CONSTRUCTION NOTES:

① INSTALL DETECTABLE WARNING SURFACE PER SHARED-USE PATH CONNECTION PER WSDOT STD F-45.10-00.
② INSTALL CONCRETE KEY STONE BLOCK WALL. SEE WALL PROFILES THIS SHEET AND WALL SCHEDULE ON SHEET AL5.
③ INSTALL TYPE 1 REST STOP, SEE SHEET DT2 FOR DETAIL.
④ INSTALL BOLLARDS AND BOLLARD STRIPING PER DETAILS ON SHEET DT2.

GENERAL NOTES:

1. PRIOR TO CONSTRUCTION, THE CONTRACTOR SHALL PRELOAD THE EXISTING TRAIL SITE WITH MINIMAL DISTURBANCE TO THE EXISTING SITE CONDITIONS IN ACCORDANCE THE WITH RECOMMENDATIONS OUTLINED IN THE GEOTECHNICAL REPORT FROM LANDAU, JUNE 2011.
2. SEE RAILING AND PEDESTRIAN CURB SCHEDULE ON SHEET AL5 FOR SPECIFIC LOCATIONS AND OFFSETS OF RAILING AND CURBING ALONG THE TRAIL.
3. INSTALL TRAIL PER SECTION A ON SHEET DT1 UNLESS OTHERWISE INDICATED ON PLANS.
4. INSTALL NEW SIGNS PER SIGN SCHEDULE, SEE SHEET AL5.

LEGEND:

🟩	PROPOSED WALL
B-1◕	BORING (GEODESIGN 2017)
B-1◎	PRIOR BORING (LANDAU 2011)

N

0 80 160

(SCALE IN FEET)

SITE PLAN BASED ON IMAGE OBTAINED FROM
PARAMETRIX, JULY 21, 2017

PLAN AND PROFILE VIEW - STA 100+00 TO STA 108+00

INTERURBAN TRAIL IMPROVEMENTS
PACIFIC, WA

FIGURE 2

KPG-80-01

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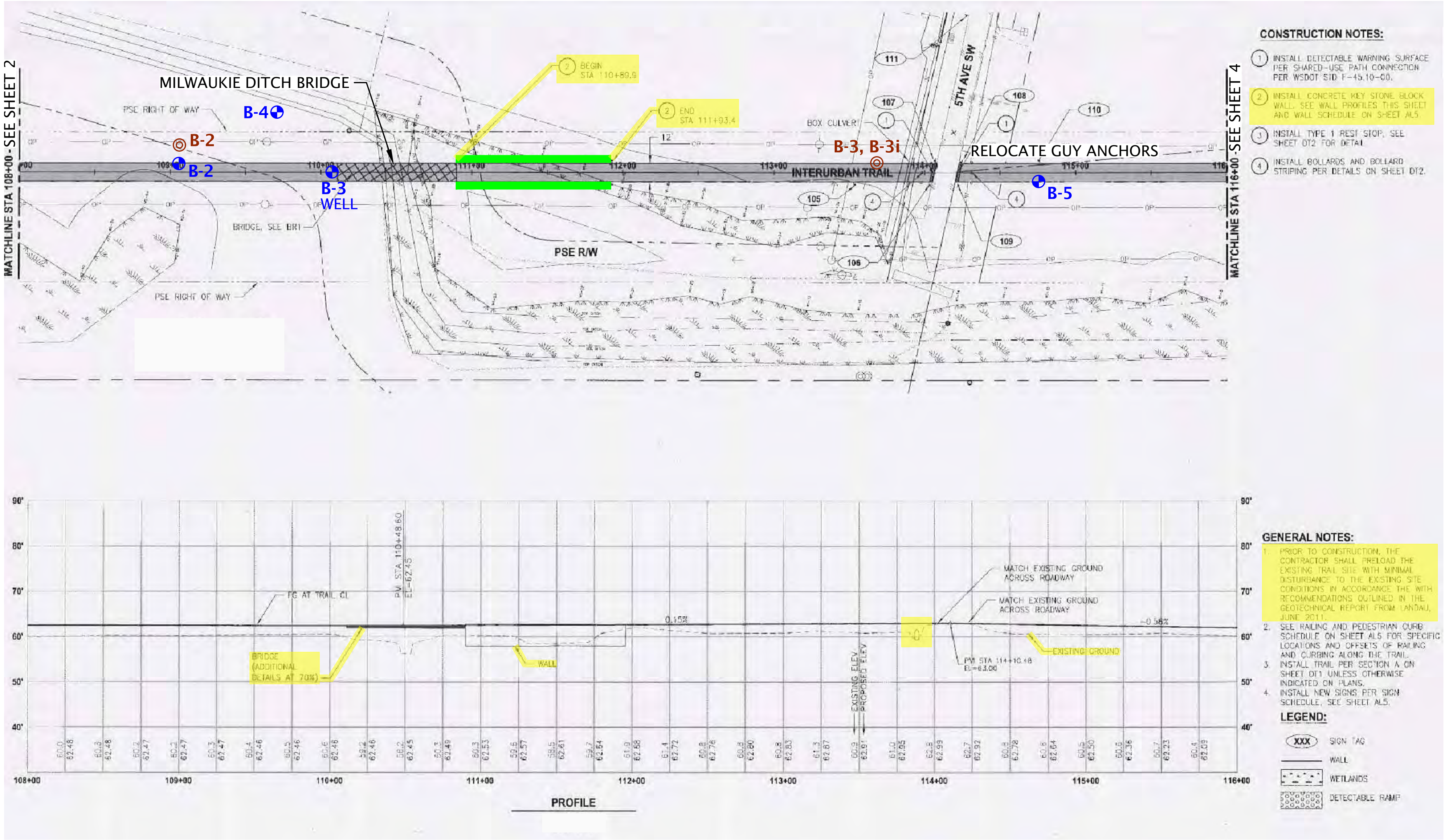


CONSTRUCTION NOTES:

① INSTALL DETECTABLE WARNING SURFACE PER SHARED-USE PATH CONNECTION PER WSDOT STD F-45.10-00.

② INSTALL CONCRETE KEY STONE BLOCK WALL. SEE WALL PROFILES THIS SHEET AND WALL SCHEDULE ON SHEET AL5.

③ INSTALL TYPE 1 REST STOP. SEE SHEET DT2 FOR DETAIL.

④ INSTALL BOLLARDS AND BOLLARD STRIPING PER DETAILS ON SHEET DT2.

GENERAL NOTES:

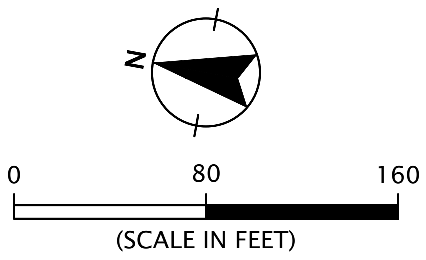
1. PRIOR TO CONSTRUCTION, THE CONTRACTOR SHALL PRELOAD THE EXISTING TRAIL SITE WITH MINIMAL DISTURBANCE TO THE EXISTING SITE CONDITIONS IN ACCORDANCE THE WITH RECOMMENDATIONS OUTLINED IN THE GEOTECHNICAL REPORT FROM LANDAU, JUNE 2011.
2. SEE RAILING AND PEDESTRIAN CURB SCHEDULE ON SHEET AL5 FOR SPECIFIC LOCATIONS AND OFFSETS OF RAILING AND CURBING ALONG THE TRAIL.
3. INSTALL TRAIL PER SECTION A ON SHEET DT1 UNLESS OTHERWISE INDICATED ON PLANS.
4. INSTALL NEW SIGNS PER SIGN SCHEDULE, SEE SHEET AL5.

LEGEND:

XXX	SIGN TAG
—	WALL
▨	WETLANDS
▨	DETECTABLE RAMP

LEGEND:

🟩	PROPOSED WALL
B-2 ◕	BORING (GEODESIGN 2017)
B-2 ◎	PRIOR BORING (LANDAU 2011)



SITE PLAN BASED ON IMAGE OBTAINED FROM
PARAMETRIX, JULY 21, 2017

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FIGURE 3

PLAN AND PROFILE VIEW - STA 108+00 TO STA 116+00

INTERURBAN TRAIL IMPROVEMENTS
PACIFIC, WA

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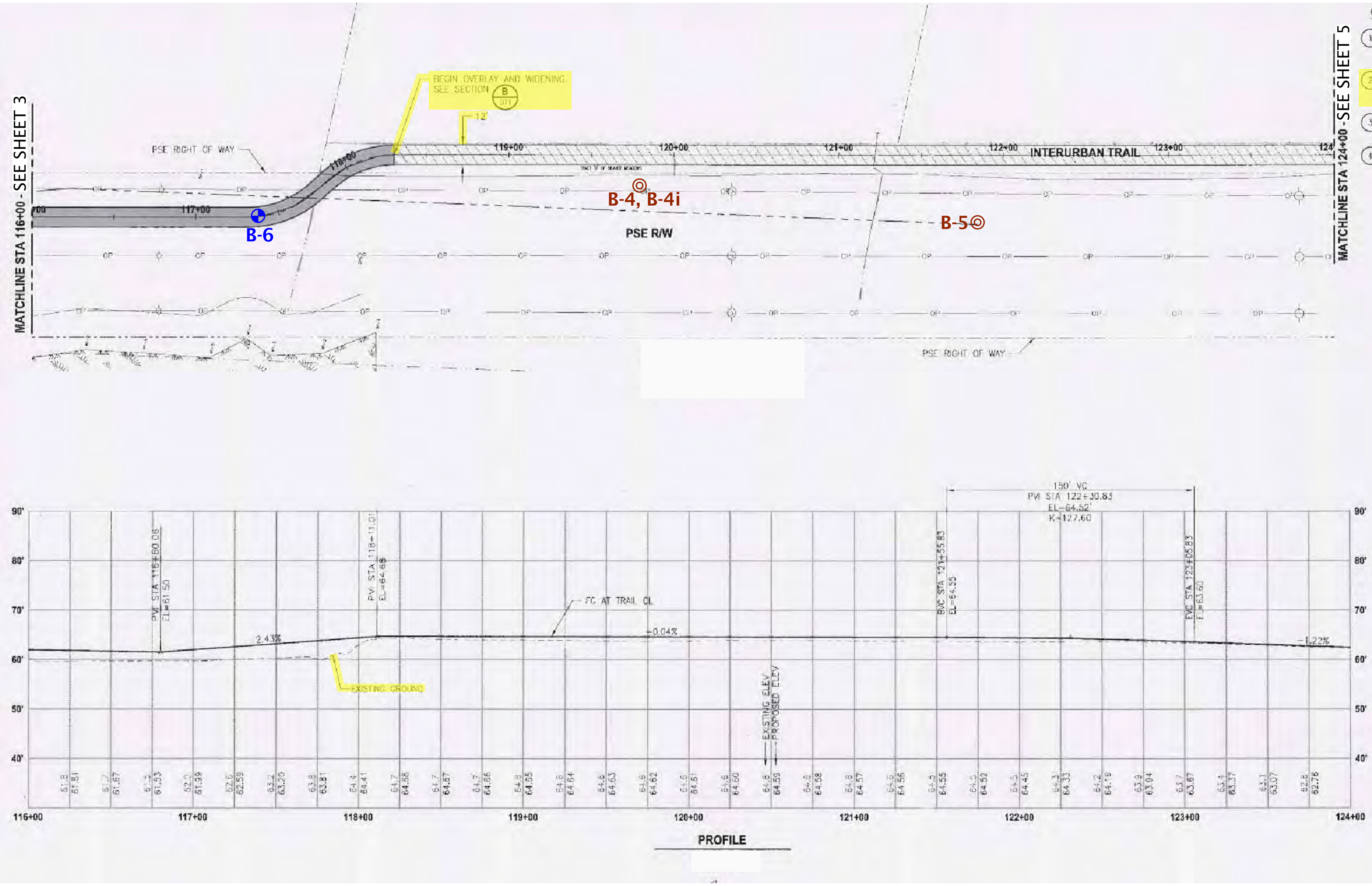


CONSTRUCTION NOTES:

① INSTALL DETECTABLE WARNING SURFACE PER SHARED-USE PATH CONNECTION PER WSDOT STD F-45.10-00.

② INSTALL CONCRETE KEY STONE BLOCK WALL. SEE WALL PROFILES THIS SHEET AND WALL SCHEDULE ON SHEET AL5.

③ INSTALL TYPE 1 REST STOP, SEE SHEET DT2 FOR DETAIL.

④ INSTALL BOLLARDS AND BOLLARD STRIPING PER DETAILS ON SHEET DT2.

