CLEAR CREEK SOLUTIONS

CLEAR CREEK SOLUTIONS, INC.

15800 Village Green Drive #3
Mill Creek, WA 98012
425-225-5997
www.clearcreeksolutions.com

DATE: 18 June 2019

TO: Eric Christensen, P.E., City of Olympia Public Works

FROM: Douglas Beyerlein, P.E., Clear Creek Solutions, Inc.
Bill Taylor, Taylor Aquatic Science
Jennifer Saltonstall, Associated Earth Sciences, Inc.

SUBJECT: BHP Study II Deliverable 4.5 Geotech Report.

Following this cover memo are the geotech memos produced by Associated Earth Sciences, Inc. for the ten bioretention sites listed below.

Abbreviation	**Jurisdiction**	**Geotech Memo**
BCK	Bellingham	150387H007_TM 2019-06-11 Site BCK
BUW	Bellingham	150387H007_TM 2019-06-11 Site BUW
FWI	Tacoma S.D.	150387H007_TM 2019-06-11 Site FWI
TWH	Tacoma S.D.	150387H007_TM 2019-06-11 Site TWH
M1C	Marysville	150387H007_TM 2019-06-14 Site M1C
M3Q	Marysville	150387H007_TM 2019-06-14 Site M3Q
MPP	Monroe S.D.	150387H007_TM 2019-06-14 Site MPP
RSH	Renton	150387H007_TM 2019-06-14 Site RSH
SSW	Monroe S.D.	150387H007_TM 2019-06-14 Site SSW
TBM	Tumwater S.D.	150387H007_TM 2019-06-14 Site TBM

This completes the requirement for Deliverable 4.5.

Technical Memorandum

Date:	June 11, 2019	**From:**	Anton Ympa Suzanne Cook, L.G.
To:	Clear Creek Solutions, Inc.	**Project Manager:**	Jennifer H. Saltonstall, L.G., L.Hg.
	15800 Village Green Drive #3 Mill Creek, Washington 98012	**Principal in Charge:**	Jennifer H. Saltonstall, L.G., L.Hg.
cc:	Eric Christensen	**Project Name:**	Bioretention Hydrologic Performance Study
Attn:	Doug Beyerlein, P.E.	**Project No:**	150387H007
Subject:	Deliverable Task 4.5, Site BCK, Geotechnical/Soils Assessment Design Data and Current Conditions, Bellingham Cornwall Avenue and Kentucky Street, Bellingham, Washington		

1.0 INTRODUCTION

This technical memorandum documents existing shallow soil and groundwater conditions in Bioretention Facility Site #2 of the ES-0512 Nevada Kentucky Bike Boulevard Project, located in the city of Bellingham, Washington (Figure BCK F1). This memorandum was prepared in accordance with Task 4 of the contract scope of work. Associated Earth Sciences, Inc. (AESI) collected shallow soil and groundwater conditions data related to bioretention cell function, and documented the current condition of the facility relative to the as-built drawings and available background geotechnical information. The information will be used in the WWHM2012 modeling that will be conducted as part of Task 5 (Data Analysis). In Task 5, the team will compare the previously documented hydrologic design information with our field-collected information and will note where there are significant differences. The purpose of this technical memorandum is to document the collection of current and accurate geotechnical, geologic, and hydrogeologic site information for this later work.

The following summary of shallow soil and groundwater conditions integrates the observations made during the geotechnical assessment which included site visits on October 11, 2018, infiltration testing on November 14, 2018, provisional results of hydrologic monitoring, and background geotechnical information.

This technical memorandum has been prepared for the exclusive use of Clear Creek Solutions and the City of Olympia and their agents for specific application to this project. Within the limitations of scope, schedule, and budget, our services have been performed in accordance with generally accepted hydrogeologic and geotechnical engineering practices in effect in this area at the time our document was prepared. No other warranty, express or implied, is made.

2.0 PURPOSE AND SCOPE

The purpose of our work was to perform a shallow soil and groundwater conditions assessment and provide baseline documentation data to assess effectiveness of bioretention hydrologic performance.

Specifically, our scope included the following activities:

- Review of project documents.
- Site reconnaissance.
- Visual condition assessment of erosion and deposition features near inlet and outlet.
- Review project plans relative to constructed facility, in particular, the number and location of inlets, energy dissipation devices, outlets, and other flow-related details.
- Survey elevations of inlet, outlet, well point rim, and other observation points relative to a project datum
- Excavate shallow hand augers through the bioretention soil.
- Classify sediment according to the Unified Soil Classification System (USCS) and *American Society for Testing and Materials* (ASTM) D2488, "Standard Recommended Practice for Description of Soils."
- Collect samples for laboratory testing of: (1) particle size distribution in accordance with ASTM D422-63, "Standard Test Method for Particle-Size Analysis of Soils"; (2) organic matter content per ASTM D2974.
- Preparation of descriptive exploration logs for each exploration.
- Conduct qualitative assessment of soil compaction via T-probe.
- Conduct infiltration testing.
- Review of hydrologic monitoring data.
- Preparation of this summary document.

Existing facility features and the locations of hand-auger boreholes completed for this study are shown on Figure BCK F2, "Facility and Exploration Plan." Project civil plans are attached as Appendix A. Exploration logs and laboratory testing data conducted as part of this study are attached as Appendix B. Background soil, geology, and groundwater information are attached as Appendix C. Soil probe, level survey, and field infiltration testing data are attached as Appendix D. Site photos are attached as Appendix E.

3.0 SITE DESCRIPTION AND DESIGN BACKGROUND

The project site is the ES-0512 Nevada Kentucky Bike Boulevard Project, located in the city of Bellingham, Washington as shown on the attached "Vicinity Map" (Figure BCK F1). The project site is located along the right-of-way of several streets in the City of Bellingham including Cornwall Avenue and Kentucky Street.

Our specific area of study for this project includes bioretention facility Site #2 located on the southeast of the intersection of Cornwall Avenue and Kentucky Street referred to as cell BCK for this study. The BCK site is bordered by Cornwall Avenue on the west, Kentucky Street on the north, and sidewalk and lawns surrounding Bellingham High School on the south and east. Site topography is generally level. No on-site surface water features are present. As described in the *Stormwater Memo* (City of Bellingham Public Works Department, May 16, 2016) the site is in the Whatcom Creek watershed.

Details of the bioretention facility design and basis for design were presented in the following documents:

- "Cornwall Avenue Infiltration Sampling," Materials Testing and Consulting, Inc., MTC Project No. 16W027-01, May 12, 2016.
- *ES-512 Stormwater Memo*, City of Bellingham Public Works Department, May 16, 2016.
- *ES-0512 Nevada Kentucky Bike Boulevard 100% Design Drawings*, City of Bellingham Public Works Department, May 6, 2016.

3.1 Summary of Facility Design

From our review of these documents, the bioretention facility design for cell BCK consists of an approximately rectangular-shaped bioretention cell with approximately 169 square feet of base area, as shown on Figure BCK F2, "Facility and Exploration Plan." We understand that the site was developed under the Stormwater Management Manual for Western Washington (SMMWW) 2014 for design and construction of stormwater facilities and modeled using WWHM2012 (Draft WWHM2012 Project Report, City of Bellingham, May 16, 2016) with a design infiltration rate of 12.3 inches per hour (in/hr) in the subgrade. Land use within the drainage basin is primarily roadway. Per sheet 23, *Bioretention Facility and Project Details, ES-0512 Nevada Kentucky Bike Boulevard* (City of Bellingham Public Works Department, December 15, 2015), the facility design includes 3 inches of mulch overlying 18 inches of bioretention soil mix overlying a 6-inch "choker course," overlying 16 inches of drain rock. The facility contains a 4-inch-diameter perforated underdrain pipe bedded in the choker course. The underdrain discharges to a catch basin, which also features a beehive grate at ground surface which acts as an overflow structure. The catch basin discharges to the City storm drain system. The upstream end of the perforated underdrain pipe is specified as being capped, with no cleanout present.

The facility is designed to infiltrate 99.99 percent of inflow into the subgrade. Stormwater enters the facility through one 6-inch green polyvinyl chloride (PVC) pipe (not shown on plan sheets) and one 1.3-foot curbcut from the east side of Cornwall Avenue. If water ponds up on the bioretention soil, the ponded water would discharge into the beehive grate located near the southern end of the cell, and then into the City storm drain system. The beehive grate is specified as 0.33 feet below the curb, with no stickup or ponding depth specified. The facility was constructed and began receiving runoff after August 2016 based on review of historic aerial imagery. We understand that the cell was "field-fit" to the site as part of a retrofit project, and therefore may differ from the plan sheets.

4.0 SITE OBSERVATIONS

During AESI's site visits, we made notes regarding the physical construction of the bioretention facilities including documenting site inlet/outlet layout relative to site plans and qualitative bioretention soil thickness and compaction. These notes were used to indicate key features of the facility in Figure BCK F2, "Facility and Exploration Plan."

- Level Survey: AESI conducted an elevation survey of the cell using a Leitz C40 automatic level and a stadia rod. An arbitrary project datum was established for this survey, with the top of the curb on the northeast corner of the facility (identified on the "BCK Level Survey Data" map in Appendix D) defined as project datum elevation 100 feet. All other elevations measured by the survey are relative to this project datum. Key level data is summarized in Table 1. Additional data points are included in Appendix D to this document. This survey was not conducted by a licensed surveyor. Surveyed elevations are expected to be sufficiently accurate for this general assessment of facility construction, but may be inaccurate for purposes requiring greater precision.

- Inflow: One curbcut and one 6-inch PVC pipe.
    - Curbcut: The primary inflow to the facility is a 1.3-foot curbcut, consistent with project plans, which discharges onto a cement slope and from there onto a bioretention soil-covered cement pad. A small amount of water was discharging at the time of our November 14, 2018 site visit, and formed a pool of water at the inlet.

    - Undocumented inflow: A second inflow is a 6-inch PVC pipe entering the north end of the facility. The pipe is not shown on project plans. AESI observed that the pipe receives inflow from three storm drain grates, two of which are installed next to the sidewalk, in landscaping areas north of cell BCK, and the northernmost of which is installed on the southern side of Kentucky Street, east of the Kentucky Street intersection with Cornwall Avenue. AESI observed that flow from all three storm drains enters cell BCK via the 6-inch pipe, and observed no other storm drain connections from or into the storm drain catch basins.

- Overflow: The overflow consists of a 22-inch by 24-inch concrete catch basin with a beehive grate. The rim of this grate was up to approximately 0.3 feet below the high point of the facility base, and was set in a cement pad surrounded by cobles. The bioretention soil around the cobbles was slightly above the level of the cement pad.

- AESI investigated the loose bioretention soil thickness present in cell BCK using a geotechnical soil T-probe. This qualitative data was used in conjunction with the hand-auger observations to understand loose soil thickness and relative potential compactness of the bioretention soils at depth. AESI measured the depth of penetration of the soils probe at locations generally arranged in a series of transects across the facility, with transects generally spaced 3 feet apart. Penetration of the T-probe generally ranged from approximately 0.8 to 2 feet, and averaged 1.5 feet. Probe penetration data is included in Appendix D to this document.

- AESI observed that the facility base is not flat as shown on the plan sheet details. Instead, it is generally constructed with a deep center and sides that slope up to closer to curb height. AESI observed that, when ponding water in the facility, the water generally only covers the lowest portion of the bioretention soil in the facility. The effective base of the bioretention facility is therefore approximately 1.5 foot wide, running along the length of the facility.

- AESI observed that the approximately 1.5-foot-wide base of the bioretention facility is not level along the length of the facility, and slopes up from the inlet area to the midpoint, causing water to pool. The base then slopes down from the midpoint to the south toward the overflow. The overflow beehive grate is at a lower elevation than the high point of the facility base, causing water to readily flow into the overflow beehive grate once it passes the high point of the facility base.

Table 1
Summary of Cell BCK
Level Survey Data

Location	Elevation (feet, project datum)
Inlet#2 (N) - 6" Green Pipe top/end @ weir	99.47
Inlet#2 (N) - 6" Green Pipe invert	98.98
Inlet#1 (W) - 6"Green Pipe top/end	100.04
Curbcut N	100.09
Curbcut low S	100.05
Curb top N of curbcut	100.49
Curb top S of curbcut	100.43
WP-1 TOC	101.15
Ponding Tube TOC (DL)	99.82
Ponding Tube TOC (Baro)	99.8
WP-1 Ground surface	99.09 to 99.1
Overflow beehive center	99.45
Overflow outer rim NE	98.93
Overflow outer rim SE	98.93
Overflow outer rim SW	98.96
Overflow outer rim NW	98.95
Overflow PVC TOC (DL)	98.22
Overflow PVC TOC (Baro)	98.19

WP: well point; TOC: top of casing; PVC: polyvinyl chloride; DL: datalogger

5.0 SITE SETTING

The text sections below describe our research findings in regards to the topographic, geologic, and hydrogeologic setting of the project site both from regional studies and background site-specific geotechnical and groundwater studies. Our sources of information included the following:

- Site-specific documents cited previously under "Project and Site Description."
- Easterbrook, D.J., 1976, *Geologic Map of Western Whatcom County, Washington*: U.S. Geological Survey (USGS), Miscellaneous Investigations Series Map I-854-B, scale 1:62,500.
- Natural Resource Conservation Service (NRCS), Web Soil Survey, United States Department of Agriculture (USDA), http://websoilsurvey.nrcs.usda.gov/, accessed January 2019.
- *Soil Survey of Whatcom County Area, Washington*, United States Department of Agriculture (USDA), Natural Resource Conservation Service (NRCS), in cooperation with Washington State Department of Natural Resources and Washington State University Agricultural Research Center, 1992.
- Newcomb, R.C. et al., *Ground-water Resources of Western Whatcom County, Washington*, U.S. Geological Survey (USGS) Open File Report 50-7, 1950.

5.1 Regional Topography and Project Grading

The project site is situated on a terrace in the Bellingham Basin. Whatcom Creek, a modern stream, has incised the terrain south and west of the site about 30 to 40 feet, creating relatively steep slopes within about 800 feet west of the bioretention cells. Elevations in the vicinity range from about 70 to 80 feet.

On a closer scale, the area near cell BCK is relatively level, and at elevations of approximately 74 to 75 feet. The BCK cell is surrounded by curbs on the west side, and level with the sidewalk on the east side. Cornwall Avenue slopes gently down to the south, and Kentucky Street slopes gently to the west in the vicinity of cell BCK.

The project site was previously developed with the construction of Cornwall Avenue, Kentucky Street, and Bellingham High School. Various utilities are present in the vicinity of the site. The geotechnical report (Materials Testing and Consulting, Inc., 2016) identified fill sediments to a depth of 3.2 feet in the vicinity of the BCK facility. Native grade is unknown, however minor cutting (about 3 feet) into the previously-constructed sidewalk and lawn area would have been required during construction, and previous construction of utilities and development in the area would have required previous cutting and filling to place the fill found by Materials Testing and Consulting, Inc.

5.2 Regional Geology and Background Geotechnical Information

According to D.J. Easterbrook, 1976, *Geologic Map of Western Whatcom County, Washington*: U.S. Geological Survey (USGS), Miscellaneous Investigations Series Map I-854-B, scale 1:62,500, the site vicinity is underlain by Bellingham Drift (Everson Interstade). As described on the geologic map, this consists of blue-gray, unsorted, pebbly sandy silt and pebbly clay, with glaciomarine drift mantling upland areas. This is consistent with our observations and interpretations of subsurface materials encountered in our explorations for this project.

- Bellingham Drift (Everson Interstade, Qb): Blue-gray, unsorted, unstratified, pebbly, sandy silt and pebbly clay. Derived from rock debris melted out of floating ice and deposited on sea floor. Locally contains mollusks and wood, radiocarbon dated between 11,000 and 12,000 years B.P., glaciomarine drift mantles upland areas between flood plains below elevations of 600 feet.

Background geotechnical information includes three geotechnical explorations, labeled HA-1 through HA-3 (Materials Testing and Consulting, Inc., 2016) from within 200 feet of cell BCK dated May 12, 2016, which reached depths of about 3.5 feet below current grades, and describe material generally consisting of silty clay with some sand and trace gravel. Materials Testing and Consulting, Inc. interpreted the material as Bellingham Drift, which is consistent with the geologic mapping in the area. Shallow fill soils were encountered in one exploration in the immediate vicinity of BCK.

5.3 Regional Soils and Soil Data Used in Site Stormwater Model

AESI reviewed the *Soil Survey of Whatcom County Area, Washington*, United States Department of Agriculture (USDA), Natural Resource Conservation Service (NRCS), in cooperation with Washington State Department of Natural Resources (DNR) and Washington State University Agricultural Research Center, 1992. The soil survey identifies different soil map units based on parent material, climate, topography (slope), organisms (biota), and time. The soils in the study area formed mostly from young glacial deposits and have not had time to develop the deep weathering profiles present in soils in unglaciated terrains. Instead, they exhibit a direct relationship to the underlying parent material, local climate, topography, and vegetation.

Mapped soils in the project area consist of urban land - Whatcom-Labounty complex. Urban land is land that has been heavily modified by development. Whatcom and Labounty soils form over glaciomarine drift.

5.4 Regional Hydrogeology and Background Groundwater Data

Regional hydrogeology is described in *Groundwater Resources of Western Whatcom County, Washington* (R.C. Newcomb et al., 1950). Newcomb et al. (1950) indicates that perched groundwater conditions can occur locally, particularly over till, silts, and clays.

On a closer scale, the site is as described in the *Stormwater Memo* (City of Bellingham, May 16, 2016) as within the Whatcom Creek watershed. Whatcom Creek discharges ultimately to Bellingham Bay approximately 3,000 feet southwest of cell BCK. No groundwater was observed in the hand-auger borings by Materials Testing and Consulting, Inc. at the time of exploration on April 28, 2016. Perched groundwater conditions often vary seasonally based on recent rainfall.

6.0 BIORETENTION CELL SUBSURFACE EXPLORATION

Limited information on subsurface conditions was obtained for this study from hand-auger samples and soil probe penetration measurements at about 2-foot increments in each hand-augered borehole. Two hand-auger borings were performed in the facility bottom and advanced through the bioretention soil and to the underlying material - one into the aggregate, and one into native sediments. Representative samples were collected, visually classified in the field, stored in water-tight containers, and transported to AESI’s offices for additional classification, geotechnical testing, and study. At the conclusion of the excavation, the boreholes were immediately backfilled with the excavated material or completed as a well point for water level monitoring (described separately below).

The various types of sediments, as well as the depths where characteristics of the sediments changed, are indicated on the exploration logs presented in Appendix B. A detailed record of the observed bioretention soil, subsurface soil, geology, and groundwater conditions was made. The sediments were described by visual and textural examination using the soil classification in general accordance with ASTM D2488, “Standard Recommended Practice for Description of Soils.” The depths indicated on the logs where conditions changed may represent gradational variations between sediment types in the field. The exploration logs in Appendix B are based on the field observations, inspection of the samples, and where applicable, laboratory grain-size analysis. Our explorations were approximately located in the field relative to known site features, and are shown on Figure BCK F2, "Facility and Exploration Plan." Global Positioning System (GPS) coordinates for the explorations were taken using a hand-held GPS, and are summarized in Appendix B.

The results presented in this document are based on the explorations completed for this study and review of background data. The number, locations, and depths of the explorations were completed within site and budgetary constraints. Because of the nature of exploratory work below ground, interpolation of subsurface conditions between field explorations is necessary. It should be noted that differing subsurface conditions may sometimes be present due to the random nature of deposition and the alteration of topography by past grading and/or filling.

6.1 Hand-Auger Borings

Hand-auger borings in cell BCK were completed on October 11, 2018. No rainfall was noted at the time of exploration.

Hand-auger boring number 1 (BCK-HA-1), which was completed in the northern perimeter of the cell, near the inflow, and hand-auger boring number 2 (BCK-HA-2), which was completed near the center of the cell, encountered approximately 1 to 1.5 feet of bioretention soil. BCK-HA-1 encountered sediment interpreted as glaciomarine drift underlying the bioretention soil, to a total depth of 3 feet. BCK-HA-2/WP encountered gravel underlying the bioretention soil, to a total depth of 1.9 feet.

6.2 Well Points

A well point was installed in BCK-HA-2/WP. Key well point dimensions are provided in Table 2, below.

Table 2
Summary of Cell BCK
Well Point Dimensions

Well Point	Exploration in which Well Point was Installed	Total Length of Casing (feet)	Interior Diameter	Stickup Height (feet)	Total Depth Inside Casing Below Ground Surface
BCK-HA-2/WP	BCK-HA-2/WP	6.2	1.25 inch nominal	2	4.2

7.0 LABORATORY ANALYSIS

Laboratory testing included mechanical grain-size distribution and percent organic matter by weight in accordance with the ASTM D422 and D2974, respectively. Bioretention soil was first tested for organic matter content and then the burned material was tested for grain-size distribution for comparison with the aggregate fraction of the bioretention soil mix guidance in the 2014 Washington State Department of Ecology (Ecology) *Stormwater Management Manual for Western Washington* (2014 Ecology Manual). One sample of material interpreted as representative of the subgrade was tested for grain-size distribution. The data is summarized in Table 3.

Table 3
Summary of Cell BCK
Organic Content and Grain Size Data

Exploration Number	Depth (feet)	Soil Type	Organic Content (% by weight)	USCS Soil Description	Fines Content (% passing #200)	Cu	Cc	USDA Soil Texture*
BCK-HA-1	0..1-0.5	Bioretention Soil	5.9	SAND, some silt, trace gravel (SP-SM)	5.3	4.7	1.0	Sand
BCK-HA-1	1.0-1.3	Glaciomarine Drift		Very silty SAND, some gravel (SM)	43.5			Sandy clay to loam
BCK-HA-2/WP	0.1-0.3	Bioretention Soil	5.1	SAND, some gravel, trace silt (SP)	4.9	4.5	0.9	Sand

USCS: Unified Soil Classification System; Cu: coefficient of uniformity; Cc: coefficient of curvature; USDA: U.S. Dept. of Agriculture;
*No hydrometers were performed. USDA soil texture range assumes fines consist entirely of silt to entirely of clay.

7.1 Bioretention Soil Mix

We compared the organic content and burned fraction gradation against the general guidelines for the bioretention soil mix (Table 4).

The organic content of the tested bioretention soils ranged between 5.1 and 5.9 percent by weight. This meets the recommended organic content by weight of 5 to 8 percent in the 2014 Ecology Manual.

The grain-size analysis test results on the burned soil fraction indicate that the bioretention soils tested correlate to a “SAND” with trace to some silt and trace to some gravel based on ASTM D2487 Unified Soil Classification System (USCS). The respective fines content as measured on the No. 200 sieve was 4.9 to 5.3 percent, on the higher end of recommended range of 2 to 5 percent. The coefficient of uniformity ranged from 4.5 to 43.7, meeting the recommended value of equal to or greater than 4. The coefficient of curvature ranged from 0.9 to 1, lower than the recommended range of greater than or equal to 1 and less than or equal to 3. The soil mix contained slightly more than the recommended range of gravel, and slightly more than the recommended range of silt. The tested bioretention soil was a poorly-graded sand.

Table 4
General Guidelines for Bioretention Soil Mix (2014 Ecology Manual)
Compared to Averaged Cell BCK Site Data

Parameter	Recommended Range	Cell BCK
Organic Content (by weight)	5 to 8 percent	5.5
Cu coefficient of uniformity	4 or greater	4.6
Cc coefficient of curvature	1 to 3	0.9
Sieve Size	**Percent Passing**	
3/8” (9.51 mm)	100	99.4
#4 (4.76 mm)	95 to 100	96.2
#10 (2.0 mm)	75 to 90	76.8
#40 (0.42 mm)	25 to 40	26.0
#100 (0.15 mm)	4 to 10	6.7
#200 (0.074 mm)	2 to 5	5.9

Note: The general guidelines for mineral aggregate gradation are from Table 7.4.1 of the 2014 Ecology Manual.
mm: millimeters.

7.2 Subgrade

In cell BCK, no samples of the subgrade could be obtained for this study due to the import gravel beneath the bioretention cell and difficulties hand auguring in this material. In BCK-HA-1, a sample was obtained from the lower side slope of the cell was sieved, interpreted to be native glaciomarine drift. The tested material correlates to a very silty SAND, some gravel with 43.5 percent by weight of the material passing the No. 200 sieve.

The grain-size distribution data were also transformed to describe the USDA soil texture. The grain-size distributions were normalized to the No. 10 sieve—i.e., the coarse sand and gravel fraction of the sample is discounted and the remainder is taken as 100 percent of the sample. The fines were assessed relative to the No. 270 sieve. The respective USDA fines content as measured on the No. 270 sieve after adjusting to remove the weight retained on the #10 sieve was 47 percent for the native glaciomarine drift.

8.0 INFILTRATION TESTING

8.1 General Infiltration Test Method

The infiltration test was conducted in general accordance with the 2014 Ecology Manual. The test was conducted by discharging water into the facility for a "soaking period," to allow the receptor soils to become saturated. After completion of the soaking period, water was discharged into the cell at a rate sufficient to maintain a relatively constant head. This constitutes the "constant-head" phase of infiltration testing. Immediately following the constant-head phase of infiltration testing, flow into the facilities was discontinued, and the water level was monitored as it dropped. This constitutes the "falling-head" portion of the infiltration testing.

The water for testing was obtained from an on-site fire hydrant and conveyed to cell BCK with fire hoses. During infiltration testing, the water was conveyed into the bioretention cell via a digital flow meter with gallons per minute (gpm) and total gallon readouts, and discharged through a flow diffuser. Water levels were monitored using an existing staff gauge (SG-1) marked in 0.01-foot increments installed adjacent BCK-HA-2/WP, a second temporary metal staff gauge (SG-2) marked in 0.01-foot increments installed near the inlets, and within the well point with a digital water level tape, and with digital pressure transducers. Data from the digital pressure transducers was compensated for barometric response using a separate digital barometer. The area of the pool was measured periodically during testing.

The infiltration test in cell BCK is discussed below, and results are presented in Table 5. Infiltration test data is included in Appendix D to this document.

8.2 Infiltration Test in Cell BCK

AESI performed infiltration testing on November 14, 2018. Heavy rainfall was noted during the beginning of testing, and flow from both of the inlets was present early in testing.

During this test, flow was initially maintained at about 3 gpm, then shut off when the combination of inflow from the hose and inflow due to rainfall caused the facility to begin to overflow into the beehive grate. After rainfall stopped approximately 1.5 hours into the test, flow was held steady at approximately 3 gpm, and the facility did not overflow. During the final approximately 30 minutes of testing, flow was increased to approximately 10 gpm, and the facility began to overflow. Throughout the test, AESI never observed discharge from the underdrain into the overflow catch basin. Inflow to the facility for the infiltration test was directed, through a diffuser, onto the cell. Initially, the water pooled near the inflows, and approached the well point (BCK)HA-2/WP) which had been installed near the high point of the facility base. When water reached the well point, it flowed past and downhill to the overflow grate, with minimal ponding at the well point. As rainfall decreased and AESI reduced the flow rate used for testing, water stopped flowing past the well point until the end of testing when AESI again increased the flow rate. Approximately 760 gallons of water were used.

Water in the well point was monitored with a data logger during the infiltration test and responded to inflow. Groundwater was present at a depth of about 3 feet beneath the bioretention cell prior to the start of inflow, and likely represents perched water in the base course of the facility. The water level in the well point responded to inflow immediately, and rose to minimum depth of approximately 2.5 feet during the course of testing. AESI interprets this response to indicate that water from the infiltration test generally infiltrated rapidly through the bioretention soil and then perched in the facility base-course. At the end of testing, when AESI discharged approximately 10 gpm into the facility, this flow of water exceeded the capacity of the bioretention soil, and began pooling until it flowed into the overflow structure.

After about 7 hours, AESI shut off the flow and monitored the water level as it fell. AESI observed that the pooled water in the inlet area of the facility infiltrated into the bioretention soil such that its depth decreased from approximately 0.4 to 0.12 feet over the course of an hour.

The constant-head test infiltration rate in Table 5 is calculated based on the flow rate from the hose for infiltration testing, and the wetted area of bioretention soil through which the water infiltrated, and represents the infiltration rate of the bioretention soil. Because no flow was observed to discharge from the underdrain pipe into the overflow catch basin over the course of the test, the fate of the water is somewhat uncertain. The subgrade beneath the cell was not well documented. The hand auger completed outside of the cell base entered sediment with a high fines content. AESI interprets that water collecting in the facility base course and flowed laterally, some infiltrating into the subgrade and some likely captured in fill/utility corridors.

Table 5
Cell BCK
Infiltration Test Results

Test No.	Surface Area (square feet)	Discharge Time (minutes)	Total Volume Discharged (gallons)	Approximate Constant-Head Level (feet)	Field Infiltration Rates	
					Constant-Head Test (in/hr)	Falling-Head Test (in/hr)
BCK (bioretention soil)	60	421	757	0.3	6.6	3.4
BCK (subgrade)	Perched water response in well point				Uncertain, interpreted to be low; likely affected by utility corridors	

in/hr: inches per hour.

9.0 CONCLUSIONS AND RECOMMENDATIONS

Portions of Cell BCK were inconsistent with the design shown on the civil plan sheets. Observations on site design, shallow soil and groundwater conditions are discussed below.

- The overflow is consistent with the plans. No ponding level is specified in site design documents.

- Bioretention soil:
  - Thickness: The apparent thickness of loose bioretention soil based on soil probe data was generally about 1.5 feet as indicated on the plan. On the edges of the facility the bioretention soil was occasionally thinner than this.
  - Composition: The soil mix generally met the recommended guidelines for organic content and sand gradation, although the soil mix contained slightly more than the recommended range of fine gravel and silt, and had a slightly low coefficient of curvature.

- Subgrade conditions: The subgrade is interpreted to consist of glaciomarine drift, with fill soils present.

- Bioretention soil field infiltration rate:
  - Measured at about 6.6 in/hr.
  - No water was observed in the underdrain, so the field infiltration rate is interpreted to represent the bioretention soil rate. The rate is lower than typical and some compaction was noted during the soil probing.

- Subgrade infiltration rate: Interpreted to be affected by unknown areas of fill sediments. Infiltration is likely primarily into the undocumented fill sediments.

- Inflow: The BCK facility receives inflow from a PVC pipe which is not indicated on project plan sheets. This pipe is connected to several storm drains, which are not indicated on project plan sheets. It is unclear if the modeled drainage area included the area drained by these storm drains.

- Base Area: AESI observed that the bioretention soil is not level across the facility base. Based on our measurements the wetted base area was approximately 60 square feet during infiltration testing with a flow of approximately 10 gpm, with water flowing into the overflow structure. This is less than the 169-square-foot base area per design.

10.0 CLOSURE

We appreciate the opportunity to be of continued service to you on this project. Should you have any questions regarding this document or other geotechnical/hydrogeologic aspects of the project, please call us at your earliest convenience.

Anton D. Ypma
Staff Geologist

Suzanne S. Cook, L.G.
Senior Project Geologist

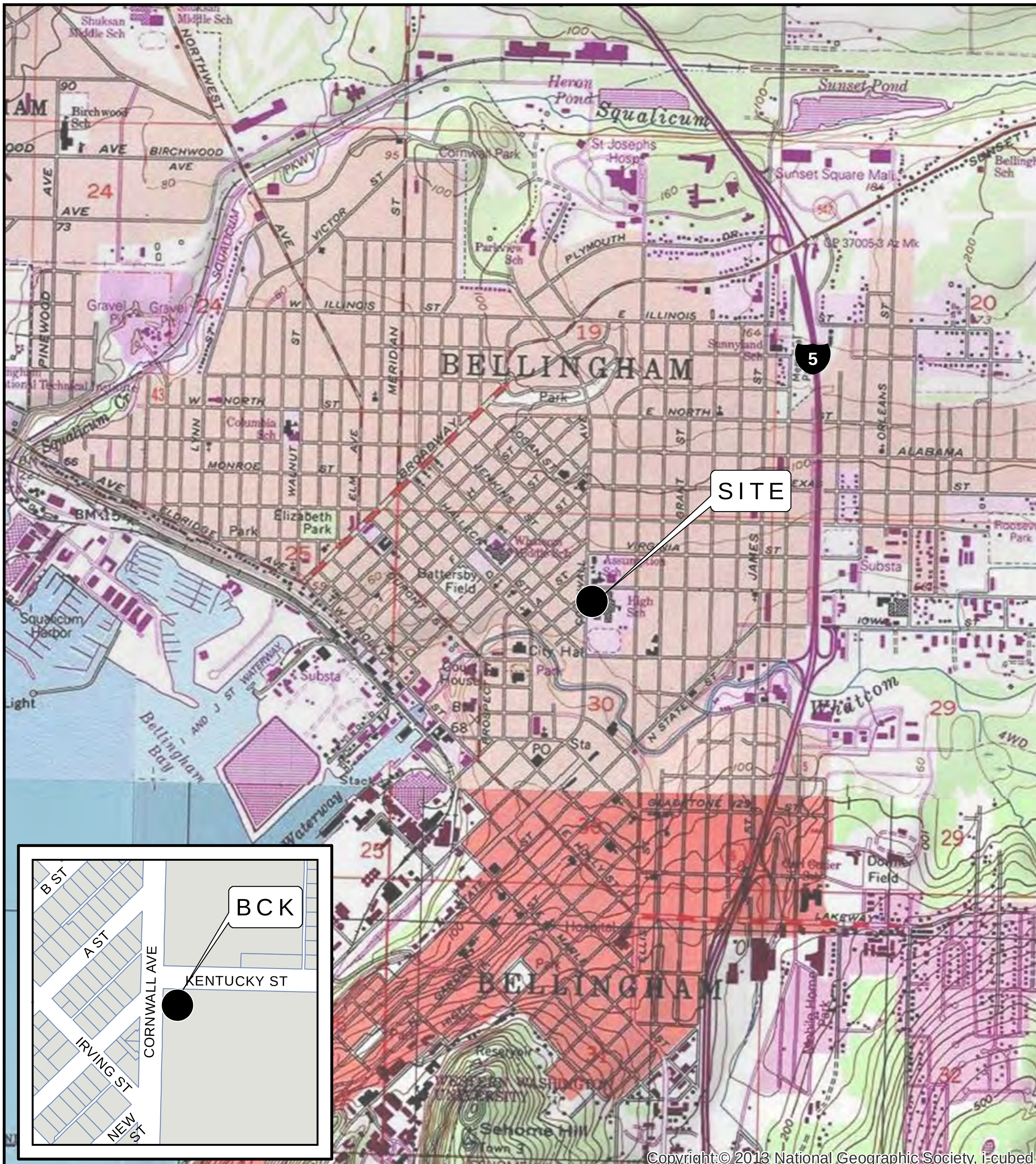
State of Washington
Hydrogeologist
2335
Licensed Geologist
Jennifer H. Saltonstall
6/11/19

Jennifer H. Saltonstall, L.G., L.Hg.
Principal Geologist/Hydrogeologist

Attachments:	Figure BCK F1:	Vicinity Map
	Figure BCK F2:	Facility and Exploration Plan
	Appendix A:	Project Civil Plans
	Appendix B:	Current Study Exploration Logs and Laboratory Testing Data
	Appendix C:	Background Soil, Geology, and Groundwater Data (Regional Maps, Previous Studies Exploration Logs and Laboratory Testing Data)
	Appendix D:	Soil Probe, Level Survey, and Field Infiltration Testing Data
	Appendix E:	Site Photos

JHS/ld - 150387H007-10 - Projects\20150387\KH\WP

Document Path: G:\GIS_Projects\aY15post0716\150387 Bioretention Hydro Performance Monitoring\mxd\PhaseII\Fig1s\150387H007 F1 VM_BCK.mxd



DATA SOURCES / REFERENCES:
USGS: 7.5' SERIES TOPOGRAPHIC MAPS, ESRI/I-CUBED/NGS 2013
WHATCOM CO: PARCELS, CITY - 4/17
CITY OF BELLINGHAM: STREETS, 3/17
LOCATIONS AND DISTANCES SHOWN ARE APPROXIMATE

N

0 1000 2000

FEET

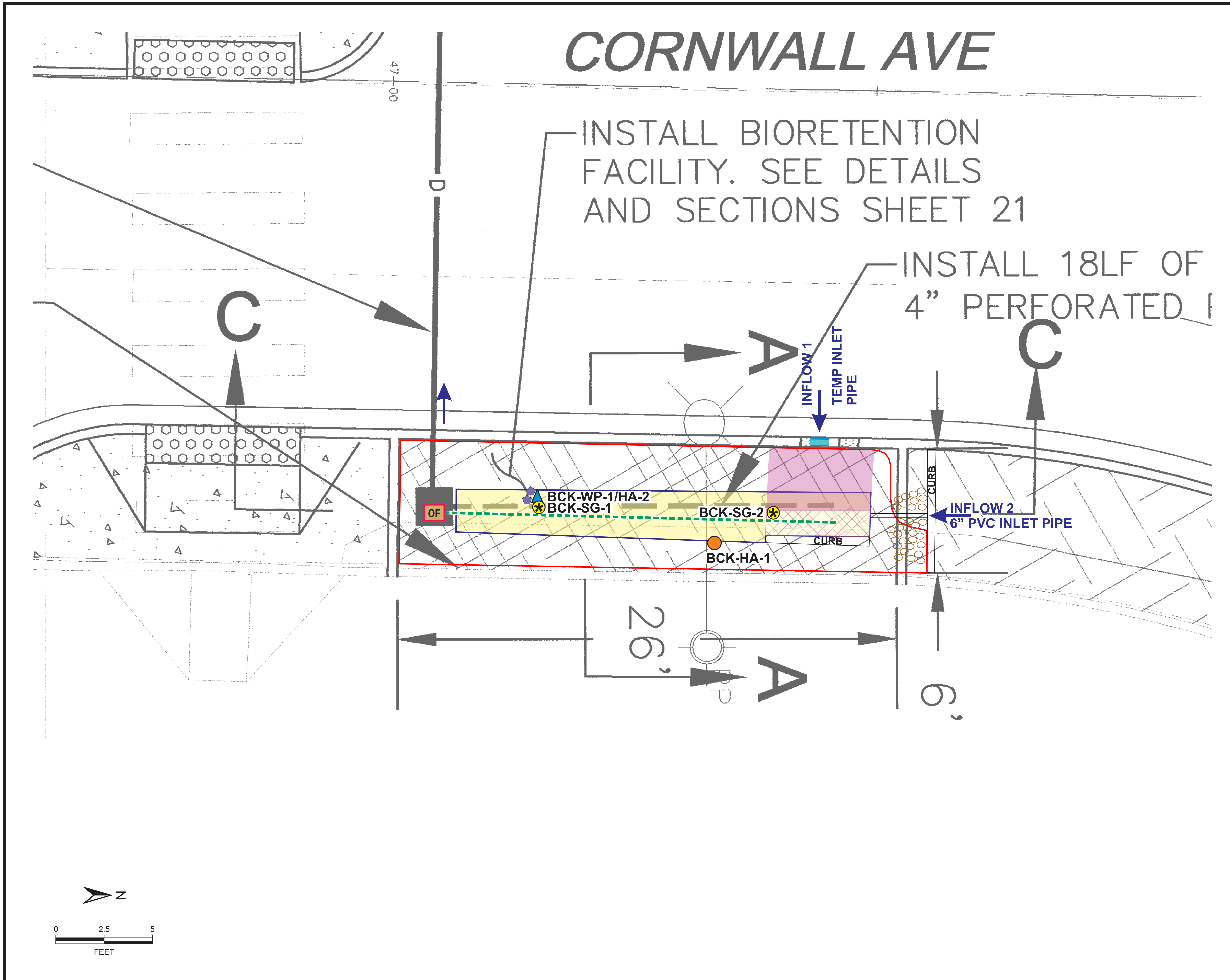
NOTE: BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION

associated earth sciences incorporated

VICINITY MAP

BIORETENTION HYDROLOGIC PERFORMANCE STUDY, BCK SITE
BELLINGHAM, WASHINGTON

PROJ NO.	DATE:	FIGURE:
150387H007	3/19	BCK F1



LEGEND:

- HA — HAND AUGER
- WP — WELL POINT
- TEMPORARY STAFF GAUGE
- BASE OF FACILITY
- TOP OF FACILITY SLOPE
- INFLOW / OVERFLOW DIRECTION
- OF — OVERFLOW GRATE - 24" X 18"
- PVC PONDING TUBE
- UNDERDRAIN
- CURB CUT
- CONCRETE SPLASH PAD
- COBBLES SET IN CONCRETE
- AREA OF BURIED ROCKS

CONTOUR INTERVAL = N/A

NOTE: LOCATION AND DISTANCES SHOWN ARE APPROXIMATE.