GENERAL NOTES:

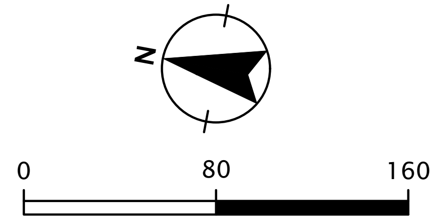
1. PRIOR TO CONSTRUCTION, THE CONTRACTOR SHALL PRELOAD THE EXISTING TRAIL SITE WITH MINIMAL DISTURBANCE TO THE EXISTING SITE CONDITIONS IN ACCORDANCE THE WITH RECOMMENDATIONS OUTLINED IN THE GEOTECHNICAL REPORT FROM LANDAU, JUNE 2011.
2. SEE RAILING AND PEDESTRIAN CURB SCHEDULE ON SHEET AL5 FOR SPECIFIC LOCATIONS AND OFFSETS OF RAILING AND CURBING ALONG THE TRAIL.
3. INSTALL TRAIL PER SECTION A ON SHEET DT1 UNLESS OTHERWISE INDICATED ON PLANS.
4. INSTALL NEW SIGNS PER SIGN SCHEDULE, SEE SHEET AL5.

LEGEND:

(XXX)	SIGN TAG
―	WALL
▨	WETLANDS
▨	DETECTABLE RAMP

LEGEND:

B-6●	BORING (GEODESIGN 2017)
B-4◎	PRIOR BORING (LANDAU 2011)



SITE PLAN BASED ON IMAGE OBTAINED FROM PARAMETRIX, JULY 21, 2017

FIGURE 4

PLAN AND PROFILE VIEW - STA 116+00 TO STA 124+00

INTERURBAN TRAIL IMPROVEMENTS
PACIFIC, WA

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CONSTRUCTION NOTES:

1. INSTALL DETECTABLE WARNING SURFACE PER SHARED-USE PATH CONNECTION PER WSDOT STD F-45.10-00.
2. INSTALL CONCRETE KEY STONE BLOCK WALL. SEE WALL PROFILES THIS SHEET AND WALL SCHEDULE ON SHEET AL5.
3. INSTALL TYPE 1 REST STOP. SEE SHEET DT2 FOR DETAIL.
4. INSTALL BOLLARDS AND BOLLARD STRIPING PER DETAILS ON SHEET DT2.

GENERAL NOTES:

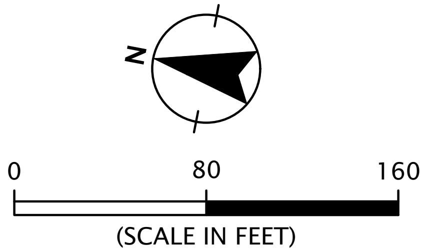
1. PRIOR TO CONSTRUCTION, THE CONTRACTOR SHALL PRELOAD THE EXISTING TRAIL SITE WITH MINIMAL DISTURBANCE TO THE EXISTING SITE CONDITIONS IN ACCORDANCE THE WITH RECOMMENDATIONS OUTLINED IN THE GEOTECHNICAL REPORT FROM LANDAU, JUNE 2011.
2. SEE RAILING AND PEDESTRIAN CURB SCHEDULE ON SHEET AL5 FOR SPECIFIC LOCATIONS AND OFFSETS OF RAILING AND CURBING ALONG THE TRAIL.
3. INSTALL TRAIL PER SECTION A ON SHEET DT1 UNLESS OTHERWISE INDICATED ON PLANS.
4. INSTALL NEW SIGNS PER SIGN SCHEDULE, SEE SHEET AL5.

LEGEND:

XXX	SIGN TAG
―	WALL
▨	WETLANDS
▨	DETECTABLE RAMP

LEGEND:

🟩	PROPOSED WALL
B-7◕	BORING (GEODESIGN 2017)
B-6p◎	PRIOR BORING (LANDAU 2011)



SITE PLAN BASED ON IMAGE OBTAINED FROM PARAMETRIX, JULY 21, 2017

FIGURE 5

PLAN AND PROFILE VIEW - STA 124+00 TO STA 132+00

INTERURBAN TRAIL IMPROVEMENTS
PACIFIC, WA

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CONSTRUCTION NOTES:

① INSTALL DETECTABLE WARNING SURFACE PER SHARED-USE PATH CONNECTION PER WSDOT STD F-45.10-00.

② INSTALL CONCRETE KEY STONE BLOCK WALL. SEE WALL PROFILES THIS SHEET AND WALL SCHEDULE ON SHEET AL5.

③ INSTALL TYPE I REST STOP, SEE SHEET DT2 FOR DETAIL.

④ INSTALL BOLLARDS AND BOLLARD STRIPING PER DETAILS ON SHEET DT2.

GENERAL NOTES:

1. PRIOR TO CONSTRUCTION, THE CONTRACTOR SHALL PRELOAD THE EXISTING TRAIL SITE WITH MINIMAL DISTURBANCE TO THE EXISTING SITE CONDITIONS IN ACCORDANCE THE WITH RECOMMENDATIONS OUTLINED IN THE GEOTECHNICAL REPORT FROM LANDAU, JUNE 2011.
2. SEE RAILING AND PEDESTRIAN CURB SCHEDULE ON SHEET AL5 FOR SPECIFIC LOCATIONS AND OFFSETS OF RAILING AND CURBING ALONG THE TRAIL.
3. INSTALL TRAIL PER SECTION A ON SHEET DT1 UNLESS OTHERWISE INDICATED ON PLANS.
4. INSTALL NEW SIGNS PER SIGN SCHEDULE, SEE SHEET AL5.

PROFILE

SIGN SCHEDULE							
SIGN NUMBER	APPROX. STATION	APPROX. OFFSET	DESCRIPTION	MUTCD SIGN CODE	SIGN SIZE	POST SIZE	REMARK
100	-	8'	STOP	R1-1	18x18	4"x4" WOOD	NEW SIGN AND POST
101	-	8'	INTERURBAN TRAIL SIGN	CUSTOM	30x30	4"x4" WOOD	NEW SIGN AND POST
102	-	8'	STOP AHEAD	W3-1	18x18	4"x4" WOOD	NEW SIGN AND POST
103		8'	CURVE AHEAD	W1-4	18x18	4"x4" WOOD	NEW SIGN AND POST
104	-	8'	CURVE AHEAD	W1-4	18x18	4"x4" WOOD	NEW SIGN AND POST
105		8	STOP AHEAD	W3-1	18x18	4"x4" WOOD	NEW SIGN AND POST
106	-	8'	STOP	R1-1	18x18	4"x4" WOOD	NEW SIGN AND POST
107	-	8	TRAIL AHEAD	W11-15, W11-15P	18x18, 18x12	4"x4" WOOD	NEW SIGN AND POST
108		8	STOP	R1-1	18x18	4"x4" WOOD	NEW SIGN AND POST
109		8	INTERURBAN TRAIL SIGN	CUSTOM	30x30	4"x4" WOOD	NEW SIGN AND POST
110	-	8	STOP AHEAD	W3-1	18x18	4"x4" WOOD	NEW SIGN AND POST
111	-	8'	TRAIL AHEAD	W11-15, W11-15P	18x18, 18x12	4"x4" WOOD	NEW SIGN AND POST
112		8'	TRAIL AHEAD	W11-15, W11-15P	18x18, 18x12	4"x4" WOOD	NEW SIGN AND POST
113	-	8'	INTERURBAN TRAIL SIGN	CUSTOM	30x30	4"x4" WOOD	NEW SIGN AND POST
114		8'	STOP	R1-1	18x18	4"x4" WOOD	NEW SIGN AND POST
115	-	8	STOP AHEAD	W3-1	18x18	4"x4" WOOD	NEW SIGN AND POST
116	-	8	INTERURBAN TRAIL SIGN	CUSTOM	30x30	4"x4" WOOD	NEW SIGN AND POST

GENERAL NOTES — TO BE COMPLETED AT 70%.

1. STATION AND OFFSET ARE TAKEN FROM CL OF TRAIL TO EDGE OF SIGN
2. WOOD POSTS SHALL CONFORM WITH ___
3. ALL PEDESTRAIN OR BICYLE WARNING SIGNS FOR DRIVERS SHALL BE FLUORSCENT YELLOW GREEN.
4. ALL SIGNS SHALL FOLLOW THE 2009 MUTCD MANUAL.

LEGEND:

(XXX)	SIGN TAG
───	WALL
▨	WETLANDS
▦	DETECTABLE RAMP

WALL SCHEDULE					
	STATION				
WALL #	BEGIN	END	OFFSET	APPROX. WALL HEIGHT (FT) (EXPOSED FACE)	CUT/FILL
1	-	-	LT	-	-
2	-	-	RT	-	-
3	-	-		-	-
4	-	-		-	-
5	-	-		-	-
6	-	-		-	-
7				-	-
8	-	-		-	-
9	-	-		-	-
10	-	-		-	-
11	-	-		-	-
12	-	-		-	-
13					-
14	-	-		-	-
15	-	-		-	-
16	-	-		-	-
17				-	-
18	-	-		-	-

TO BE COMPLETED AT 70%.

PEDESTRAIN 4" CURB			
STATION BEGIN	STATION END	OFFSET	NOTE
-	-	6.0'	
-	-	6.0'	
-	-	6.0'	
		6.0'	
-	-	6.0'	
	-	6.0'	
-	-	6.0'	
-	-	6.0'	
-	-	6.0'	
-	-	6.0'	
-	-	6.0'	
-	-	6.0'	
-	-	6.0'	
-	-	6.0'	
		6.0'	
-	-	6.0'	
-	-	6.0'	
-	-	6.0'	

PEDESTRAIN RAILING			
STATION BEGIN	STATION END	OFFSET	NOTE
-	-	6.0'	
-	-	6.0'	
		6.0'	
-	-	6.0'	
-	-	6.0'	
-	-	6.0'	
		6.0'	
-	-	6.0'	
-	-	6.0'	
-	-	6.0'	
		6.0'	
-	-	6.0'	
-	-	6.0'	
-	-	6.0'	
		6.0'	
-	-	6.0'	
-	-	6.0'	
-	-	6.0'	

LEGEND:

B-8p◎	PRIOR BORING (LANDAU 2011)

N

0 80 160

(SCALE IN FEET)

SITE PLAN BASED ON IMAGE OBTAINED FROM PARAMETRIX, JULY 21, 2017

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FIGURE 6

PLAN AND PROFILE VIEW - STA 132+00 TO STA 137+00

INTERURBAN TRAIL IMPROVEMENTS
PACIFIC, WA

KPG-80-01

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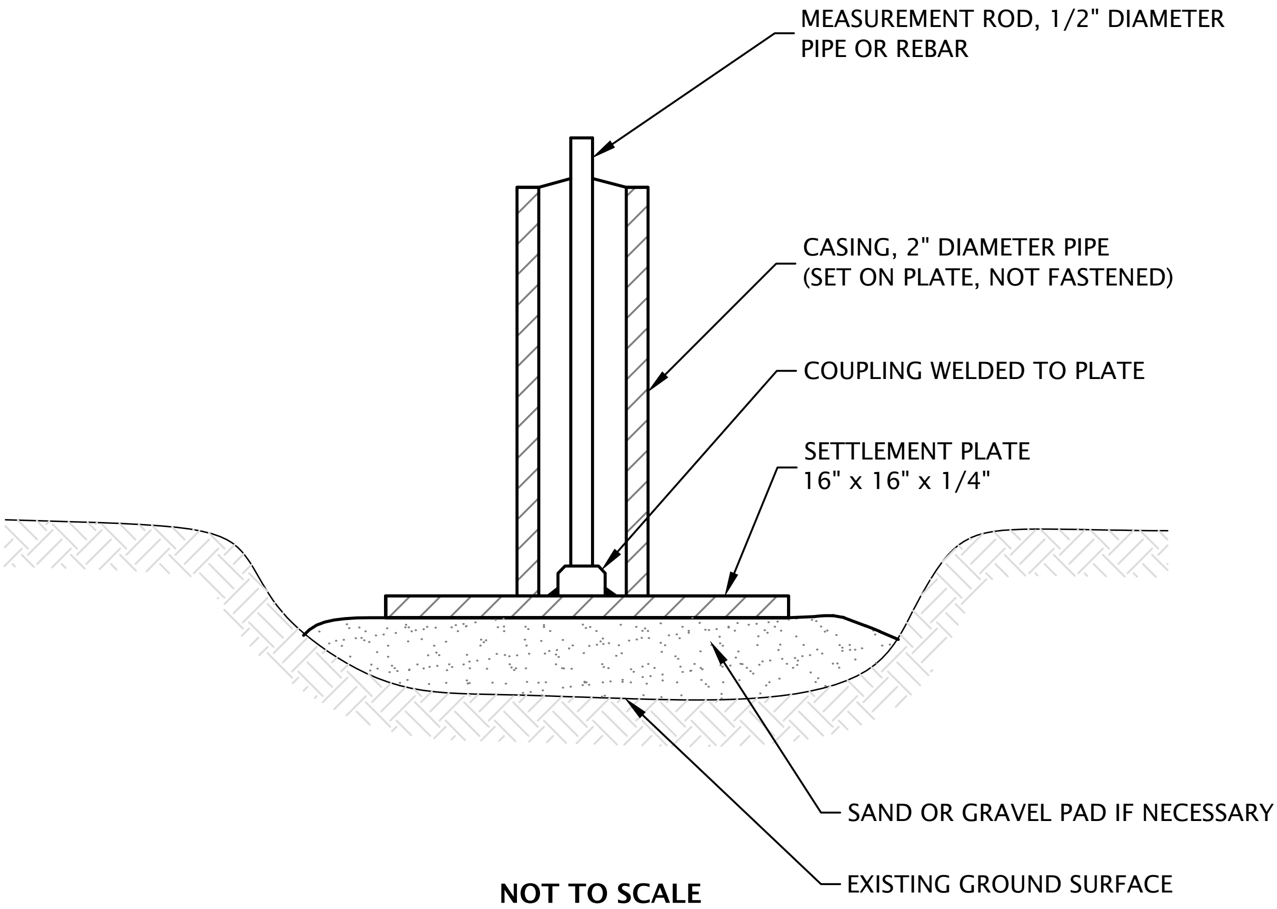

NOTES:

1. INSTALL MARKERS ON FIRM GROUND OR ON SAND OR GRAVEL PADS IF NEEDED FOR STABILITY. TAKE INITIAL READING ON TOP OF ROD AND AT ADJACENT GROUND LEVEL PRIOR TO PLACING ANY FILL.
2. FOR EASE IN HANDLING, ROD AND CASING ARE USUALLY INSTALLED IN 5-FOOT SECTIONS. AS FILL PROGRESSES, COUPLINGS ARE USED TO INSTALL ADDITIONAL LENGTHS. CONTINUITY IS MAINTAINED BY READING THE TOP OF THE MEASUREMENT ROD, THEN IMMEDIATELY ADDING THE NEW SECTION AND READING THE TOP OF THE ADDED ROD. BOTH READINGS ARE RECORDED.
3. RECORD THE ELEVATION OF THE TOP OF THE MEASUREMENT ROD IN EACH MARKER AT THE RECOMMENDED TIME INTERVALS. EACH TIME, NOTE THE ELEVATION OF THE ADJACENT FILL SURFACE.
4. READ THE MARKER TO THE NEAREST 0.01 FOOT, OR 0.005 FOOT IF POSSIBLE. NOTE THE FILL ELEVATION TO THE NEAREST 0.1 FOOT.
5. THE ELEVATIONS SHOULD BE REFERENCED TO A TEMPORARY BENCHMARK LOCATED ON STABLE GROUND AT LEAST 100 FEET FROM THE EMBANKMENT.

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TYPICAL SETTLEMENT PLATE DETAIL

INTERURBAN TRAIL IMPROVEMENTS
PACIFIC, WA

FIGURE 7

APPENDIX A

APPENDIX A

FIELD EXPLORATIONS

GENERAL

Subsurface conditions at the site were explored by drilling eight borings (B-1 through B-8) to depths ranging between 11.5 and 41.5 feet BGS. The borings were completed on October 16 and 17, 2017 by Boretec1 of Valleyford, Washington, using a track-mounted drill rig and hollow-stem auger drilling techniques. The exploration logs are presented in this appendix. The locations of the explorations were determined in the field by using hand-held GPS equipment. This information should be considered accurate to the degree implied by the methods used.

SOIL SAMPLING

A member of our geotechnical staff observed the explorations. We collected representative samples of the various soils encountered in the explorations for geotechnical laboratory testing. Samples were collected using an SPT at 2.5-foot intervals to a depth of 10.0 feet BGS and then at 5-foot intervals. Sampling methods and intervals are shown on the exploration logs.

SOIL CLASSIFICATION

The soil samples were classified in accordance with the “Exploration Key” (Table A-1) and “Soil Classification System” (Table A-2), which are presented in this appendix. The exploration logs indicate the depths at which the soils or their characteristics change, although the change could be gradual. A horizontal line between soil types indicates an observed change. If the change was gradual the change is indicated using a dashed line. Classifications are shown on the exploration logs.

LABORATORY TESTING

CLASSIFICATION

The soil samples were classified in the laboratory to confirm field classifications. The laboratory classifications are shown on the exploration logs if those classifications differed from the field classifications.

CONSOLIDATION TESTING

Consolidation testing was performed on a select soil sample in general accordance with ASTM D2435. This test determines the magnitude and rate of consolidation of soil when it is restrained laterally and drained axially while subjected to incrementally applied controlled-stress loading. The test results are used to estimate the magnitude and rate of settlement of the site soil under a specific increase in effective stress. The test results are presented in this appendix.

GRAIN-SIZE ANALYSIS

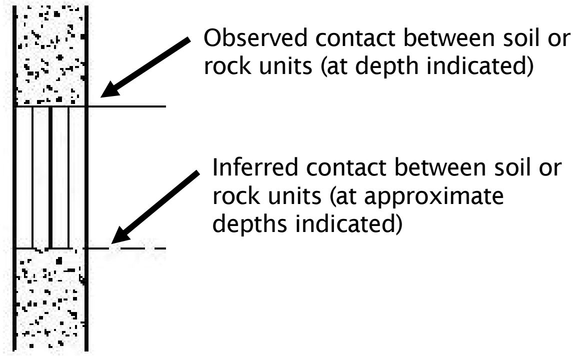
We completed grain-size testing on select soil samples in order to determine the distribution of soil particle sizes. The testing consisted of full sieve analyses completed in general accordance with ASTM C136. The test results are presented in this appendix.

MOISTURE CONTENT

We tested the moisture content of select soil samples in general accordance with ASTM D2216. The moisture content is a ratio of the weight of the water to soil in a test sample and is expressed as a percentage. The test results are presented in this appendix.

SYMBOL	SAMPLING DESCRIPTION
◧	Location of sample obtained in general accordance with ASTM D 1586 Standard Penetration Test with recovery
◨	Location of sample obtained using thin-wall Shelby tube or Geoprobe® sampler in general accordance with ASTM D 1587 with recovery
▤	Location of sample obtained using Dames & Moore sampler and 300-pound hammer or pushed with recovery
▤	Location of sample obtained using Dames & Moore and 140-pound hammer or pushed with recovery
◩	Location of sample obtained using 3-inch-O.D. California split-spoon sampler and 140-pound hammer
☒	Location of grab sample
▒	Rock coring interval
▽	Water level during drilling
▼	Water level taken on date shown

Graphic Log of Soil and Rock Types



Observed contact between soil or rock units (at depth indicated)

Inferred contact between soil or rock units (at approximate depths indicated)

GEOTECHNICAL TESTING EXPLANATIONS

ATT	Atterberg Limits	P	Pushed Sample
CBR	California Bearing Ratio	PP	Pocket Penetrometer
CON	Consolidation	P200	Percent Passing U.S. Standard No. 200 Sieve
DD	Dry Density		
DS	Direct Shear	RES	Resilient Modulus
HYD	Hydrometer Gradation	SIEV	Sieve Gradation
MC	Moisture Content	TOR	Torvane
MD	Moisture-Density Relationship	UC	Unconfined Compressive Strength
NP	Nonplastic	VS	Vane Shear
OC	Organic Content	kPa	Kilopascal

ENVIRONMENTAL TESTING EXPLANATIONS

CA	Sample Submitted for Chemical Analysis	ND	Not Detected
P	Pushed Sample	NS	No Visible Sheen
PID	Photoionization Detector Headspace Analysis	SS	Slight Sheen
		MS	Moderate Sheen
ppm	Parts per Million	HS	Heavy Sheen

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EXPLORATION KEY

TABLE A-1

RELATIVE DENSITY - COARSE-GRAINED SOILS

Relative Density	Standard Penetration Resistance	Dames & Moore Sampler (140-pound hammer)	Dames & Moore Sampler (300-pound hammer)
Very Loose	0 – 4	0 - 11	0 - 4
Loose	4 – 10	11 - 26	4 - 10
Medium Dense	10 – 30	26 - 74	10 - 30
Dense	30 – 50	74 - 120	30 - 47
Very Dense	More than 50	More than 120	More than 47

CONSISTENCY - FINE-GRAINED SOILS

Consistency	Standard Penetration Resistance	Dames & Moore Sampler (140-pound hammer)	Dames & Moore Sampler (300-pound hammer)	Unconfined Compressive Strength (tsf)
Very Soft	Less than 2	Less than 3	Less than 2	Less than 0.25
Soft	2 - 4	3 – 6	2 - 5	0.25 - 0.50
Medium Stiff	4 - 8	6 – 12	5 - 9	0.50 - 1.0
Stiff	8 - 15	12 – 25	9 - 19	1.0 - 2.0
Very Stiff	15 - 30	25 – 65	19 – 31	2.0 - 4.0
Hard	More than 30	More than 65	More than 31	More than 4.0

PRIMARY SOIL DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE-GRAINED SOILS (more than 50% retained on No. 200 sieve)	GRAVEL (more than 50% of coarse fraction retained on No. 4 sieve)	CLEAN GRAVELS (< 5% fines)	GW or GP	GRAVEL
		GRAVEL WITH FINES (≥ 5% and ≤ 12% fines)	GW-GM or GP-GM	GRAVEL with silt
			GW-GC or GP-GC	GRAVEL with clay
		GRAVELS WITH FINES (> 12% fines)	GM	silty GRAVEL
			GC	clayey GRAVEL
			GC-GM	silty, clayey GRAVEL
	SAND (50% or more of coarse fraction passing No. 4 sieve)	CLEAN SANDS (<5% fines)	SW or SP	SAND
		SANDS WITH FINES (≥ 5% and ≤ 12% fines)	SW-SM or SP-SM	SAND with silt
			SW-SC or SP-SC	SAND with clay
		SANDS WITH FINES (> 12% fines)	SM	silty SAND
			SC	clayey SAND
			SC-SM	silty, clayey SAND
FINE-GRAINED SOILS (50% or more passing No. 200 sieve)	SILT AND CLAY	Liquid limit less than 50	ML	SILT
			CL	CLAY
			CL-ML	silty CLAY
			OL	ORGANIC SILT or ORGANIC CLAY
		Liquid limit 50 or greater	MH	SILT
			CH	CLAY
			OH	ORGANIC SILT or ORGANIC CLAY
HIGHLY ORGANIC SOILS			PT	PEAT

MOISTURE CLASSIFICATION

Term	Field Test
dry	very low moisture, dry to touch
moist	damp, without visible moisture
wet	visible free water, usually saturated

ADDITIONAL CONSTITUENTS

Secondary granular components or other materials such as organics, man-made debris, etc.					
Percent	Silt and Clay In:		Percent	Sand and Gravel In:	
	Fine-Grained Soils	Coarse-Grained Soils		Fine-Grained Soils	Coarse-Grained Soils
< 5	trace	trace	< 5	trace	trace
5 – 12	minor	with	5 – 15	minor	minor
> 12	some	silty/clayey	15 – 30	with	with
			> 30	sandy/gravelly	Indicate %