NOTES:
1. BASE MAP REFERENCE: CITY OF BELLINGHAM PUBLIC WORKS DEPT, ES-0512 NEVADA KENTUCKY BIKE BLVD, BIORETENTION FACILITIES PLAN, SHEET 21 OF 26, 5/2015

associated earth sciences incorporated

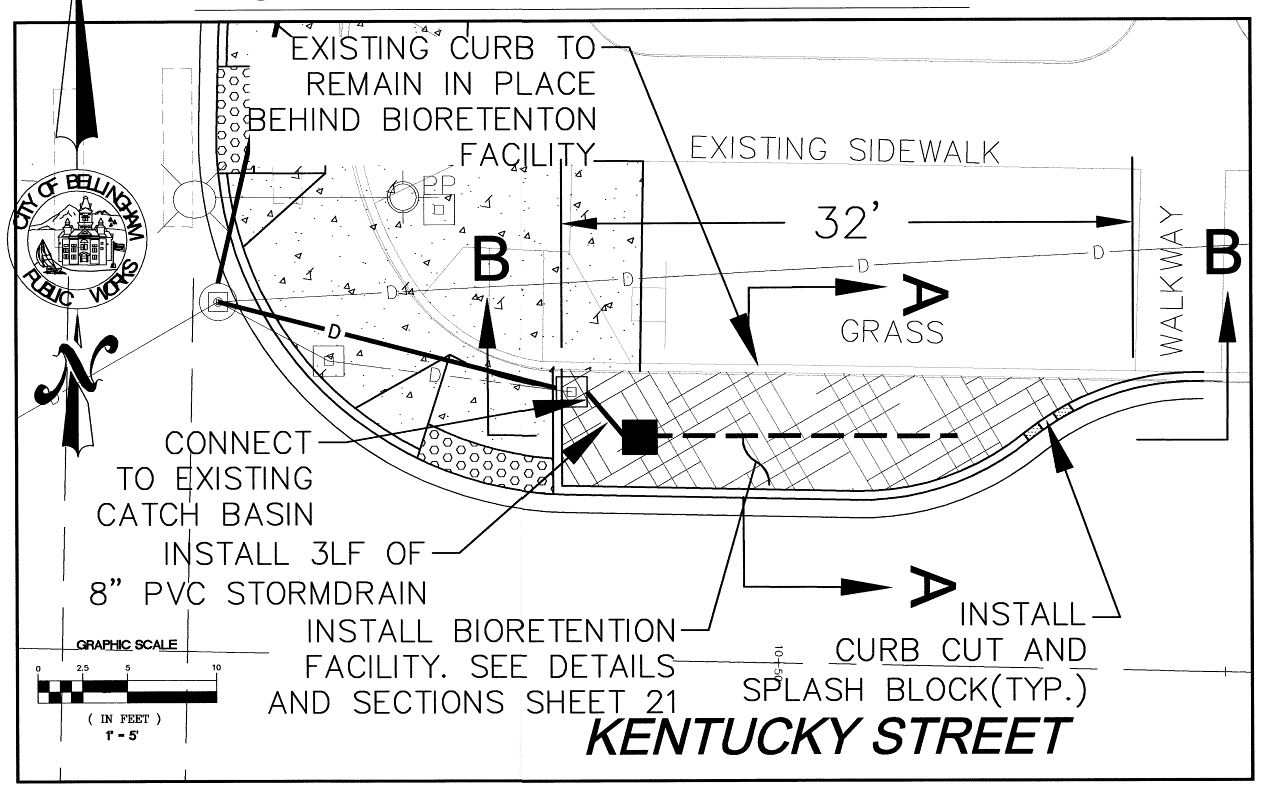
FACILITY AND EXPLORATION PLAN
BCK SITE
BIORETENTION HYDROLOGIC PERFORMANCE
BELLINGHAM, WASHINGTON

PROJ NO.	DATE:	FIGURE:
150387H007	3/19	BCK F2

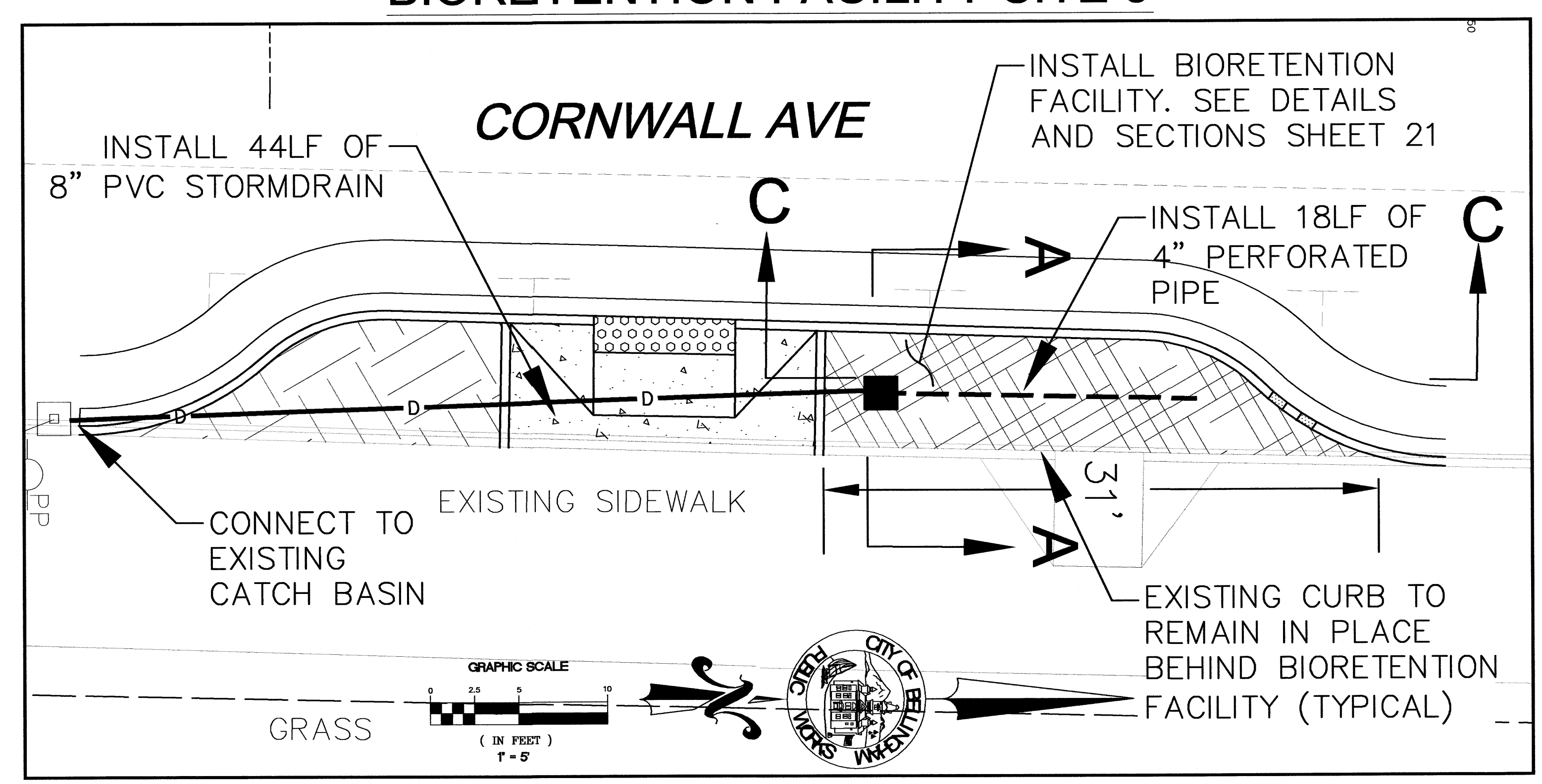
APPENDIX A

Project Civil Plans

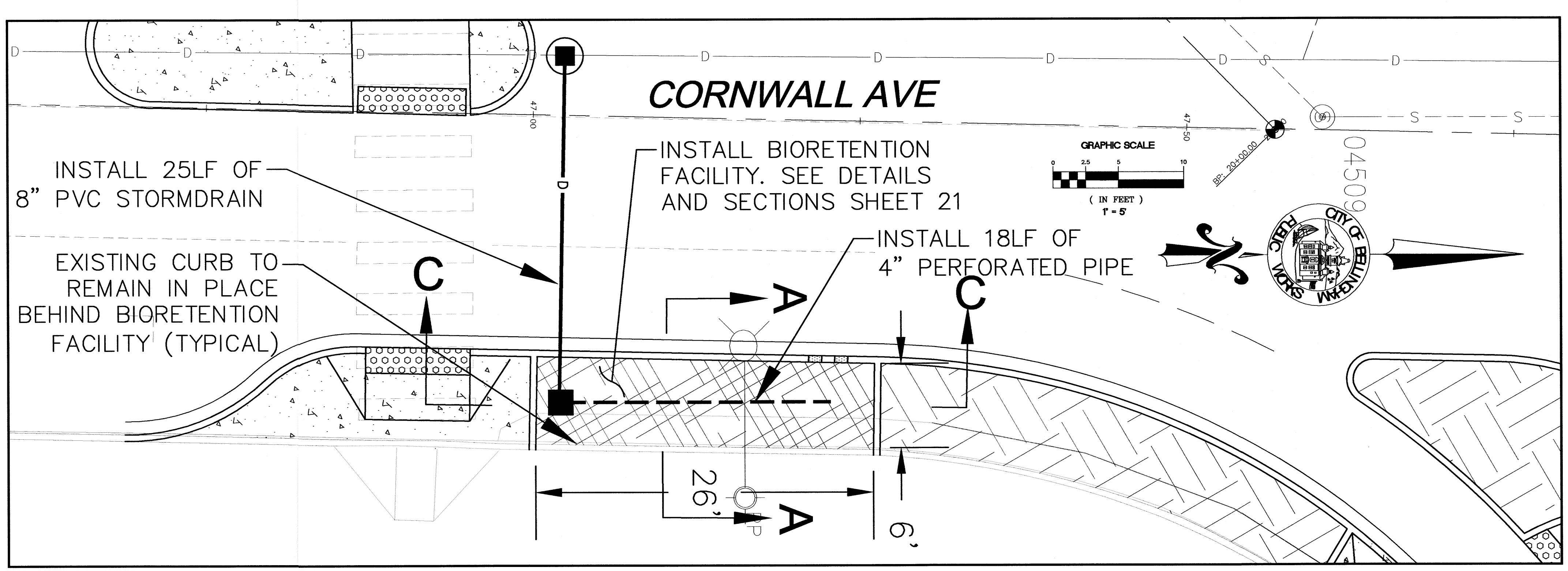
BIORETENTION FACILITY SITE 1



BIORETENTION FACILITY SITE 3



BIORETENTION FACILITY SITE 2



40148 REGISTERED PROFESSIONAL ENGINEER

6 May 2016

Date	No	Revision	By
	4		
	3		
	2		
	1		

PROJECT ENGINEER F.A.
DESIGNED/DRAWN E.L.H.
INSPECTOR

DIRECTOR OF PUBLIC WORKS T.A.C.
CITY ENGINEER
ASSISTANT DIRECTOR E.C.J.

CITY OF BELLINGHAM, WASHINGTON
PUBLIC WORKS DEPARTMENT
ENGINEERING DIVISION

SCALE
Horiz. 1"= 5'
Vert. 1"= N/A

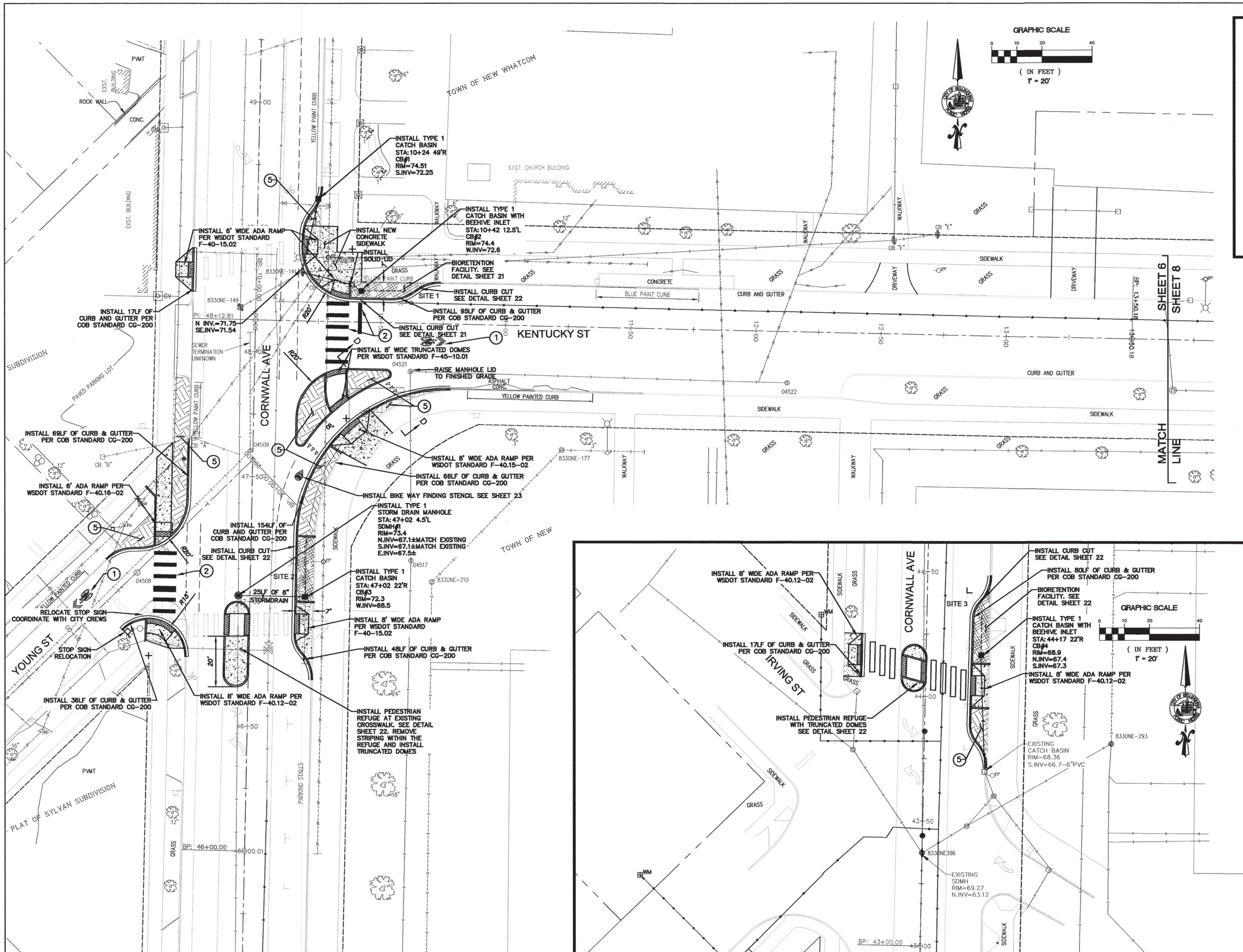
DATUM

Job. No. ES-0512
Date MAY , 2015
Field Bk. 1013-1

ES-0512 NEVADA KENTUCKY BIKE BLVD.
BIORETENTION FACILITIES PLAN

SHEET 21 OF 26

CONTACT PERSON: ____________ , PROJECT ENGINEER AT 778-7900



STORM SEWER TABLE			
STRUCTURE NO.	RIM ELEV. (N)	INVERT ELEV'S.	PIPE SIZE/TYPE OF PIPE(DIRECTION)
8330NE-396	69.27	63.21	15" CONC. (N)
8330NE-149	74.57	68.21 68.29 68.46	15" CONC. (S) 15" CONC. (N) 12" CONC. (NE)
1729	81.52	75.32	15" CONC. (S)
8330NE-293	72.11	65.64	12" PVC (N)
8330NE-210	74.63	67.39 67.58	12" PVC (S) 12" PVC (NE)
8330NE-177	74.27	67.92 67.74	12" PVC (SW) 12" PVC (E)
8330NE-141	74.35	70.37 71.54 71.50 72.35	12" CONC. (SW) 6" CONC. (NE) 8" PVC (SE) 3" CONC. (NE)
CB "A"	73.09	71.09 68.88±	6" CONC. (W) 8" CONC.(SE NOT VISIBLE, GATED)
CB "B"	73.17	72.17	6" CONC. (E)
CB "C"	74.06	72.04 72.15	8" PVC (NW) 8" PVC (SE)
CB "D"	73.80	72.36	8" PVC (W)
CB "E"	75.27	73.05	6" PVC (SW)
CB "F"	75.69	72.72 72.83 72.89	8" CONC. (W) 12" CPEP (N) 6" PVC (E)

* * STRUCTURES SHOWN W/ASTERISK'S HAVE STANDING WATER IN STRUCTURE

CONSTRUCTION NOTES

1. INSTALL SHARED LANE MARKING SYMBOL PER CITY OF BELLINGHAM STANDARD TC-316
2. INSTALL STOP BAR AND CROSSWALK PER CITY OF BELLINGHAM STANDARD TC-310
3. INSTALL BICYCLE DETECTOR SYMBOL PER CITY OF BELLINGHAM STANDARD TC-317
4. NEW STOP SIGN TO BE INSTALLED BY CITY CREWS
5. INSTALL MINIMUM 6" OF NATIVE SOILS, 4" MINIMUM TOP SOIL, TOP WITH SOD.
6. INSTALL EXTRUDED CURB WITH CURB CUTS EVERY 25' PER CITY OF BELLINGHAM STANDARD CG-212

6 MAY 2016

Date	No	Revision	By
	4		
	3		
	2		
	1		

PROJECT ENGINEER F.A.
DESIGNED/DRAWN E.L.H.
INSPECTOR

DIRECTOR OF PUBLIC WORKS T.A.C.
CITY ENGINEER
ASSISTANT DIRECTOR E.C.J.

CITY OF BELLINGHAM, WASHINGTON
PUBLIC WORKS DEPARTMENT
ENGINEERING DIVISION

SCALE
Horiz. 1"= 20'
Vert. 1"= N/A

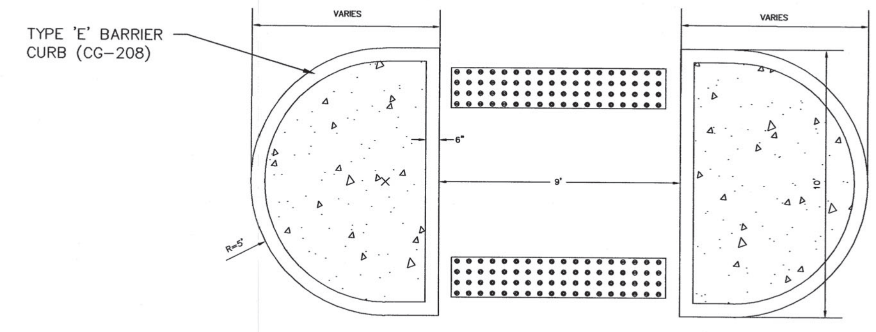
DATUM
NAVD 88
NAD 83/98

Job. No. ES-0512
Date MAY, 2015
Field Bk. 1013-1

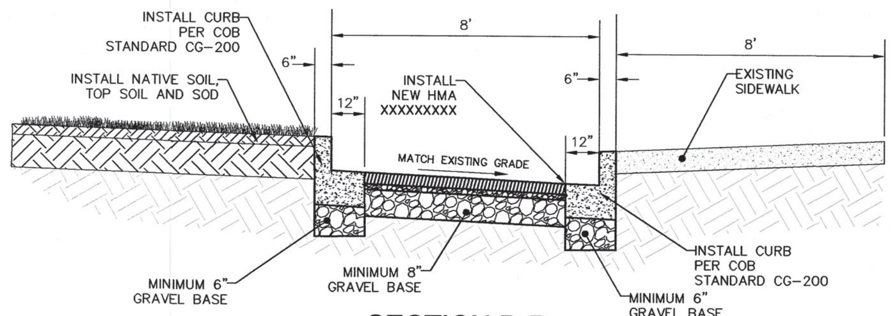
ES-0512 NEVADA KENTUCKY BIKE BLVD.
KENTUCKY ST & CORNWALL ST. PLAN

SHEET 7 OF 26

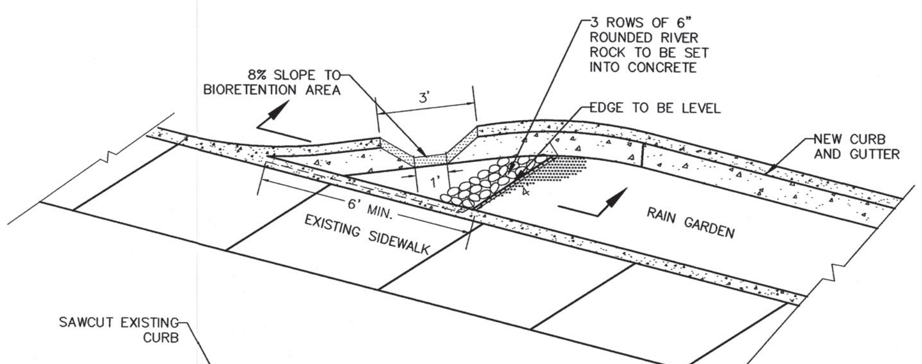
CONTACT PERSON: FREEMAN ANTHONY P.E. , PROJECT ENGINEER AT 778-7900

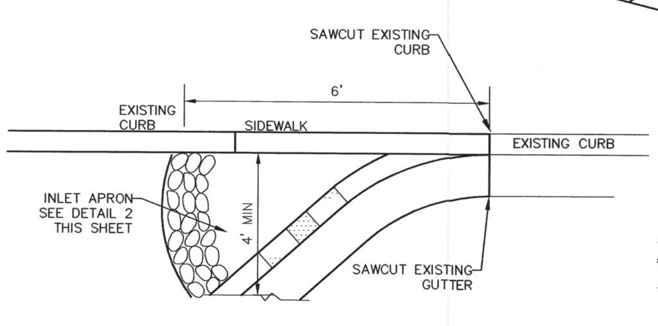


PEDESTRIAN REFUGE
N.T.S.

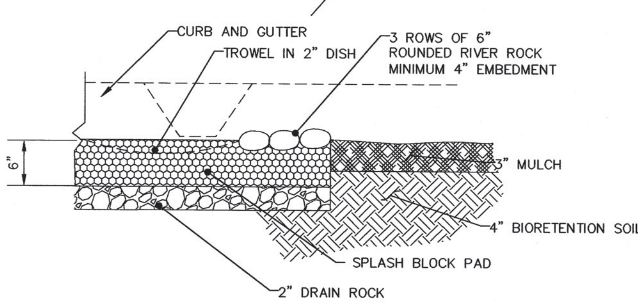


SECTION D-D
N.T.S.

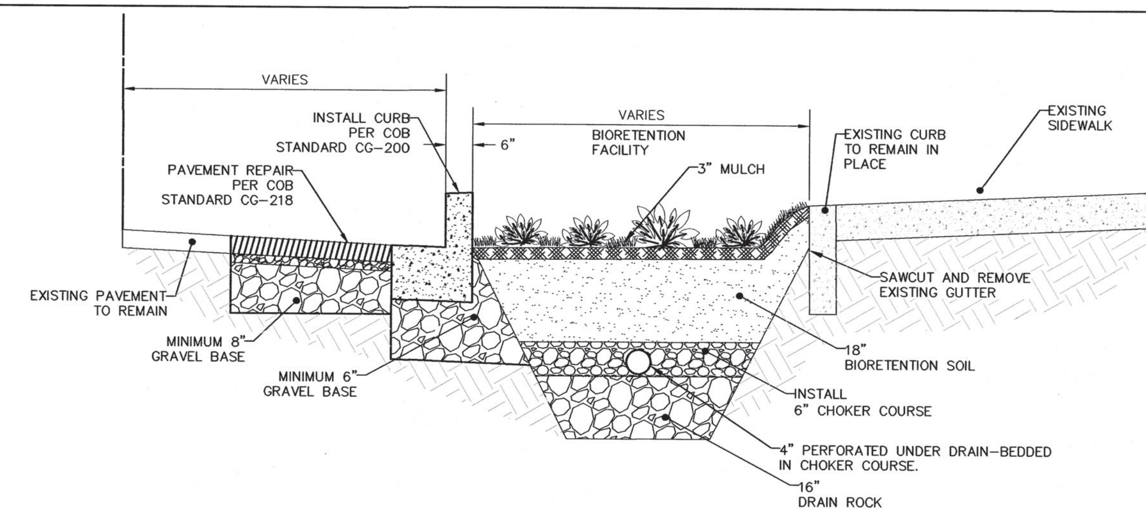




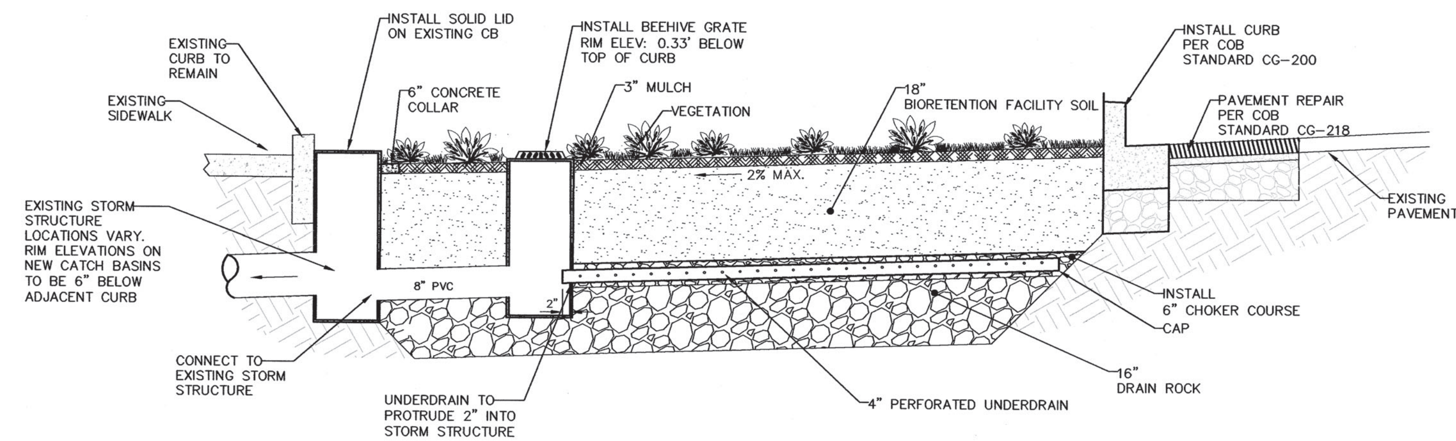
DETAIL 1
CURB CONNECTION DETAIL
NTS



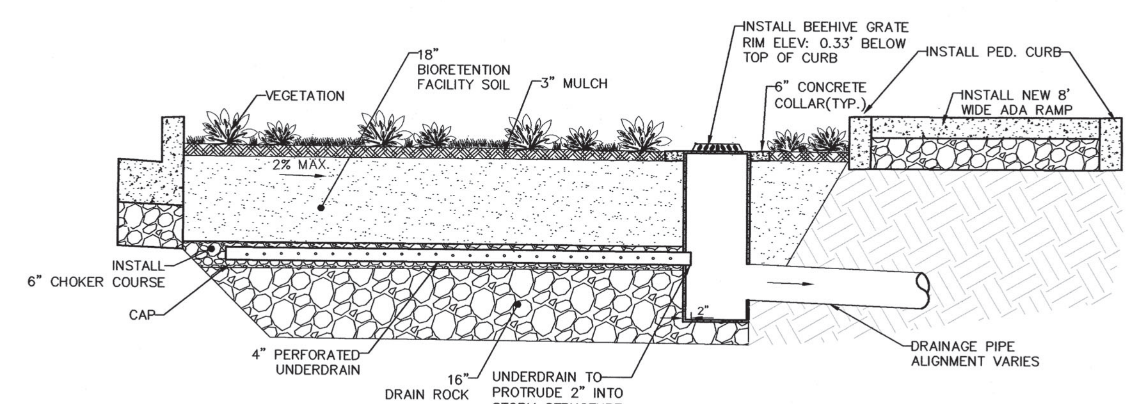
DETAIL 2
CURB RETURN INLET/SPLASH BLOCK
NTS



BIORETENTION DETAIL SECTION A-A



BIORETENTION DETAIL SECTION B-B SITE 1



TYPICAL BIORETENTION DETAIL SECTION C-C SITES 2 & 3

4 MAY 2016

Date	No	Revision	By
	4		
	3		
	2		
	1		

PROJECT ENGINEER FA
DESIGNED/DRAWN ELH
INSPECTOR XX

DIRECTOR PUBLIC WORKS T.A.C.
CITY ENGINEER R.A.R.
ASSISTANT DIRECTOR E.C.J.

CITY OF BELLINGHAM, WASHINGTON
PUBLIC WORKS DEPARTMENT
ENGINEERING DIVISION

SCALE
Horiz. 1"= 20'
Vert. 1"= NA

DATUM

Job. No. ES-0512
Date 12-15-2015
Field Bk. 1013

ES-0512 NEVADA KENTUCKY BIKE BLVD.
BIORETENTION FACILITY AND PROJECT DETAILS

SHEET 23 OF 26

CONTACT PERSON: FREEMAN ANTHONY P.E. , PROJECT ENGINEER AT 778-7900

APPENDIX B

Current Study Exploration Logs and Laboratory Testing Data

associated earth sciences incorporated

Exploration Log

Project Number	Exploration Number	Sheet
150387H007	BCK-HA-1	1 of 1

Project Name	Bioretention Hydrologic Performance Study	Ground Surface Elevation (ft)	
Location	Bellingham, WA	Datum	N/A
Driller/Equipment	Hand Auger	Date Start/Finish	10/11/18,10/11/18
Hammer Weight/Drop	N/A	Hole Diameter (in)	4 inches

Depth (ft)	S T	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Water Level	Blows/6"	Blows/Foot (10 20 30 40)	Other Tests
				Fine Mulch					
				Bioretention Soil Mix					
		S-1		Loose, slightly moist, medium SAND, trace to some gravel, trace silt; organic rich; massive (SP).					
				Glaciomarine Drift					
		S-2		Stiff, slightly moist, grayish brown, very silty, fine SAND to very sandy, SILT, trace gravel; gravel interpreted as dropstones (SM-ML).					
		S-3							
				Bottom of exploration boring at 3 feet.					
5									

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample
- M - Moisture
- Water Level ()
- Water Level at time of drilling (ATD)

Logged by: ADY
Approved by: JHS

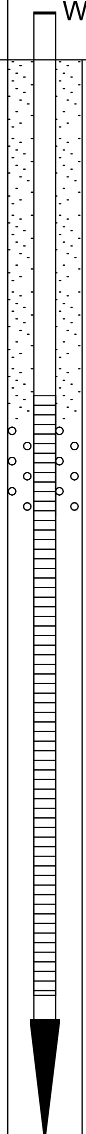
Geologic & Monitoring Well Construction Log

associated earth sciences incorporated

Project Number	Well Number	Sheet
150387H007	BCK-HA-2/WP	1 of 1

Project Name	Bioretention Hydrologic Performance Study	Location	Bellingham, WA
Elevation (Top of Well Casing)	101.2 (Project Datum)	Surface Elevation (ft)	99.1 (Project Datum)
Water Level Elevation	Dry	Date Start/Finish	10/11/18,10/11/18
Drilling/Equipment	Hand Auger	Hole Diameter (in)	4 inches
Hammer Weight/Drop	N/A		

Depth (ft) | Water Level | WELL CONSTRUCTION | S T | Blows/ 6" | Graphic Symbol | DESCRIPTION



WELL CONSTRUCTION

Threaded steel pipe 1.25 inches I.D. with threaded and vented PVC cap -2 to 1.1 feet

Fine mulch 0 to 0.1 feet

Bioretention soil mix 0.1 to 1.5 feet

Gravel fill 1.5 to 1.9 feet

Driven into existing sediments 1.9 to 4.5 feet

Stainless steel jacket cover stainless steel #60 gauze welded to perforated steel pipe 1.4 to 3.9 feet

Threaded steel pipe 1.25 inches I.D. and drive point 3.9 to 4.5 feet

5

Note: ~4 inches of "dead space" below bottom of perforated openings and total inside depth. Total inside depth = 6.2 feet.

DESCRIPTION

Fine Mulch

Bioretention Soil Mix

Loose, slightly moist, medium SAND, trace to some gravel, trace silt; organic rich; massive (SP).

Underdrain Gravel Bedding

Loose, angular GRAVEL (0.5 to 1 inch); partially mixed with bioretention soil mix (GP).

Boring terminated at 1.9 feet
Well completed at 4.5 feet on 10/11/18.
Refusal due to caving.
Steel drive point placed in borehole and hand-driven with slide hammer to depth of 3.6 feet.