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SOIL CLASSIFICATION SYSTEM

TABLE A-2

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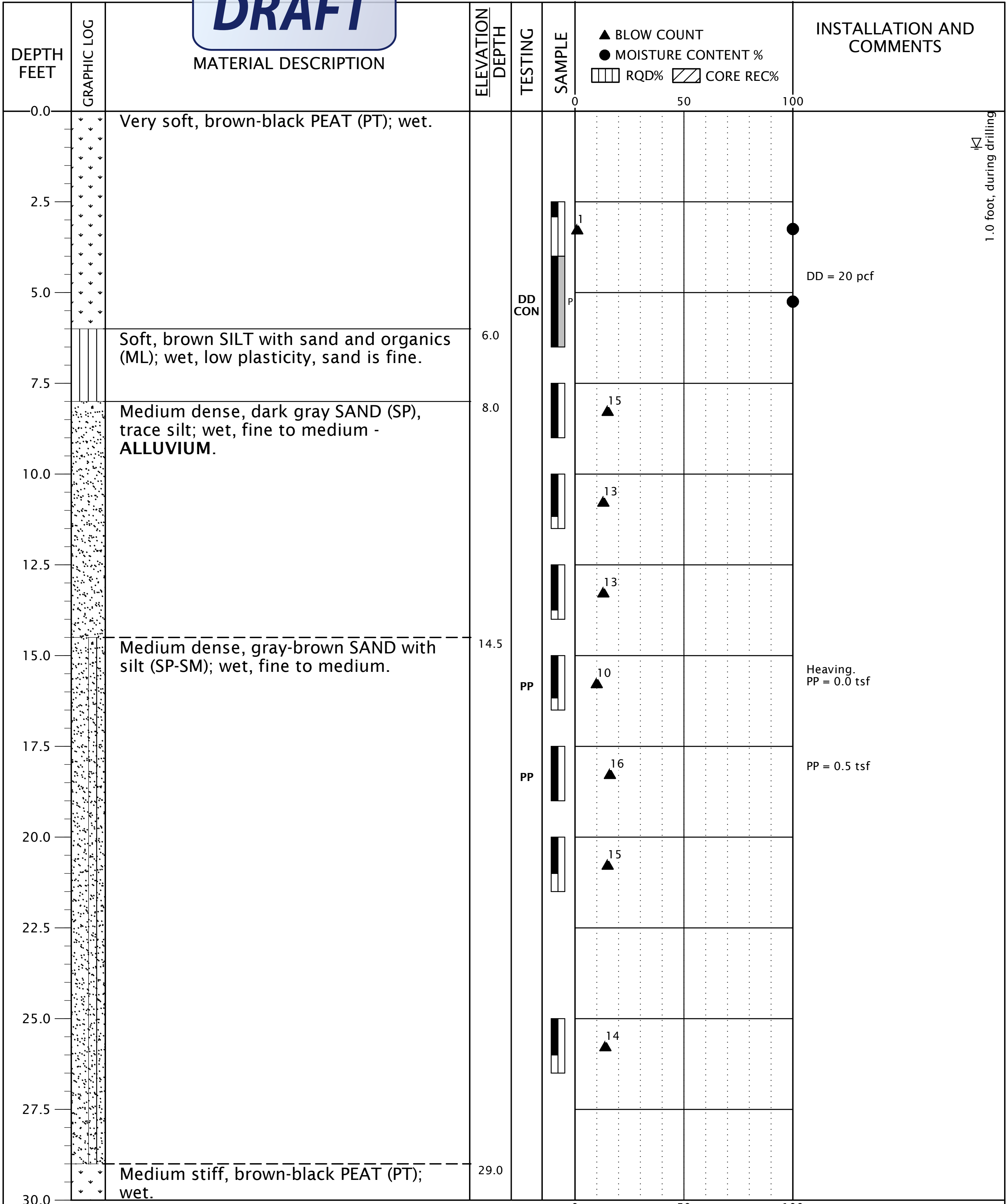

MATERIAL DESCRIPTION

INSTALLATION AND COMMENTS

Very soft, brown-black PEAT (PT); wet.

Soft, brown SILT with sand and organics (ML); wet, low plasticity, sand is fine.

Medium dense, dark gray SAND (SP), trace silt; wet, fine to medium - **ALLUVIUM**.

Medium dense, gray-brown SAND with silt (SP-SM); wet, fine to medium.

Medium stiff, brown-black PEAT (PT); wet.

1.0 foot, during drilling

DD = 20 pcf

Heaving.
PP = 0.0 tsf

PP = 0.5 tsf

DRILLED BY: Boretec®

LOGGED BY: JAM

COMPLETED: 10/16/17

BORING METHOD: hollow-stem auger (see document text)

BORING BIT DIAMETER: 6 1/4 inches

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BORING B-1

INTERURBAN TRAIL IMPROVEMENTS
PACIFIC, WA

FIGURE A-1

DRAFT

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	▲ BLOW COUNT ● MOISTURE CONTENT % ▥ RQD% ▨ CORE REC% (0 50 100)	INSTALLATION AND COMMENTS
30.0		(continued from previous page)		PP	■	8	PP = 0.5 tsf
		Medium stiff, gray SILT with organics (ML); wet, low plasticity.	31.0				
32.5							
35.0		soft; moist to wet at 35.0 feet		PP	■	3	Moderate heaving. PP = 0.5 tsf
		Dense, dark gray SAND (SP), trace silt; wet, fine to medium.	37.0				
37.5							
40.0					■	33	
		Exploration completed at a depth of 41.5 feet.	41.5				Surface elevation was not measured at the time of exploration.
42.5							
45.0							
47.5							
50.0							
52.5							
55.0							
57.5							
60.0							

DRILLED BY: Boretec®

LOGGED BY: JAM

COMPLETED: 10/16/17

BORING METHOD: hollow-stem auger (see document text)

BORING BIT DIAMETER: 6 1/4 inches

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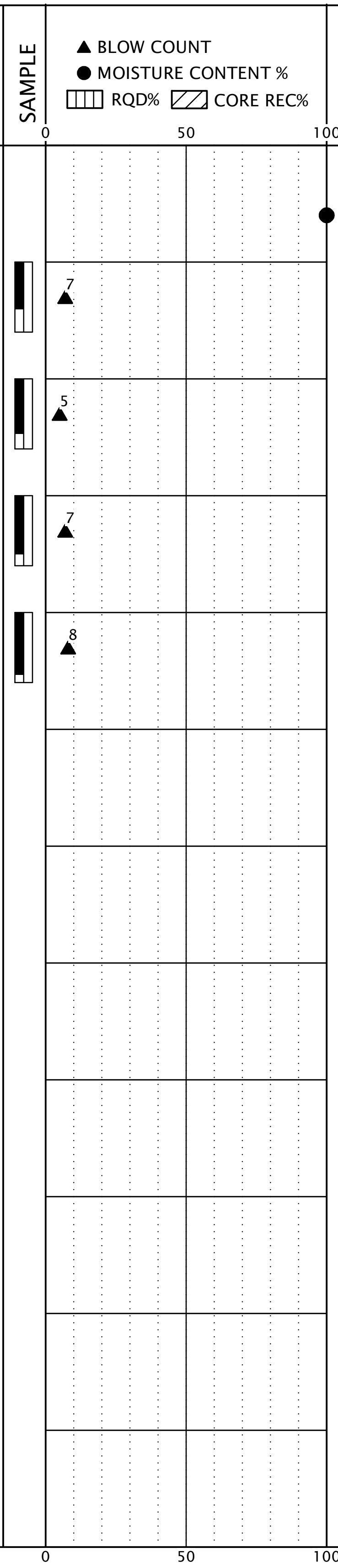
BORING B-1
(continued)

INTERURBAN TRAIL IMPROVEMENTS
PACIFIC, WA

FIGURE A-1

DRAFT

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	BLOW COUNT	INSTALLATION AND COMMENTS
0.0	Brown PEAT (PT); moist to wet (topsoil).				
2.5	Loose, gray SAND (SP), trace silt; wet, fine to medium - **ALLUVIUM**.	2.5		7	▽ ~3.5 feet, during drilling
5.0	trace organics at 5.0 feet			5	Driller Comment: groundwater, heaving at 5.0 feet.
7.5				7	
10.0	dark gray, without organics at 10.0 feet			8	
11.5	Exploration completed at a depth of 11.5 feet.	11.5			Surface elevation was not measured at the time of exploration.



DRILLED BY: Boretec®

LOGGED BY: JAM

COMPLETED: 10/16/17

BORING METHOD: hollow-stem auger (see document text)

BORING BIT DIAMETER: 6 1/4 inches

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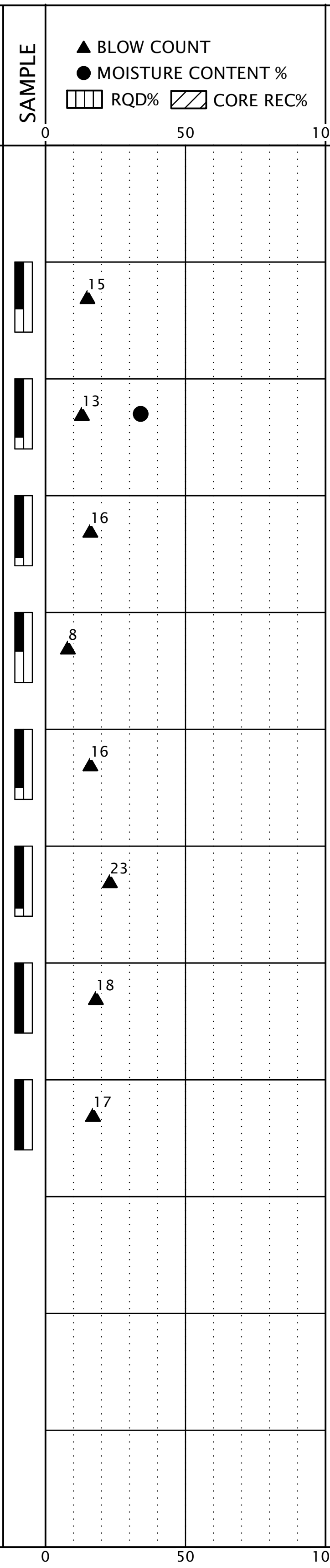
BORING B-2

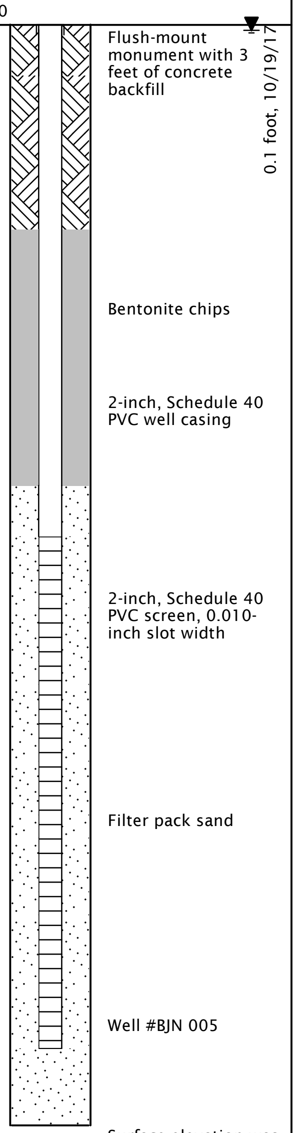
INTERURBAN TRAIL IMPROVEMENTS
PACIFIC, WA

FIGURE A-2

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING
0.0	Soft to very soft, black-brown PEAT (PT); wet.		
2.5	Medium dense, gray, silty SAND (SM); wet, fine to medium - **ALLUVIUM**.	2.5	
5.0			SIEV
7.5			
10.0	loose, dark gray at 10.0 feet		
12.5	medium dense at 12.5 feet		
15.0			
17.5			
20.0	gray at 20.0 feet		
21.5	Exploration completed at a depth of 21.5 feet.	21.5	
22.5			
25.0			
27.5			
30.0			



INSTALLATION AND COMMENTS



Flush-mount monument with 3 feet of concrete backfill

Bentonite chips

2-inch, Schedule 40 PVC well casing

2-inch, Schedule 40 PVC screen, 0.010-inch slot width

Filter pack sand

Well #BJN 005

Surface elevation was not measured at the time of exploration.

DRILLED BY: Boretec®
LOGGED BY: JAM
COMPLETED: 10/16/17

BORING METHOD: hollow-stem auger (see document text)
BORING BIT DIAMETER: 7 1/2 inches

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BORING B-3

INTERURBAN TRAIL IMPROVEMENTS
PACIFIC, WA

FIGURE A-3

▲ BLOW COUNT
● MOISTURE CONTENT %
▥ RQD% ▨ CORE REC%

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	BLOW COUNT (0 – 50 – 100)	INSTALLATION AND COMMENTS
0.0	Very soft to soft, black-brown PEAT (PT); wet.			∇ 0.3 foot, during drilling
2.5				
	Loose, gray SAND (SP), trace silt; wet, fine to medium.	3.0	7	
	Very soft, brown-black PEAT (PT); wet.	4.5		
5.0			7	
	Loose, gray SAND (SP), trace silt; wet, fine to medium - **ALLUVIUM**.	6.0		
7.5	medium dense, trace organics at 7.5 feet		14	
10.0			15	
12.5				
15.0	dark gray at 15.0 feet		15	
17.5				
	Medium dense, light gray SAND with silt (SP-SM); wet, fine.	19.0		
20.0			14	
22.5				
	Medium dense, gray SAND (SP); wet, fine to medium.	24.0		
25.0			14	
27.5				
30.0				

DRILLED BY: Boretec®
LOGGED BY: JAM
COMPLETED: 10/17/17

BORING METHOD: hollow-stem auger (see document text)
BORING BIT DIAMETER: 6 1/4 inches

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BORING B-4

INTERURBAN TRAIL IMPROVEMENTS
PACIFIC, WA

FIGURE A-4

DRAFT

▲ BLOW COUNT ● MOISTURE CONTENT % ▥ RQD% ▨ CORE REC%

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	BLOW COUNT (0–50–100)	INSTALLATION AND COMMENTS
30.0		(continued from previous page)				17	
33.0		Soft, gray SILT (ML), minor organics (rootlets); wet, low plasticity.	33.0				
35.0				PP		2	Brown streaks in sample. PP = 0.5 tsf Push Shelby, no sample/too wet at 36.5 feet.
40.0						10	
41.5		Exploration completed at a depth of 41.5 feet.	41.5				Surface elevation was not measured at the time of exploration.

DRILLED BY: Boretec®

LOGGED BY: JAM

COMPLETED: 10/17/17

BORING METHOD: hollow-stem auger (see document text)

BORING BIT DIAMETER: 6 1/4 inches

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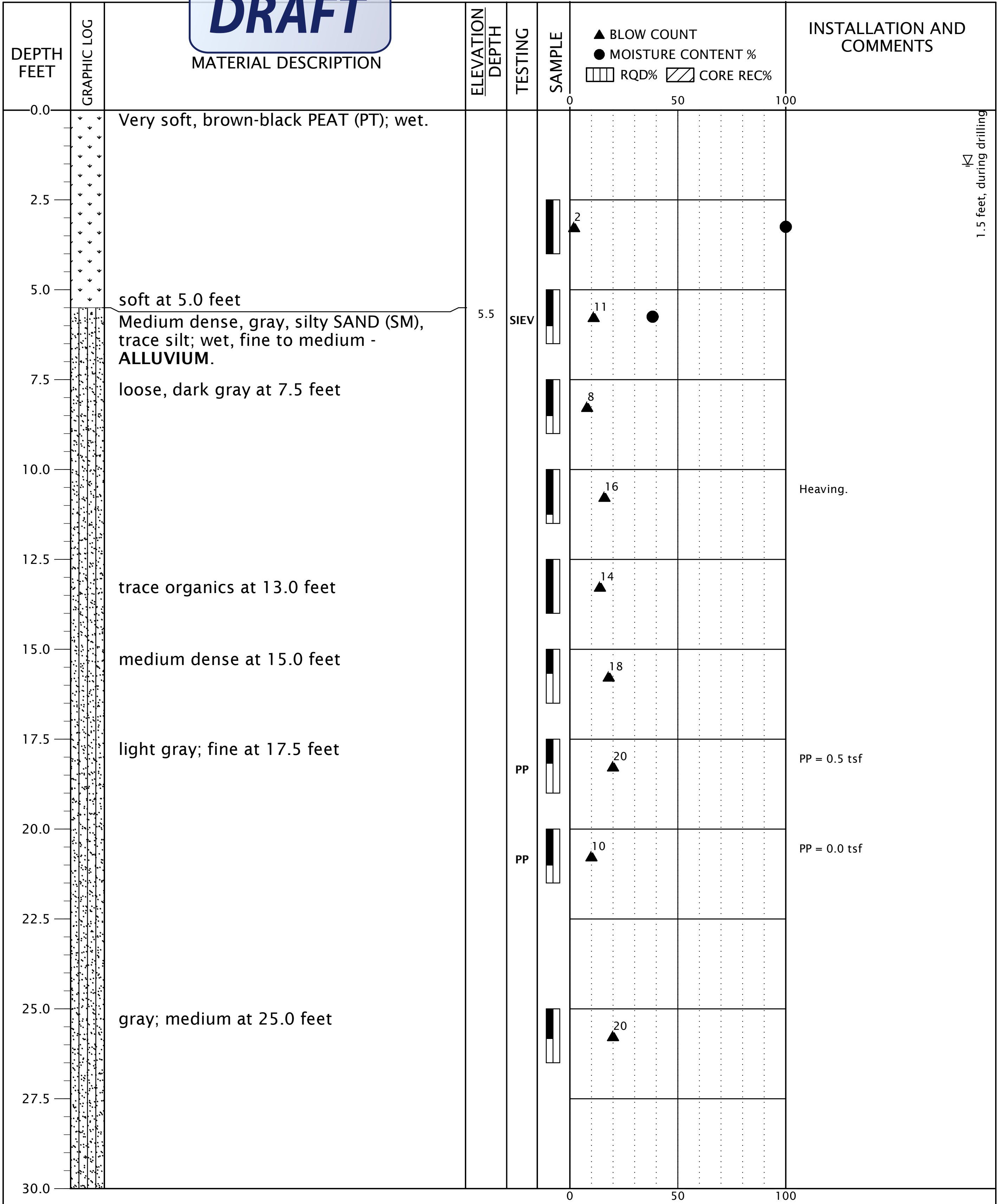
BORING B-4
(continued)

INTERURBAN TRAIL IMPROVEMENTS
PACIFIC, WA

FIGURE A-4



DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	BLOW COUNT	INSTALLATION AND COMMENTS
0.0	Very soft, brown-black PEAT (PT); wet.				⊻ 1.5 feet, during drilling
2.5				2	
5.0	soft at 5.0 feet Medium dense, gray, silty SAND (SM), trace silt; wet, fine to medium - **ALLUVIUM**.	5.5	SIEV	11	
7.5	loose, dark gray at 7.5 feet			8	
10.0				16	Heaving.
12.5	trace organics at 13.0 feet			14	
15.0	medium dense at 15.0 feet			18	
17.5	light gray; fine at 17.5 feet		PP	20	PP = 0.5 tsf
20.0			PP	10	PP = 0.0 tsf
25.0	gray; medium at 25.0 feet			20	

DRILLED BY: Boretec®　LOGGED BY: JAM　COMPLETED: 10/17/17

BORING METHOD: hollow-stem auger (see document text)　BORING BIT DIAMETER: 6 1/4 inches

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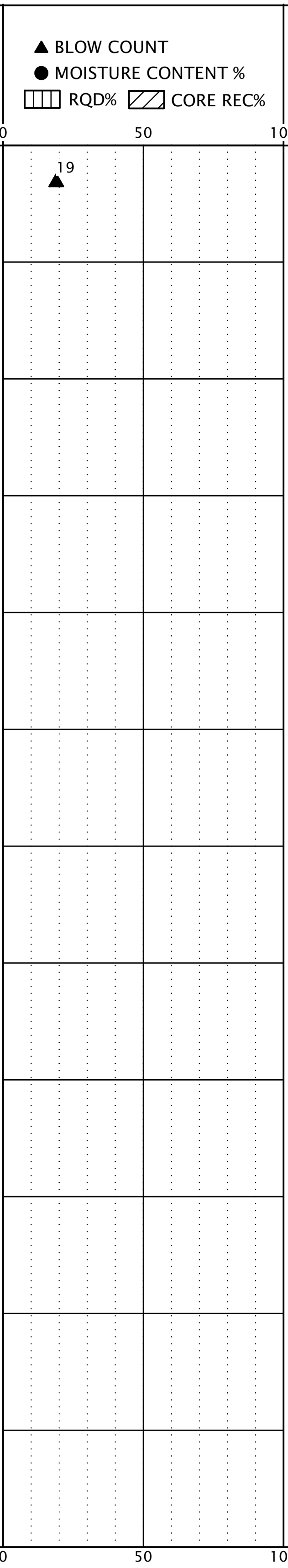
BORING B-5

INTERURBAN TRAIL IMPROVEMENTS
PACIFIC, WA

FIGURE A-5

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	INSTALLATION AND COMMENTS
30.0		fine to medium at 30.0 feet				
		Exploration completed at a depth of 31.5 feet.	31.5			Surface elevation was not measured at the time of exploration.
32.5						
35.0						
37.5						
40.0						
42.5						
45.0						
47.5						
50.0						
52.5						
55.0						
57.5						
60.0						



DRILLED BY: Boretec®

LOGGED BY: JAM

COMPLETED: 10/17/17

BORING METHOD: hollow-stem auger (see document text)

BORING BIT DIAMETER: 6 1/4 inches

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BORING B-5
(continued)

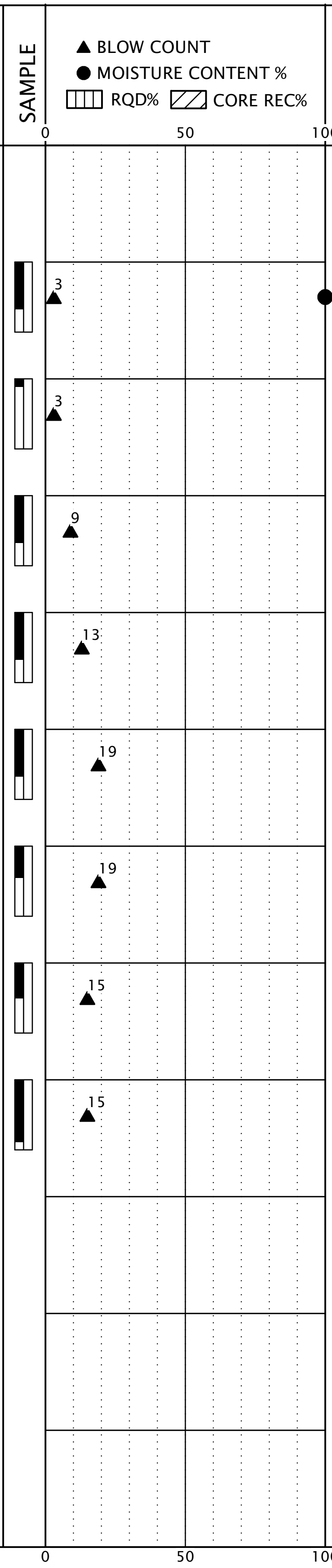
INTERURBAN TRAIL IMPROVEMENTS
PACIFIC, WA

FIGURE A-5

BORING LOG KPG-80-01-B1_8.GPJ GEODESIGN.GDT PRINT DATE: 1/22/18:RC:KT

DRAFT

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	INSTALLATION AND COMMENTS
0.0	Soft, dark brown PEAT (PT); wet.			⊻ 1.0 foot, during drilling
5.0			PP	PP = 0.0 tsf
	Loose, gray SAND with silt (SP-SM); wet.	6.3		Likely transition to clean sand.
	Soft, dark brown PEAT (PT); wet.	7.0		
7.5	Medium dense, gray SAND (SP), trace silt; wet, fine to medium - **ALLUVIUM**.	7.8		
10.0	dark gray at 10.0 feet			
12.5	trace organics (rootlets) at 13.0 feet			
15.0	without organics at 15.0 feet			
17.5	Medium stiff, light gray SILT (ML); wet, low plasticity.	18.0		Peat layer (less than 1 inch) at 18.0 feet.
20.0	Soft WOOD.	20.0		
	Medium dense, dark gray SAND (SP); wet, fine to medium.	20.5		
	Exploration completed at a depth of 21.5 feet.	21.5		Surface elevation was not measured at the time of exploration.



DRILLED BY: Boretec®
LOGGED BY: JAM
COMPLETED: 10/18/17

BORING METHOD: hollow-stem auger (see document text)
BORING BIT DIAMETER: 6 1/4 inches