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample

M - Moisture
Water Level ()
Water Level at time of drilling (ATD)

Logged by: ADY
Approved by: JHS

associated earth sciences incorporated

Moisture, Ash, and Organic Matter of Peat and Other Organic Soils - ASTM 2974

Date Sampled	Project	Project No.		Soil Description
10/11/2018	Bioretention Hydrologic Performance Monitoring Study	150387 E007		Bioretention soil mix
Tested By	**Location**	**EB/EP No.**	**Depth**	
BN	Onsite- BCK			

Moisture Content

Sample ID	HA-1 (0.1'-0.5')	HA-2 (0.1'-0.3')
Wet Weight + Pan	830.04	864.86
Dry Weight + Pan	791.49	832.48
Weight of Pan	434.52	536.76
Weight of Moisture	38.55	32.38
Dry Weight of Soil	356.97	295.72
% Moisture	9.7	9.9

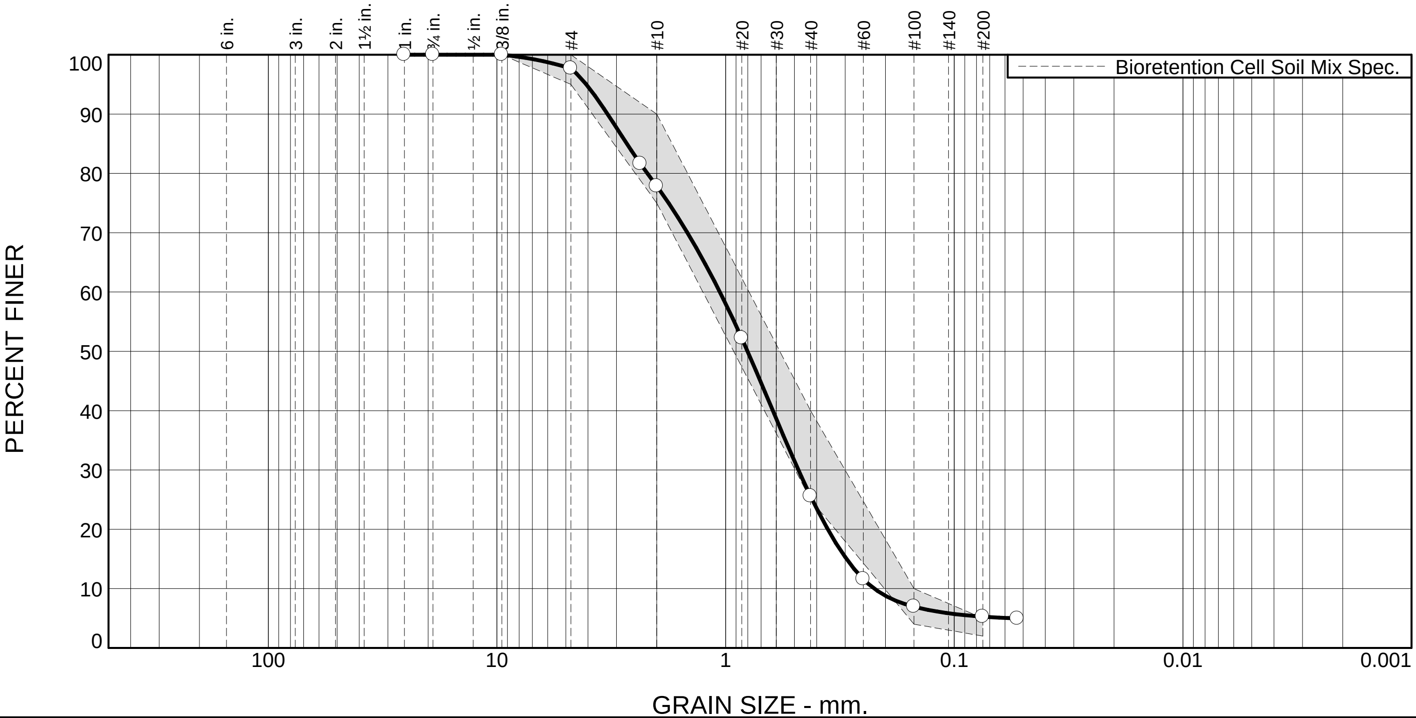
Organic Matter and Ash Content

Dry Soil Befor Burn + Pan	467.15	611.75
Dry Soil After Burn + Pan	454.26	600.50
Weight of Pan	247.04	391.90
Wt. Loss Due to Ignition	12.89	11.25
Actual Wt. Of Soil After Burr	207.22	208.60
% Organics	5.9	5.1

ASSOCIATED EARTH SCIENCES, INC.

911 5th Ave., Suite 100 Kirkland, WA 98033 425-827-7701 FAX 425-827-5424

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	2.3	19.9	52.2	20.3	5.3	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1	100.0		
0.75	100.0		
.375	100.0	100.0	
#4	97.7	95.0 - 100.0	
#8	81.6		
#10	77.8	75.0 - 90.0	
#20	52.2		
#40	25.6	25.0 - 40.0	
#60	11.6		
#100	7.0	4.0 - 10.0	
#200	5.3	2.0 - 5.0	X
#270	4.9		

* Bioretention Cell Soil Mix Spec.

Material Description

SAND, some silt, trace gravel

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP-SM **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 3.2822 D_{85}= 2.7043 D_{60}= 1.0597
D_{50}= 0.8015 D_{30}= 0.4806 D_{15}= 0.2959
D_{10}= 0.2238 C_u= 4.73 C_c= 0.97

Remarks

Collected by: ADY

Bioretention soil mix burned first per ASTM D2974 then sieved.

Date Received: 10/16/2018 **Date Tested:** 10/18/2018

Tested By: MS

Checked By: JHS

Title:

Source of Sample: (BCK) Bellingham- Cornwall and Kentucky **Depth:** 0.1'-0.5' **Date Sampled:** 10/11/2018

Sample Number: HA-1

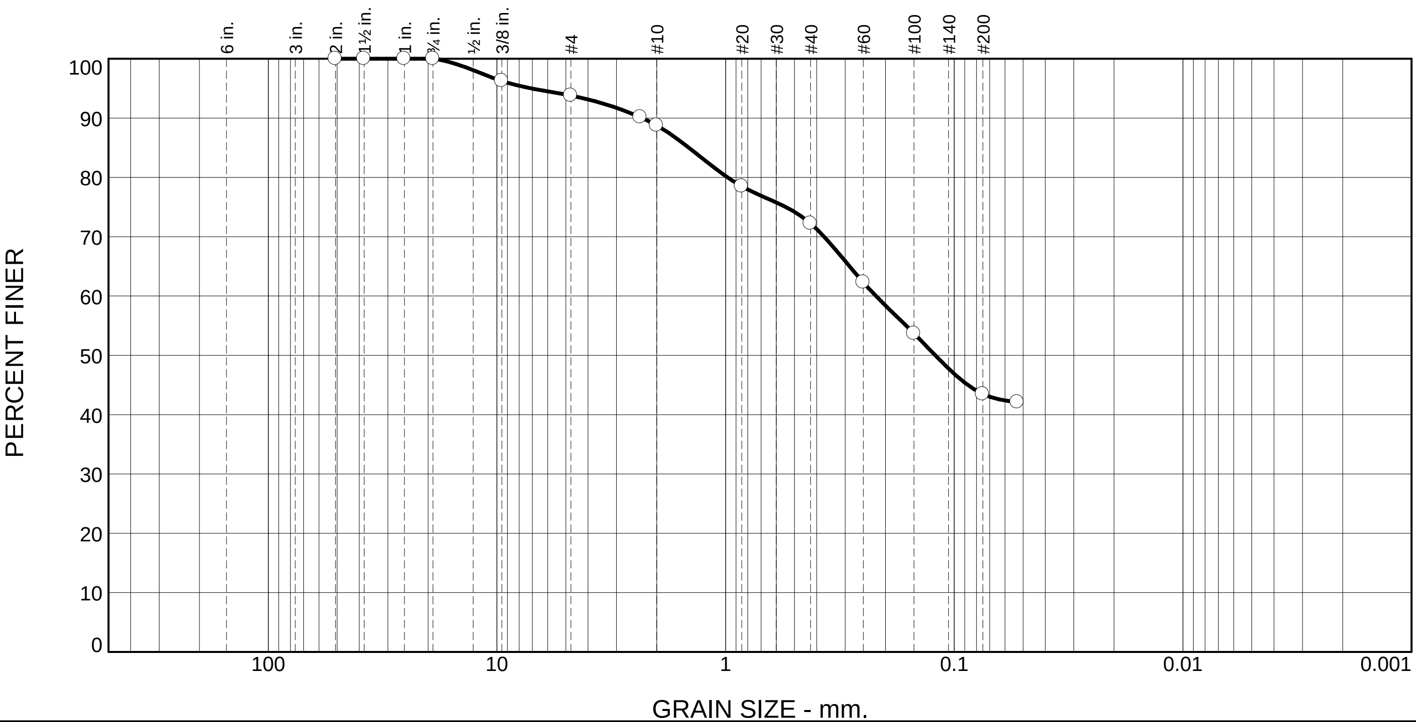
associated earth sciences incorporated

Client: Clear Creek Solutions

Project: Bioretention Hydrologic Performance Study

Project No: 150387 H004 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	6.2	5.0	16.6	28.7	43.5	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
2	100.0		
1.5	100.0		
1	100.0		
.75	100.0		
.375	96.3		
#4	93.8		
#8	90.1		
#10	88.8		
#20	78.5		
#40	72.2		
#60	62.3		
#100	53.7		
#200	43.5		
#270	42.1		

* (no specification provided)

Material Description

Very silty SAND, some gravel

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-4(0)

Coefficients

D_{90}= 2.3179 D_{85}= 1.4481 D_{60}= 0.2200
D_{50}= 0.1211 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Collected by: ADY

Date Received: 10/16/2018 **Date Tested:** 11/12/2018

Tested By: BN

Checked By: JHS

Title:

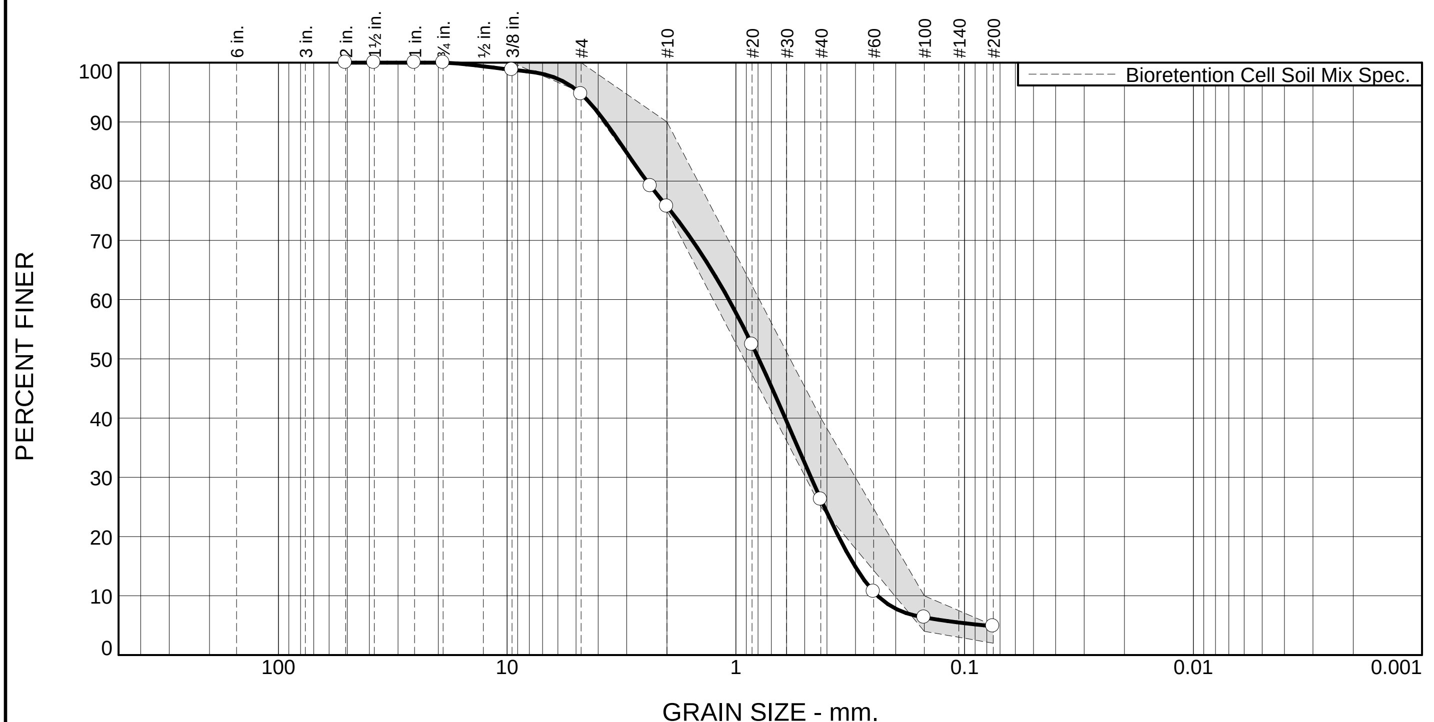
Source of Sample: (BCK) Bellingham- Cornwall and Kentucky **Depth:** 2.5'-3' **Date Sampled:** 10/11/2018
Sample Number: HA-1

a s s o c i a t e d
e a r t h s c i e n c e s
i n c o r p o r a t e d

Client: Clear Creek Solutions
Project: Bioretention Hydrologic Performance Study

Project No: 150387 H004 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	5.3	19.0	49.4	21.4	4.9	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
2	100.0		
1.5	100.0		
1	100.0		
.75	100.0		
.375	98.8	100.0	X
#4	94.7	95.0 - 100.0	X
#8	79.2		
#10	75.7	75.0 - 90.0	
#20	52.4		
#40	26.3	25.0 - 40.0	
#60	10.7		
#100	6.4	4.0 - 10.0	
#200	4.9	2.0 - 5.0	

* Bioretention Cell Soil Mix Spec.

Material Description

SAND, some gravel, trace silt

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP **AASHTO (M 145)=** A-1-b

Coefficients

$D_{90}=$ 3.7253 $D_{85}=$ 3.0237 $D_{60}=$ 1.0736
$D_{50}=$ 0.7941 $D_{30}=$ 0.4697 $D_{15}=$ 0.3015
$D_{10}=$ 0.2402 $C_u=$ 4.47 $C_c=$ 0.86

Remarks

Collected by: ADY

Bioretention soil mix burned first per ASTM D2974 then sieved.

Date Received: 10/16/2018 **Date Tested:** 11/12/2018

Tested By: BN

Checked By: JHS

Title:

Source of Sample: (BCK) Bellingham- Cornwall and Kentucky **Depth:** 0.1'-0.3' **Date Sampled:** 10/11/2018
Sample Number: HA-2

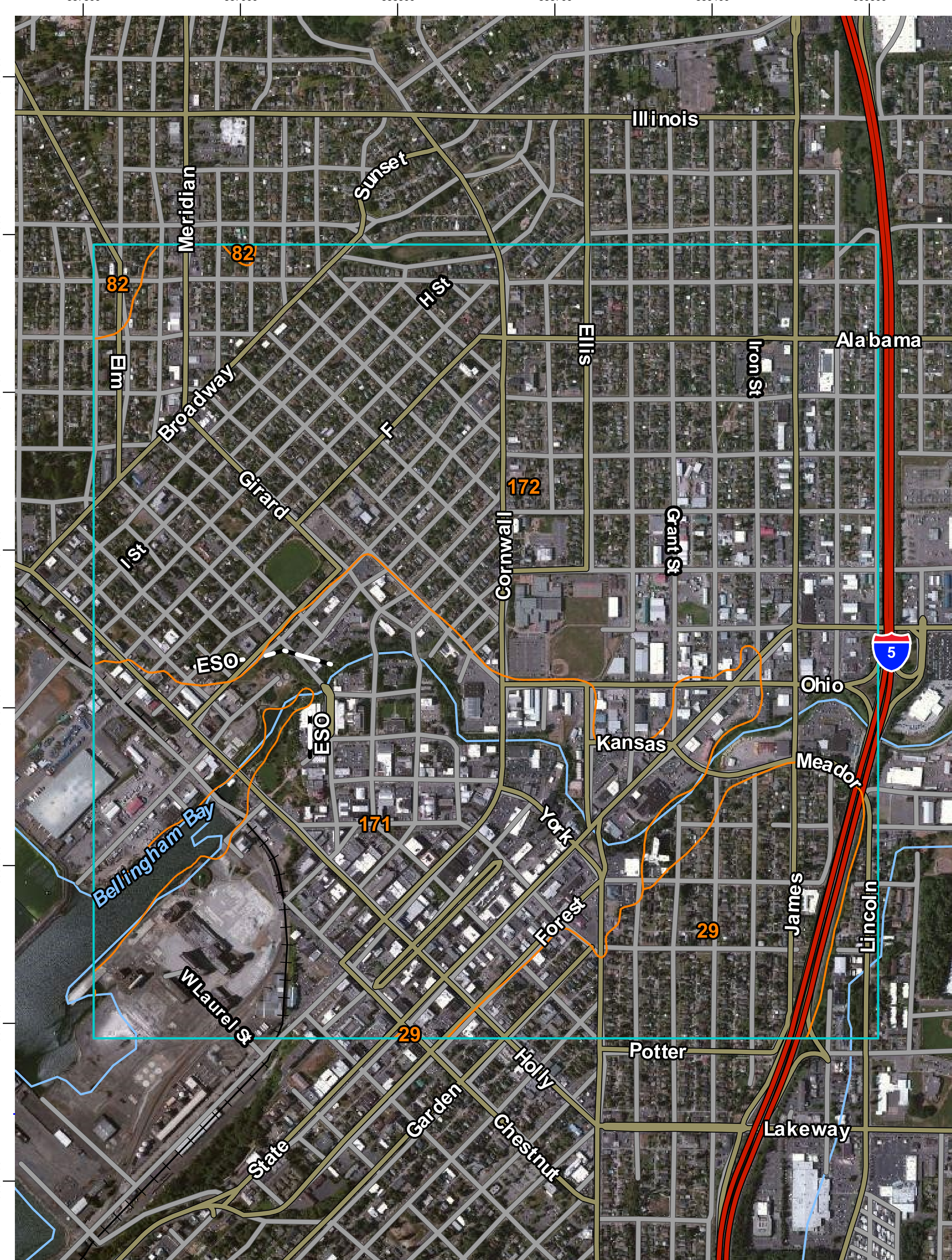
associated earth sciences incorporated

Client: Clear Creek Solutions
Project: Bioretention Hydrologic Performance Study

Project No: 150387 H004 **Figure**

APPENDIX C

Background Soil, Geology, and Groundwater Data (Regional Maps, Previous Studies Exploration Logs and Laboratory Testing Data)



Map Scale: 1:15,500 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0, 200, 400, 800, 1200

Feet: 0, 500, 1000, 2000, 3000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Whatcom County Area, Washington
Survey Area Data: Version 18, Sep 10, 2018

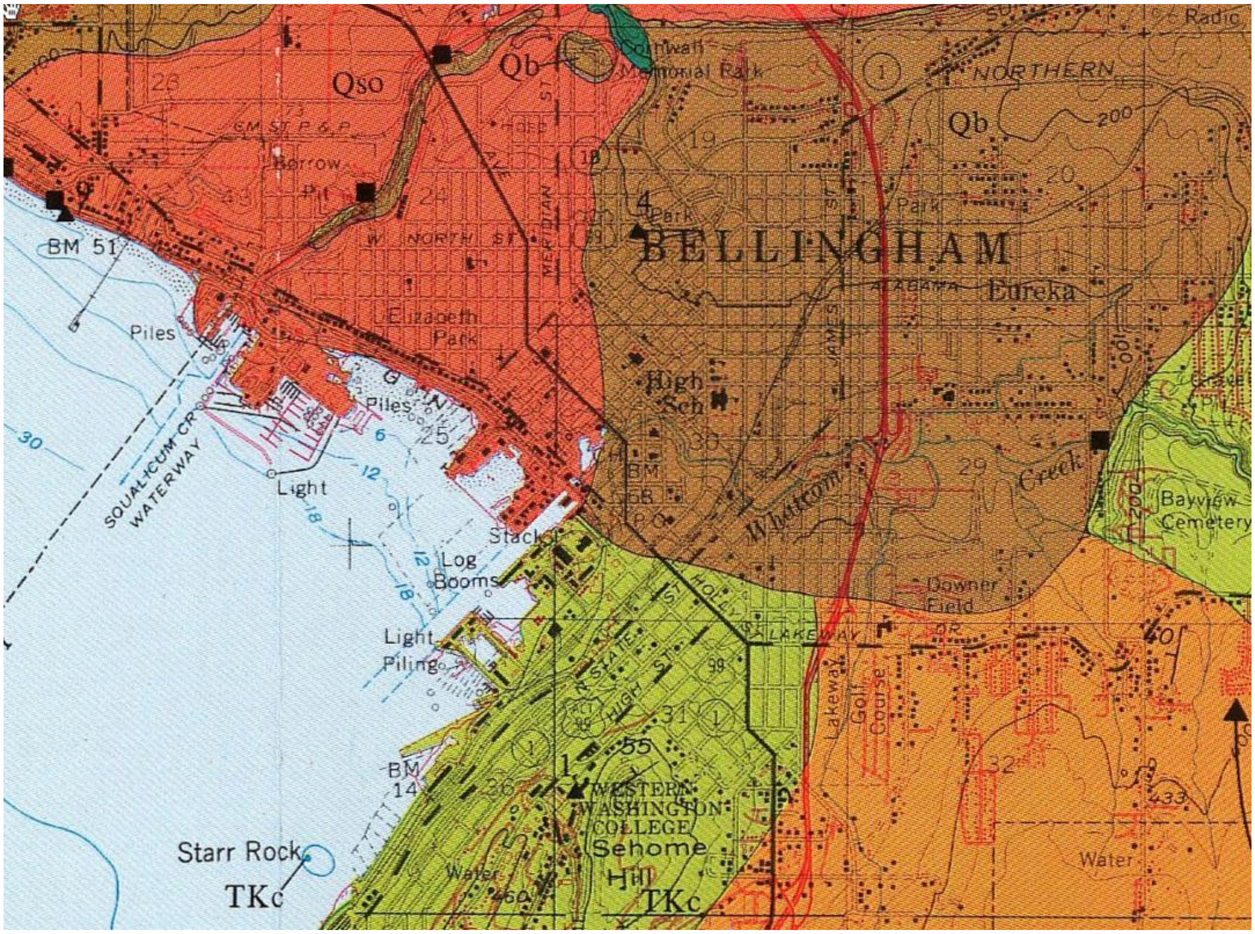
Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jul 9, 2010—Aug 28, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
29	Chuckanut-Urban land complex, 5 to 20 percent slopes	98.4	9.9%
82	Kickerville-Urban land complex, 0 to 3 percent slopes	7.2	0.7%
171	Urban land	314.2	31.5%
172	Urban land-Whatcom-Labounty complex, 0 to 8 percent slopes	560.1	56.2%
Totals for Area of Interest		**996.9**	**100.0%**



Excerpt from:

Easterbrook, D.J., 1976, Geologic map of western Whatcom County, Washington: U.S. Geological Survey, Miscellaneous Investigations Series Map I-854-B, scale 1:62,500

Appendix A: Site Plan with Test Locations

Source: City of Bellingham Public Works-Engineering
Overlay by MTC: KWP
Not to Scale – Shown is approximate
Not for Construction

0 **150**

SCALE (FEET)
1 inch ~150 feet

Materials Testing & Consulting 777 Chrysler Drive Burlington, WA 98233	**Site Map and Test Locations** Cornwall Avenue Infiltration Sampling Cornwall Avenue & Kentucky Street Bellingham, WA	**FIGURE** **1**

Appendix B: Exploration Logs

Unified Soil Classification System Chart

Major Divisions			Graph	USCS	Typical Description
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		GW	Well-graded Gravels, Gravel-Sand Mixtures
				GP	Poorly-Graded Gravels, Gravel-Sand Mixtures
		Gravels With Fines		GM	Silty Gravels, Gravel-Sand-Silt Mixtures
				GC	Clayey Gravels, Gravel-Sand-Clay Mixtures
	Sand More Than 50% of Coarse Fraction Passing No. 4 Sieve	Clean Sands		SW	Well-graded Sands, Gravelly Sands
				SP	Poorly-Graded Sands, Gravelly Sands
		Sands With Fines		SM	Silty Sands, Sand-Silt Mixtures
				SC	Clayey Sands, Clay Mixtures
Fine Grained Soils More Than 50% Passing The No. 200 Sieve	**Silts & Clays**	Liquid Limit Less Than 50		ML	Inorganic Silts, rock Flour, Clayey Silts With Low Plasticity
				CL	Inorganic Clays of Low To Medium Plasticity
				OL	Organic Silts and Organic Silty Clays of Low Plasticity
	Silts & Clays	Liquid Limit Greater Than 50		MH	Inorganic Silts of Moderate Plasticity
				CH	Inorganic Clays of High Plasticity
				OH	Organic Clays And Silts of Medium to High Plasticity
Highly Organic Soils				PT	Peat, Humus, Soils with Predominantly Organic Content

Sampler Symbol Description

- Standard Penetration Test (SPT)
- Shelby Tube
- Grab or Bulk
- California (3.0" O.D.)
- Modified California (2.5" O.D.)

Stratigraphic Contact

- Distinct Stratigraphic Contact Between Soil Strata
- Gradual Change Between Soil Strata
- Approximate location of stratagraphic change

- Groundwater observed at time of exploration
- Measured groundwater level in exploration, well, or piezometer
- Perched water observed at time of exploration

Modifiers

Description	%
Trace	>5
Some	5-12
With	>12

Soil Consistency

Granular Soils		Fine-grained Soils	
Density	***SPT Blowcount***	***Consistency***	***SPT Blowcount***
Very Loose	0-4	Very Soft	0-2
Loose	4-10	Soft	2-4
Medium Dense	10-30	Firm	4-8
Dense	30-50	Stiff	8-15
Very Dense	> 50	Very Stiff	15-30
		Hard	> 30

Grain Size

DESCRIPTION		SIEVE SIZE	GRAIN SIZE	APPROXIMATE SIZE
Boulders		> 12"	> 12"	Larger than a basketball
Cobbles		3 - 12"	3 - 12"	Fist to basketball
Gravel	Coarse	3/4 - 3"	3/4 - 3"	Thumb to fist
	Fine	#4 - 3/4"	0.19 - 0.75"	Pea to thumb
Sand	Coarse	#10 - #4	0.079 - 0.19"	Rock salt to pea
	Medium	#40 - #10	0.017 - 0.079"	Sugar to rock salt
	Fine	#200 - #40	0.0029 - 0.017"	Flour to Sugar
Fines		Passing #200	< 0.0029"	Flour and smaller

Materials Testing & Consulting, Inc.	Exploration Log Key	FIGURE
777 Chrysler Drive Burlington, WA 98233	Cornwall Avenue Infiltration Sampling Cornwall Avenue & Kentucky Street Bellingham, WA	2

Materials Testing and Consulting 805 Dupont St, Suite 5 Bellingham, WA	Boring Log HA-1 (Page 1 of 1)
Cornwall Avenue Infiltration Cornwall Ave & Kentucky St City of Bellingham, WA-Public Works MTC Job #: 16W027-01	Date Started : 4/28/2016 Date Completed : 4/28/2016 Sampling Method : Grab Sample Location : Kentucky St: 2.4' S of curb, 7.3' E of sidewalk Logged By : KWP

Depth in Feet	USCS	GRAPHIC	DESCRIPTION	Samples	Water Level	Percent Moisture	% Finer #200 Sieve
0	AC		ASPHALT PAVEMENT: Top Course 0.17', Base Course 0.21'.				
	CP		CONCRETE PAVEMENT				
1	ML		SANDY SILT, some clay, soft to firm, damp, trace organics (roots), some orange mottling at base of concrete. GRAY BROWN **WEATHERED BELLINGHAM DRIFT** Mottling absent after 1.5' BPG				
2	ML		SILTY CLAY, some sand, stiff to hard with depth, damp. GRAY **BELLINGHAM DRIFT** Trace gravel, 1/2", subround.	X			
			Trace gravel, 1/2", subround.				
3				X		28.3	97.3
			Terminated at planned depth. TD: 3.4' No groundwater encountered during excavations.				
4							
5							

05-09-2016 Z:\Burlington Office\Geotechnical Services\2 Bham\2016 Projects\Cornwall Infiltration CoB\HA logs\HA-1.bor

Materials Testing and Consulting 805 Dupont St, Suite 5 Bellingham, WA	Boring Log HA-2 (Page 1 of 1)
Cornwall Avenue Infiltration Cornwall Ave & Kentucky St City of Bellingham, WA-Public Works MTC Job #: 16W027-01	Date Started : 4/28/2016 Date Completed : 4/28/2016 Sampling Method : Grab Sample Location : Cornwall Ave N: 3' W of curb, 12' N of crosswalk Logged By : KWP

Depth in Feet	USCS	GRAPHIC	DESCRIPTION	Samples	Water Level	Percent Moisture	% Finer #200 Sieve
0	AC		ASPHALT PAVEMENT: Top Course 0.2', Base Course 0.06'.				
	CP		CONCRETE PAVEMENT				
1	GW-GM		GRAVEL with sand, some silt, medium-dense, damp to wet, trace to some organics (roots), gravel to 1/2" subround. BROWN **STRUCTURAL FILL-PIT RUN** Trace to some cobbles to 4", round to subround, continue to TD.				
2				X			
3				X		5.6	5.1
			Terminated at planned depth. TD: 3.2' No groundwater encountered during excavations.				
4							
5							

05-09-2016 Z:\Burlington Office\Geotechnical Services\2 Bham\2016 Projects\Cornwall Infiltration CoB\HA logs\HA-2.bor

Materials Testing and Consulting
805 Dupont St, Suite 5
Bellingham, WA

Boring Log HA-3

(Page 1 of 1)

Cornwall Avenue Infiltration
Cornwall Ave & Kentucky St
City of Bellingham, WA-Public Works
MTC Job #: 16W027-01

Date Started : 4/28/2016
Date Completed : 4/28/2016
Sampling Method : Grab Sample
Location : Cornwall Ave S: 2.9' W of curb, 4.4' S of storm drain
Logged By : KWP

Depth in Feet	USCS	GRAPHIC	DESCRIPTION	Samples	Water Level	Percent Moisture	% Finer #200 Sieve
0	AC		ASPHALT PAVEMENT				
	CP		CONCRETE PAVEMENT				
1	CL-ML		SILTY CLAY, firm, damp, trace organics (roots), some orange mottling. BROWN **WEATHERED BELLINGHAM DRIFT** Orange mottling increase to moderate. Density increase to stiff-very stiff.				
2				X			
3	CL-ML		SILTY CLAY, some sand, trace gravel, very stiff, damp, lacks mottling, gravel to 1/2", subround. GRAY **BELLINGHAM DRIFT**	X		27.2	85.9
			Terminated at planned depth. TD: 3.4' No groundwater encountered during excavations.				
4							
5							

05-09-2016 Z:\Burlington Office\Geotechnical Services\2 Bham\2016 Projects\Cornwall Infiltration CoB\HA logs\HA-3.bor

APPENDIX D

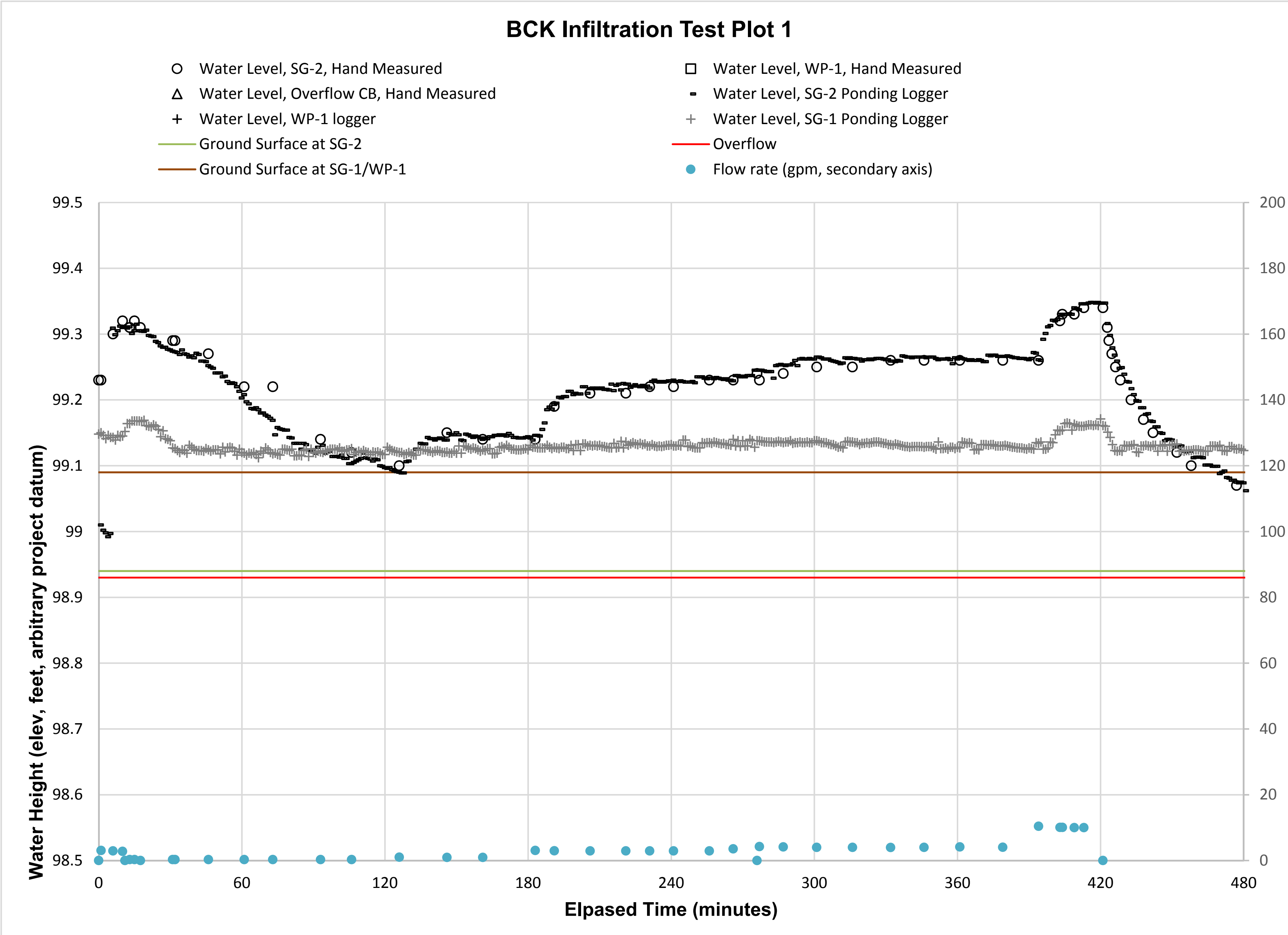
Soil Probe, Level Survey, and Field Infiltration Testing Data

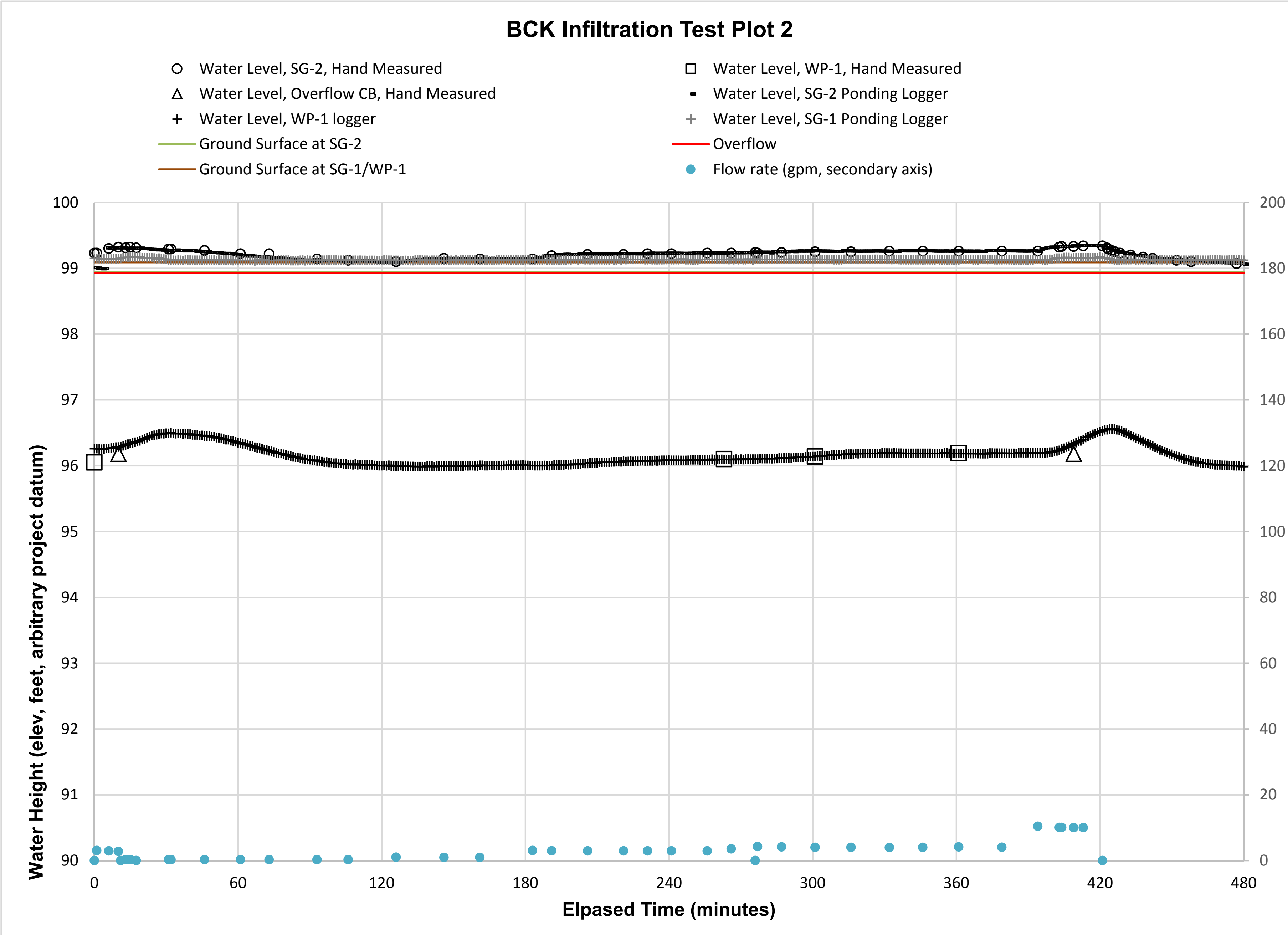
Project Name:	BHPS	**Water Source:**	Hydrant
Project Number:	150387H007	**Meter:**	AESI FM8,9
Date:	11/14/2018	**Base Area (sq.ft.):**	NA
Weather:	Intermittent rain, 60's	**Ponded Area(sq.ft.):**	60.0
Test No.:	BCK	**Test Depth (feet):**	NA
Performed By:	ADY, SC	**Receptor Soils:**	Glaciomarine Drift/Fill

Time (24-hr)	Flow Rate (gpm)	SG-2 Stage (feet)	Totalizer (gallons)	Comments
8:29	0	0.29	0	Flow on, FM9. Raining.
8:30	3.07	0.29	0	
8:35	2.92	0.36	18.59	
8:39	2.78	0.38	29.29	
8:40	0		33.39	Flow off FM9
8:42	0.3	0.37	33.39	Flow on FM8
8:44	0.3	0.38	34.79	
8:46	0	0.37	35.45	Water entering overflow grate. Flow off.
9:00	0.3	0.35	35.45	No flow observed in underdrain. Discahrge to overflow grate stopped. Flow resumed.
9:01	0.3	0.35	35.86	
9:15	0.3	0.33	40.11	
9:30	0.3	0.28	44.6	
9:42	0.3	0.28	48.49	Flow off.
10:02	0.3	0.2	54.39	Rain stops.
10:15	0.3	0.18	58.05	No flow observed in underdrain.
10:35	1	0.16	63.94	
10:55	0.96	0.21	82.03	
11:10	0.94	0.2	96.87	
11:32	3.06	0.2	117.23	
11:40	2.94	0.25	139.13	Wetted area approx. 2.5ft x 7ft.
11:55	2.92	0.27	183.33	
12:10	2.92	0.27	227.65	
12:20	2.92	0.28	256.97	
12:30	2.93	0.28	285.62	
12:45	2.92	0.29	330.23	No rain. No underdrain flow observed.
12:52				
12:55	3.55	0.29	359	
13:05	0	0.3	393	
13:06	4.24	0.29	43	
13:16	4.13	0.3	57	
13:30	4	0.31	113	
13:45	3.98	0.31	172	
14:01	3.96	0.32	236	
14:15	3.98	0.32	292	
14:30	4.12	0.32	353	No rain. No underdrain flow observed.
14:48	4.04	0.32	425	
15:03	10.43	0.32	492	Flow rate increased.
15:12	10.05	0.38	577	Flow approaching overflow grate.