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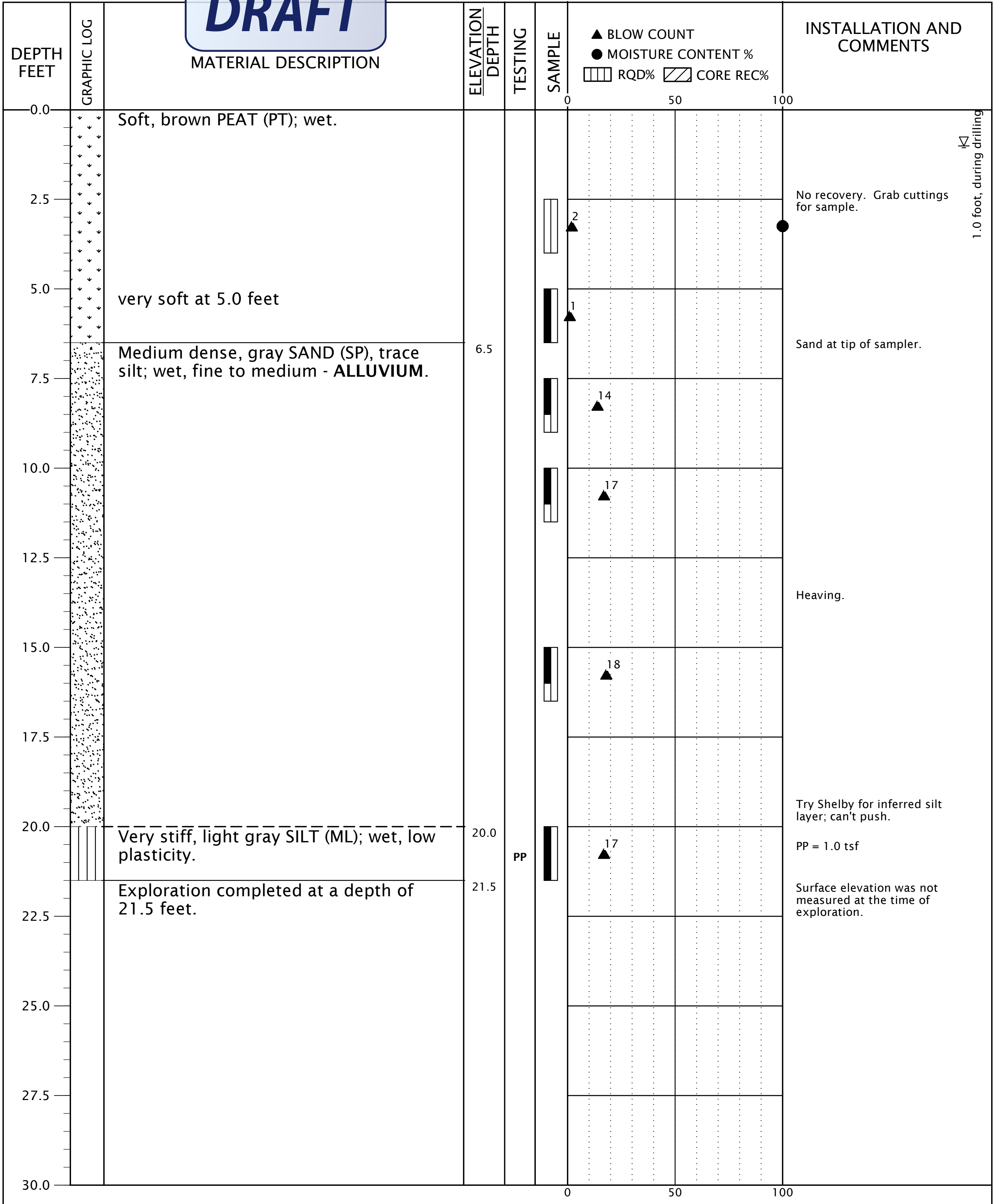
BORING B-6

INTERURBAN TRAIL IMPROVEMENTS
PACIFIC, WA

FIGURE A-6

DRAFT

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	BLOW COUNT	INSTALLATION AND COMMENTS
0.0	Soft, brown PEAT (PT); wet.				▽ 1.0 foot, during drilling
2.5				2	No recovery. Grab cuttings for sample.
5.0	very soft at 5.0 feet			1	Sand at tip of sampler.
6.5	Medium dense, gray SAND (SP), trace silt; wet, fine to medium - **ALLUVIUM**.	6.5			
7.5				14	
10.0				17	
12.5					Heaving.
15.0				18	
17.5					Try Shelby for inferred silt layer; can't push.
20.0	Very stiff, light gray SILT (ML); wet, low plasticity.	20.0	PP	17	PP = 1.0 tsf
21.5	Exploration completed at a depth of 21.5 feet.	21.5			Surface elevation was not measured at the time of exploration.



DRILLED BY: Boretec®

LOGGED BY: JAM

COMPLETED: 10/17/17

BORING METHOD: hollow-stem auger (see document text)

BORING BIT DIAMETER: 6 1/4 inches

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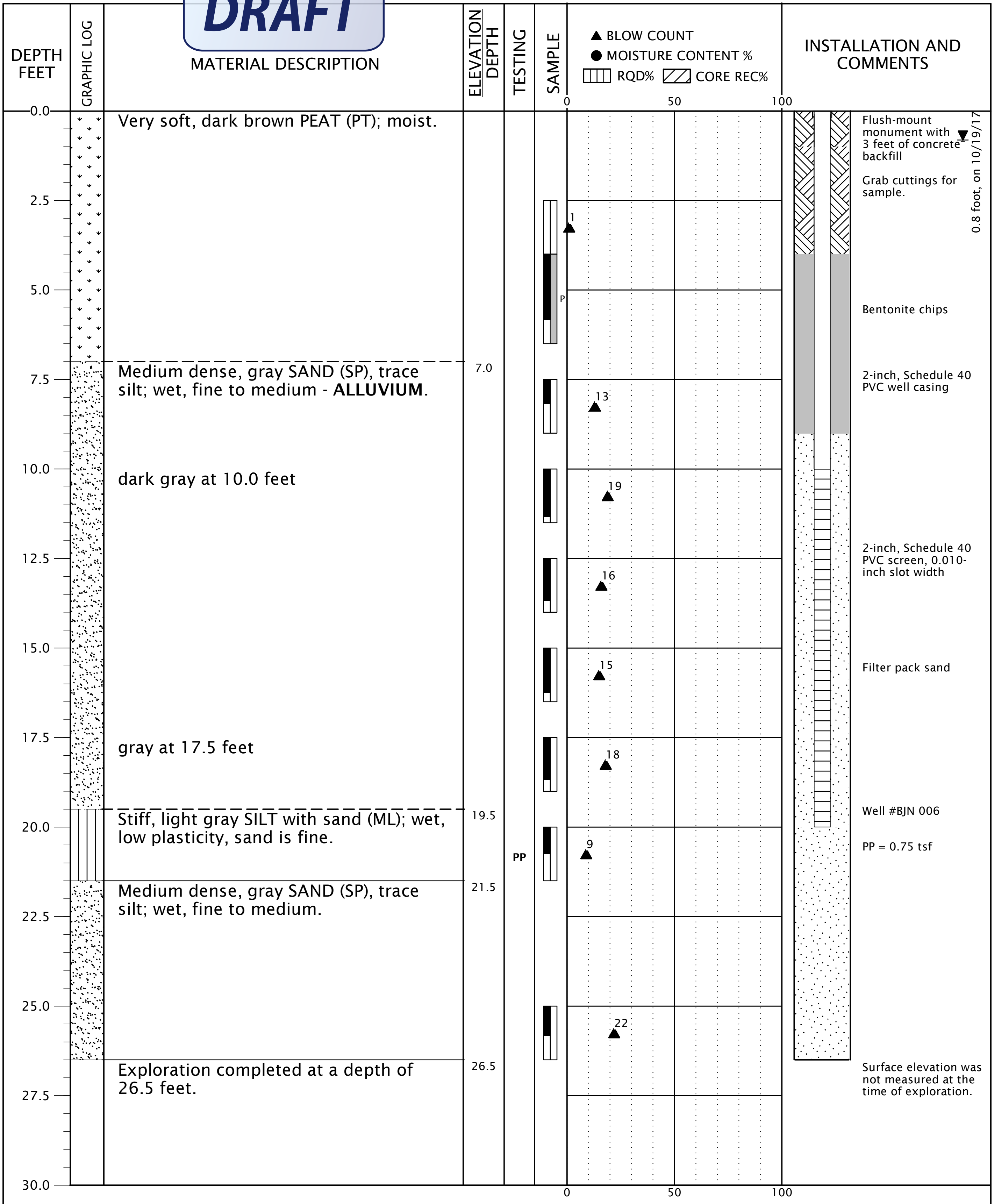
BORING B-7

INTERURBAN TRAIL IMPROVEMENTS
PACIFIC, WA

FIGURE A-7



Very soft, dark brown PEAT (PT); moist.

7.0

Medium dense, gray SAND (SP), trace silt; wet, fine to medium - **ALLUVIUM**.

dark gray at 10.0 feet

gray at 17.5 feet

19.5

Stiff, light gray SILT with sand (ML); wet, low plasticity, sand is fine.

PP

21.5

Medium dense, gray SAND (SP), trace silt; wet, fine to medium.

26.5

Exploration completed at a depth of 26.5 feet.

Flush-mount monument with 3 feet of concrete backfill

Grab cuttings for sample.

Bentonite chips

2-inch, Schedule 40 PVC well casing

2-inch, Schedule 40 PVC screen, 0.010-inch slot width

Filter pack sand

Well #BJN 006

PP = 0.75 tsf

Surface elevation was not measured at the time of exploration.

DRILLED BY: Boretec®

LOGGED BY: JAM

COMPLETED: 10/19/17

BORING METHOD: hollow-stem auger (see document text)

BORING BIT DIAMETER: 7 1/2 inches

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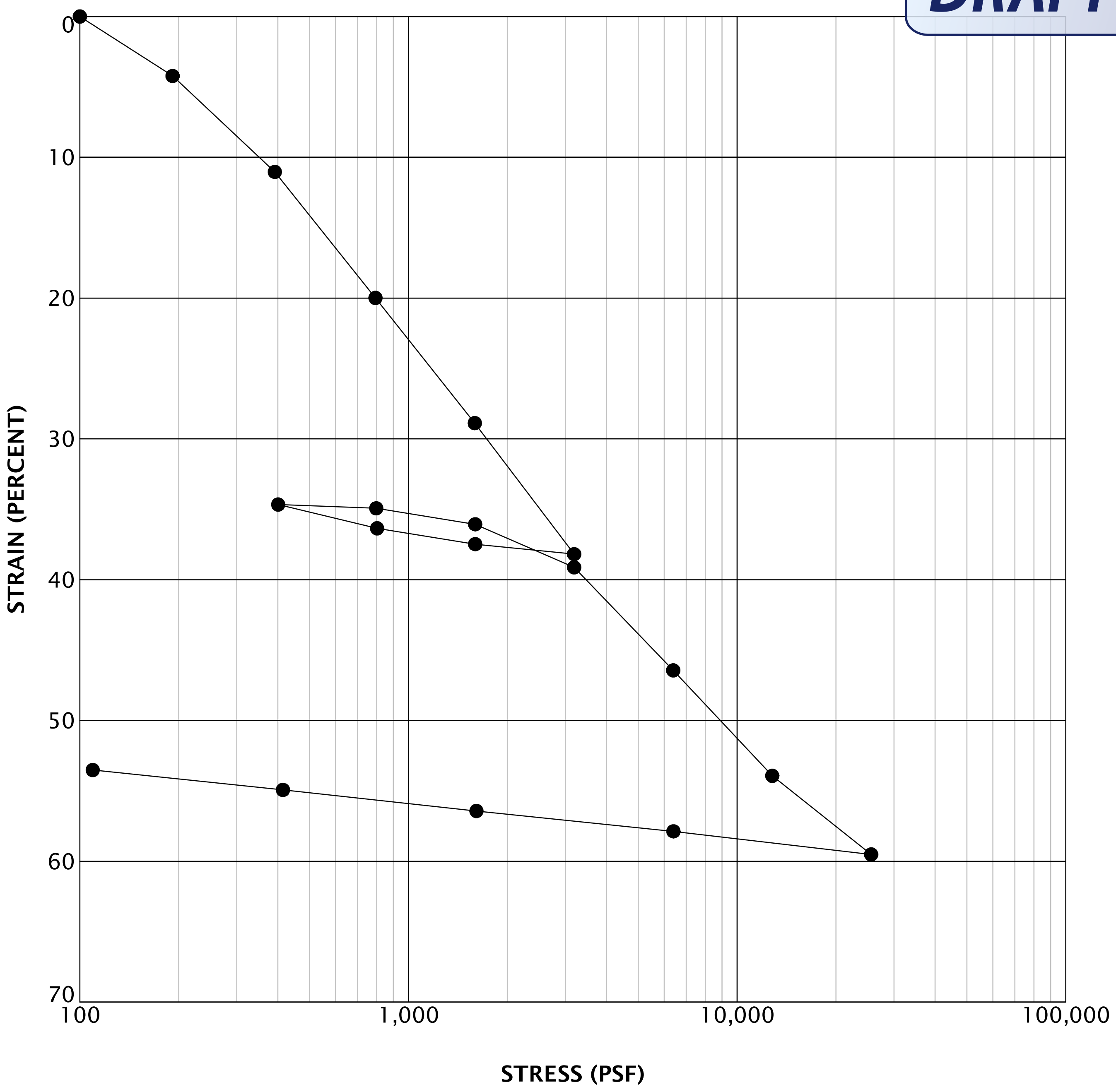
BORING B-8

INTERURBAN TRAIL IMPROVEMENTS
PACIFIC, WA

FIGURE A-8



KEY	EXPLORATION NUMBER	SAMPLE DEPTH (FEET)	MOISTURE CONTENT (PERCENT)	DRY DENSITY (PCF)
●	B-1	4.0	307	20

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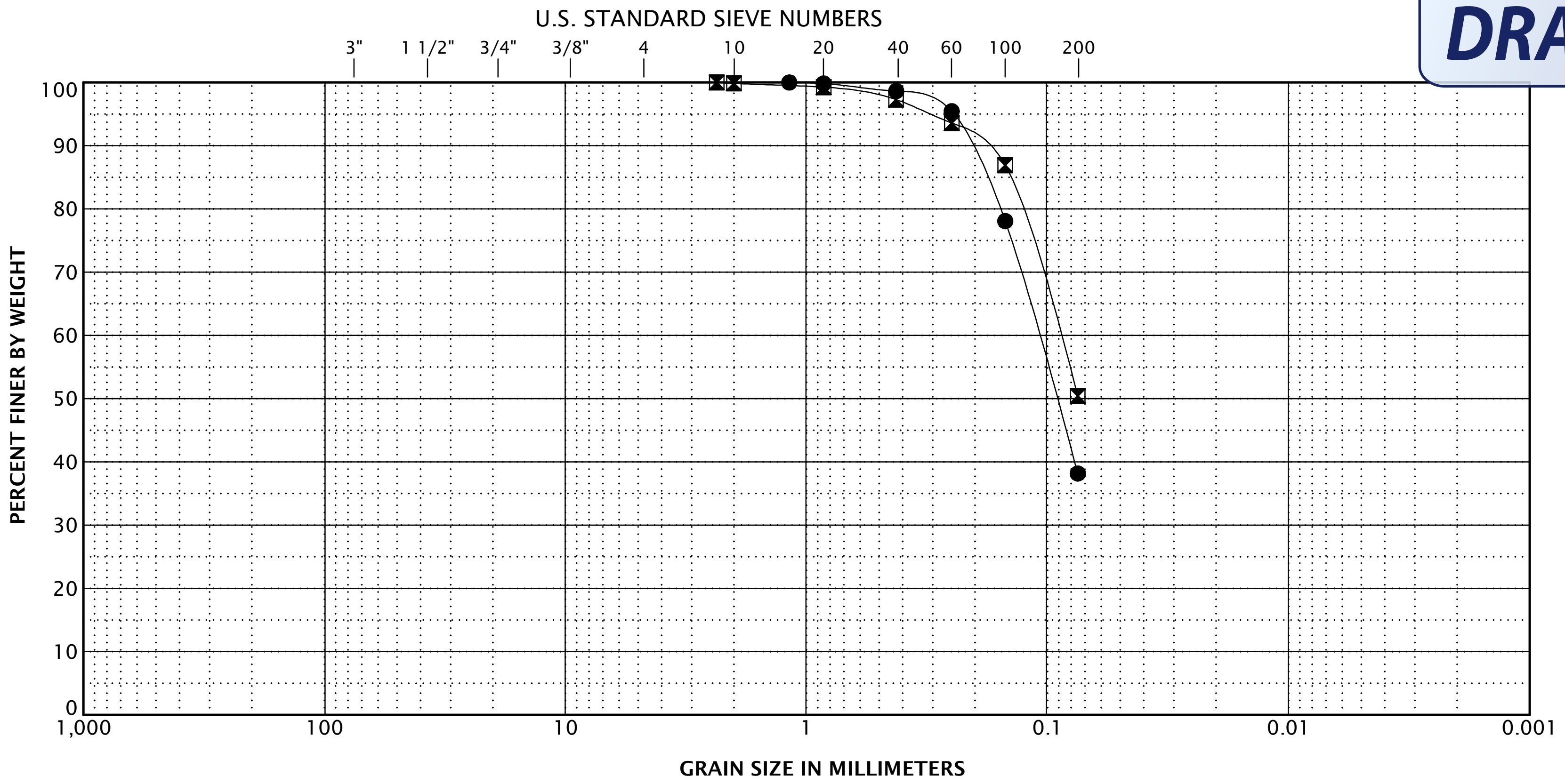
CONSOLIDATION TEST RESULTS

INTERURBAN TRAIL IMPROVEMENTS
PACIFIC, WA

FIGURE A-9

GRAIN SIZE NO P200 KPG-80-01-B1_8.GPJ GEODESIGN.GDT PRINT DATE: 1/20/18:KT



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

KEY	EXPLORATION NUMBER	SAMPLE DEPTH (FEET)	MOISTURE CONTENT (PERCENT)	D60	D50	D30	D10	D5	GRAVEL (PERCENT)	SAND (PERCENT)	SILT (PERCENT)	CLAY (PERCENT)
●	B-3	5.0	34	0.11	0.09				0	62	38	
☒	B-5	5.0	38	0.09					0	50	50	

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GRAIN-SIZE TEST RESULTS

INTERURBAN TRAIL IMPROVEMENTS
PACIFIC, WA

FIGURE A-10

SAMPLE INFORMATION			MOISTURE CONTENT (PERCENT)	DRY DENSITY (PCF)	SIEVE			ATTERBERG LIMITS		
EXPLORATION NUMBER	SAMPLE DEPTH (FEET)	ELEVATION (FEET)			GRAVEL (PERCENT)	SAND (PERCENT)	P200 (PERCENT)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
B-1	2.5		187							
B-1	4.0		307	20						
B-2	1.5		103							
B-3	5.0		34		0	62	38			
B-5	2.5		267							
B-5	5.0		38		0	50	50			
B-6	2.5		317							
B-7	2.5		234							

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SUMMARY OF LABORATORY DATA

INTERURBAN TRAIL IMPROVEMENTS
PACIFIC, WA

FIGURE A-11

APPENDIX B

B-1

LAI Project No: 193056.020

SAMPLE DATA

SOIL PROFILE

Drilling Method: Hand Auger
Ground Elevation (ft): 60.4 (NAVD88)
Drilled By: Landau Associates, Inc.
Logged By: TJS Date: 04/07/11

Moisture Content (%) Plastic Limit ●— Liquid Limit 20 40 60 80
▲ SPT N-Value ▲ △ Non-Standard N-Value △ 20 40 60 80
× Fines Content (%) × 20 40 60 80

Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	USCS Symbol	Description	Groundwater	Moisture Content (%)
0					PT	Brown, silty PEAT (very soft to soft, wet) **(ALLUVIUM)**		
	S-1	d3		W = 174				174
	S-2	d3						
2							∇	
						- grades to very silty		
	S-3A	d3		W = 251				251
					ML	Gray, sandy SILT with interbeds of PEAT (very soft to soft, wet)		
4	S-3B	d3						

Boring Completed 04/07/11
Total Depth of Boring = 4.5 ft.

6

8

10

12

14

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

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Interurban Trail Extension
Along PSE Corridor
Pacific, Washington

Log of Boring B-1

Figure
A-2

B-2

LAI Project No: 193056.020

SAMPLE DATA / SOIL PROFILE

Drilling Method: Hand Auger
Ground Elevation (ft): 60.3 (NAVD88)
Drilled By: Landau Associates, Inc.
Logged By: TJS Date: 04/07/11

Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	USCS Symbol	Description	Groundwater	Moisture Content (%)
0	S-1	d3		W = 106 GS	SM	Brown, very silty, fine to coarse SAND with peat (very loose, wet) **(ALLUVIUM)**		106
	S-2	d3		W = 125	PT	Brown PEAT with interbeds of gray SILT and silty, fine SAND (soft to medium stiff, wet)		125
2	S-3	d3					∇	
	S-4	d3		W = 398	ML	Gray SILT with 1" to 3" interbeds of PEAT (soft to medium stiff, wet)		398
4								

Moisture Content (%): Plastic Limit, Liquid Limit; 20 40 60 80
▲ SPT N-Value ▲ △ Non-Standard N-Value △ 20 40 60 80
× Fines Content (%) × 20 40 60 80

Boring Completed 04/07/11
Total Depth of Boring = 4.0 ft.

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

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Interurban Trail Extension
Along PSE Corridor
Pacific, Washington

Log of Boring B-2

Figure
A-3

B-3

LAI Project No: 193056.020

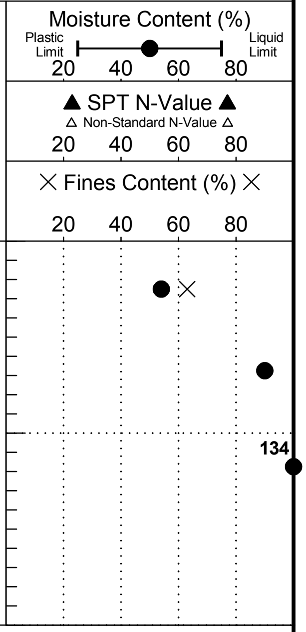
Drilling Method: Hand Auger

Ground Elevation (ft): 60.5 (NAVD88)

Drilled By: Landau Associates, Inc.

Logged By: TJS Date: 04/07/11

Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	USCS Symbol	SOIL PROFILE	Groundwater
0	S-1	d3		W = 54 GS	ML	Brown, very sandy SILT with organics (soft to medium stiff, wet) **(ALLUVIUM)**	
	S-2	d3		W = 90		- grades with PEAT interbeds	∇
2	S-3	d3		W = 134	PT	Brown, silty PEAT with 2" to 3" gray SILT layers (soft to medium stiff, wet)	
		d3					
4							



Boring Completed 04/07/11
Total Depth of Boring = 4.0 ft.

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

193056.02 6/3/11 Y:\193056.020\T\193056.020.GPJ SOIL BORING LOG WITH GRAPH

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Interurban Trail Extension
Along PSE Corridor
Pacific, Washington

Log of Boring B-3

Figure
A-4

B-4

LAI Project No: 193056.020

SAMPLE DATA / SOIL PROFILE

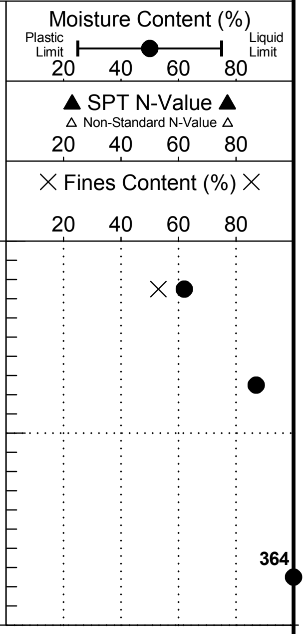
Drilling Method: Hand Auger

Ground Elevation (ft): 59.5 (NAVD88)

Drilled By: Landau Associates, Inc.

Logged By: TJS Date: 04/07/11

Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Description	Groundwater
0	S-1	d3		W = 62 GS		ML	Brown, very sandy SILT with organics (very soft to soft, wet) **(ALLUVIUM)**	
	S-2	d3		W = 87		PT	Brown PEAT with interbeds of SILT (very soft to soft, wet)	
2	S-3	d3						▽
	S-4	d3		W = 364				
4								



Boring Completed 04/07/11
Total Depth of Boring = 4.0 ft.

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

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Interurban Trail Extension
Along PSE Corridor
Pacific, Washington

Log of Boring B-4

Figure
A-5

B-5

LAI Project No: 193056.020

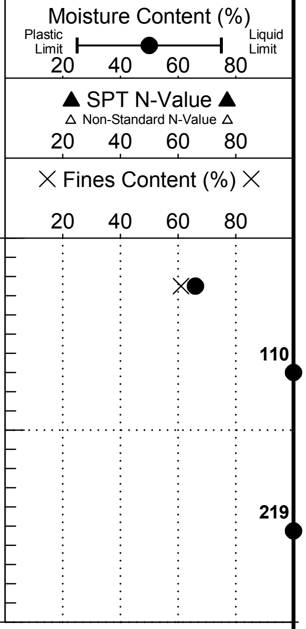
Drilling Method: Hand Auger
Ground Elevation (ft): 59.3 (NAVD88)
Drilled By: Landau Associates, Inc.
Logged By: TJS Date: 04/07/11

SAMPLE DATA

Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data
0	S-1	d3		W = 66 GS
	S-2	d3		W = 110
2	S-3	d3		
	S-4	d3		W = 219
4				

SOIL PROFILE

Graphic Symbol	USCS Symbol	Description	Groundwater
	ML	Brown, very sandy SILT with organics (very soft to soft, wet) **(ALLUVIUM)**	
	PT	Brown PEAT with interbeds of gray SILT (very soft to soft, wet)	∇



Boring Completed 04/07/11
Total Depth of Boring = 4.0 ft.