15:13	10.05	0.39		Flow entering overflow grate. No nunderdrain flow observed. No rain.
15:18	10	0.39	637	
15:22	10	0.4	384.91	
15:30	0	0.4	757.16	Flow off
15:31		0.37		
15:32		0.35		
15:33		0.33		
15:35		0.31		
15:37		0.29		
15:41		0.26		
15:47		0.23		
15:51		0.21		Observed slow inflow from backed-up water in northern inlet pipe.
16:01		0.18		
16:07		0.16		
16:26		0.13		
16:30		0.12		

	Average Infiltration Rate (in/hr) during last hour of inflow:	6.6
	Average Infiltration Rate (in/hr) during falling head:	3.4


BCK Infiltration Test Plot 1
Water Level, SG-2, Hand Measured
Water Level, WP-1, Hand Measured
Water Level, Overflow CB, Hand Measured
Water Level, SG-2 Ponding Logger
Water Level, WP-1 logger
Water Level, SG-1 Ponding Logger
Ground Surface at SG-2
Overflow
Ground Surface at SG-1/WP-1
Flow rate (gpm, secondary axis)
Water Height (elev, feet, arbitrary project datum)
99.5
99.4
99.3
99.2
99.1
99
98.9
98.8
98.7
98.6
98.5
200
180
160
140
120
100
80
60
40
20
0
0
60
120
180
240
300
360
420
480
Elpased Time (minutes)


BCK Infiltration Test Plot 2
Water Level, SG-2, Hand Measured
Water Level, Overflow CB, Hand Measured
Water Level, WP-1 logger
Ground Surface at SG-2
Ground Surface at SG-1/WP-1
Water Level, WP-1, Hand Measured
Water Level, SG-2 Ponding Logger
Water Level, SG-1 Ponding Logger
Overflow
Flow rate (gpm, secondary axis)
Water Height (elev, feet, arbitrary project datum)
100
99
98
97
96
95
94
93
92
91
90
200
180
160
140
120
100
80
60
40
20
0
0
60
120
180
240
300
360
420
480
Elpased Time (minutes)

APPENDIX E

Site Photos

Cell BCK overview, overflow in lower center of photo

Cell BCK overview, curbcut inlet shown

Cell BCK, curb cut inlet and undocumented inlet (green pipe). Above photo is prior to install of weir. Lower photo is after weir install and during infiltration testing.

Technical Memorandum

Date:	June 11, 2019	**From:**	Anton Ympa Suzanne Cook, L.G.
To:	Clear Creek Solutions, Inc.	**Project Manager:**	Jennifer H. Saltonstall, L.G., L.Hg.
	15800 Village Green Drive #3 Mill Creek, Washington 98012	**Principal in Charge:**	Jennifer H. Saltonstall, L.G., L.Hg.
cc:	Eric Christensen	**Project Name:**	Bioretention Hydrologic Performance Study
Attn:	Doug Beyerlein, P.E.	**Project No:**	150387H007
Subject:	Deliverable Task 4.5, Site BUW, Geotechnical/Soils Assessment Design Data and Current Conditions, Bellingham Utter Street and Washington Street, Bellingham, Washington		

1.0 INTRODUCTION

This technical memorandum documents existing shallow soil and groundwater conditions in Bioretention Facility Cell #5 of the Colombia Water Quality Improvements Project, located in the city of Bellingham, Washington (Figure BUW F1). This memorandum was prepared in accordance with Task 4 of the contract scope of work. Associated Earth Sciences, Inc. (AESI) collected shallow soil and groundwater conditions data related to bioretention cell function, and documented the current condition of the facility relative to the as-built drawings and available background geotechnical information. The information will be used in the WWHM2012 modeling that will be conducted as part of Task 5 (Data Analysis). In Task 5, the team will compare the previously documented hydrologic design information with our field-collected information and will note where there are significant differences. The purpose of this technical memorandum is to document the collection of current and accurate geotechnical, geologic, and hydrogeologic site information for this later work.

The following summary of shallow soil and groundwater conditions integrates the observations made during the geotechnical assessment which included site visits on October 11, 2018, infiltration testing on November 15, 2018, provisional results of hydrologic monitoring, and background geotechnical information.

This technical memorandum has been prepared for the exclusive use of Clear Creek Solutions and the City of Olympia and their agents for specific application to this project. Within the limitations of scope, schedule, and budget, our services have been performed in accordance with generally accepted hydrogeologic and geotechnical engineering practices in effect in this area at the time our document was prepared. No other warranty, express or implied, is made.

2.0 PURPOSE AND SCOPE

The purpose of our work was to perform a shallow soil and groundwater conditions assessment and provide baseline documentation data to assess effectiveness of bioretention hydrologic performance.

Specifically, our scope included the following activities:

- Review of project documents.
- Site reconnaissance.
- Visual condition assessment of erosion and deposition features near inlet and outlet.
- Review project plans relative to constructed facility, in particular, the number and location of inlets, energy dissipation devices, outlets, and other flow-related details.
- Survey elevations of inlet, outlet, well point rim, and other observation points relative to a project datum.
- Excavate shallow hand augers through the bioretention soil.
- Classify sediment according to the Unified Soil Classification System (USCS) and *American Society for Testing and Materials* (ASTM) D2488, "Standard Recommended Practice for Description of Soils."
- Collect samples for laboratory testing of: (1) particle size distribution in accordance with ASTM D422-63, "Standard Test Method for Particle-Size Analysis of Soils"; (2) organic matter content per ASTM D2974.
- Preparation of descriptive exploration logs for each exploration.
- Conduct qualitative assessment of soil compaction via T-probe.
- Conduct infiltration testing.
- Review of hydrologic monitoring data.
- Preparation of this summary document.

Existing facility features and the locations of hand-auger boreholes completed for this study are shown on Figure BUW F2, "Facility and Exploration Plan." Project civil plans are attached as Appendix A. Exploration logs and laboratory testing data conducted as part of this study are attached as Appendix B. Background soil, geology, and groundwater information are attached as Appendix C. Soil probe, level survey, and field infiltration testing data are attached as Appendix D. Site photos are attached as Appendix E.

3.0 SITE DESCRIPTION AND DESIGN BACKGROUND

The project site is the Colombia Water Quality Improvements Project, located in the city of Bellingham, Washington as shown on the attached "Vicinity Map" (Figure BUW F1). The project site is located along the right-of-way of several streets in the City of Bellingham including Utter Street and Washington Street.

Our specific area of study for this project includes bioretention cell #5 located on the southeast of the intersection of Utter Street and Washington Street referred to as cell BUW for this study. The BUW site is bordered by Washington Street on the west, Utter Street to the south, and sidewalk and single-family residences to the north and east. Site topography is generally level, sloping gently downhill to the south. No on-site surface water features are present. As described in the Drainage Report (Columbia Neighborhood Water Quality Improvements, November 10, 2016) the site drains to Bellingham Bay.

Details of the bioretention facility design and basis for design were presented in the following documents:

- “Columbia Neighborhood Water Quality Improvement Project, Preliminary Geotechnical Conditions Assessment,” Bellingham, Washington, Element Solutions, October 26, 2016.
- “Columbia Neighborhood Water Quality Improvements,”, Pacific Surveying and Engineering, November 10, 2016.
- “Columbia Neighborhood Water Quality Improvements Project (EV-0120),” Memorandum, Pacific Surveying and Engineering, July 28, 2017.
- “Columbia Water Quality Improvements,”, Pacific Surveying and Engineering, October 30, 2017.

3.1 Summary of Facility Design

From our review of these documents, the bioretention facility design for cell BUW consists of an approximately rectangular-shaped bioretention cell with approximately 211 square feet of base area, as shown on Figure BUW F2, “Facility and Exploration Plan.” We understand that the site was developed under the Washington State Department of Ecology (Ecology) 2014 *Stormwater Management Manual for Western Washington* (2014 Ecology Manual) for design and construction of stormwater facilities and modeled using WWHM2012 with a design infiltration rate of 6 inches per hour (in/hr) in the bioretention soil. It was unclear whether an infiltration rate was applied to the native subgrade. The facility has an underdrain as part of the design. Land use within the drainage basin is primarily lawn and roadway. Per Sheet C22, “Bioretention Cell Details, Columbia Water Quality Improvements,” Pacific Surveying and Engineering, October 30, 2017, the facility design includes 3 inches of mulch and 18 inches of bioretention soil mix overlying a 6-inch “choker course,” overlying 18 inches of mineral aggregate for bioretention cells. The facility contains a 4-inch-diameter perforated underdrain pipe bedded in the mineral aggregate. The underdrain discharges to a catch basin, which also features a beehive grate with a rim 0.3 feet above the level of the base of the facility. The catch basin discharges to the City storm drain system. The upstream end of the perforated underdrain pipe terminates in another catch basin within the bioretention cell.

The facility is designed to discharge 98.22 percent of inflow through the underdrain. Stormwater enters the facility through two curbcuts along the eastern side of Utter Street. Only one curbcut, on the northern end of the cell, is depicted on plan sheet C16 (Pacific Surveying and Engineering, October 30, 2016). If water ponds up on the bioretention soil, the ponded water would discharge into the beehive grate located near the south end of the cell, and then into the City storm drain system. The rim of the Type I Catch Basin was designed to be 0.3 feet higher than the cell base to create 0.3 feet of ponding depth. The facility was constructed and began receiving runoff after July 2017, based on review of historic aerial imagery.

4.0 SITE OBSERVATIONS

During AESI's site visits, we made notes regarding the physical construction of the bioretention facilities including documenting site inlet/outlet layout relative to site plans and qualitative bioretention soil thickness and compaction. These notes were used to indicate key features of the facility in Figure BUW F2, "Facility and Exploration Plan."

- Level Survey: AESI conducted an elevation survey of the cell using a Leitz C40 automatic level and a stadia rod. An arbitrary project datum was established for this survey, with the east rim of the storm manhole cover on Utter Street, near the bioretention cell (identified on the "BUW Level Survey Data" map in Appendix D) defined as project datum elevation 100 feet. All other elevations measured by the survey are relative to this project datum. Key level data is summarized in Table 1. Additional data points are included in Appendix D to this document. This survey was not conducted by a licensed surveyor. Surveyed elevations are expected to be sufficiently accurate for this general assessment of facility construction, but may be inaccurate for purposes requiring greater precision.

- Inflow: Two curbcuts are present along the west side of the cell:
    - Primary: The primary inflow (Inlet 1) to the facility is a 1-foot curbcut, consistent with project plans, which discharges onto a rounded rock energy dissipation pad approximately 3 feet wide and 3 feet long. A small amount of water was discharging during the brief period of rain at the time of our November 15, 2018 site visit.

    - Undocumented inflow: A second inflow (Inlet 2) to the facility is a 1-foot curbcut entering near the southern end of the facility near the overflow beehive grate. This inlet has an approximately 4-foot-wide by 3-foot-long energy dissipater pad, and the inlet and pad are not shown on project plan sheets. A small amount of water was discharging during the brief period of rain at the time of our November 15, 2018 site visit.

- Overflow: The overflow consists of a22-inch by 25-inch concrete catch basin with a beehive grate (SDCB#29A). The rim of this grate is 0.5 inches to 2.5 inches above the base of the facility, lower than the 0.3 feet specified on the plan sheets. During our November 15, 2018 site visit, while discharging water to the curb of the street uphill (north) of the northern inlet, we observed a portion of the water flowing through the southern inlet and directly into the overflow beehive grate, as discussed under "Infiltration Testing."

- AESI investigated the loose bioretention soil thickness present in cell BUW using a geotechnical soil T-probe. This qualitative data was used in conjunction with the hand-auger observations to understand loose soil thickness and relative potential compactness of the bioretention soils at depth. AESI measured the depth of penetration of the soils probe at locations generally arranged in an approximately 3-foot grid on the facility base. Penetration of the T-probe generally ranged from approximately 1.2 to 1.7 feet and averaged 1.5 feet. Probe penetration data is included in Appendix D to this document.

- AESI observed that the facility base generally slopes down to the south, such that the overflow rim elevation (99.14-foot low point) is below the level of the cell base on the northern, uphill, end.

Table 1
Summary of Cell BUW
Level Survey Data

Location	Elevation (feet, project datum)
Inlet #2 (S), curb top (S)	99.69
Inlet #2 (S), curb top (N)	99.85
Inlet #2 (S) curbcut S/low, inside lip	99.30
Overflow outer rim, SW corner/low	99.14
Overflow inside rim @ notch (W)	99.01
Inlet #2 (S) green pipe top/end	99.80
Inlet #1 (N) curb top (S)	100.17
Inlet #1 (N) curbcut center/low, inside lip	99.64
Inlet #1 (N) curb top (N)	100.10
Inlet #1 (N) green pipe top/end	100.22
WP-1 TOC	101.30
Ponding Tube TOC (Baro)	100.78
Ponding Tube TOC (DL)	100.04

WP: well point; TOC: top of casing; DL: datalogger

5.0 SITE SETTING

The text sections below describe our research findings in regards to the topographic, geologic, and hydrogeologic setting of the project site both from regional studies and background site-specific geotechnical and groundwater studies. Our sources of information included the following:

- Site-specific documents cited previously under "Project and Site Description."
- Easterbrook, D.J., 1976, *Geologic Map of Western Whatcom County, Washington*: U.S. Geological Survey (USGS), Miscellaneous Investigations Series Map I-854-B, scale 1:62,500, Natural Resource Conservation Service (NRCS), Web Soil Survey, United States Department of Agriculture (USDA), http://websoilsurvey.nrcs.usda.gov/, accessed January 2019.

- *Soil Survey of Whatcom County Area, Washington*, United States Department of Agriculture (USDA), Natural Resource Conservation Service (NRCS), in cooperation with Washington State Department of Natural Resources (DNR) and Washington State University Agricultural Research Center, 1992.
- Newcomb, R.C. et al., *Ground-water Resources of Western Whatcom County, Washington*, U.S. Geological Survey (USGS) Open File Report 50-7, 1950.

5.1 Regional Topography and Project Grading

The project site is situated on a generally level terrace in the Bellingham Basin, near Bellingham Bay. Squalicum Creek and Whatcom Creek, modern streams, have incised the terrain approximately 2,500 feet northwest and 3,000 feet southeast of the site by up to about 50 feet. The streams both discharge into Bellingham Bay. Elevations on the larger project site range from about 70 to 80 feet.

On a closer scale, the area near cell BUW is relatively level, situated at about elevation 75 feet. The site is located about 1,500 feet northeast from the coastline of Bellingham Bay. Sidewalk and road areas surround the cell on the south, east, and west. Grass is present on the short northern edge. A curb separates the paved surfaces from the cell.

The project site was previously developed with the construction of Utter and Washington streets, and single-family residences in the area. Various utilities are present in the vicinity of the site, including a buried water main which runs underneath the cell on the Utter Street (west) side. Native grade is unknown, however minor cutting (about 3 feet) into the previously constructed sidewalk and lawn area would have been required during construction, and previous construction of utilities and development in the area would have required previous cutting and filling to place the utilities present under the site.

5.2 Regional Geology and Background Geotechnical Information

According to D.J. Easterbrook, 1976, *Geologic Map of Western Whatcom County, Washington*: U.S. Geological Survey, Miscellaneous Investigations Series Map I-854-B, scale 1:62,500, the site vicinity is underlain by outwash sand and gravel (Sumas Stade). As described on the geologic map, these consist of sands and gravels. Bellingham Drift (Everson Interstade) is present in the vicinity. As described on the geologic map, this consists of blue-gray, unsorted, pebbly sandy silt and pebbly clay, with glaciomarine drift mantling upland areas. This is consistent with our observations and interpretations of subsurface materials encountered in our explorations for this project.

- <u>Bellingham Drift (Everson Interstade, Qb)</u>: Blue-gray, unsorted, unstratified, pebbly, sandy silt and pebbly clay. Derived from rock debris melted out of floating ice and deposited on sea floor. Locally contains mollusks and wood, radiocarbon dated between 11,000 and 12,000 years B.P., Glaciomarine Drift mantles upland areas between flood plains below elevations of 600 feet.

- Outwash sand and gravel (Sumas Stade): Former outwash plain underlain by cobble and boulder gravel near Canadian border, grading southwestward to sand near Lynden. Sandy gravel between Everson and Laurel, grading to sand westward.

Background geotechnical information includes boring B2 (Element Solutions, 2016) within 20 feet of cell BUW dated January 17, 2016, which reached depths of about 16.5 feet below current grades. The explorations described in the geotechnical report (Element Solutions, 2016) identified fill (asphalt and concrete) overlying a sequence of sand, silt, and clay layers in the vicinity of the BUW site. Static groundwater was encountered at approximately 5 feet at the time of exploration. Element Solutions did not make geologic unit interpretations.

5.3 Regional Soils and Soil Data Used in Site Stormwater Model

AESI reviewed the *Soil Survey of Whatcom County Area, Washington*, United States Department of Agriculture (USDA), Natural Resource Conservation Service (NRCS), in cooperation with Washington State Department of Natural Resources (DNR) and Washington State University Agricultural Research Center, 1992. The soil survey identifies different soil map units based on parent material, climate, topography (slope), organisms (biota), and time. The soils in the study area formed mostly from young glacial deposits and have not had time to develop the deep weathering profiles present in soils in unglaciated terrains. Instead, they exhibit a direct relationship to the underlying parent material, local climate, topography, and vegetation.

Mapped soils in the project area consist of urban land - Whatcom-Labounty complex. Urban land is land that has been heavily modified by development. Whatcom and Labounty soils form over glaciomarine drift.

As described in the Pacific Surveying and Engineering, “Columbia Neighborhood Water Quality Improvements,” Design Report, November 10, 2016, the pre-developed condition was modeled as type C soils and impervious surfaces, consistent with mapped soil and background geotechnical data.

5.4 Regional Hydrogeology and Background Groundwater Data

Regional hydrogeology is described in *Groundwater Resources of Western Whatcom County, Washington* (R.C. Newcomb et al., 1950). Newcomb et al. (1950) indicates that glacial outwash can be an aquifer where saturated, and that perched groundwater conditions can occur locally within these units, particularly over till, silts, and clays such as those comprising glaciomarine drift.

On a closer scale, as described in the Drainage Report (Pacific Surveying and Engineering, 2016), the site discharges ultimately to Bellingham Bay. Limited background groundwater level data was collected in boreholes near the BUW site; however, perched groundwater was encountered at approximately 5 feet below ground surface in both borings accomplished within “Zone A” which the BUW site is situated within. One of these exploration borings was located within approximately

20 feet of the location of cell BUW. Groundwater is expected to perch at this shallower depth under the developed conditions due to stormwater infiltration from the bioretention cells.

6.0 BIORETENTION CELL SUBSURFACE EXPLORATION

Limited information on subsurface conditions was obtained for this study from hand-auger samples and soil probe penetration measurements at about 2-foot increments in each hand-augered borehole. Three hand-auger borings were performed in the facility bottom and advanced through the bioretention soil and to the underlying material – two into the aggregate, and one into native sediments. Representative samples were collected, visually classified in the field, stored in water-tight containers, and transported to AESI's offices for additional classification, geotechnical testing, and study. At the conclusion of the excavation, the boreholes were immediately backfilled with the excavated material or completed as a well point for water level monitoring (described separately below).

The various types of sediments, as well as the depths where characteristics of the sediments changed, are indicated on the exploration logs presented in Appendix B. A detailed record of the observed bioretention soil, subsurface soil, geology, and groundwater conditions was made. The sediments were described by visual and textural examination using the soil classification in general accordance with ASTM D2488, "Standard Recommended Practice for Description of Soils." The depths indicated on the logs where conditions changed may represent gradational variations between sediment types in the field. The exploration logs in Appendix B are based on the field observations, inspection of the samples, and where applicable, laboratory grain-size analysis. Our explorations were approximately located in the field relative to known site features, and are shown on Figure BUW F2, "Facility and Exploration Plan. Global Positioning System (GPS) coordinates for the explorations were taken using a handheld GPS, and are summarized in Appendix B.

The results presented in this document are based on the explorations completed for this study and review of background data. The number, locations, and depths of the explorations were completed within site and budgetary constraints. Because of the nature of exploratory work below ground, interpolation of subsurface conditions between field explorations is necessary. It should be noted that differing subsurface conditions may sometimes be present due to the random nature of deposition and the alteration of topography by past grading and/or filling.

6.1 Hand-Auger Borings

Hand-auger borings in cell BUW were completed on October 11, 2018. No rainfall was noted at the time of exploration.

Hand-auger boring number 1 (BUW-HA-1/WP) and number two (BUW-HA-2), were completed in the base of the cell, generally in the southern and northern ends, respectively. The borings encountered bioretention soil mix to depths of 1.5 and 1.2 feet, respectively, overlying drain rock. Hand-auger boring number 3 (BUW-HA-3), situated on the upper edge of the cell, encountered 0.3 feet of shredded wood chips and 1.7 feet of bioretention soil mix, overlying silt and very silty fine sand interpreted as glaciomarine drift at a depth of 2 feet, extending to the bottom of the exploration at a depth of 3 feet. No seepage or caving was observed, except within the loose drain rock and bioretention soil mix.

6.2 Well Points

A well point was installed in BUW-HA-1/WP. Key well point dimensions are provided in Table 2, below.

Table 2
Summary of Cell BUW
Well Point Dimensions

Well Point	Exploration in which Well Point was Installed	Total Length of Casing (feet)	Interior Diameter	Stickup Height (feet)	Total Depth Inside Casing Below Ground Surface
BUW-HA-1/WP	BUW-HA-1/WP	5.1	1.25 inch nominal	2	3.1

7.0 LABORATORY ANALYSIS

Laboratory testing included mechanical grain-size distribution and percent organic matter by weight in accordance with the ASTM D422 and D2974, respectively. Bioretention soil was first tested for organic matter content and then the burned material was tested for grain-size distribution for comparison with the aggregate fraction of the bioretention soil mix guidance in the 2014 Ecology Manual. One sample of material interpreted as representative of the subgrade was tested for grain-size distribution. The data is summarized in Table 3.

Table 3
Summary of Cell BUW
Organic Content and Grain Size Data

Exploration Number	Depth (feet)	Soil Type	Organic Content (% by weight)	USCS Soil Description	Fines Content (% passing #200)	Cu	Cc	USDA Soil Texture*
BUW-HA-1	0.2-0.5	Bioretention Soil	6.9	SAND, trace silt, trace gravel	1.7	4.0	1.0	SAND
BUW-HA-2	0.2-0.5	Bioretention Soil	6.5	SAND, trace silt, trace gravel	2.0	4.5	1.0	SAND
BUW-HA-3	2.1-2.6	Glaciomarine Drift		Very silty SAND, trace gravel	46.1			Sandy clay to silt loam

USCS: Unified Soil Classification System; Cu: coefficient of uniformity; Cc: coefficient of curvature; USDA: U.S. Dept. of Agriculture; *No hydrometers were performed. USDA soil texture range assumes fines consist entirely of silt to entirely of clay.

7.1 Bioretention Soil Mix

We compared the organic content and burned fraction gradation against the general guidelines for the bioretention soil mix (Table 4).

The organic content of the tested bioretention soils ranged between 6.5 and 6.9 percent by weight. This meets the recommended organic content by weight of 5 to 8 percent in the 2014 Ecology Manual.

The grain-size analysis test results on the burned soil fraction indicate that the bioretention soils tested correlate to a "SAND" with trace to some silt and trace gravel based on ASTM D2487 Unified Soil Classification System (USCS). The respective fines content as measured on the No. 200 sieve was 1.7 to 2 percent, on the lower end or lower than the recommended range of 2 to 5 percent. The coefficient of uniformity ranged from 4 to 4.5, meeting the recommended value of equal to or greater than 4. The coefficient of curvature was 1, at the low end of the recommended range of greater than or equal to 1 and less than or equal to 3. The soil mix was generally coarser-grained with more than the recommended range of medium- to coarse-grained sand and not enough fine-grained sand. The tested bioretention soil was a poorly-graded sand.

Table 4
General Guidelines for Bioretention Soil Mix (2014 Ecology Manual)
Compared to Averaged Cell BUW Site Data

Parameter	Recommended Range	Cell BUW
Organic Content (by weight)	5 to 8 percent	6.7 percent by weight
Cu coefficient of uniformity	4 or greater	4.3
Cc coefficient of curvature	1 to 3	1
Sieve Size	**Percent Passing**	
3/8" (9.51 mm)	100	100
#4 (4.76 mm)	95 to 100	99.5
#10 (2.0 mm)	75 to 90	75.9
#40 (0.42 mm)	25 to 40	14.9
#100 (0.15 mm)	4 to 10	2.9
#200 (0.074 mm)	2 to 5	1.9

Note: The general guidelines for mineral aggregate gradation are from Table 7.4.1 of the 2014 Ecology Manual.
mm: millimeters.

7.2 Subgrade

In BUW-HA-1, a sample of native glaciomarine drift was sieved. The tested material correlates to a very silty SAND, trace gravel with 46.1 percent by weight of the material passing the No. 200 sieve.

The grain-size distribution data were also transformed to describe the USDA soil texture. The grain-size distributions were normalized to the No. 10 sieve—i.e., the coarse sand and gravel fraction of the sample is discounted and the remainder is taken as 100 percent of the sample. The fines were assessed relative to the No. 270 sieve. The respective USDA fines content as measured on the No. 270 sieve after adjusting to remove the weight retained on the #10 sieve was 50.4 percent for the native glaciomarine drift.

8.0 INFILTRATION TESTING

8.1 General Infiltration Test Method

The infiltration test was conducted in general accordance with the 2014 Ecology Manual. The test was conducted by discharging water into the facility for a "soaking period," to allow the receptor soils to become saturated. After completion of the soaking period, water was discharged into the cell at a rate sufficient to maintain a relatively constant head. This constitutes the "constant-head" phase of infiltration testing. Immediately following the constant-head phase of infiltration testing, flow into the facilities was discontinued, and the water level was monitored as it dropped. This constitutes the "falling-head" portion of the infiltration testing.

The water for testing was obtained from an on-site fire hydrant and conveyed to cell BUW with fire hoses. During infiltration testing, the water was conveyed into the bioretention cell via a digital flow meter with gallons per minute (gpm) and total gallon readouts, and discharged through a flow diffuser. Water levels were monitored using a staff gauge (SG-1) marked in 0.01-foot increments installed adjacent BUW-HA-1/WP, a second temporary metal staff gauge (SG-2) marked in 0.01-foot increments installed near the overflow beehive grate, within the well point with a digital water level tape, and with digital pressure transducers. Data from the digital pressure transducers was compensated for barometric response using a separate digital barometer. The area of the pool was measured periodically during testing.

The infiltration test in cell BUW is discussed below, and results are presented in Table 5. Infiltration test data is included in Appendix D to this document.

8.2 Infiltration Test in Cell BUW

AESI performed infiltration testing on November 15, 2018. Light rainfall was noted for approximately 1 hour during testing and the rainfall contributed only minor inflow during that time. Due to the high infiltration rate of the bioretention soil and lack of surface pooling, the inflow was moved a few times during the test to observe cell performance, as described below.

Initially, inflow to the facility for the infiltration test was directed, through a diffuser, onto the cell. Throughout the test, beginning approximately 40 minutes into testing, AESI observed discharge from the underdrain.

Weirs for flow monitoring were in place at the time of testing. During this test, flow was initially maintained at about 47 gpm, increased to 120 gpm temporarily and shut off after the inflow began to backwater the flow monitoring device in the northern inlet, and flow back along the road, into the southern inlet, and into the southern portion of the facility at the base of the southern inlet. During this time, water did not saturate the entire length of the facility base; it saturated only a portion of the base around each inlet.

AESI then directed discharge into the roadway along the curb immediately next to the northern inlet. AESI observed that, when discharging approximately 78 gpm to the curb, a portion of the flow entered the northern inlet, and a portion of the flow bypassed the northern inlet and entered the southern inlet. Approximately 5 gpm of the water bypassing the northern curbcut and entering the southern curbcut flowed directly into the overflow beehive grate near the southern curbcut. At this flow rate, water also bypassed the southern inlet, pooled on the road, and entered the storm drain south of the southern inlet. AESI observed that with the flow reduced to approximately 41 gpm, bypass of the southern inlet and weir did not occur, and no flow directly to overflow was observed. When the flow was increased to 45 gpm, the portion of the flow bypassing the northern inlet to the southern inlet began to bypass the southern inlet and flow into the storm drain south of the inlet.

For the final approximately 100 minutes of testing, AESI moved the discharge hose to near the well point, and discharged water at approximately 120 gpm.

Approximately 31,000 gallons of water were used.

Water in the well point was monitored with a data logger during the infiltration test and responded to inflow. Groundwater was not observed beneath the bioretention cell prior to the start of inflow. The water level in the well point responded to inflow within several minutes, and rose to a depth of approximately 1.5 feet below ground surface at the well point. AESI interprets this response to indicate that water from the infiltration test infiltrated rapidly through the bioretention soil, perched on the native subgrade, and then filled the facility base-course before entering the underdrain.

After about 7 hours, AESI shut off the flow and monitored the water level as it fell. AESI observed that the pooled water in the base of the facility infiltrated over the course of approximately 1 minute.

The constant-head test infiltration rate in Table 5 is calculated based on flow rate from the hose for infiltration testing, and the wetted area of bioretention soil through which the water infiltrated, and represents the infiltration rate of the bioretention soil. AESI observed the discharge from the underdrains, indicating that the majority of inflow was leaving the facility via the underdrains and little to no inflow was infiltrating into the subgrade.

Table 5
Cell BUW
Infiltration Test Results

Test No.	Surface Area (square feet, ponding)	Discharge Time (minutes)	Total Volume Discharged (gallons)	Approximate Constant-Head Level (feet)	Field Infiltration Rates	
					Constant-Head Test (in/hr)	Falling-Head Test (in/hr)
BUW (bioretention soil)	37	441	31,121	0.2	310	147
BUW (subgrade)	Perched water response in well point				Unknown; interpreted to be low based on the underdrain outflow	

in/hr: inches per hour.

9.0 CONCLUSIONS AND RECOMMENDATIONS

Portions of Cell BUW were inconsistent with the design shown on the civil plan sheets. Observations on site design, shallow soil and groundwater conditions are discussed below.

- The overflow is lower relative to the facility base than shown on the plans, but is otherwise generally consistent with the plans. Site design documents indicate that the ponding level was designed as 0.3 feet. AESI observed that the facility base generally slopes down to the south, such that the overflow rim elevation is below the level of the cell base on the northern, uphill, end. There is an additional curbcut on the south side of the cell.

- Bioretention soil:
    - Thickness: The apparent thickness of loose bioretention soil based on soil probe data was generally about 1.5 feet as indicated on the plan.
    - Composition: The soil tested in generally the recommended guidelines for organic content and was generally coarser-grained with more than the recommended range of medium- to coarse-grained sand and not enough fine-grained sand.

- Subgrade conditions: The subgrade is interpreted to consist of glaciomarine drift, with fill soils present in the vicinity of existing utilities.

- Bioretention soil field infiltration rate:
    - Measured at about 310 in/hr.
    - Water readily soaked through the bioretention soil mix and the field rate is interpreted to represent the bioretention soil infiltration rate.

- Subgrade infiltration rate: Interpreted to be low and affected by unknown areas of fill sediments. The majority of flow is interpreted to leave the cell via the underdrain.

10.0 CLOSURE

We appreciate the opportunity to be of continued service to you on this project. Should you have any questions regarding this document or other geotechnical/hydrogeologic aspects of the project, please call us at your earliest convenience.