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

193056.02 6/3/11 Y:\193\056.020\T\193056.020.GPJ SOIL BORING LOG WITH GRAPH

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Interurban Trail Extension
Along PSE Corridor
Pacific, Washington

Log of Boring B-5

Figure
A-6

B-6P

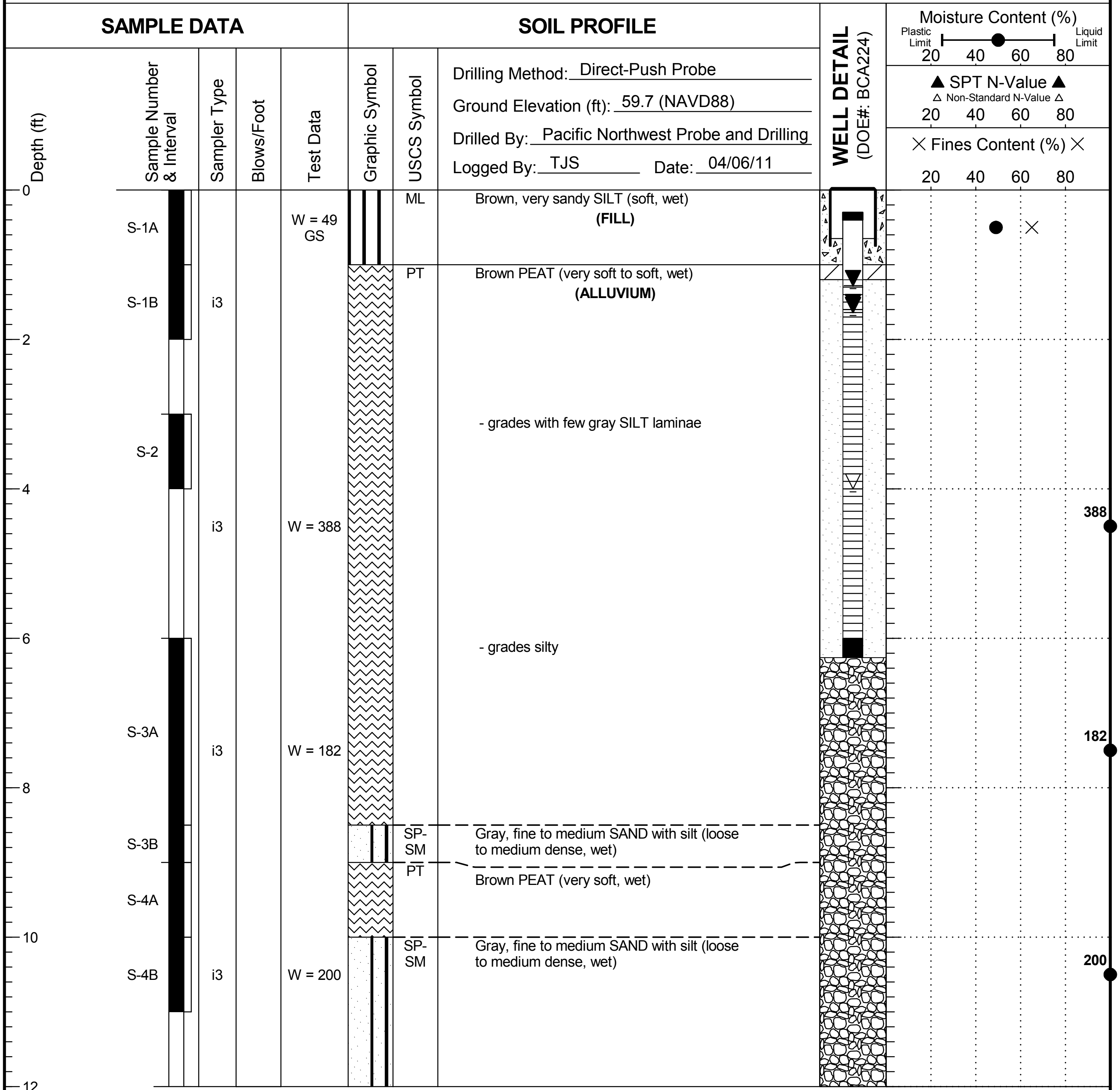
LAI Project No: 193056.020

Drilling Method: Direct-Push Probe

Ground Elevation (ft): 59.7 (NAVD88)

Drilled By: Pacific Northwest Probe and Drilling

Logged By: TJS Date: 04/06/11



Sample Number & Interval	Sampler Type	Blows/Foot	Test Data
S-1A			W = 49 GS
S-1B	i3		
S-2			
	i3		W = 388
S-3A	i3		W = 182
S-3B			
S-4A			
S-4B	i3		W = 200

USCS Symbol	
ML	Brown, very sandy SILT (soft, wet) **(FILL)**
PT	Brown PEAT (very soft to soft, wet) **(ALLUVIUM)** - grades with few gray SILT laminae - grades silty
SP-SM	Gray, fine to medium SAND with silt (loose to medium dense, wet)
PT	Brown PEAT (very soft, wet)
SP-SM	Gray, fine to medium SAND with silt (loose to medium dense, wet)

Boring Completed 04/06/11
Total Depth of Boring = 12.0 ft.

Piezometer Completed 04/06/11
Elevation at Top of Protective Casing = 59.70 ft.
Elevation at Top of Piezometer Casing = 59.50 ft.
Total Depth of Piezometer = 6.0 ft.

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

193056.02 6/3/11 Y:\193056.020\T\193056.020.GPJ SOIL BORING LOG WITH GRAPH

LANDAU ASSOCIATES

Interurban Trail Extension
Along PSE Corridor
Pacific, Washington

Log of Boring B-6P

Figure
A-7

B-7

LAI Project No: 193056.020

Drilling Method: Hand Auger

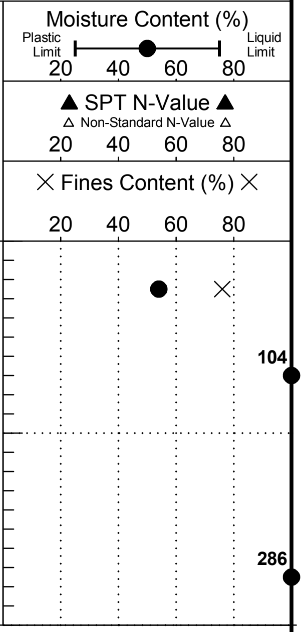
Ground Elevation (ft): 58.8 (NAVD88)

Drilled By: Landau Associates, Inc.

Logged By: TJS Date: 04/07/11

SAMPLE DATA					SOIL PROFILE			
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol		Groundwater
0	S-1	d3		W = 54 GS		ML	Brown, sandy SILT with organics (very soft to soft, wet) **(ALLUVIUM)**	
	S-2	d3		W = 104		PT	Brown PEAT with interbeds of gray SILT (very soft to medium stiff, wet)	
2	S-3	d3						∇
	S-4	d3		W = 286				
4								

Boring Completed 04/07/11
Total Depth of Boring = 4.0 ft.



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

Landau Associates

Interurban Trail Extension
Along PSE Corridor
Pacific, Washington

Log of Boring B-7

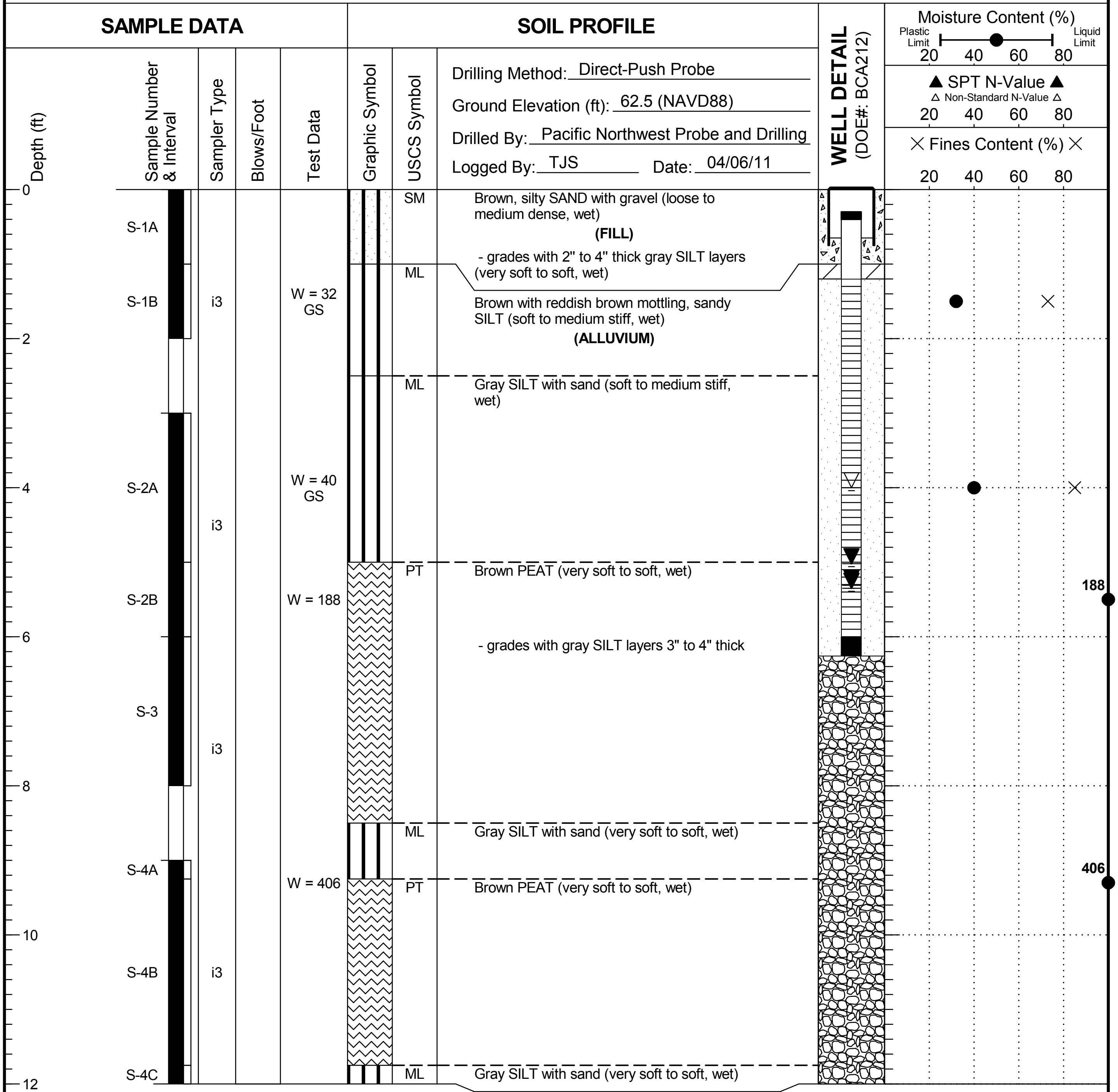
Figure
A-8

B-8P

LAI Project No: 193056.020

Drilling Method: Direct-Push Probe
Ground Elevation (ft): 62.5 (NAVD88)
Drilled By: Pacific Northwest Probe and Drilling
Logged By: TJS Date: 04/06/11

SAMPLE DATA / SOIL PROFILE



Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	USCS Symbol	Description
S-1A				SM	Brown, silty SAND with gravel (loose to medium dense, wet) **(FILL)** - grades with 2" to 4" thick gray SILT layers (very soft to soft, wet)
S-1B	i3		W = 32 GS	ML	Brown with reddish brown mottling, sandy SILT (soft to medium stiff, wet) **(ALLUVIUM)**
				ML	Gray SILT with sand (soft to medium stiff, wet)
S-2A	i3		W = 40 GS		
S-2B			W = 188	PT	Brown PEAT (very soft to soft, wet) - grades with gray SILT layers 3" to 4" thick
S-3	i3				
				ML	Gray SILT with sand (very soft to soft, wet)
S-4A			W = 406	PT	Brown PEAT (very soft to soft, wet)
S-4B	i3				
S-4C				ML	Gray SILT with sand (very soft to soft, wet)

Boring Completed 04/06/11
Total Depth of Boring = 12.0 ft.

Piezometer Completed 04/06/11
Elevation at Top of Protective Casing = 62.50 ft.
Elevation at Top of Piezometer Casing = 62.30 ft.
Total Depth of Piezometer = 6.2 ft.

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

LANDAU ASSOCIATES

Interurban Trail Extension
Along PSE Corridor
Pacific, Washington

Log of Boring B-8P

Figure
A-9

ACRONYMS AND ABBREVIATIONS

ACRONYMS AND ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
AC	asphalt concrete
APWA	American Public Works Association
ASTM	American Society for Testing and Materials
ATPB	asphalt-treated permeable base
BGS	below ground surface
CMU	concrete masonry unit
g	gravitational acceleration (32.2 feet/second^2)
GSP	General Special Provisions
GPS	global positioning system
H:V	horizontal to vertical
HMA	hot mix asphalt
IBC	International Building Code
MCE	maximum considered earthquake
MSE	mechanically stabilized earth
OSHA	Occupational Safety and Health Administration
PCC	Portland cement concrete
pcf	pounds per cubic foot
PG	performance grade
PGA	peak ground acceleration
PSE	Puget Sound Energy
psf	pounds per square foot
RSS	reinforced soil slope
SPT	standard penetration test
WSDOT	Washington State Department of Transportation
WSS	Washington Standard Specifications for Road, Bridge, and Municipal Construction (2016)