State of Washington
Hydrogeologist
2335
Licensed Geologist
Jennifer H. Saltonstall

6/11/19

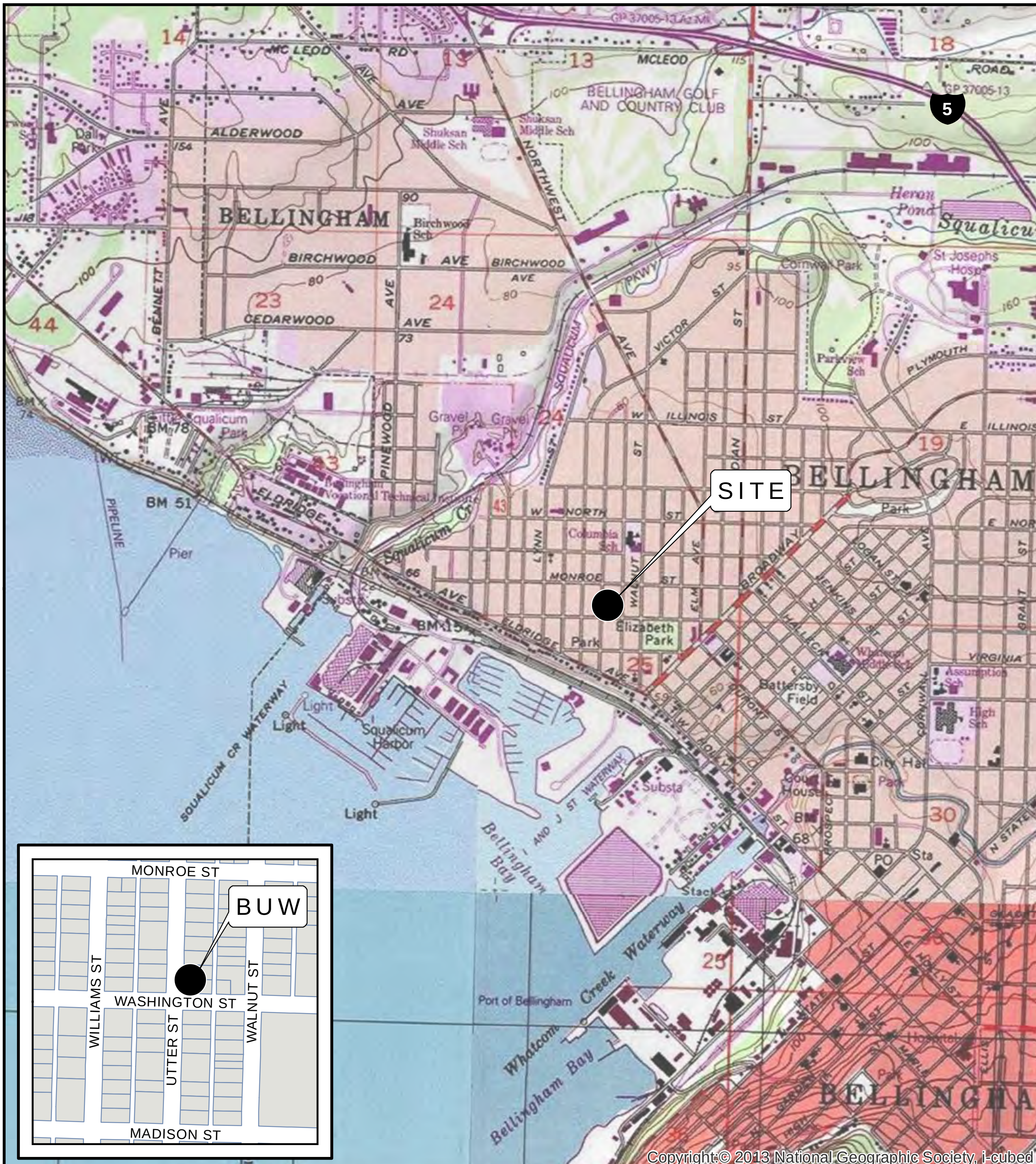
Anton D. Ypma
Staff Geologist

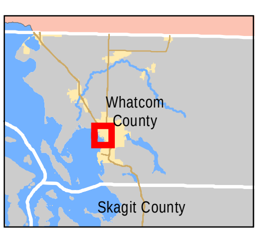
Suzanne S. Cook, L.G.
Senior Project Geologist

Jennifer H. Saltonstall, L.G., L.Hg.
Principal Geologist/Hydrogeologist

Attachments:	Figure BUW F1:	Vicinity Map
	Figure BUW F2:	Facility and Exploration Plan
	Appendix A:	Project Civil Plans
	Appendix B:	Current Study Exploration Logs and Laboratory Testing Data
	Appendix C:	Background Soil, Geology, and Groundwater Data (Regional Maps, Previous Studies Exploration Logs and Laboratory Testing Data)
	Appendix D:	Soil Probe, Level Survey, and Field Infiltration Testing Data
	Appendix E:	Site Photos

JHS/ld
150387H007-6
Projects\20150387\KH\WP





N

0 1000 2000

FEET

DATA SOURCES / REFERENCES:
USGS: 7.5' SERIES TOPOGRAPHIC MAPS, ESRI/I-CUBED/NGS 2013
WHATCOM CO: PARCELS, CITY - 4/17
CITY OF BELLINGHAM: STREETS, 3/17
LOCATIONS AND DISTANCES SHOWN ARE APPROXIMATE

NOTE: BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION

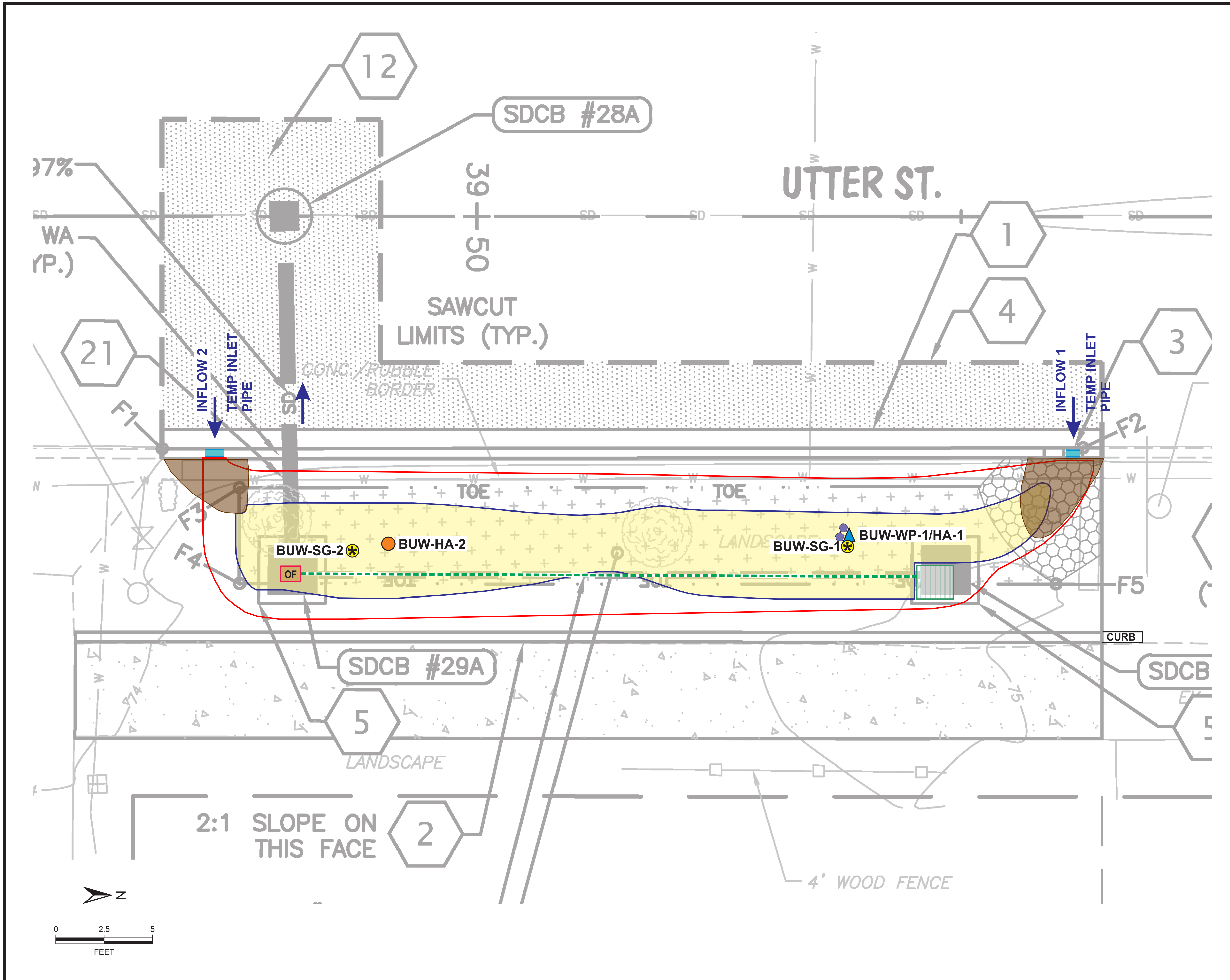
associated earth sciences incorporated

VICINITY MAP

BIORETENTION HYDROLOGIC PERFORMANCE STUDY, BUW SITE
BELLINGHAM, WASHINGTON

PROJ NO.	DATE:	FIGURE:
150387H007	3/19	BUW F1

Document Path: G:\GIS_Projects\aY15post0716\150387\150387 Bioretention Hydro Performance Monitoring\mxd\PhaseII\Fig1s\150387H007 F1 VM_BUW.mxd



LEGEND:

- HA — HAND AUGER
- WP — WELL POINT
- TEMPORARY STAFF GAUGE
- BASE OF FACILITY
- TOP OF FACILITY SLOPE
- INFLOW / OVERFLOW DIRECTION
- OF — OVERFLOW GRATE - 24" X 18"
- PVC PONDING TUBE
- UNDERDRAIN
- CURB CUT
- ENERGY DISSIPATER
- UNDERDRAIN CLEANOUT

CONTOUR INTERVAL = N/A

NOTE: LOCATION AND DISTANCES SHOWN ARE APPROXIMATE.

NOTES:
1. BASE MAP REFERENCE: CITY OF BELLINGHAM PUBLIC WORKS DEPT, COLUMBIA WATER QUALITY IMPROVEMENTS, DRAINAGE IMPROVEMENTS, UTTER STREET 2, SHEET C16 OF C32, 10/30/17

associated earth sciences incorporated

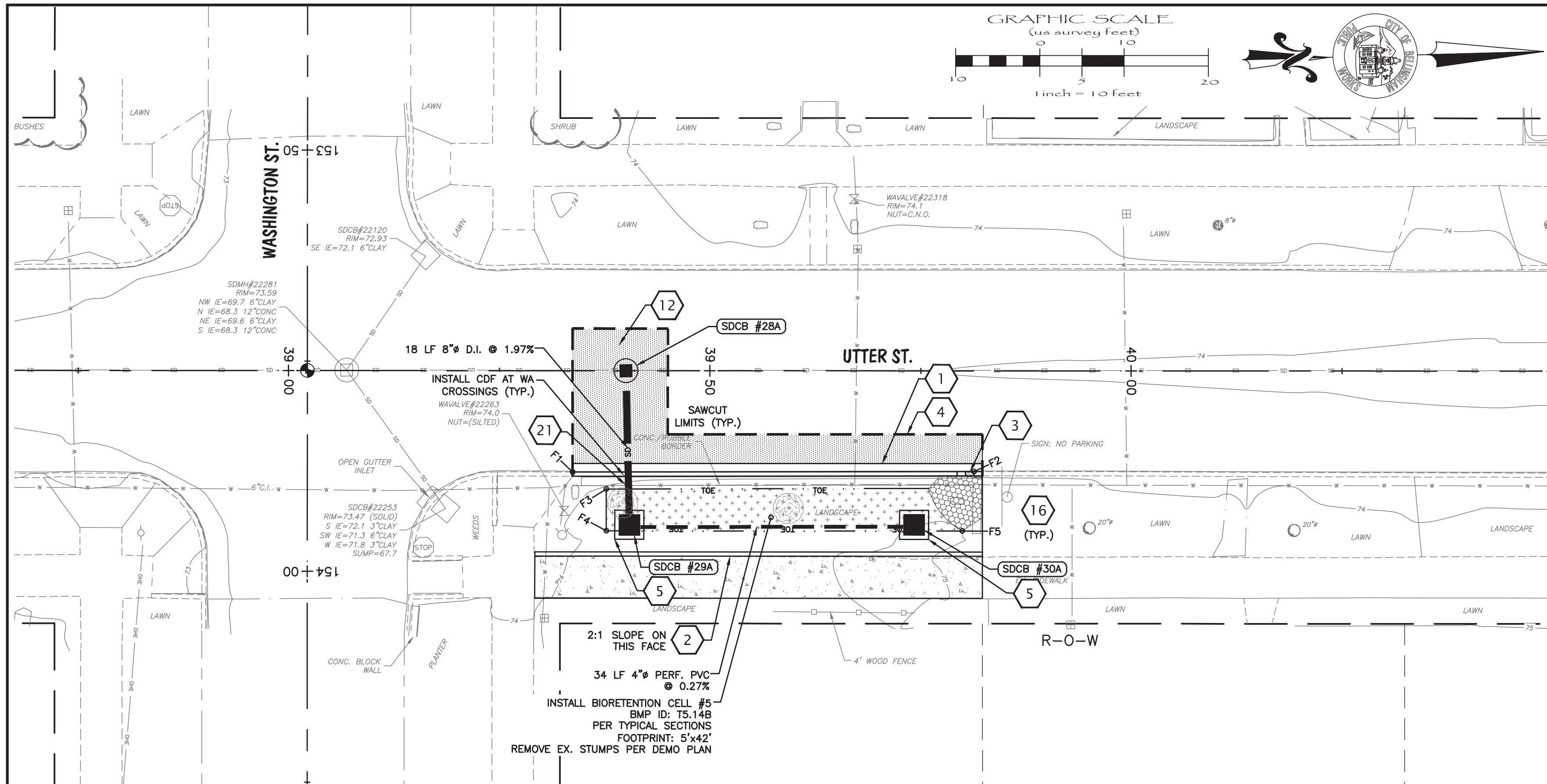
FACILITY AND EXPLORATION PLAN
BUW SITE
BIORETENTION HYDROLOGIC PERFORMANCE
BELLINGHAM, WASHINGTON

PROJ NO.	DATE:	FIGURE:
150387H007	3/19	BUW F2

150387 BHPS MCCA \ 150387H007 Site-Expl ALL.cdr PAGE x: BUW F2

APPENDIX A

Project Civil Plans



BIORETENTION CELL #5
ALL WORK INCLUDED IN SCHEDULE 'A'
H SCALE: 1"=10'

POINT TABLE			
	DESCRIPTION	STATION/OFFSET (F/C IN CURBLINE)	FL ELEV.
F1	MATCH EX.	STA 39+33.7, 12.0' R UTTER	73.34
F2	CURB INLET FL	STA 39+81.3, 12.0' R UTTER	73.62
F3	BIOCELL FG	STA 39+37.7, 14.0' R UTTER	72.89
F4	BIOCELL FG	STA 39+37.7, 19.0' R UTTER	72.89
F5	BIOCELL FG	STA 39+79.9, 19.0' R UTTER	73.39

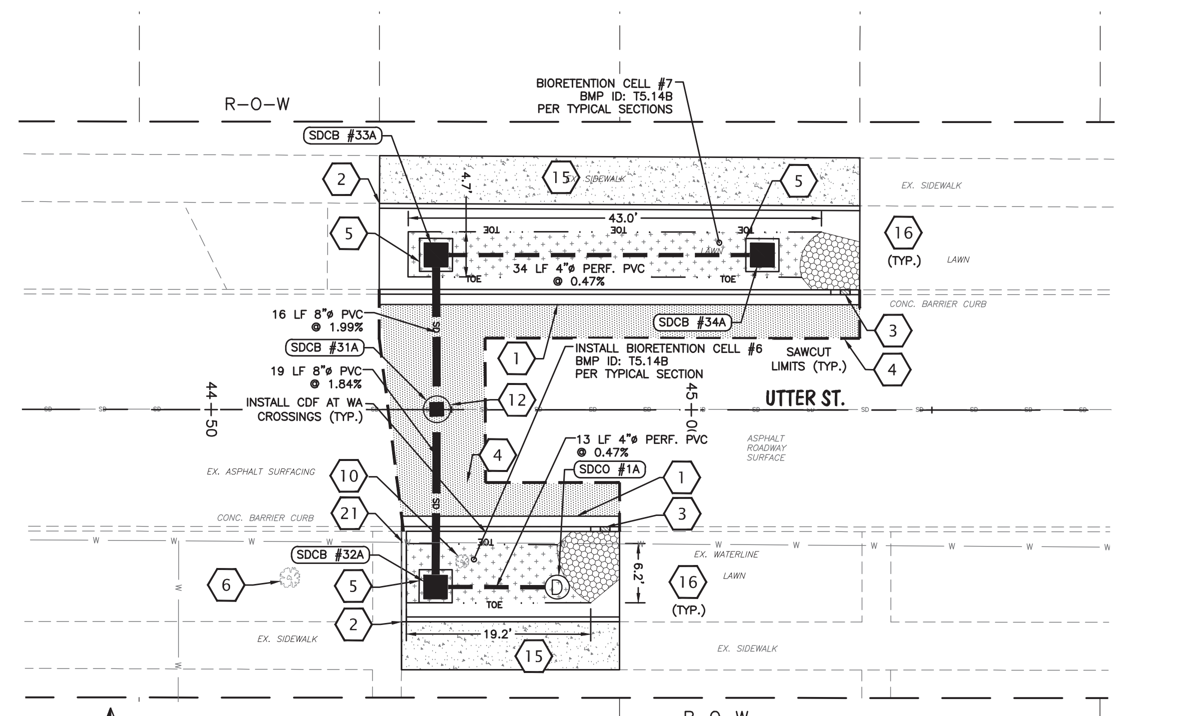
GRADING NOTE

NO VERTICAL GRADING INFORMATION PROVIDED FOR BIORETENTION CELL #5 – #8. CONTRACTOR TO FIELD FIT GRADING OF BIORETENTION CELLS BASED ON DETAIL ON SHEET C22 AND COORDINATE WITH ENGINEER TO DETERMINE GRADES.

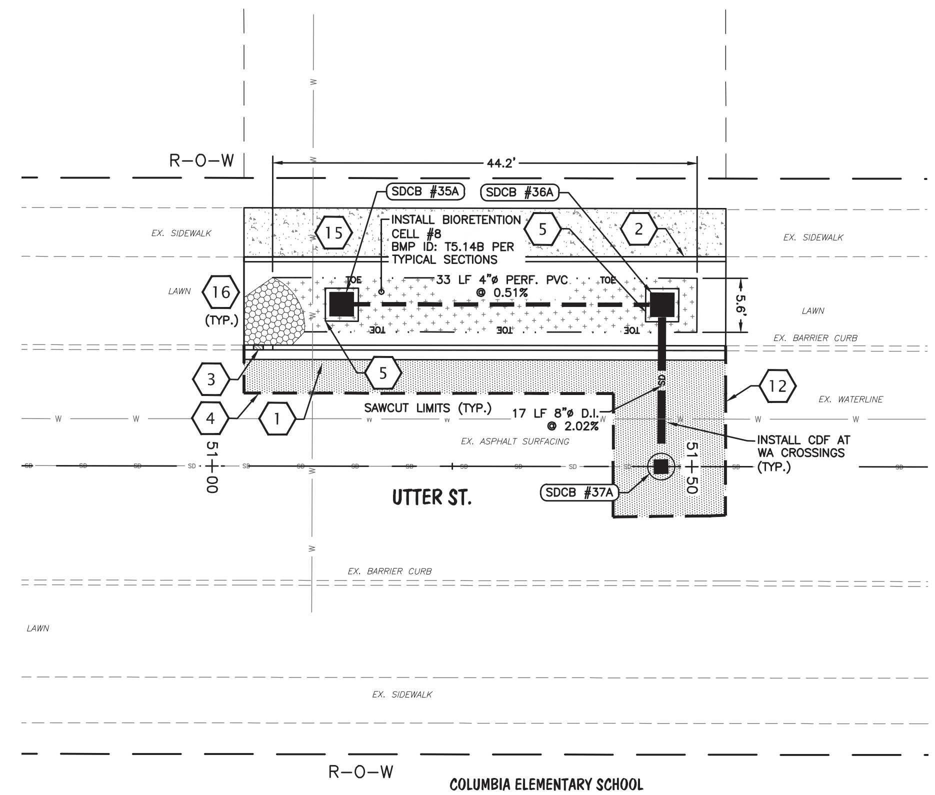
CONSTRUCTION NOTES:

1. INSTALL 18" CONC. CURB & GUTTER PER COB DETAIL CG-200
2. INSTALL BARRIER CURB PER COB DETAIL CG-208
3. INSTALL CURB INLET AND HAND PLACED, MORTARED, RIVER ROCK APRON PER TYPICAL BIORETENTION CELL DETAIL
4. SAWCUT AND REMOVE EXISTING ASPHALT OR CONCRETE PER DEMOLITION PLAN. REPAIR PAVEMENT PER COB DETAIL CG-218 (CURB REPLACEMENT)
5. INSTALL 6" CONCRETE COLLAR PER DETAIL
6. DO NOT DISTURB EXISTING TREES/LANDSCAPING
10. REMOVE EX. TREE IN PLANTER
12. SAWCUT, REMOVE AND REPAIR CONC. OR ASPHALT PER COB DETAIL ST-180 HORIZONTAL PAVEMENT REPAIR (STREET CROSSING)
15. REPLACE EX. SIDEWALK PER COB DETAIL CG-230
16. INSTALL 8" TOPSOIL AND SEEDED LAWN ON DISTURBED AREAS (TYP.)
21. POTHOLE EXISTING UTILITY TO VERIFY DEPTH.

= PROPOSED ASPHALT SURFACING
= PROPOSED CONCRETE SURFACING
= PROPOSED BIORETENTION CELL FOOTPRINT



BIORETENTION CELLS #6 AND #7
ALL WORK INCLUDED IN SCHEDULE 'A'
H SCALE: 1"=10'



BIORETENTION CELL #8
ALL WORK INCLUDED IN SCHEDULE 'A'
H SCALE: 1"=10'

STORM DRAINAGE NOTES:

SDCB #28A
STA 39+40, 0.0' L @ C/S
TYPE 2-48" SOLID RING & COVER
RIM: 73.87
IE-E: (8"ø D.I.) 70.31
EX. IE-S: (12" CONC.) 68.39

SDCB #29A
STA 39+40.4, 18.3' R @ C/S
TYPE 1, BEEHIVE GRATE
RIM: 73.22
IE-N: (4"ø PERF. PVC) 70.67
IE-W: (8"ø D.I.) 70.67

SDCB #30A
STA 39+74.2, 18.3' R @ C/S
TYPE 1, SOLID LID
RIM: 73.31
IE-S: (4"ø PERF. PVC) 70.76

SDCB #31A
STA 44+73.4, 0.0' L @ C/S
TYPE 2-48" SOLID RING & COVER
RIM: 75.28
IE-W: (8"ø PVC) 71.22
IE-E: (8"ø PVC) 71.54
EX. IE: (12"ø PVC) 69.93
EX. IE: (12"ø PVC) 69.93

SDCB #32A
STA 44+73.3, 18.5' R @ C/S
TYPE 1, BEEHIVE GRATE
RIM: 74.85
IE-W: (8"ø PVC) 71.88
IE-N: (4"ø PERF. PVC) 72.07

SDCB #33A
STA 44+73.4, 16.1' L @ C/S
TYPE 1, BEEHIVE GRATE
RIM: 74.85
IE-N: (4"ø PERF. PVC) 72.23
IE-E: (8"ø PVC) 71.54

SDCB #34A
STA 45+07.3, 16.1' L @ C/S
TYPE 1, SOLID LID
RIM: 74.95
IE-S: (4"ø PERF. PVC) 72.07

SDCO #1A
STA 44+85.99, 18.48' R @ CTR STR
RIM: 74.75
IE-S: (4"ø PERF. PVC) 72.13

FIELD VERIFY RIM ELEVATIONS

SDCB #35A
STA 51+13.4, 16.9' L @ C/S
TYPE 1, SOLID LID
RIM: 75.38
IE-N: (4"ø PERF. PVC) 73.21

SDCB #36A
STA 51+46.8, 16.8' L @ C/S
TYPE 1, BEEHIVE GRATE
RIM: 75.66
IE-E: (8"ø D.I.) 72.86
IE-S: (4"ø PERF. PVC) 73.04

SDCB #37A
STA 51+46.7, 0.0' R @ C/S
TYPE 2-48" SOLID RING & COVER
RIM: 76.39
IE-W: (8"ø D.I.) 73.20
EX. N-IE: (8" CONC.) 70.63
EX. S-IE: (8" CONC.) 70.63
(CONNECT TO EX. PIPES)

FIELD VERIFY RIM ELEVATIONS

JEFFREY A. VANDER YACHT · STATE OF WASHINGTON · 37432 · REGISTERED PROFESSIONAL ENGINEER · 10-30-2017

BID SET DRAWINGS

PACIFIC SURVEYING & ENGINEERING
1812 CORNWALL AVE., BELLINGHAM, WA 98225
PHONE: 360.671.7387 FAX: 360.671.4685

Date	No	Revision	By

PROJECT ENGINEER JVY
DESIGNED/DRAWN SIG
DIRECTOR OF PUBLIC WORKS TAC
CITY ENGINEER CMAS

CITY OF BELLINGHAM, WASHINGTON
PUBLIC WORKS DEPARTMENT

SCALE
Horiz. GRAPHIC SCALE
Vert. GRAPHIC SCALE

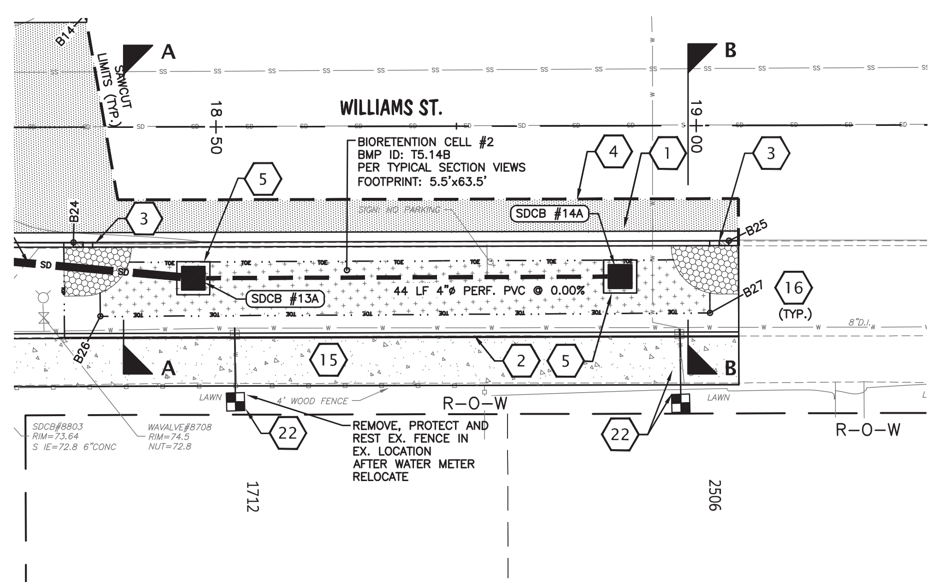
DATUM
HORIZ.=NAD 83/07
VERT.=NAVD 88

Job. No. EV-0120, 2014221
Date OCT. 30, 2017
Field Bk. #1022 SERIES

COLUMBIA WATER QUALITY IMPROVEMENTS
DRAINAGE IMPROVEMENTS - UTTER STREET 2

SHEET C16 OF C32

CONTACT PERSON: CRAIG MUELLER, P.E. , PROJECT ENGINEER AT 360-778-7922 FILE PATH: P:\Pse Project\2014221\DWGs_SHEET\2014221_ecP_BD.dwg



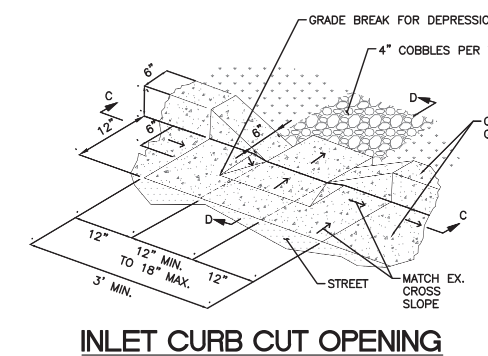
TYPICAL BIORETENTION CELL PLAN VIEW

H SCALE: 1"=10'

CONSTRUCTION NOTES:

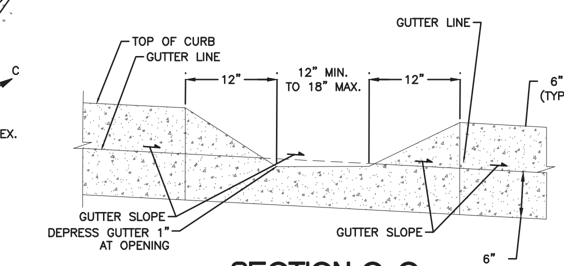
1. INSTALL 18" CONC. CURB & GUTTER PER COB DETAIL CG-200
2. INSTALL BARRIER CURB PER COB DETAIL CG-208
3. INSTALL CURB INLET AND HAND PLACED, MOTARED, QUARRY SPALL APRON PER TYPICAL BIORETENTION CELL DETAIL
4. SAWCUT AND REMOVE EXISTING ASPHALT OR CONCRETE PER DEMOLITION PLAN. REPAIR PAVEMENT PER COB DETAIL CG-218 (CURB REPLACEMENT)
5. INSTALL 6" CONCRETE COLLAR PER DETAIL
15. REPLACE EX. SIDEWALK PER COB DETAIL CG-230
16. INSTALL 8" TOPSOIL AND SEEDED LAWN ON DISTURBED AREAS (TYP.)
21. POTHOLE EXISTING UTILITY TO VERIFY DEPTH.
22. RELOCATE EX. WATER METER PER DETAIL WA-830. INSTALL 1" COPPER PIPE TO LENGTH.

= PROPOSED ASPHALT SURFACING
= PROPOSED CONCRETE SURFACING
= PROPOSED BIORETENTION CELL FOOTPRINT



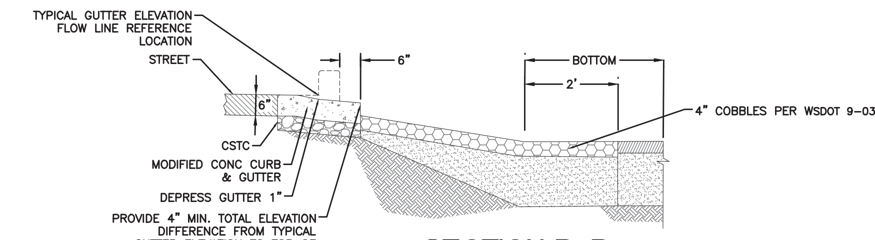
INLET CURB CUT OPENING

NTS



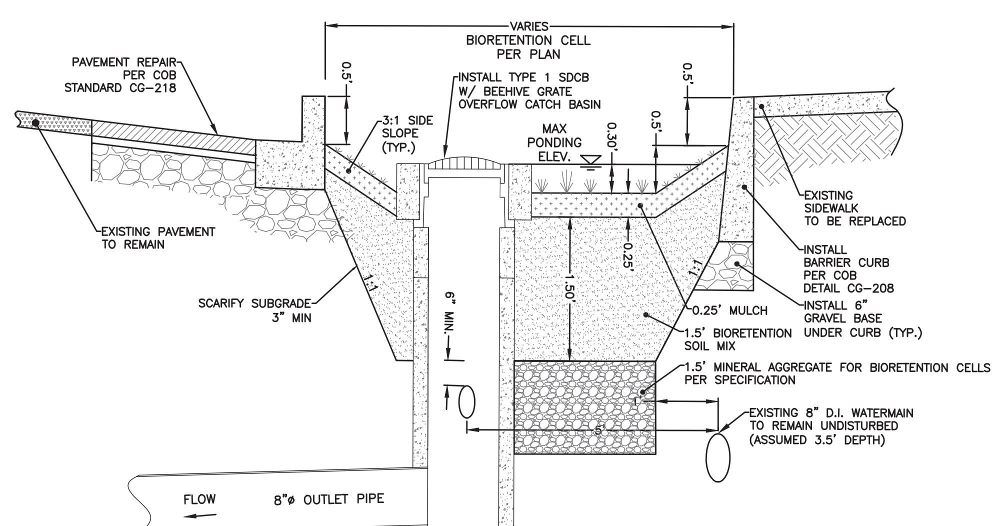
SECTION C-C

NTS



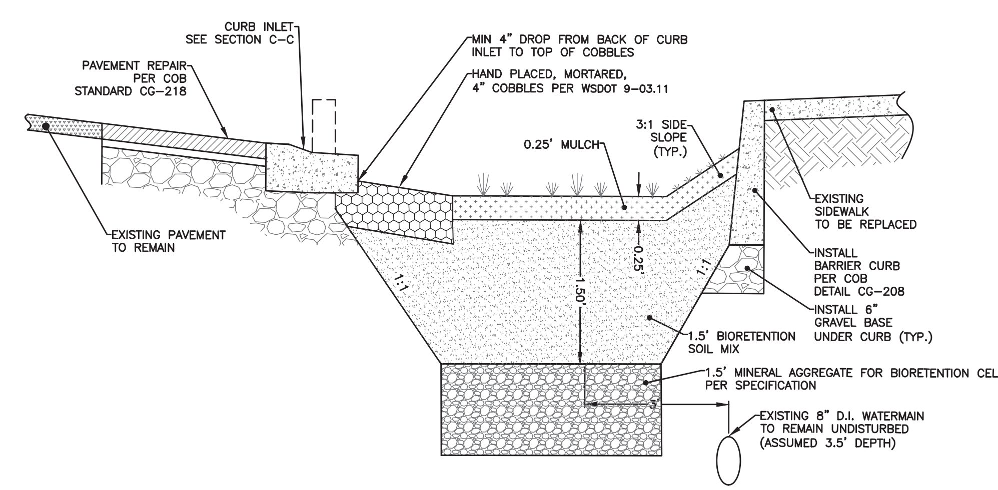
SECTION D-D

NTS



TYPICAL BIORETENTION SECTION A-A

H SCALE: 1"=10'



TYPICAL BIORETENTION SECTION B-B

H SCALE: 1"=10'

PACIFIC SURVEYING & ENGINEERING
1812 CORNWALL AVE., BELLINGHAM, WA 98225
PHONE: 360.671.7387 FAX: 360.671.4685

JEFFREY A. VANDER YACHT, STATE OF WASHINGTON, 37432, REGISTERED PROFESSIONAL ENGINEER
10-30-2017

BID SET DRAWINGS

Date	No	Revision	By

PROJECT ENGINEER JVY
DESIGNED/DRAWN SIG
DIRECTOR OF PUBLIC WORKS TAC
CITY ENGINEER CMAS

CITY OF BELLINGHAM, WASHINGTON
PUBLIC WORKS DEPARTMENT

SCALE
Horiz. GRAPHIC SCALE
Vert. GRAPHIC SCALE

DATUM
HORIZ.=NAD 83/07
VERT.=NAVD 88

Job. No. EV-0120, 2014221
Date OCT. 30, 2017
Field Bk. #1022 SERIES

COLUMBIA WATER QUALITY IMPROVEMENTS
BIORETENTION CELL DETAILS

SHEET C22 OF C32

CONTACT PERSON: CRAIG MUELLER, P.E. , PROJECT ENGINEER AT 360-778-7922 FILE PATH: P:\Pse Project\2014221\DWGs_SHEET\2014221_ecP_BD.dwg

APPENDIX B

Current Study Exploration Logs and Laboratory Testing Data

Geologic & Monitoring Well Construction Log

associated earth sciences incorporated

Project Number	Well Number	Sheet
150387H007	BUW-HA-1/WP	1 of 1

Project Name	Bioretention Hydrologic Performance Study	Location	Bellingham, WA
Elevation (Top of Well Casing)	101.3 (Project Datum)	Surface Elevation (ft)	99.3 (Project Datum)
Water Level Elevation	Dry	Date Start/Finish	10/11/18,10/11/18
Drilling/Equipment	Hand Auger	Hole Diameter (in)	4 inches
Hammer Weight/Drop	N/A		

Depth (ft)	Water Level	WELL CONSTRUCTION	S T	Blows/ 6"	Graphic Symbol	DESCRIPTION
		Threaded steel pipe 1.25 inches I.D. with threaded and vented PVC cap -2 to 0.2 feet Shredded wood chips 0 to 0.1 feet Top of well point at 0.2 feet				**Shredded Wood Chips** **Bioretention Soil Mix**
		Bioretention soil mix 0.1 to 1.5 feet				Loose, moist, dark brown medium, SAND, trace silt, trace gravel; organic rich; massive (SP).
		Gravel fill 1.5 to 2 feet				**Underdrain Gravel Bedding** Loose, angular gravel (0.5 to 0.75 inch), partially mixed with bioretention soil mix.
		Driven into existing sediments 2 to 3.6 feet. Stainless steel jacket over stainless steel #60 gauze, welded to perforated steel pipe 0.4 to 2.9 feet				Boring terminated at 2 feet Well completed at 3.6 feet on 10/11/18. Steel drive points placed in borehole and hand driven with slide hammer to depth of 3.6 feet.
		Threaded steel pipe 1.25 inches I.D. and drive point 2.9 to 3.6 feet				
		Note: ~4 inches of "dead space" below bottom of perforated openings and total inside depth. Total inside depth = 5.1 feet.				
5						

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample
- M - Moisture
- Water Level ()
- Water Level at time of drilling (ATD)

Logged by: ADY
Approved by: JHS

Exploration Log

associated earth sciences incorporated

Project Number	Exploration Number	Sheet
150387H007	BUW-HA-2	1 of 1

Project Name: Bioretention Hydrologic Performance Study
Location: Bellingham, WA
Driller/Equipment: Hand Auger
Hammer Weight/Drop: N/A

Ground Surface Elevation (ft):
Datum: N/A
Date Start/Finish: 10/11/18,10/11/18
Hole Diameter (in): 4 inches

Depth (ft)	S T	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Water Level	Blows/6"	Blows/Foot (10 20 30 40)	Other Tests
				Shredded Wood Chips					
		S-1		**Bioretention Soil Mix** Loose, moist, dark brown, medium SAND, trace silt, trace gravel; organic rich; massive (SP).					
		S-2		**Underdrain Gravel Bedding** Loose, angular gravel (0.5 to 0.75 inch), partially mixed with bioretention soil mix.					
				Bottom of exploration boring at 1.5 feet.					
5									

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample
- M - Moisture
- Water Level ()
- Water Level at time of drilling (ATD)

Logged by: ADY
Approved by: JHS

associated earth sciences incorporated

Exploration Log

Project Number	Exploration Number	Sheet
150387H007	BUW-HA-3	1 of 1

Project Name	Bioretention Hydrologic Performance Study	Ground Surface Elevation (ft)	
Location	Bellingham, WA	Datum	N/A
Driller/Equipment	Hand Auger	Date Start/Finish	10/11/18,10/11/18
Hammer Weight/Drop	N/A	Hole Diameter (in)	4 inches

Depth (ft)	S T	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Water Level	Blows/6"	Blows/Foot 10 20 30 40	Other Tests
				Shredded Wood Chips					
		S-1		**Bioretention Soil Mix** Loose, moist, dark brown, medium SAND, trace silt, trace gravel; organic rich; abundant fine roots; massive (SP).					
		S-2		**Glaciomarine Drift** Stiff, slightly moist, brownish gray, very silty, medium SAND, trace gravel (SM).					
				Bottom of exploration boring at 3 feet.					
5									

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample
- M - Moisture
- Water Level ()
- Water Level at time of drilling (ATD)

Logged by: ADY
Approved by: JHS

associated earth sciences incorporated

Moisture, Ash, and Organic Matter of Peat and Other Organic Soils - ASTM 2974

Date Sampled	Project	Project No.		Soil Description
10/11/2018	Bioretention Hydrologic Performance Monitoring Study	150387 E007		Bioretention soil mix
Tested By	**Location**	**EB/EP No.**	**Depth**	
BN	Onsite- BUW			

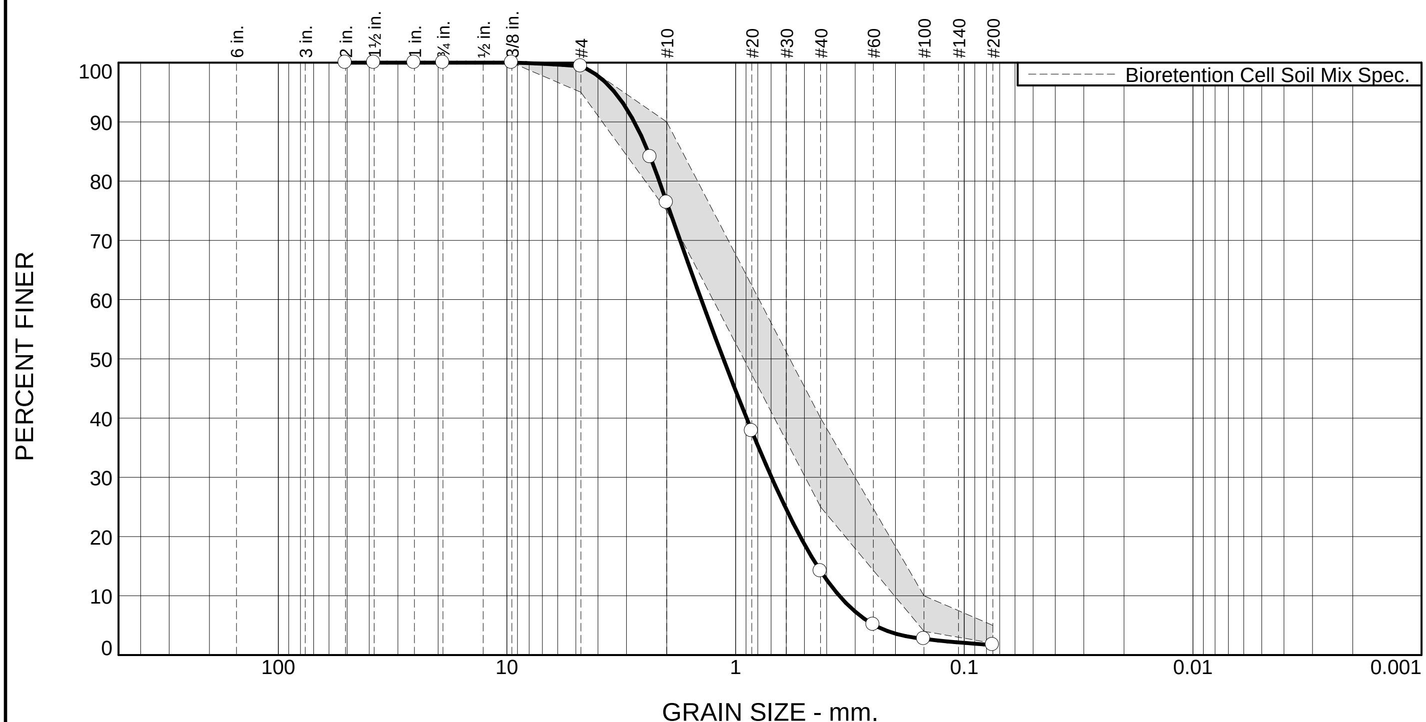
Moisture Content

Sample ID	HA-1 (0.2'-0.5')	HA-2 (0.2'-0.5')
Wet Weight + Pan	983.51	783.83
Dry Weight + Pan	925.90	699.81
Weight of Pan	534.24	392.48
Weight of Moisture	57.61	84.02
Dry Weight of Soil	391.66	307.33
% Moisture	12.8	21.5

Organic Matter and Ash Content

Dry Soil Befor Burn + Pan	623.06	631.32
Dry Soil After Burn + Pan	607.01	615.87
Weight of Pan	391.92	391.91
Wt. Loss Due to Ignition	16.05	15.45
Actual Wt. Of Soil After Burr	215.09	223.96
% Organics	6.9	6.5

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.6	23.0	62.2	12.5	1.7	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
2	100.0		
1.5	100.0		
1	100.0		
.75	100.0		
.375	100.0	100.0	
#4	99.4	95.0 - 100.0	
#8	84.1		
#10	76.4	75.0 - 90.0	
#20	37.8		
#40	14.2	25.0 - 40.0	X
#60	5.1		
#100	2.7	4.0 - 10.0	X
#200	1.7	2.0 - 5.0	X

* Bioretention Cell Soil Mix Spec.

Material Description

SAND, trace silt, trace gravel

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=**

Classification

USCS (D 2487)= SP **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 2.7742 D_{85}= 2.4138 D_{60}= 1.4126
D_{50}= 1.1314 D_{30}= 0.6964 D_{15}= 0.4388
D_{10}= 0.3518 C_u= 4.02 C_c= 0.98

Remarks

Collected by: ADY

Bioretention soil mix burned first per ASTM D2974 then sieved.

Date Received: 10/16/2018 **Date Tested:** 11/12/2018

Tested By: BN

Checked By: JHS

Title:

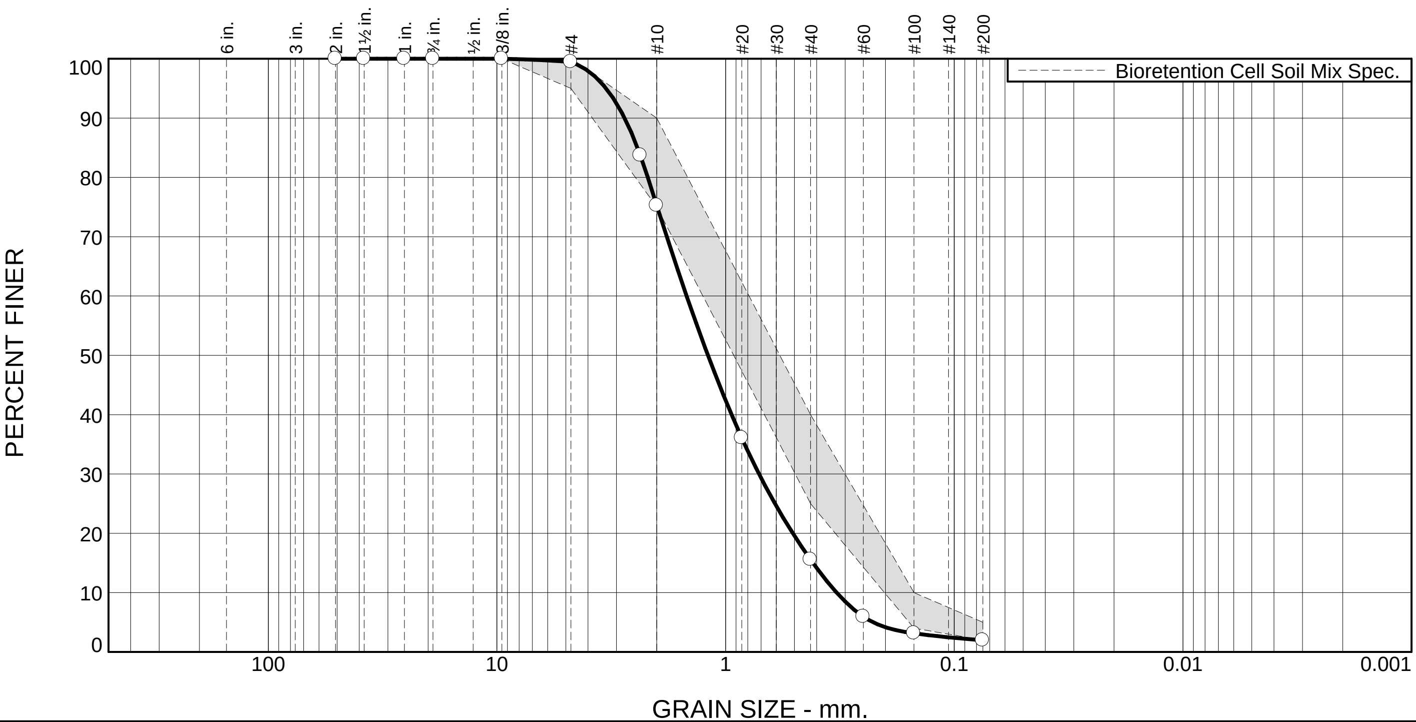
Source of Sample: (BUW) Bellingham- Utter and Washington **Depth:** 0.2'-0.5' **Date Sampled:** 10/11/2018
Sample Number: HA-1

associated earth sciences incorporated

Client: Clear Creek Solutions
Project: Bioretention Hydrologic Performance Study

Project No: 150387 H004 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.5	24.2	59.7	13.6	2.0	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
2	100.0		
1.5	100.0		
1	100.0		
.75	100.0		
.375	100.0	100.0	
#4	99.5	95.0 - 100.0	
#8	83.7		
#10	75.3	75.0 - 90.0	
#20	36.1		
#40	15.6	25.0 - 40.0	X
#60	6.0		
#100	3.1	4.0 - 10.0	X
#200	2.0	2.0 - 5.0	

* Bioretention Cell Soil Mix Spec.

Material Description

SAND, trace silt, trace gravel

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 2.7655 D_{85}= 2.4287 D_{60}= 1.4805
D_{50}= 1.1945 D_{30}= 0.7142 D_{15}= 0.4149
D_{10}= 0.3270 C_u= 4.53 C_c= 1.05

Remarks

Collected by: ADY

Bioretention soil mix burned first per ASTM D2974 then sieved.

Date Received: 10/19/2018 **Date Tested:** 11/12/2018

Tested By: BN

Checked By: JHS

Title:

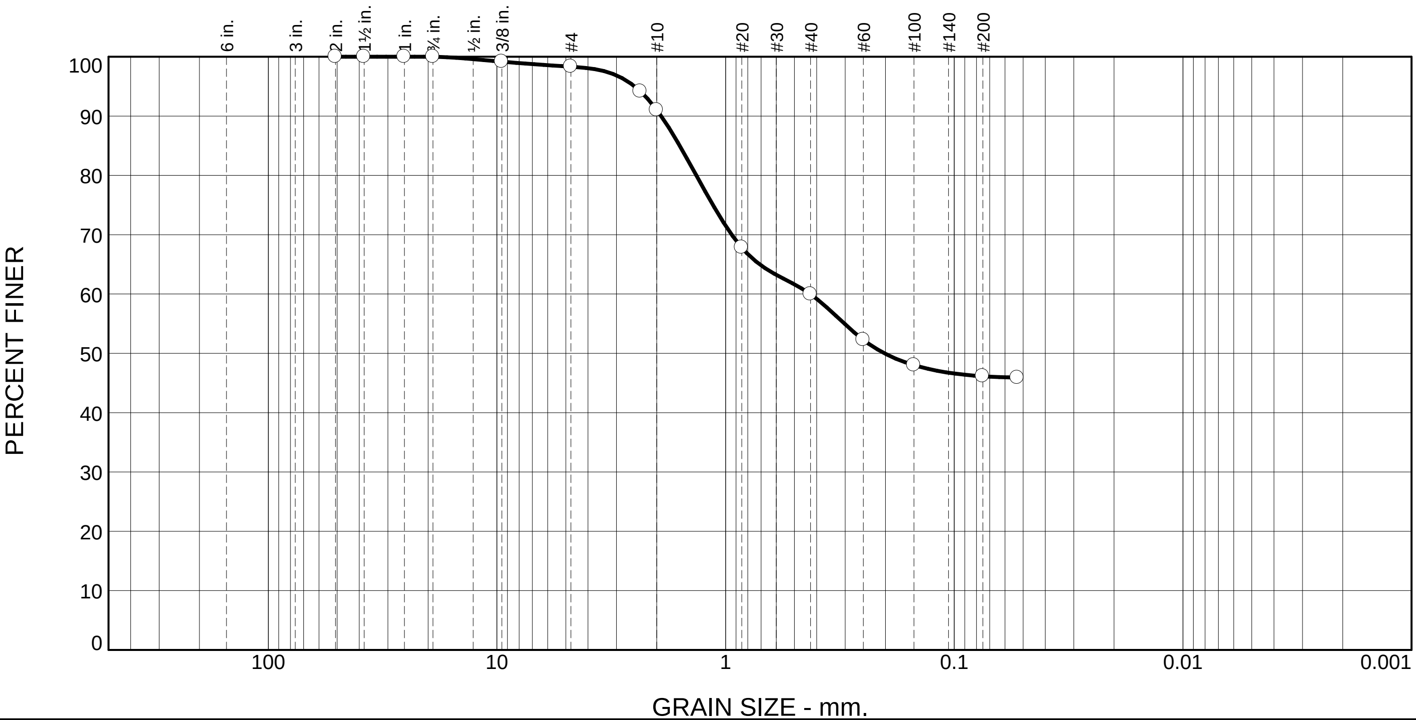
Source of Sample: (BUW) Bellingham- Utter and Washington **Depth:** 0.2'-0.5' **Date Sampled:** 10/11/2018
Sample Number: HA-2

a s s o c i a t e d
e a r t h s c i e n c e s
i n c o r p o r a t e d

Client: Clear Creek Solutions
Project: Bioretention Hydrologic Performance Study

Project No: 150387 H004 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	1.7	7.3	31.0	13.9	46.1	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
2	100.0		
1.5	100.0		
1	100.0		
.75	100.0		
.375	99.2		
#4	98.3		
#8	94.2		
#10	91.0		
#20	67.8		
#40	60.0		
#60	52.3		
#100	48.0		
#200	46.1		
#270	45.9		

* (no specification provided)

Material Description

very silty SAND, trace gravel

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-4(0)

Coefficients

$D_{90}=$ 1.9138 $D_{85}=$ 1.5881 $D_{60}=$ 0.4265
$D_{50}=$ 0.2020 $D_{30}=$ $D_{15}=$
$D_{10}=$ $C_u=$ $C_c=$

Remarks

Collected by: ADY

Date Received: 10/16/2018 **Date Tested:** 10/18/2018

Tested By: MS

Checked By: JHS

Title:

Source of Sample: (BUW) Bellingham- Utter and Washington **Depth:** 2.1'-2.6' **Date Sampled:** 10/11/2018
Sample Number: HA-3

associated earth sciences incorporated

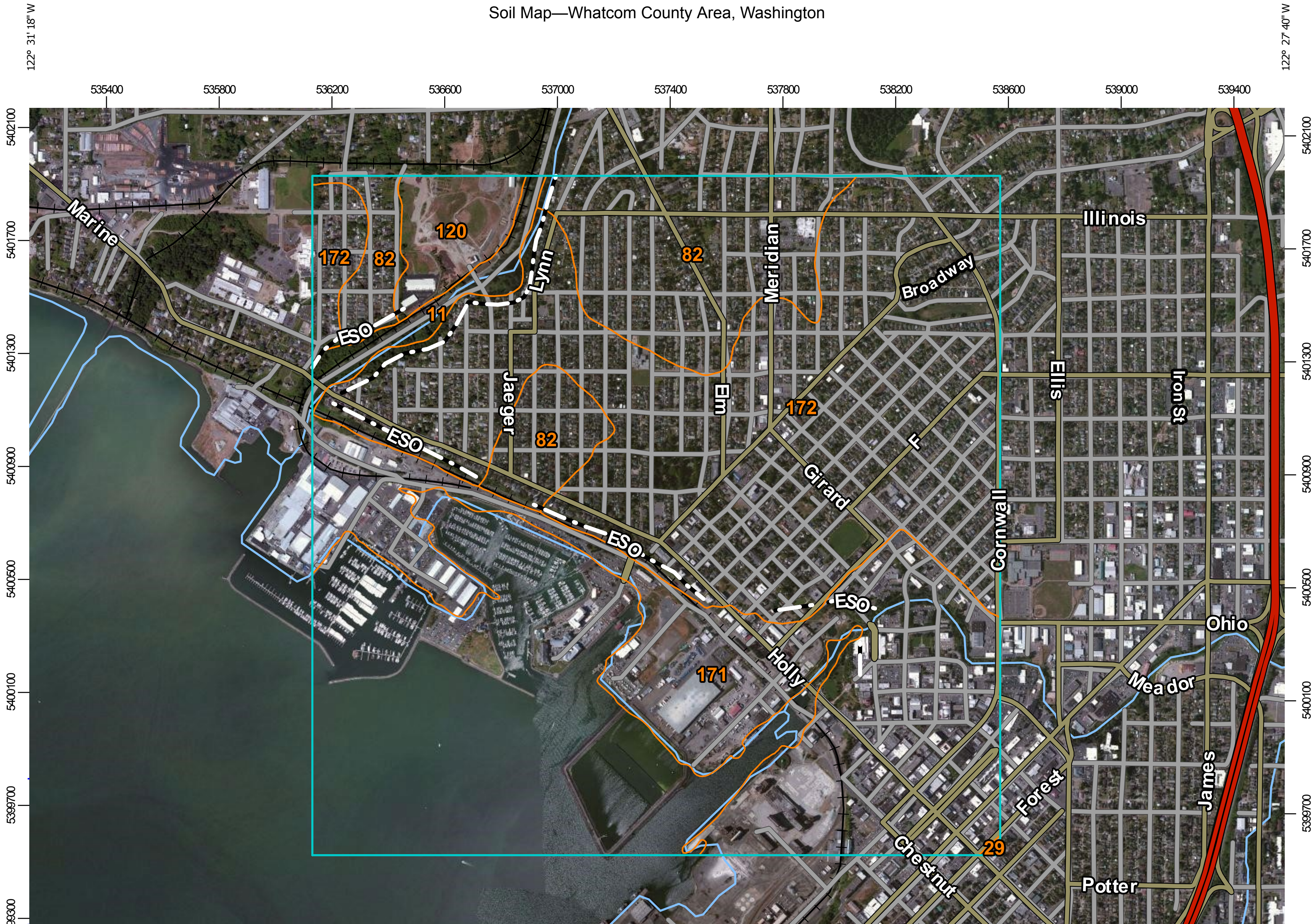
Client: Clear Creek Solutions
Project: Bioretention Hydrologic Performance Study

Project No: 150387 H004 **Figure**

APPENDIX C

Background Soil, Geology, and Groundwater Data (Regional Maps, Previous Studies Exploration Logs and Laboratory Testing Data)

Soil Map—Whatcom County Area, Washington



Map Scale: 1:20,400 if printed on A landscape (11" x 8.5") sheet.

Meters: 0, 300, 600, 1200, 1800

Feet: 0, 500, 1000, 2000, 3000

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features

- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Whatcom County Area, Washington
Survey Area Data: Version 18, Sep 10, 2018

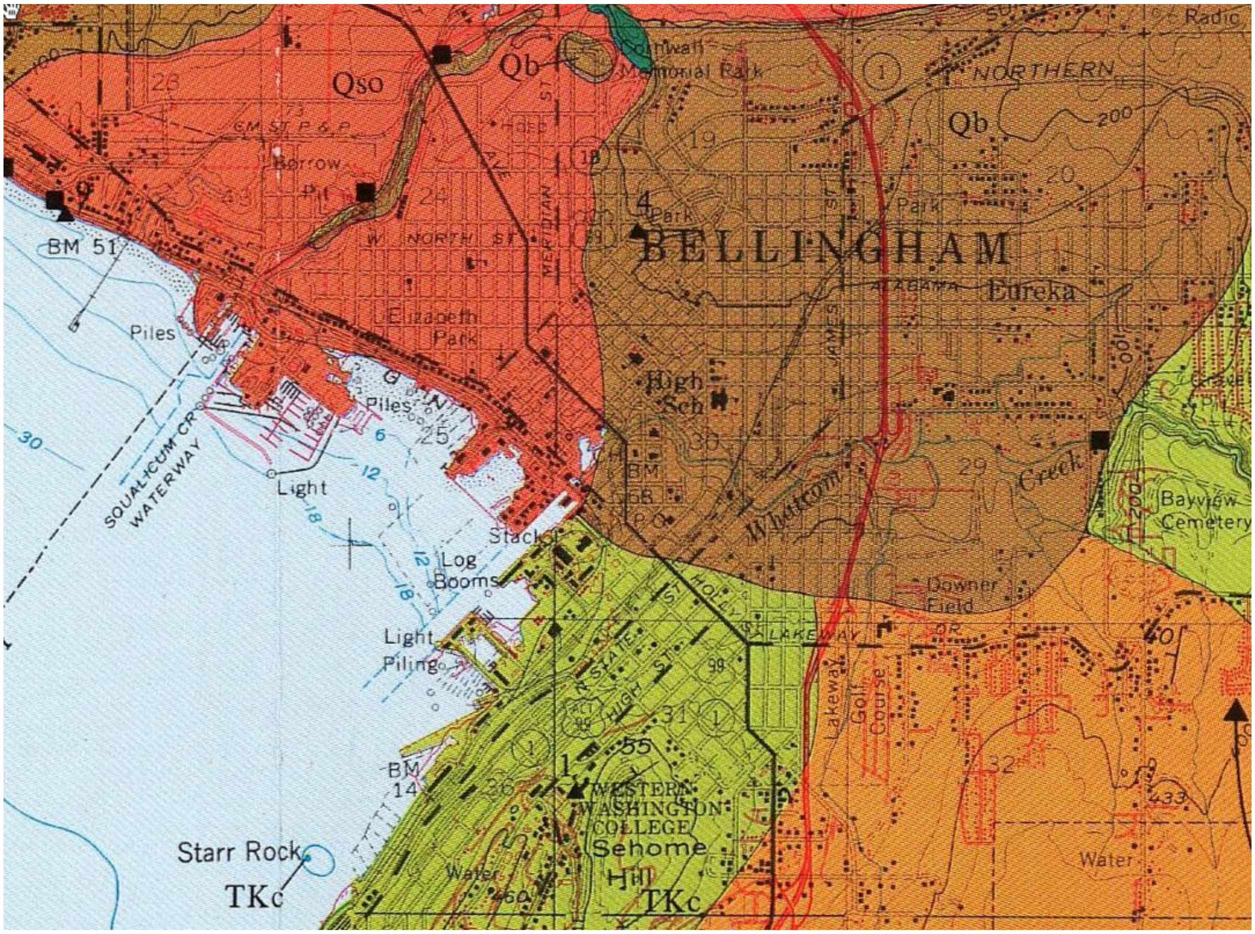
Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jul 9, 2010—Aug 28, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
11	Bellingham silty clay loam, 0 to 2 percent slopes	25.0	1.7%
29	Chuckanut-Urban land complex, 5 to 20 percent slopes	0.7	0.0%
82	Kickerville-Urban land complex, 0 to 3 percent slopes	187.2	12.8%
120	Pits, gravel	38.3	2.6%
171	Urban land	333.2	22.9%
172	Urban land-Whatcom-Labounty complex, 0 to 8 percent slopes	527.8	36.2%
Totals for Area of Interest		**1,457.1**	**100.0%**



Excerpt from:

Easterbrook, D.J., 1976, Geologic map of western Whatcom County, Washington: U.S. Geological Survey, Miscellaneous Investigations Series Map I-854-B, scale 1:62,500

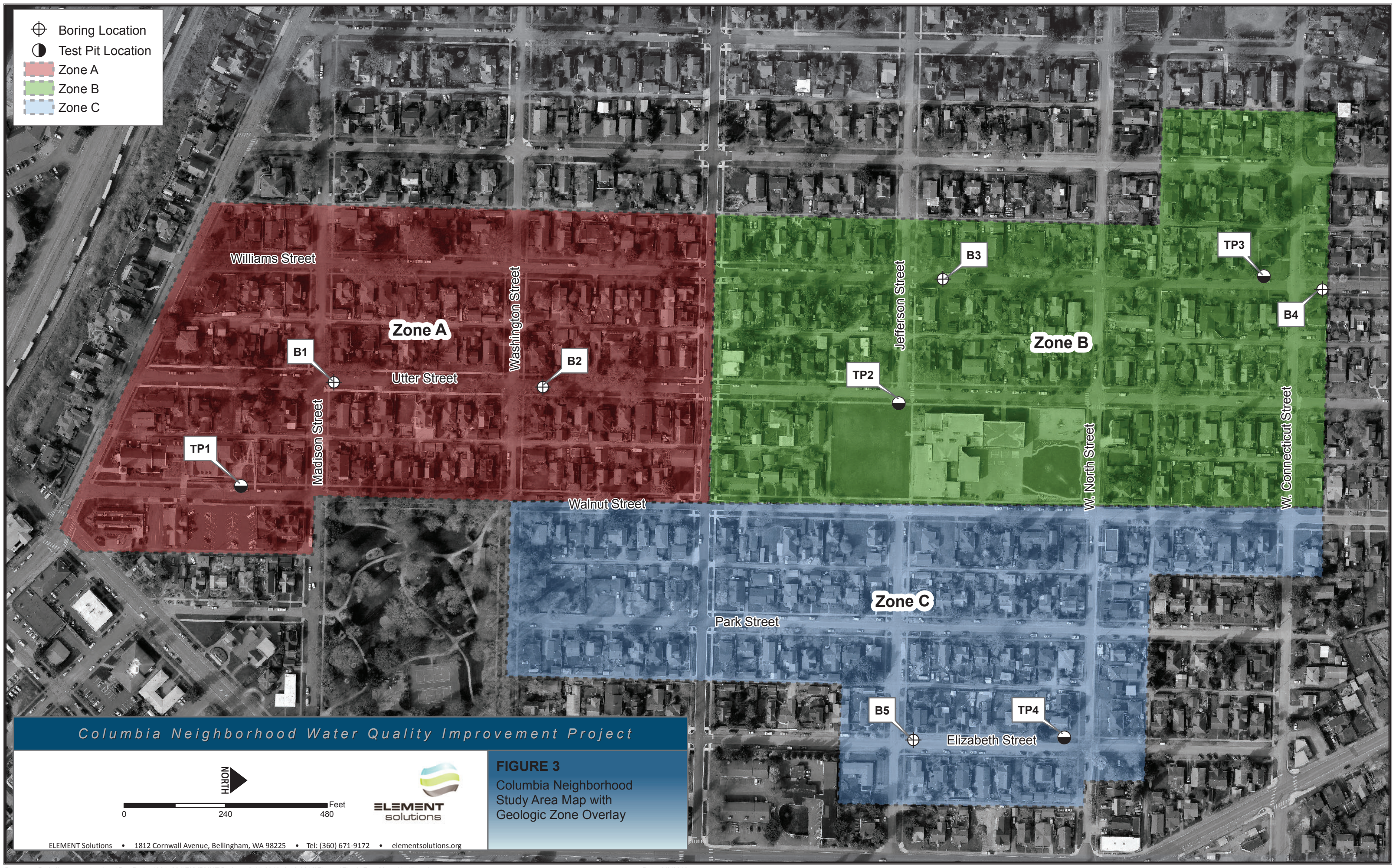


FIGURE 3
Columbia Neighborhood Study Area Map with Geologic Zone Overlay

Document Path: \\pseserver\projects\Pse Project\2014221\ENVRMNT\Borings_2-17-2016_2-18-2016\Figures\Fig_3_ZoneMap_11x17.mxd

Date: 3/3/2016

Appendix II

1) Test Pit Logs (TP1-TP4) - December 17, 2015
2) Borehole Logs (B1-B5) - February 17 to 18, 2016
3) Laboratory Test Data - GeoTest Services, Inc., March 3, 2016

Element Solutions
1812 Cornwall Avenue
Bellingham, WA 98225
Telephone: 360-671-9172
Fax: 360-671-4685

TEST PIT NUMBER TP1

CLIENT City of Bellingham Public Works Department
PROJECT NAME Columbia Neighborhood Infiltration Test Pits
PROJECT NUMBER 2014221
PROJECT LOCATION Columbia Neighborhood - Bellingham, WA
DATE STARTED 12/7/15 **COMPLETED** 12/7/15
GROUND ELEVATION 69.7 ft **TEST PIT SIZE** 16 square feet
EXCAVATION CONTRACTOR Ram Construction
GROUND WATER LEVELS:
EXCAVATION METHOD Kubota KX121-3 Excavator
AT TIME OF EXCAVATION ---
LOGGED BY MG **CHECKED BY** PP
AT END OF EXCAVATION ---
NOTES
AFTER EXCAVATION ---

DEPTH (ft)	SAMPLE TYPE NUMBER	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	
0		OL		(OL)	
1			1.0		68.7
		CL		(CL) Firm to stiff silty CLAY; tan, with some redoximorphic mottling.	
2					
3			3.0		66.7

Bottom of test pit at 3.0 feet.

Element Solutions
1812 Cornwall Avenue
Bellingham, WA 98225
Telephone: 360-671-9172
Fax: 360-671-4685

TEST PIT NUMBER TP2

CLIENT City of Bellingham Public Works Department
PROJECT NAME Columbia Neighborhood Infiltration Test Pits
PROJECT NUMBER 2014221
PROJECT LOCATION Columbia Neighborhood - Bellingham, WA
DATE STARTED 12/7/15 **COMPLETED** 12/7/15
GROUND ELEVATION 76.8 ft **TEST PIT SIZE** 12 square feet
EXCAVATION CONTRACTOR Ram Construction
GROUND WATER LEVELS:
EXCAVATION METHOD Kubota KX121-3 Excavator
AT TIME OF EXCAVATION ---
LOGGED BY MG **CHECKED BY** PP
AT END OF EXCAVATION ---
NOTES
AFTER EXCAVATION ---

DEPTH (ft)	SAMPLE TYPE NUMBER	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	
0		OL		ORGANIC SOIL, (OL)	
1				1.0	75.8
		CL-ML		(CL-ML) Silty CLAY with some gravel and sand.	
2				2.3	74.6
		GW		(GW) Well graded GRAVEL with sand and some fines.	
3				3.0	73.8

Bottom of test pit at 3.0 feet.

Element Solutions
1812 Cornwall Avenue
Bellingham, WA 98225
Telephone: 360-671-9172
Fax: 360-671-4685

TEST PIT NUMBER TP3

CLIENT City of Bellingham Public Works Department
PROJECT NAME Columbia Neighborhood Infiltration Test Pits
PROJECT NUMBER 2014221
PROJECT LOCATION Columbia Neighborhood - Bellingham, WA
DATE STARTED 12/7/15 **COMPLETED** 12/7/15
GROUND ELEVATION 76.3 ft **TEST PIT SIZE** 12 square feet
EXCAVATION CONTRACTOR Ram Construction
GROUND WATER LEVELS:
EXCAVATION METHOD Kubota KX121-3 Excavator
AT TIME OF EXCAVATION ---
LOGGED BY MG **CHECKED BY** PP
AT END OF EXCAVATION ---
NOTES
AFTER EXCAVATION ---

DEPTH (ft)	SAMPLE TYPE NUMBER	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	Depth	Elevation
0		OL		GRAVELLY ORGANIC SOIL, (OL)	0.8	75.5
1, 2, 3		GW		(GW) Well graded GRAVEL with sand and some fines; occasional cobbles and construction debris (FILL).	3.0	73.3

Bottom of test pit at 3.0 feet.

Element Solutions
1812 Cornwall Avenue
Bellingham, WA 98225
Telephone: 360-671-9172
Fax: 360-671-4685

TEST PIT NUMBER TP4

CLIENT City of Bellingham Public Works Department
PROJECT NAME Columbia Neighborhood Infiltration Test Pits
PROJECT NUMBER 2014221
PROJECT LOCATION Columbia Neighborhood - Bellingham, WA
DATE STARTED 12/7/15 **COMPLETED** 12/7/15
GROUND ELEVATION 80.1 ft **TEST PIT SIZE** 12 square feet
EXCAVATION CONTRACTOR Ram Construction
GROUND WATER LEVELS:
EXCAVATION METHOD Kubota KX121-3 Excavator
AT TIME OF EXCAVATION ---
LOGGED BY MG **CHECKED BY** PP
AT END OF EXCAVATION ---
NOTES
AFTER EXCAVATION ---

DEPTH (ft)	SAMPLE TYPE NUMBER	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	
0		OL		ORGANIC SOIL, (OL) topsoil fill	
1			1.0		79.1
		CL-ML		(CL-ML) Silty CLAY with fine sand and occasional gravel; tan to dusky yellowish brown.	
2					
			2.5		77.6
		GW		(GW) Well-graded GRAVEL with sand and some fines; tan to light brown.	
3			3.0		77.1

Bottom of test pit at 3.0 feet.

Element Solutions
1812 Cornwall Avenue
Bellingham, WA 98225
Telephone: 360-671-9172
Fax: 360-671-4685

BORING NUMBER B1

CLIENT City of Bellingham Public Works Department
PROJECT NAME Columbia Neighborhood Drainage Improvement Project
PROJECT NUMBER 2014221
PROJECT LOCATION Columbia Neighborhood - Bellingham, WA
DATE STARTED 2/17/16 **COMPLETED** 2/17/16
GROUND ELEVATION 70.67 ft NAVD 88 **HOLE SIZE** 3 inches
DRILLING CONTRACTOR Holocene Drilling Inc.
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger (HSA)
▽ **AT TIME OF DRILLING** 7.50 ft / Elev 63.17 ft
LOGGED BY MG **CHECKED BY** PP
▼ **AT END OF DRILLING** 5.00 ft / Elev 65.67 ft
NOTES
AFTER DRILLING ---

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)
0.0		Asphalt (FILL).										
		Concrete (FILL).										
		SAND with fines (SP/SM).	GB									
2.5		Stiff; tan silty CLAY with trace fine sand (CL/ML).	SS	89	5-8-7 (15)							
		Medium dense; medium grained SAND with some silt (SP/SM). 1% gravel, 75% sand, 24% silt (composite sieve, 2.5-6.4 feet bgs).										
5.0	▼		SS	100	4-6-5 (11)							
		Stiff; tan silty CLAY. Blocky fracture, desiccated (CL).										
7.5	▽	Loose to medium dense; poorly graded SAND with some silt (SP). 2% gravel, 86% sand, 12% fines (composite sieve, 7.5-11 feet bgs).	SS	100	7-5-7 (12)							
10.0			SS	100	3-3-5 (8)							
12.5		Firm; tan CLAY with silt and fine sand, some redox mottling observed (CL/ML). 16% sand, 84% fines.	SS	100	3-3-3 (6)							
		Loose; medium grained silty SAND (SP/SM).										

Bottom of borehole at 14.0 feet.

Element Solutions
1812 Cornwall Avenue
Bellingham, WA 98225
Telephone: 360-671-9172
Fax: 360-671-4685

BORING NUMBER B2

CLIENT City of Bellingham Public Works Department
PROJECT NAME Columbia Neighborhood Drainage Improvement Project
PROJECT NUMBER 2014221
PROJECT LOCATION Columbia Neighborhood - Bellingham, WA
DATE STARTED 2/17/16 **COMPLETED** 2/17/16
GROUND ELEVATION 74.88 ft NAVD 88 **HOLE SIZE** 3 inches
DRILLING CONTRACTOR Holocene Drilling Inc.
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger (HSA)
▽ **AT TIME OF DRILLING** 7.50 ft / Elev 67.38 ft
LOGGED BY MG **CHECKED BY** PP
▼ **AT END OF DRILLING** 5.00 ft / Elev 69.88 ft
NOTES
AFTER DRILLING ---

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)
0.0		Asphalt (FILL).										
		Concrete (FILL).										
		Sand with fines (SP/SM).										
2.5		Firm to stiff; tan CLAY with redox mottling, silty with trace fine sand (CL).	SS	78	2-4-8 (12)							
		Sandy clayey SILT grading to silty SAND at 4' bgs (SP/SM).										
		Medium dense; medium to coarse grained SAND with some gravel (SW/GW).										
5.0 ▼			SS	56	9-13-9 (22)							
		Tan CLAY with blocky fracture, some redox mottling (CL).										
7.5 ▽		Medium dense to dense; gravelly well-graded SAND with some silt grading to fine sand at 16.3' bgs (SW/SM). 15% gravel, 78% sand, 7% fines.	SS	72	10-22-26 (48)							
10.0			SS	83	13-15-18 (33)							
12.5			SS	100	12-14-15 (29)							
15.0			SS	94	5-9-10 (19)							
		CLAY (CL).										

Bottom of borehole at 16.5 feet.

Element Solutions
1812 Cornwall Avenue
Bellingham, WA 98225
Telephone: 360-671-9172
Fax: 360-671-4685

BORING NUMBER B3

CLIENT City of Bellingham Public Works Department
PROJECT NAME Columbia Neighborhood Drainage Improvement Project
PROJECT NUMBER 2014221
PROJECT LOCATION Columbia Neighborhood - Bellingham, WA
DATE STARTED 2/18/16 **COMPLETED** 2/18/16
GROUND ELEVATION 75.21 ft NAVD 88 **HOLE SIZE** 3 inches
DRILLING CONTRACTOR Holocene Drilling Inc.
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger (HSA)
AT TIME OF DRILLING --- No groundwater observed during/after drilling.
LOGGED BY MG **CHECKED BY** PP
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)
0.0		Asphalt (FILL).										
		Concrete (FILL).										
		Medium dense; poorly graded GRAVEL with sand and occasional cobbles (GP/GW).										
2.5			SS	44	5-6-7 (13)							
5.0		Note: Coarse gravel and cobbles, rough drilling F/~5' T/ ~8' bgs.										
			GB									
7.5												
10.0		52% gravel, 45% sand, 3% fines (composite sieve, 10-16.5 feet bgs).	SS	61	7-13-15 (28)							
12.5			SS	56	12-14-14 (28)							
15.0			SS	56	11-12-11 (23)							

Bottom of borehole at 16.5 feet.

Element Solutions
1812 Cornwall Avenue
Bellingham, WA 98225
Telephone: 360-671-9172
Fax: 360-671-4685

BORING NUMBER B4

CLIENT City of Bellingham Public Works Department
PROJECT NAME Columbia Neighborhood Drainage Improvement Project
PROJECT NUMBER 2014221
PROJECT LOCATION Columbia Neighborhood - Bellingham, WA
DATE STARTED 2/18/16 **COMPLETED** 2/18/16
GROUND ELEVATION 76.63 ft NAVD 88 **HOLE SIZE** 3 inches
DRILLING CONTRACTOR Holocene Drilling Inc.
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger (HSA)
AT TIME OF DRILLING --- No groundwater observed during/after drilling.
LOGGED BY MG **CHECKED BY** PP
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)
0.0		Asphalt (FILL).										
		Pit run (FILL).										
		Loose to dense; poorly graded GRAVEL with silt, sand and occasional cobbles (GP). 55% gravel, 36% sand, 9% fines.										
2.5			SS	22	6-5-4 (9)							
5.0			SS	22	4-9-15 (24)							
7.5			SS	22	5-5-14 (19)							
10.0			SS	22	14-19-24 (43)							
12.5			SS	56	14-15-11 (26)							

Bottom of borehole at 14.0 feet.

Element Solutions
1812 Cornwall Avenue
Bellingham, WA 98225
Telephone: 360-671-9172
Fax: 360-671-4685

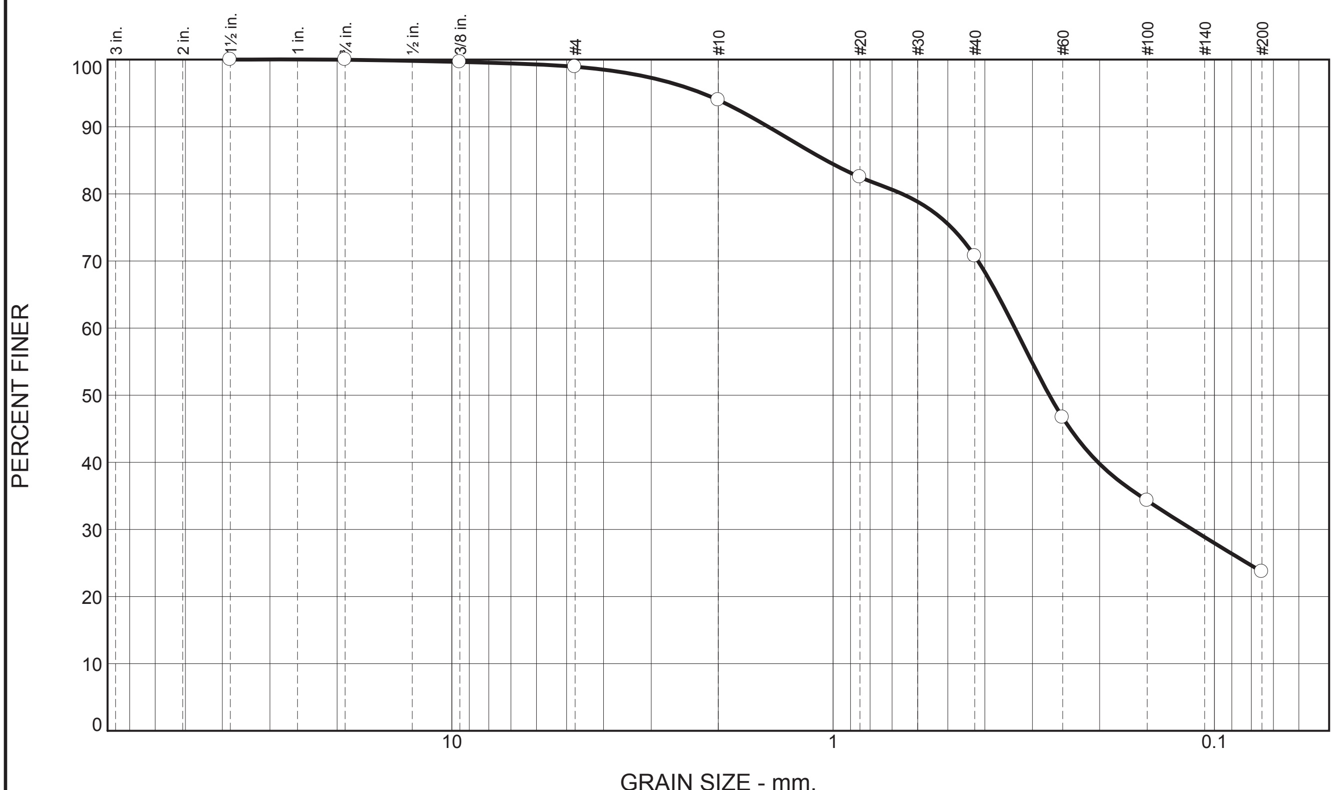
BORING NUMBER B5

CLIENT City of Bellingham Public Works Department
PROJECT NAME Columbia Neighborhood Drainage Improvement Project
PROJECT NUMBER 2014221
PROJECT LOCATION Columbia Neighborhood - Bellingham, WA
DATE STARTED 2/18/16 **COMPLETED** 2/18/16
GROUND ELEVATION 80.07 ft NAVD 88 **HOLE SIZE** 3 inches
DRILLING CONTRACTOR Holocene Drilling Inc.
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger (HSA)
AT TIME OF DRILLING 6.00 ft / Elev 74.07 ft
LOGGED BY MG **CHECKED BY** PP
AT END OF DRILLING ---
NOTES
0.1hrs AFTER DRILLING 5.75 ft / Elev 74.32 ft

DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (%)
0.0	Asphalt (FILL).										
	Concrete (FILL).										
	Asphaltic road bed material (FILL).										
2.5	Disturbed ground (FILL); medium dense; silty CLAY with redox mottling, gravel and silt. Note: Approx 1" diameter metal pipe (unmarked inactive utility) encountered at ~6' bgs; temporarily halted drilling, continued drilling T/ TD after confirming utility was inactive.	SS	39	3-7-13 (20)							
5.0	Blow count exaggerated over interval (5' - 6.5') due to buried pipe.	NR	0	17-40-43 (83)							
	Medium dense; angular, well graded GRAVEL (GW).										
7.5	Stiff; silty CLAY with trace very fine sand (CL/ML).	SS	83	10-9-4 (13)							
	Firm to stiff; glaciomarine drift CLAY (CL).										
10.0		SS	100	2-3-7 (10)							
12.5	Loose; fine to very fine SAND with silt (SP/SM).	SS	100	3-2-4 (6)							
	Very soft; glaciomarine drift CLAY (CL).										
15.0		SS	100	1-1-1 (2)							

Bottom of borehole at 16.5 feet.

Sieve Analysis Test Report - ASTM C136/C117



% +3"	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt
0	0	1	5	23	47	24

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1-1/2"	100		
3/4"	100		
3/8"	100		
#4	99		
#10	94		
#20	83		
#40	71		
#60	47		
#100	34		
#200	24		

* (no specification provided)

Material Description

Columbia Neighborhood Geotechnical
B-1 at 2.5-6.4 feet
silty sand

Atterberg Limits

PL= NP LL= NV PI=

Coefficients

D_{90}= 1.4790 D_{85}= 1.0442 D_{60}= 0.3337
D_{50}= 0.2708 D_{30}= 0.1143 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= SM AASHTO=

Remarks

Specification was not provided by client.

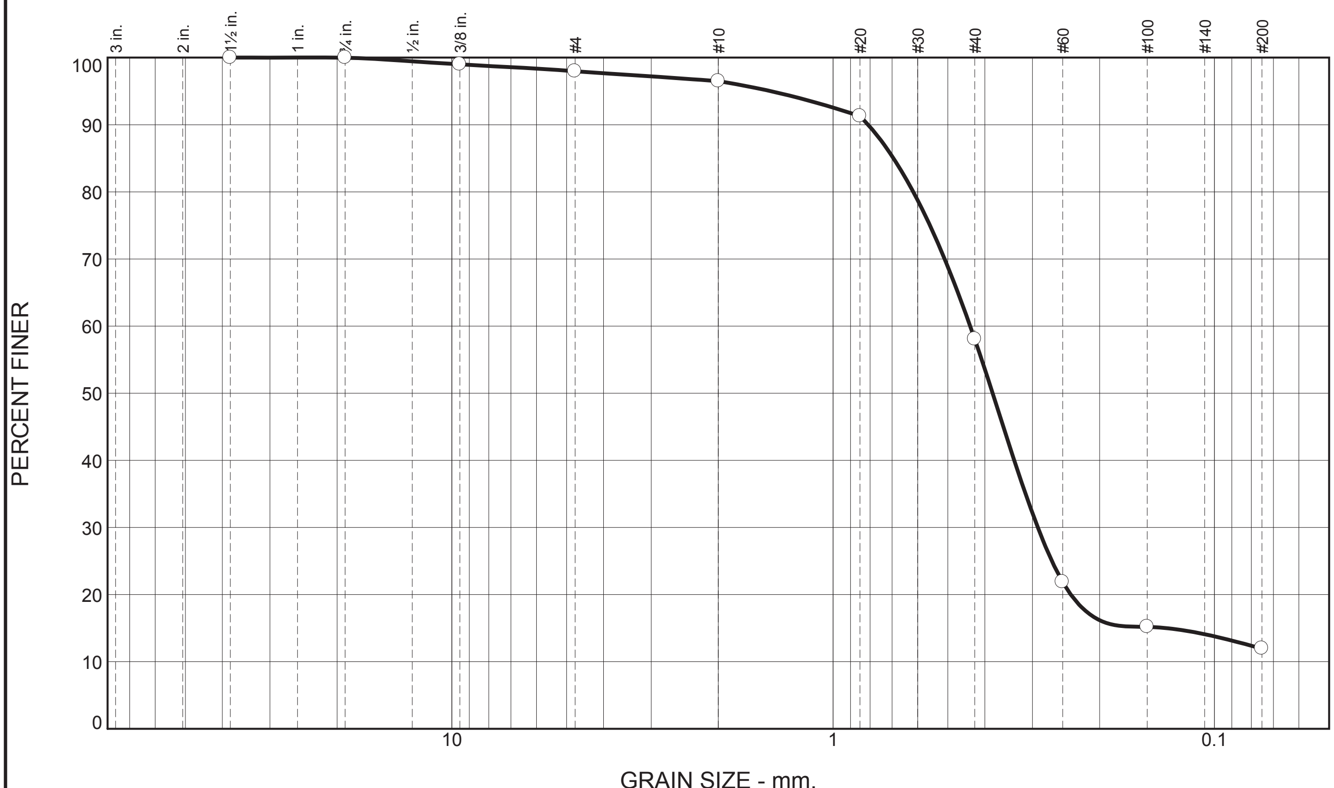
Location: Columbia Neighborhood Geotechnical - B-1 at 2.5-6.4 feet
Sample Number: 7367
Date: 2-18-2016

GEOTEST

Client: Element Solutions
Project: General Services
Project No: 16-0077 **Figure** SA006

Tested By: SE **Checked By:** DL

Sieve Analysis Test Report - ASTM C136/C117



% +3"	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt
0	0	2	2	38	46	12

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1-1/2"	100		
3/4"	100		
3/8"	99		
#4	98		
#10	96		
#20	91		
#40	58		
#60	22		
#100	15		
#200	12		

* (no specification provided)

Material Description

Columbia Neighborhood Geotechnical
B-1 at 7.5-11.5 feet
poorly graded sand with silt

Atterberg Limits

PL= NP LL= NV PI=

Coefficients

D_{90}= 0.8091 D_{85}= 0.6945 D_{60}= 0.4369
D_{50}= 0.3816 D_{30}= 0.2906 D_{15}= 0.1337
D_{10}= C_u= C_c=

Classification

USCS= SP-SM AASHTO=

Remarks

Specification was not provided by client.

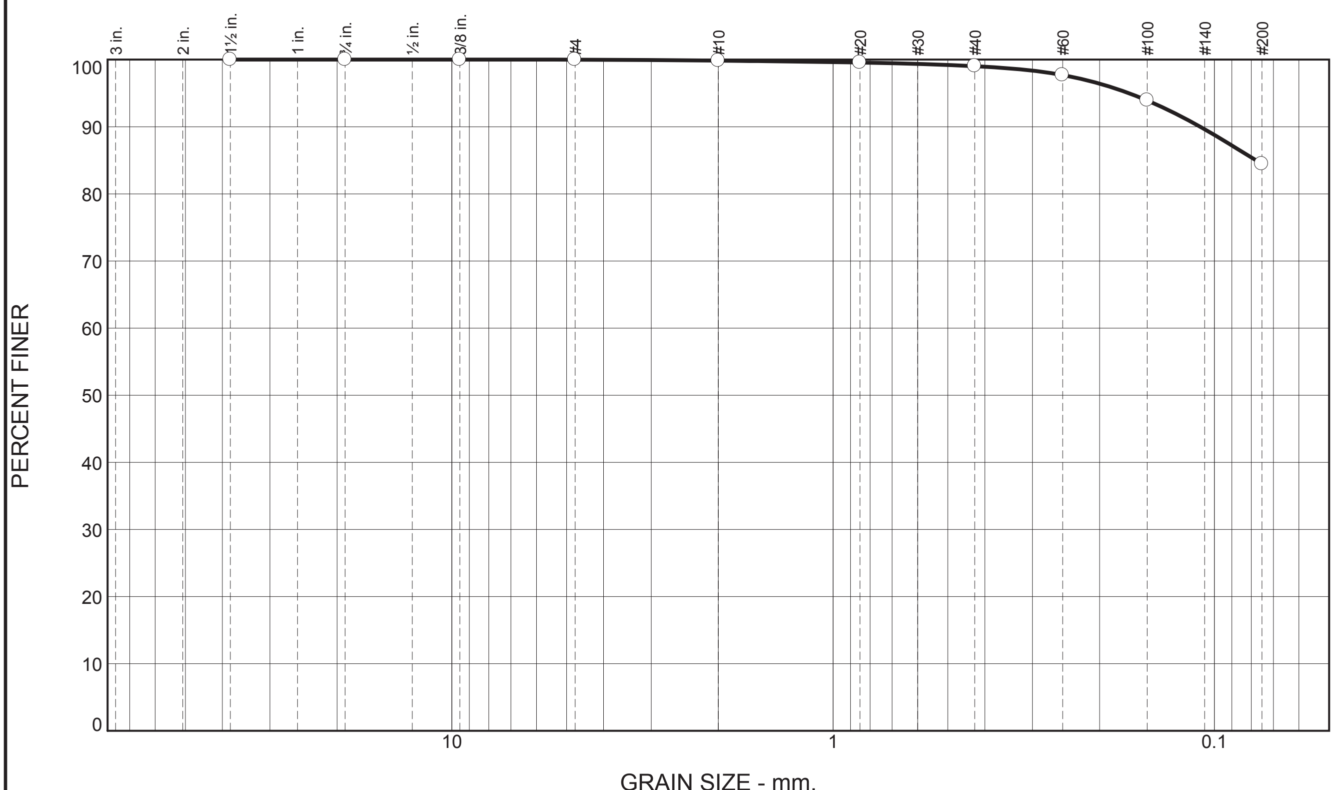
Location: Columbia Neighborhood Geotechnical - B-1 at 7.5-11.5 feet
Sample Number: 7368
Date: 2-18-2016

GEOTEST

Client: Element Solutions
Project: General Services
Project No: 16-0077 **Figure** SA007

Tested By: SE **Checked By:** DL

Sieve Analysis Test Report - ASTM C136/C117



% +3"	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt
0	0	0	0	1	15	84

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1-1/2"	100		
3/4"	100		
3/8"	100		
#4	100		
#10	100		
#20	100		
#40	99		
#60	98		
#100	94		
#200	84		

* (no specification provided)

Material Description

Columbia Neighborhood Geotechnical
B-1 at 12.5-13.5 feet
silt with sand

Atterberg Limits

PL= NP   LL= NV   PI=

Coefficients

D_{90}= 0.1092 D_{85}= 0.0777 D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= ML   AASHTO=

Remarks

Specification was not provided by client.

Location: Columbia Neighborhood Geotechnical - B-1 at 12.5-13.5 feet
Sample Number: 7365
Date: 2-18-2016

GEOTEST

Client: Element Solutions
Project: General Services
Project No: 16-0077   **Figure** SA004

Tested By: SE   **Checked By:** DL

Sieve Analysis Test Report - ASTM C136/C117

% +3"	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt
0	2	13	14	38	26	7

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1-1/2"	100		
3/4"	98		
3/8"	91		
#4	85		
#10	71		
#20	54		
#40	33		
#60	19		
#100	12		
#200	7.3		

* (no specification provided)

Material Description

Columbia Neighborhood Geotechnical
B-2 at 10-14 feet
well-graded sand with silt and gravel

Atterberg Limits

PL= NP LL= NV PI=

Coefficients

D_{90}= 8.1909 D_{85}= 4.8158 D_{60}= 1.1162
D_{50}= 0.7465 D_{30}= 0.3901 D_{15}= 0.1977
D_{10}= 0.1223 C_u= 9.13 C_c= 1.11

Classification

USCS= SW-SM AASHTO=

Remarks

Specification was not provided by client.

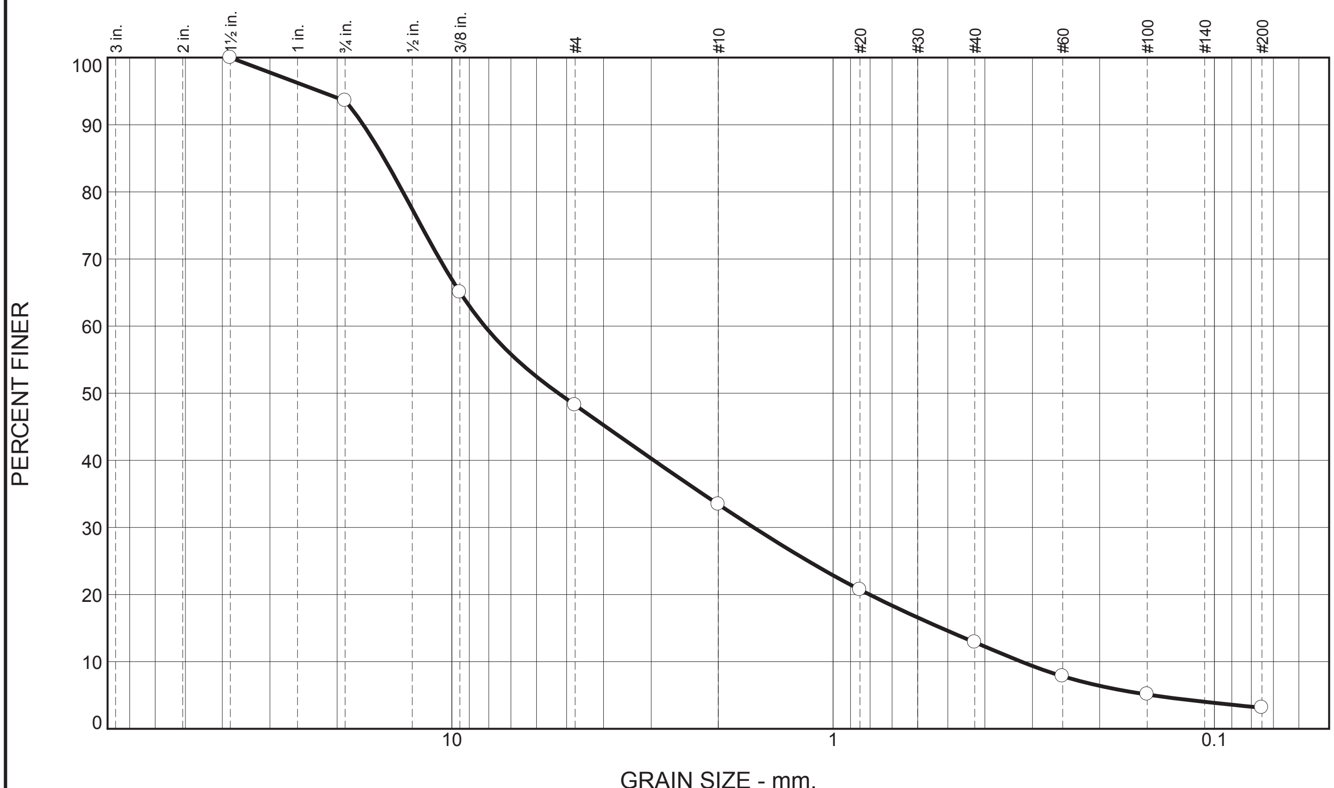
Location: Columbia Neighborhood Geotechnical - B-2 at 10-14 feet
Sample Number: 7366
Date: 2-18-2016

GEOTEST

Client: Element Solutions
Project: General Services
Project No: 16-0077 **Figure** SA005

Tested By: SE **Checked By:** DL

Sieve Analysis Test Report - ASTM C136/C117



% +3"	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt
0	6	46	15	20	10	3

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1-1/2"	100		
3/4"	94		
3/8"	65		
#4	48		
#10	33		
#20	21		
#40	13		
#60	8		
#100	5		
#200	3.1		

* (no specification provided)

Material Description

Columbia Neighborhood Geotechnical
B-3 at 10-16.5 feet
poorly graded gravel with sand

Atterberg Limits

PL= LL= NV PI=

Coefficients

D_{90}= 17.0758 D_{85}= 15.0584 D_{60}= 8.1953
D_{50}= 5.2524 D_{30}= 1.6161 D_{15}= 0.5193
D_{10}= 0.3209 C_u= 25.54 C_c= 0.99

Classification

USCS= GP AASHTO=

Remarks

Specification was not provided by client.

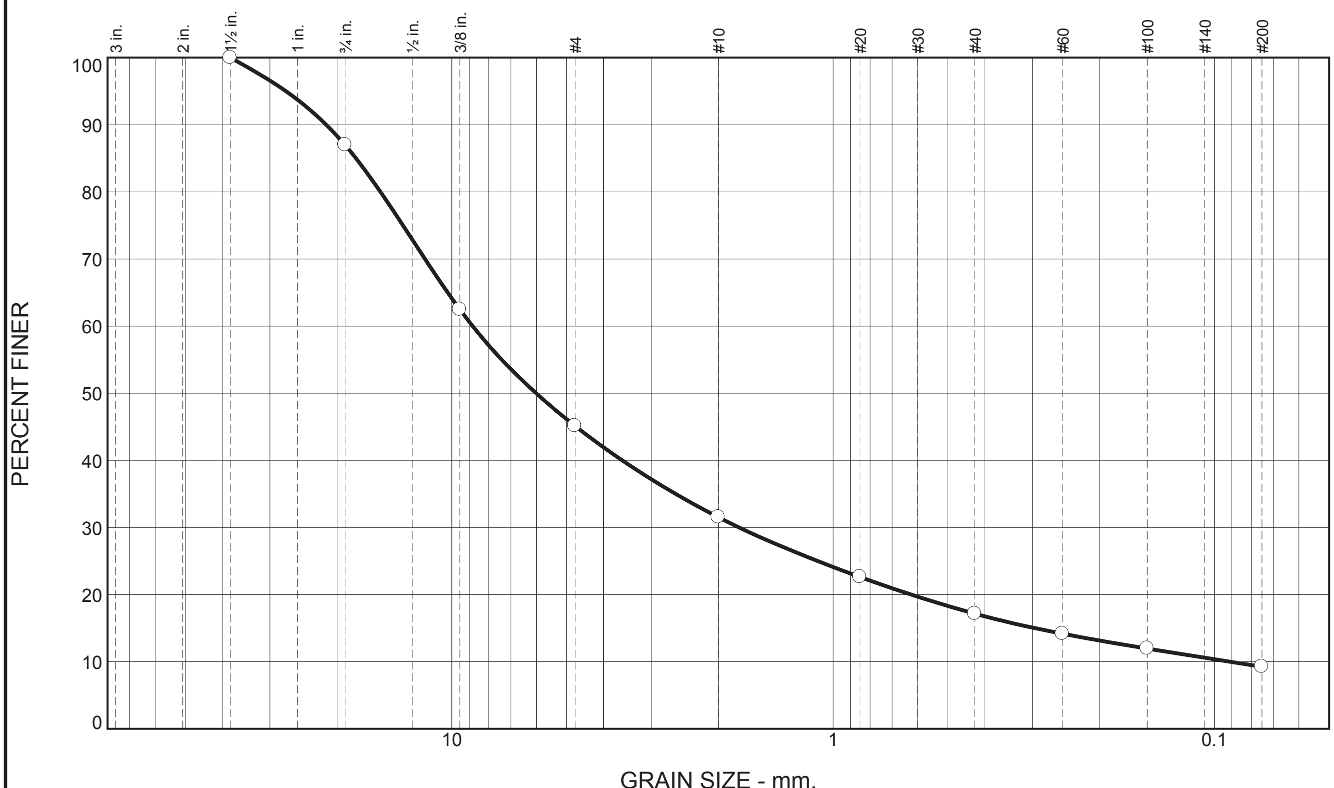
Location: Columbia Neighborhood Geotechnical - B-3 at 10-16.5 feet
Sample Number: 7369
Date: 2-18-2016

GEOTEST

Client: Element Solutions
Project: General Services
Project No: 16-0077 **Figure** SA008

Tested By: SE **Checked By:** DL

Sieve Analysis Test Report - ASTM C136/C117



% +3"	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt
0	13	42	13	15	8	9

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1-1/2"	100		
3/4"	87		
3/8"	62		
#4	45		
#10	32		
#20	23		
#40	17		
#60	14		
#100	12		
#200	9.2		

* (no specification provided)

Material Description

Columbia Neighborhood Geotechnical
B-4 at 5-14 feet
poorly graded gravel with silt and sand

Atterberg Limits

PL= NP LL= NV PI=

Coefficients

D_{90}= 21.3511 D_{85}= 17.8449 D_{60}= 8.8187
D_{50}= 6.0182 D_{30}= 1.7651 D_{15}= 0.2960
D_{10}= 0.0912 C_u= 96.66 C_c= 3.87

Classification

USCS= GP-GM AASHTO=

Remarks

Specification was not provided by client.

Location: Columbia Neighborhood Geotechnical - B-4 at 5-14 feet
Sample Number: 7364
Date: 2-18-2016

GEOTEST

Client: Element Solutions
Project: General Services
Project No: 16-0077 **Figure** SA003

Tested By: SE **Checked By:** DL

APPENDIX D

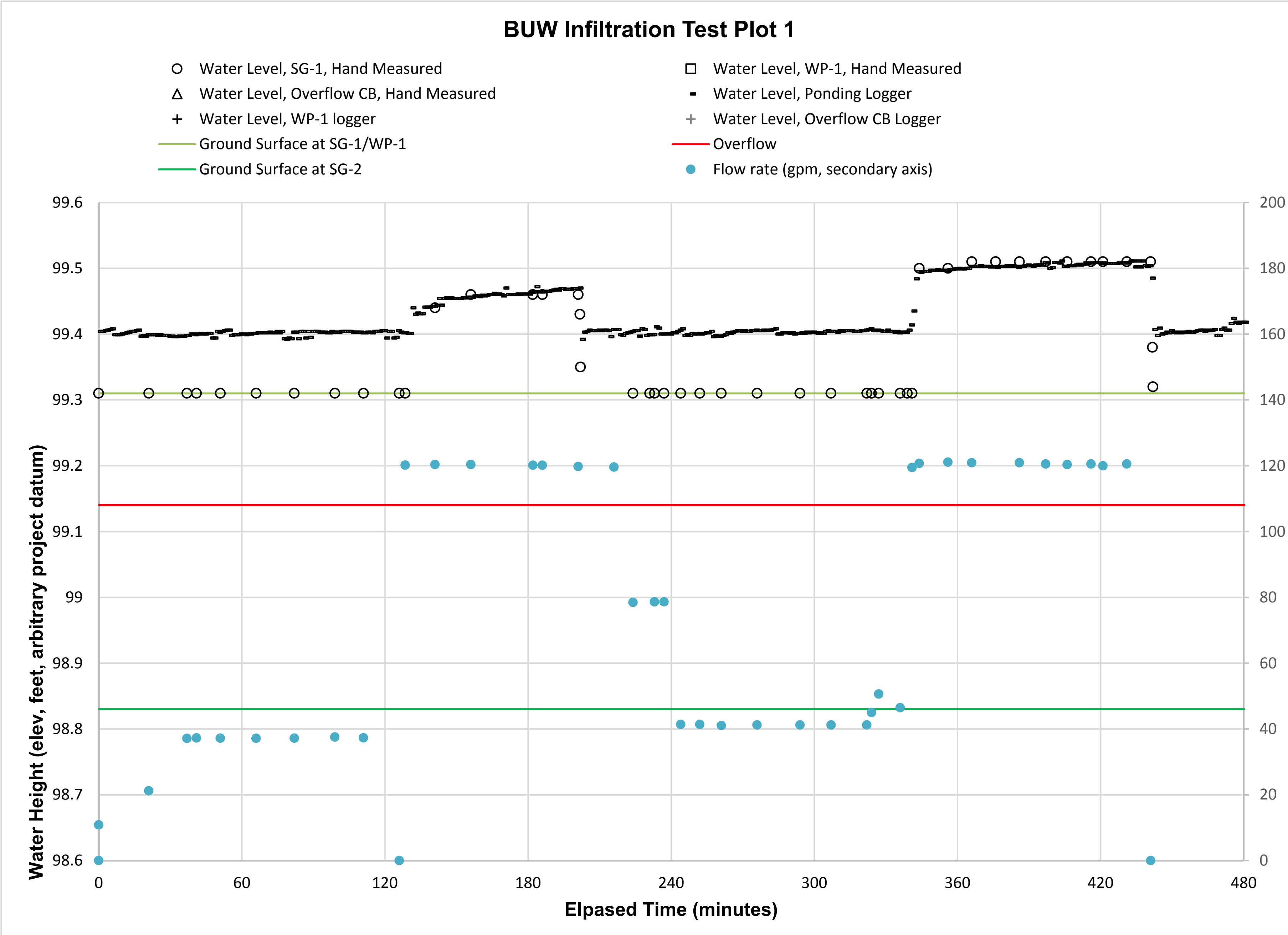
Soil Probe, Level Survey, and Field Infiltration Testing Data

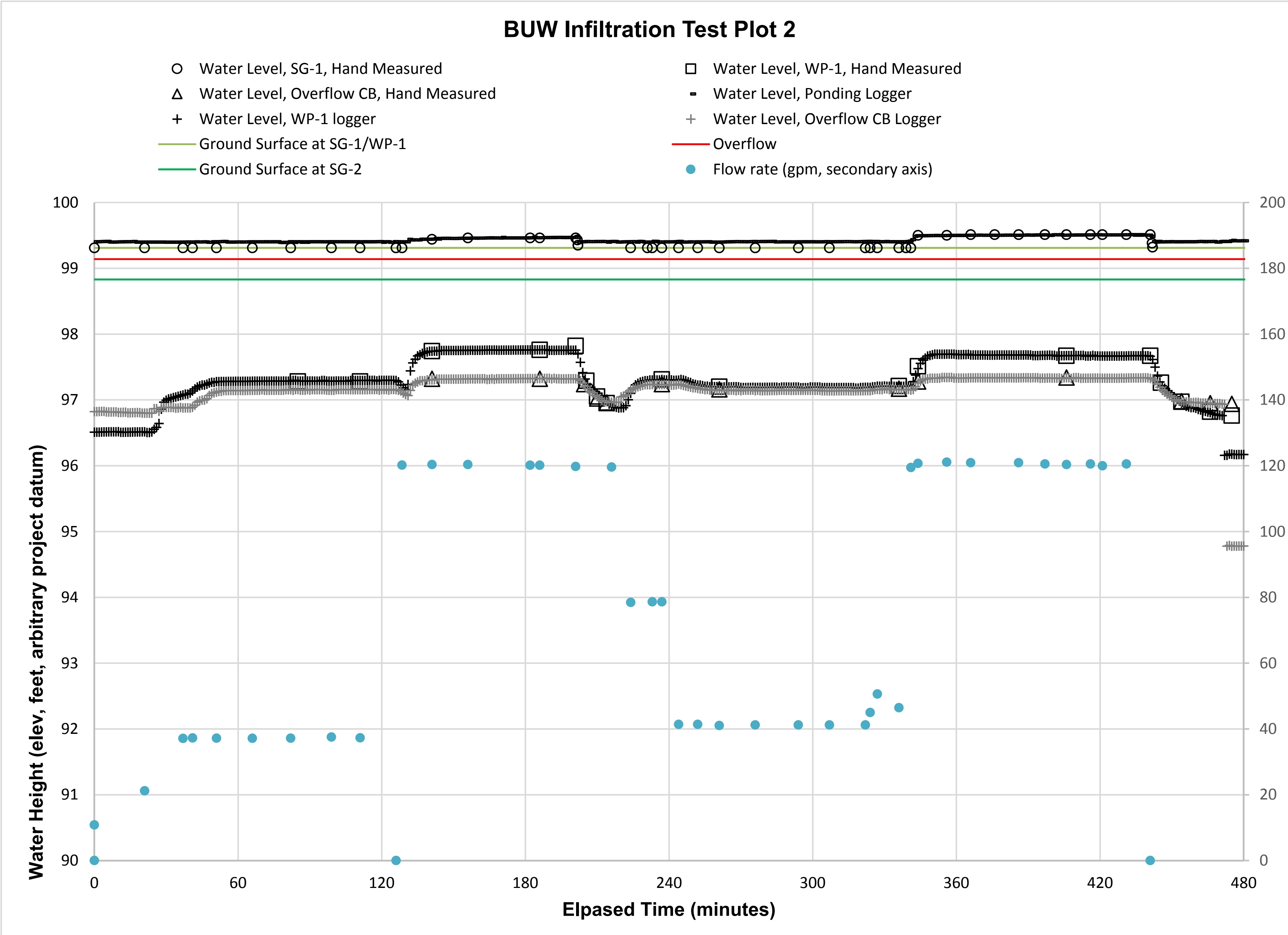
Project Name:	BHPS	**Water Source:**	Hydrant
Project Number:	150387H007	**Meter:**	AESI FM5, 9
Date:	11/15/2018	**Base Area (sq.ft.):**	NA
Weather:	Intermittent rain, 60's	**Ponded Area(sq.ft.):**	37.0
Test No.:	BUW	**Test Depth (feet):**	NA
Performed By:	ADY, SC	**Receptor Soils:**	Glaciomarine drift/Fill

Time (24-hr)	**Flow Rate (gpm)**	**SG-1 Stage (feet)**	**Totalizer (gallons)**	**Comments**
	0		0	Initial hydrant flush by City, water enters cell.
			0	Hydrant leaking aprox. 0.5 gpm, continues throughout test, leak flows to cell.
8:39	10.82	0	0	Flow on
9:00	21.2	0	220.19	
9:16	37.12	0	557.89	
9:20	37.24	0		Underdrain flow observed.
9:30	37.17	0	1056	Underdrain flowing, minimal ponding.
9:45	37.15	0	1613	Installed SG-2 near overflow grate.
10:01	37.19	0	2233	
10:04				
10:18	37.52	0	2850	
10:30	37.3	0	3299	
10:45	0	0	3853	Flow off,remove FM9
10:47	120.18	0	3853	Flow on FM5
10:48				North inlet weir backwatered.
11:00	120.34	0.13	5322	Underdrain pipe backed up with silty water. At northern inlet, ~5gpm (visual estimate) is flowing back out inlet to curb and back in via southern inlet.
11:15	120.34	0.15	7090	Water in overflow nearly at top of weir.
11:41	120.15	0.15	10240	Water discharge from underdrain is silty.
11:45	120.15	0.15	10665	Wetted area ~35 sq ft
12:00	119.76	0.15	12516	
12:00		0.12		
12:01		0.04		Water in underdrain is becoming less silty
12:01		dry		
12:03				
12:04				Light rain begins.
12:09				
12:13				Light rain continues
12:15	119.6		12516	Flow redirected to curb
12:19				Water flowing past N curb cut to S curb cut, into overflow
12:23	78.45	0		water bypassing south weir, pooling on road
12:30		0		

12:32	78.62	0	14060	Sides of curb cut lining adjusted, no bypass. Overflow receiving appro 5 gpm.
12:36	78.62	0	14390	~2gpm flowing past south curb cut to storm drain
12:43	41.4	0		
12:51	41.4	0	15316	Rain stopped
13:00	41.04	0	15666	
13:15	41.22	0	16286	
13:33	41.22	0	17020	
13:46	41.22	0	17604	
14:01	41.22	0	18189	
14:03	45			
14:06	50.6			
14:15	46.46	0	18854	
14:18				
14:20	119.44		19094	Discharge moved into cell near WP-1
14:23	120.71	0.19	19416	
14:35	121.08	0.19	20858	
14:45	120.9	0.2	22064	
14:55	12090	0.2	23270	
15:05	120.9	0.2	24503	
15:16	120.52	0.2	25882	
15:25	120.34	0.2	26966	
15:35	120.52	0.2	28074	
15:40	119.96	0.2	28716	
15:50	120.52	0.2	29890	
16:00	0	0.2	31121	Flow off
16:00		0.07		
16:00		0.01		
16:01				
16:04				
16:13				
16:25				
16:34				
16:45				

Average Infiltration Rate (in/hr) during last hour of inflow:	310
Average Infiltration Rate (in/hr) during falling head:	147


BUW Infiltration Test Plot 1
Water Level, SG-1, Hand Measured
Water Level, WP-1, Hand Measured
Water Level, Overflow CB, Hand Measured
Water Level, Ponding Logger
Water Level, WP-1 logger
Water Level, Overflow CB Logger
Ground Surface at SG-1/WP-1
Overflow
Ground Surface at SG-2
Flow rate (gpm, secondary axis)
Water Height (elev, feet, arbitrary project datum)
Elpased Time (minutes)
99.6
99.5
99.4
99.3
99.2
99.1
99
98.9
98.8
98.7
98.6
200
180
160
140
120
100
80
60
40
20
0
0
60
120
180
240
300
360
420
480


BUW Infiltration Test Plot 2
Water Level, SG-1, Hand Measured
Water Level, WP-1, Hand Measured
Water Level, Overflow CB, Hand Measured
Water Level, Ponding Logger
Water Level, WP-1 logger
Water Level, Overflow CB Logger
Ground Surface at SG-1/WP-1
Overflow
Ground Surface at SG-2
Flow rate (gpm, secondary axis)
Water Height (elev, feet, arbitrary project datum)
Elpased Time (minutes)
100
99
98
97
96
95
94
93
92
91
90
200
180
160
140
120
100
80
60
40
20
0
0
60
120
180
240
300
360
420
480

APPENDIX E

Site Photos

Cell BUW, primary curb cut inlet. Above photo is prior to install
of weir. Lower photo is after weir install and during infiltration testing.

Above photo: BUW secondary curbcut. Overflow beehive just visible in vegetation, upper right.
Lower Photo: close up of overflow structure.

associated earth sciences incorporated

Technical Memorandum

Date:	June 11, 2019	**From:**	Anton Ypma Suzanne Cook, L.G.
To:	Clear Creek Solutions, Inc.	**Project Manager:**	Jennifer H. Saltonstall, L.G., L.Hg.
	15800 Village Green Drive #3 Mill Creek, Washington 98012	**Principal in Charge:**	Jennifer H. Saltonstall, L.G., L.Hg.
cc:	Eric Christensen	**Project Name:**	Bioretention Hydrologic Performance Study
Attn:	Doug Beyerlein, P.E.	**Project No:**	150387H007
Subject:	Deliverable Task 4.5, Site FWI Geotechnical/Soils Assessment Design Data and Current Conditions, Wainwright Intermediate School, Fircrest, Washington		

1.0 INTRODUCTION

This technical memorandum documents existing shallow soil and groundwater conditions in Bioretention Facility Cell #4 of the Wainwright Intermediate School Project, located in the city of Fircrest, Washington (Figure FWI F1). This memorandum was prepared in accordance with Task 4 of the contract scope of work. Associated Earth Sciences, Inc. (AESI) collected shallow soil and groundwater conditions data related to bioretention cell function, and documented the current condition of the facility relative to the as-built drawings and available background geotechnical information. The information will be used in the WWHM2012 modeling that will be conducted as part of Task 5 (Data Analysis). In Task 5, the team will compare the previously documented hydrologic design information with our field-collected information and will note where there are significant differences. The purpose of this technical memorandum is to document the collection of current and accurate geotechnical, geologic, and hydrogeologic site information for this later work.

The following summary of shallow soil and groundwater conditions integrates the observations made during the geotechnical assessment which included site visits on October 2, 2018, infiltration testing on October 25, 2018, and background geotechnical information.

This technical memorandum has been prepared for the exclusive use of Clear Creek Solutions and the City of Olympia and their agents for specific application to this project. Within the limitations of scope, schedule, and budget, our services have been performed in accordance with generally accepted hydrogeologic and geotechnical engineering practices in effect in this area at the time our document was prepared. No other warranty, express or implied, is made.

2.0 PURPOSE AND SCOPE

The purpose of our work was to perform a shallow soil and groundwater conditions assessment and provide baseline documentation data to assess effectiveness of bioretention hydrologic performance.

Specifically, our scope included the following activities:

- Review of project documents.
- Site reconnaissance.
- Visual condition assessment of erosion and deposition features near inlet and outlet.
- Review project plans relative to constructed facility, in particular, the number and location of inlets, energy dissipation devices, outlets, and other flow-related details.
- Survey elevations of inlet, outlet, well point rim, and other observation points relative to a project datum.
- Excavate shallow hand augers through the bioretention soil.
- Classify sediment according to the Unified Soil Classification System (USCS) and *American Society for Testing and Materials* (ASTM) D2488, "Standard Recommended Practice for Description of Soils."
- Collect samples for laboratory testing of: (1) particle-size distribution in accordance with ASTM D422-63, "Standard Test Method for Particle-Size Analysis of Soils"; (2) organic matter content per ASTM D2974.
- Preparation of descriptive exploration logs for each exploration.
- Conduct qualitative assessment of soil compaction via T-probe.
- Conduct infiltration testing.
- Review of hydrologic monitoring data.
- Preparation of this summary document.

Existing facility features and the locations of hand-auger boreholes completed for this study are shown on Figure FWI F2, "Facility and Exploration Plan." Project civil plans are attached as Appendix A. Exploration logs and laboratory testing data conducted as part of this study are attached as Appendix B. Background soil, geology, and groundwater information are attached as Appendix C. Soil probe, level survey, and field infiltration testing data are attached as Appendix D. Site photos are attached as Appendix E.

3.0 SITE DESCRIPTION AND DESIGN BACKGROUND

The project site is the Wainwright Intermediate School Project, located in Fircrest, Washington as shown on the attached "Vicinity Map" (Figure FWI F1). The Wainwright Intermediate School is located on a pair of parcels totaling 7.27 acres. The site is bordered by single-family residences on the north, west, and south, and by single-family residences and Almaeda Avenue to the east. Site topography is generally gently sloping down towards the south. No on-site surface water features are present. Per the Washington State Source Water Assessment Program (SWAP) Mapping Application, the site is located within the 1-year time of travel for the City of Fircrest Well #9, a Group A water supply well. Our specific area of study for this project includes bioretention cell #4 located on the northern portion of campus in the parking lot traffic island, referred to as cell FWI for this study.

Details of the bioretention facility design and basis for design were presented in the following documents:

- "Subsurface Exploration, Infiltration Assessment, and Geotechnical Engineering Evaluation, Wainwright Elementary School Renovation," Associated Earth Sciences, Inc., December 2014.
- "Stormwater Site Plan, Wainwright Intermediate School," AHBL, March 2015, Revised May 2015.
- Wainwright Intermediate School, Bid Set, DLR Group, May 29, 2015.

3.1 Summary of Facility Design

From our review of these documents, the bioretention facility design for cell FWI consists of an approximately triangular-shaped bioretention cell with approximately 159 square feet of base area, as shown on Figure FWI F2, "Facility and Exploration Plan." We understand that the site was developed under the Washington State Department of Ecology (Ecology) 2014 *Stormwater Management Manual for Western Washington* (2014 Ecology Manual) for design and construction of stormwater facilities and modeled using WWHM2012 with a design infiltration rate of 1.5 inches per hour (in/hr) in the native subgrade. Land use within the drainage basin is primarily roadway and parking area. Per Storm Drainage Notes and Details, plan sheet C4.3 (DLR Group, May 29, 2015), the facility design includes 18 inches of bioretention soil mix overlying a minimum 1-foot-thick rock-filled trench. The rock-filled trench contains a 6-inch-diameter perforated underdrain pipe bedded in "¾ to 1½ inch" washed rock. The underdrain pipe is a minimum of 0.5 feet above the base of the washed rock layer. The underdrain pipe discharge to another stormwater detention cell.

The facility is designed to infiltrate 96.25 percent of inflow into the subgrade. Stormwater enters the facility through two curbcuts. If water ponds up on the bioretention soil, the ponded water would discharge into a yard drain (YD 25) with a beehive grate located near the southern perimeter, and then into the on-site stormwater system. The rim of the yard drain was designed to be 1 foot higher than the cell base to create 1 foot of ponding depth. The facility was constructed during 2016 and is likely to have begun receiving inflow in 2017.

4.0 SITE OBSERVATIONS

During AESI's site visits, we made notes regarding the physical construction of the bioretention facilities including documenting site inlet/outlet layout relative to site plans and qualitative bioretention soil thickness and compaction. These notes were used to indicate key features of the facility in Figure FWI F2, “Facility and Exploration Plan.”

- Level Survey: AESI conducted an elevation survey of the cell using a Leitz C40 automatic level and a stadia rod. An arbitrary project datum was established for this survey, with the top of the concrete lamp post base on the east side of the cell (identified on the ”FWI Level Survey Data” map in Appendix D) defined as project datum elevation 100 feet. All other elevations measured by the survey are relative to this project datum. Key level data is summarized in Table 1. Additional data points are included in Appendix D to this document. This survey was not conducted by a licensed surveyor. Surveyed elevations are expected to be sufficiently accurate for this general assessment of facility construction, but may be inaccurate for purposes requiring greater precision.

- Inflow: Two curbcuts allow inflow into cell FWI.
  - The eastern inlet (Inlet 1) to the facility is a 2-foot curbcut consistent with project plans, which discharges onto a rounded rock energy dissipation pad approximately 5.5 to 8.5 feet wide and 11.5 feet long. Minor leaf litter was present, concentrated near the inlet.
  - The western inlet (Inlet 2) to the facility is a 2-foot curbcut, consistent with project plans which discharges onto a rounded rock energy dissipation pad approximately 6 to 9 feet wide and 10.5 feet long. Minor leaf litter with vegetation growth and silt were present. A rill, 0.5 to 1 foot wide and 1 to 2 inches deep, was observed where flow was concentrated between grass clumps in the inlet. The rill did not extend to the cell base.
  - AESI observed that the plan sheets indicate that the energy dissipater pads shall consist of 6-inch streambed cobbles. AESI observes that the energy dissipater pads generally consist of approximately ¾-inch to 1½-inch gravel with cobbles.

- Overflow: The overflow consists of a yard drain (YD 25) with a beehive grate. The rim of this grate was approximately 1.4 feet above the adjacent base of the facility, and approximately 1 foot above the majority of the facility base area. One pipe exits the yard drain to convey water to the storm drain system.

- AESI observed that the base of the facility is not level. The low point in the base of the facility, near the overflow and the western inlet, was approximately 0.4 feet lower than the majority of the facility base area.

- AESI investigated the loose bioretention soil thickness present in cell FWI using a geotechnical soil T-probe. This qualitative data was used in conjunction with the hand-auger observations to understand loose soil thickness and relative potential compactness of the bioretention soils at depth. AESI measured the depth of penetration of the soils probe at locations generally arranged in a 4-foot grid on the facility base. Penetration of the T-probe generally ranged from approximately 1.1 to 1.7 feet and averaged 1.5 feet. Probe penetration data is included in Appendix D to this document.

Table 1
Summary of Cell FWI
Level Survey Data

Location	Elevation (feet, project datum)
WP-1 TOC	96.04
WP-1 GS (S)/Temp SG#1	94.28
Ponding Tube TOC (Baro)	95.74
Ponding Tube TOC (DL)	95.17
Overflow PVC TOC LOW (W)	95.22
Inlet (W) 8" green pipe top/end	95.56
Inlet (W) Curbcut LOW (N)	95.36
Inlet (E) 6" green pipe top/end	96.41
Inlet (E) Curbcut LOW (S)	96.26
In CB PVC TOC (DL)	95.54
In CB PVC TOC (Baro)	94.95
CB inside lip, SE corner	95.87

TOC: top of casing; GS: ground surface; DL: datalogger; PVC: polyvinyl chloride; CB: catch basin

5.0 SITE SETTING

The text sections below describe our research findings in regards to the topographic, geologic, and hydrogeologic setting of the project site both from regional studies and background site-specific geotechnical and groundwater studies. Our sources of information included the following:

- Site-specific documents cited previously under “Project and Site Description.”
- *Draft Geologic Map for the Steilacoom 7.5 Minute Quadrangle*, U.S. Geological Survey (USGS), 2006.
- Natural Resource Conservation Service (NRCS), Web Soil Survey, United States Department of Agriculture (USDA), http://websoilsurvey.nrcs.usda.gov/, accessed February 2019.
- *Soil Survey of Pierce County Area, Washington*, United States Department of Agriculture (USDA), Natural Resource Conservation Service (NRCS), in cooperation with Washington Agricultural Experiment Station, 1979.
- Griffin, W.C., Sceva, J.E., Swenson, H.A., and Mundroff, M.J., *Water Resources of the Tacoma Area, Washington*, United States Department of the Interior, Geological Survey, 1962.

5.1 Regional Topography and Project Grading

The project site is situated on an undulating upland. The nearest surface water feature is China Lake approximately half a mile northeast of the site. Elevations on the larger project site range from about 290 feet on the northern edge, to 278 feet on the southern edge of the property.

On a closer scale, the area near cell FWI is at an elevation of 283 to 285 feet, and land use consists of a parking lot and drive lane which generally slopes down to the south and west. A curb separates the paved surfaces from the cell.

The project site was previously developed as Wainwright Intermediate School which was remodeled in 2016. The bioretention cells in the parking lot area, including cell FWI, were installed as part of the remodel. Minor cutting (about 3 feet) was needed to achieve design bioretention cell grades based on a review of existing topography compared with built topography.

5.2 Regional Geology and Background Geotechnical Information

According to the current draft U.S. Geological Survey (USGS) *Geologic Map for the Steilacoom 7.5 Minute Quadrangle* (USGS - Miscellaneous Field Investigation, 2006), the project site lies within an extensive zone of Vashon recessional outwash. This material is deposited by stream channels that emanate from a stagnant or receding glacier. Recessional outwash typically consists of loose to medium dense sands with varying amounts of silt and gravel. Thicknesses can range from a few feet to several tens of feet. Recessional outwash is commonly underlain by dense to very dense deposits of lodgement till or advance outwash. Vashon lodgement till is mapped in the site vicinity, and was deposited directly from basal, debris-laden, glacial ice during the Vashon Stade of the Fraser Glaciation, approximately 12,500 to 15,000 years ago. The high relative density characteristic of the Vashon lodgement till is due to its consolidation by the massive weight of the glacial ice from which it was deposited.

Background geotechnical information includes exploration logs EP-2 from approximately 50 feet south of cell FWI, and IT-2 from the location of bioretention cell #3, approximately 100 feet south of cell FWI. EP-2, dated October 29, 2014, and IT-2, dated December 2, 2014, both encountered sediments interpreted as till to the total depth explored of 6 and 10 feet, respectively. EP-1, approximately 150 feet northwest of cell FWI, encountered 1 foot of artificially-placed fill, and Vashon recessional outwash sediments to a depth of 6.5 feet, directly overlying Vashon lodgement till. Shallow fill soils were encountered in other explorations to a maximum depth of 5 feet.
This interpretation is generally consistent with the geologic mapping in the area.

- <u>Vashon Recessional Outwash (Qvr)</u>: Where encountered in geotechnical explorations onsite, this deposit typically comprised loose to medium dense, weakly stratified sands, with minor amounts of silt and gravel. Recessional outwash was deposited during the retreat of glacial ice, and has not been glacially overridden.

- <u>Vashon Lodgement Till (Qvt)</u>: Five of the eleven exploration pits previously observed onsite encountered medium dense to very dense glacial lodgement till below the site. This deposit typically consisted of silty sands with varying amounts of gravel, although the till surface was weathered to a silt in some locations. Depths to the till horizon ranged from zero (in EP-2 near cell FWI) to about 12 feet (in EP-3 near the southern edge of the property).

We inferred that the till horizon lies closely below the termination depths of most other exploration pits, reflecting a general dip toward the south or southwest.

5.3 Regional Soils and Soil Data Used in Site Stormwater Model

AESI reviewed the *Soil Survey of Pierce County Area, Washington* (Natural Resource Conservation Service [NRCS], 1979) and soils mapping from the NRCS web portal (NRCS, 2019). The soil survey identifies different soil map units based on parent material, climate, topography (slope), organisms (biota), and time. The soils in the study area formed mostly from young glacial deposits and have not had time to develop the deep weathering profiles present in soils in unglaciated terrains. Instead, they exhibit a direct relationship to the underlying parent material, local climate, topography, and vegetation.

Mapped soils in the project area consist of Alderwood gravelly sandy loam soils. Alderwood formed from the weathering of glacial till, and typically perches shallow groundwater within the weathered soil horizon. NRCS describes the permeability as moderately well drained (NRCS, 2019) in the upper portion of the soil unit.

As described in the stormwater site plan (AHBL, 2015), the pre-developed condition was modeled as Type C soils. This is consistent with the 2014 Ecology Manual, which classifies the Alderwood soil as hydrologic soil group C.

5.4 Regional Hydrogeology and Background Groundwater Data

Regional hydrogeology is described in *Water Resources of the Tacoma Area, Washington* (Griffin et al., 1962). Griffin et al. (1962) indicates that recessional outwash is typically a productive aquifer, while the Vashon lodgement till typically perches water.

On a closer scale, in our previous explorations onsite, we observed slow groundwater seepage at a depth of approximately 6 feet in EP-3 near the southern edge of the site, and some orange mottling at depths ranging from about 1 to 8 feet in several other exploration pits. Groundwater is expected to perch at this shallower depth under the developed conditions due to stormwater infiltration from the bioretention cells and other site infiltration features.

6.0 BIORETENTION CELL SUBSURFACE EXPLORATION

Limited information on subsurface conditions was obtained for this study from hand-auger samples and soil probe penetration measurements at about 2-foot increments in each hand-augered borehole. Three hand-auger borings were performed in the facility bottom and advanced through the bioretention soil and underlying aggregate rock. Representative samples were collected, visually classified in the field, stored in water-tight containers, and transported to AESI's offices for additional classification, geotechnical testing, and study. At the conclusion of the excavation, the boreholes were immediately backfilled with the excavated material or completed as a well point for water level monitoring (described separately below).

The various types of sediments, as well as the depths where characteristics of the sediments changed, are indicated on the exploration logs presented in Appendix B. A detailed record of the observed bioretention soil, subsurface soil, geology, and groundwater conditions was made. The sediments were described by visual and textural examination using the soil classification in general accordance with ASTM D2488, "Standard Recommended Practice for Description of Soils." The depths indicated on the logs where conditions changed may represent gradational variations between sediment types in the field. The exploration logs in Appendix B are based on the field observations, inspection of the samples, and where applicable, laboratory grain-size analysis. Our explorations were approximately located in the field relative to known site features, and are shown on Figure FWI F2, "Facility and Exploration Plan." Global Positioning System (GPS) coordinates for the explorations were taken using a handheld GPS, and are summarized in Appendix B.

The results presented in this document are based on the explorations completed for this study and review of background data. The number, locations, and depths of the explorations were completed within site and budgetary constraints. Because of the nature of exploratory work below ground, interpolation of subsurface conditions between field explorations is necessary. It should be noted that differing subsurface conditions may sometimes be present due to the random nature of deposition and the alteration of topography by past grading and/or filling.

6.1 Hand-Auger Borings

Hand-auger borings in cell FWI were completed on October 2, 2018. Light rainfall was noted, beginning shortly after the time of exploration.

Hand-auger boring number 1 (FWI-HA-1), which was completed in the southern portion of the cell, near the inflow, and hand-auger boring number 2 (FWI-HA-2), which was completed in the northern portion of the cell, encountered approximately 1.4 feet of bioretention soil, overlying material interpreted as drain rock to a total depth of 1.9 and 1.6 feet, respectively. Hand-auger boring number 3 (FWI-HA-3), situated in the eastern edge of the bioretention cell, encountered 2.4 feet of bioretention soil mix, overlying drain rock to a total depth of 2.5 feet. No seepage or caving were observed.

6.2 Well Points

A well point was installed in FWI-HA-1. Key well point dimensions are provided in Table 2, below.

Table 2
Summary of Cell FWI
Well Point Dimensions

Well Point	Exploration in which Well Point was Installed	Total Length of Casing (feet)	Interior Diameter	Stickup Height (feet)	Total Depth Inside Casing Below Ground Surface
FWI-HA-1/WP	FWI-HA-1	4.7	1.25 inch nominal	1.8	2.9

7.0 LABORATORY ANALYSIS

Laboratory testing included mechanical grain-size distribution and percent organic matter by weight in accordance with the ASTM D422 and D2974, respectively. Bioretention soil was first tested for organic matter content and then the burned material was tested for grain-size distribution for comparison with the aggregate fraction of the bioretention soil mix guidance in the 2014 Ecology Manual. No material representative of the subgrade was encountered in our hand-auger explorations. The data is summarized in Table 3.

Table 3
Summary of Cell FWI
Organic Content and Grain Size Data

Exploration Number	Depth (feet)	Soil Type	Organic Content (% by weight)	USCS Soil Description	Fines Content (% passing #200)	Cu	Cc	USDA Soil Texture*
FWI-HA-1	0.1-0.5	Bioretention Soil	5.2	SAND, some silt, trace gravel (SP-SM)	5.2	6.9	0.9	Sand
FWI-HA-2	0.1-0.5	Bioretention Soil	5.0	SAND, some silt, trace gravel (SP-SM)	5.1	6.9	1.0	Sand
FWI-HA-3	0.1-0.5	Bioretention Soil	7.0	SAND, some silt, trace gravel (SP-SM)	5.5	7.3	0.9	Sand

USCS: Unified Soil Classification System; Cu: coefficient of uniformity; Cc: coefficient of curvature; USDA: U.S. Dept. of Agriculture;
*No hydrometers were performed. USDA soil texture range assumes fines consist entirely of silt to entirely of clay.

7.1 Bioretention Soil Mix

We compared the organic content and burned fraction gradation against the general guidelines for the bioretention soil mix (Table 4).

The organic content of the tested bioretention soils ranged between 5 and 7 percent by weight. This meets the recommended organic content by weight of 5 to 8 percent in the 2014 Ecology Manual.

The grain-size analysis test results on the burned soil fraction indicate that the bioretention soils tested correlate to a “SAND” with some silt and trace gravel based on ASTM D2487 Unified Soil Classification System (USCS). The respective fines content as measured on the No. 200 sieve was 5.1 to 5.5 percent, higher than the recommended range of 2 to 5 percent. The remaining grain size fraction was within the recommended ranges. The coefficient of uniformity ranged from 6.9 to 7.3, meeting the recommended value of equal to or greater than 4. The coefficient of curvature ranged from 0.9 to 1, lower than the recommended range of greater than or equal to 1 and less than or equal to 3. The tested bioretention soil was a poorly-graded sand.

7.2 Subgrade

In cell FWI, no samples of the subgrade could be obtained for this study due to the import gravel beneath the bioretention soil and difficulties hand auguring in this material. Based on the existing geotechnical information from previous explorations onsite, the subgrade could consist of either Vashon recessional outwash and/or Vashon lodgement till.

Table 4
General Guidelines for Bioretention Soil Mix (2014 Ecology Manual)
Compared to Averaged Cell FWI Site Data

Parameter	Recommended Range	Cell FWI
Organic Content (by weight)	5 to 8 percent	5.7 percent by weight
Cu coefficient of uniformity	4 or greater	7
Cc coefficient of curvature	1 to 3	0.9
Sieve Size	**Percent Passing**	
3/8” (9.51 mm)	100	99.7
#4 (4.76 mm)	95 to 100	98.6
#10 (2.0 mm)	75 to 90	78.4
#40 (0.42 mm)	25 to 40	28.6
#100 (0.15 mm)	4 to 10	8.5
#200 (0.074 mm)	2 to 5	5.3

Note: The general guidelines for mineral aggregate gradation are from Table 7.4.1 of the 2014 Ecology Manual.
mm: millimeters.

8.0 INFILTRATION TESTING

8.1 General Infiltration Test Method

The infiltration test was conducted in general accordance with the 2014 Ecology Manual. The test was conducted by discharging water into the facility for a “soaking period,” to allow the receptor soils to become saturated. After completion of the soaking period, water was discharged into the cell at a rate sufficient to maintain a relatively constant head. This constitutes the “constant-head” phase of infiltration testing. Immediately following the constant-head phase of infiltration testing, flow into the facilities was discontinued, and the water level was monitored as it dropped. This constitutes the “falling-head” portion of the infiltration testing.

The water for testing was obtained from an on-site fire hydrant and conveyed to cell FWI with fire hoses. During infiltration testing, the water was conveyed into the bioretention cell via a digital flow meter with gallons per minute (gpm) and total gallon readouts, and discharged through a flow diffuser. Water levels were monitored using a staff gauge (SG-1) marked in 0.01-foot increments installed adjacent to the well point, a second temporary metal staff gauge (SG-2) marked in 0.01-foot increments installed near in the deep point of the facility for the duration of the test, and within the well point with a digital water level tape, and with digital pressure transducers. Data from the digital pressure transducers was compensated for barometric response using a separate digital barometer. The underdrain catchbasin was observed during testing to visually observe underdrain flow. The area of the pool was measured periodically during testing.

The infiltration test in cell FWI is discussed below, and results are presented in Table 5. Infiltration test data is included in Appendix D to this document.

8.2 Infiltration Test in Cell FWI

AESI performed infiltration testing on October 25, 2018. Intermittent rainfall was noted during testing, and no flow from the inflow curbcuts was present.

During this test, flow was initially maintained at 12 to 50 gpm, then increased to 100 gpm, and finally increased to approximately 152 gpm (the maximum flow rate from the hydrant) for the remaining duration of test. Inflow to the facility for the infiltration test was directed, through a diffuser, onto the energy dissipation pad by the eastern inlet. Initially, the water pooled near in the deep point of the cell, while spreading across the majority of the base in a shallow pool less than 0.1 foot deep. After approximately 270 minutes, flow was increased to the maximum level, and the pool across the majority of the base grew to a depth of approximately 0.5 feet by the end of testing.

After approximately 7 hours, the water level in the wetted area was about 0.47 feet as measured on SG-1. The wetted pool area had been generally stable for about 2 hours, and had filled in the low areas near Inlet 1 and Inlet 2 covering an area of about 200 square feet. Approximately 45,000 gallons of water were used.

AESI observed that after approximately 15 minutes into the test the underdrain was active for the remaining duration of the test, and visually estimated that flow from the underdrain appeared similar to the inflow to the facility, indicating that most to all inflow left the cell via the underdrain.

Water in WP-1 was monitored with a data logger during the infiltration test and responded to inflow. Water was present at about 2 feet beneath the bioretention cell prior to the start of inflow, and likely represents perched water in the base of the drain rock. The water level in WP-1 responded to inflow after about 25 minutes, and rose approximately 1.3 feet during the course of testing. AESI interprets this response to indicate that water from the infiltration test infiltrated rapidly through the bioretention soil, perched on the native subgrade, and then mounded within the gravel base course before entering the underdrain.

After about 7 hours, AESI shut off the flow and monitored the water level as it fell. AESI observed that the pooled water in the base of the facility infiltrated over the course of approximately 8 minutes for the majority of the facility, with a small amount in the deepest part of the facility near the overflow taking an additional approximately 35 minutes to drain.

The constant-head test infiltration rate in Table 5 is calculated based on flow rate from the hose for infiltration testing, and the wetted area of bioretention soil through which the water infiltrated, and represents the infiltration rate of the bioretention soil. AESI visually estimated that flow from the underdrain appeared similar to the inflow to the facility, indicating that the majority of inflow was leaving the facility via the underdrain and little to no inflow was infiltrating into the subgrade.

Table 5
Cell FWI
Infiltration Test Results

Test No.	Surface Area (square feet)	Discharge Time (minutes)	Total Volume Discharged (gallons)	Approximate Constant-Head Level (feet)	Field Infiltration Rates: Constant-Head Test (in/hr)	Field Infiltration Rates: Falling-Head Test (in/hr)
FWI (bioretention soil)	200	420	44,808	0.45	66	43
FWI (subgrade)	Perched water response in well point				Unknown; interpreted to be low based on the underdrain outflow	

in/hr: inches per hour.

9.0 CONCLUSIONS AND RECOMMENDATIONS

Cell FWI was generally consistent with the design shown on the civil plan sheets. Observations on site design, shallow soil and groundwater conditions are discussed below.

- The overflow is generally consistent with the plans. Site design documents indicate that the ponding level was designed as 1 foot. Although the overflow sticks up 1.4 feet from the ground surface immediately around it, it is approximately 1 foot above the ground surface in the majority of the cell base.

- Bioretention soil:
    - Thickness: The apparent thickness of loose bioretention soil based on soil probe data was generally about 1.5 feet as indicated on the plan.
    - Composition: The soil tested in generally the recommended guidelines for organic content and sand gradation, although the soil mix contained slightly more than the recommended range of silt and had a slightly low coefficient of curvature.

- Subgrade conditions: The subgrade could consist of either Vashon recessional outwash and/or Vashon lodgement till, based on previous explorations onsite. Based on the response of WP-1 during infiltration testing, and our observation that inflow appeared visually similar to the flow from the underdrain, we interpret that the subgrade has a low infiltration rate, and is most likely Vashon lodgement till.

- Bioretention soil field infiltration rate:
    - Measured at about 66 in/hr.
    - Water readily soaked through the bioretention soil mix and the field rate is interpreted to represent the bioretention soil infiltration rate.

- Native subgrade infiltration rate: not measured. Previous infiltration testing in the weathered Vashon lodgement till onsite approximately 100 feet south of cell FWI measured an infiltration rate of 0.4 in/hr (AESI, 2014) with the water interpreted to be moving laterally during testing.

10.0 CLOSURE

We appreciate the opportunity to be of continued service to you on this project. Should you have any questions regarding this document or other geotechnical/hydrogeologic aspects of the project, please call us at your earliest convenience.

State of Washington
Hydrogeologist
2335
Licensed Geologist
Jennifer H. Saltonstall

6/11/19

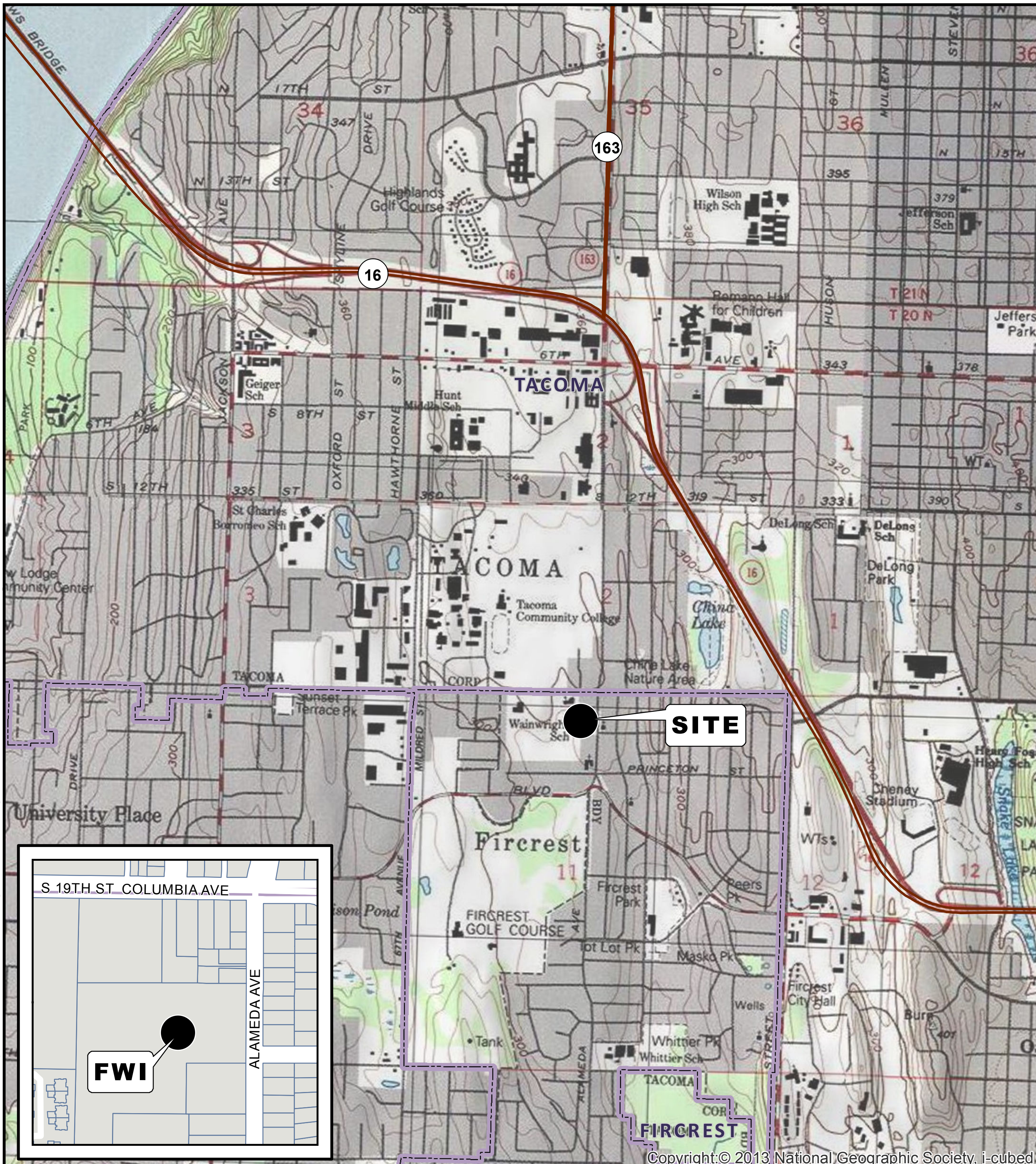
Anton D. Ypma
Staff Geologist

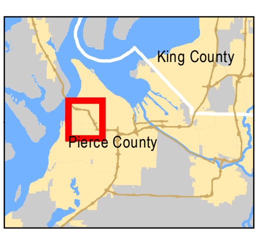
Suzanne S. Cook, L.G.
Senior Project Geologist

Jennifer H. Saltonstall, L.G., L.Hg.
Principal Geologist/Hydrogeologist

Attachments:	Figure FWI F1:	Vicinity Map
	Figure FWI F2:	Facility and Exploration Plan
	Appendix A:	Project Civil Plans
	Appendix B:	Current Study Exploration Logs and Laboratory Testing Data
	Appendix C:	Background Soil, Geology, and Groundwater Data (Regional Maps, Previous Studies Exploration Logs and Laboratory Testing Data)
	Appendix D:	Soil Probe, Level Survey, and Field Infiltration Testing Data
	Appendix E:	Site Photos

JHS/ld
150387H007-7
Projects\20150387\KH\WP





N

0 1000 2000

FEET

associated earth sciences incorporated

VICINITY MAP

BIORETENTION HYDROLOGIC PERFORMANCE STUDY, FWI SITE
FIRCREST, WASHINGTON

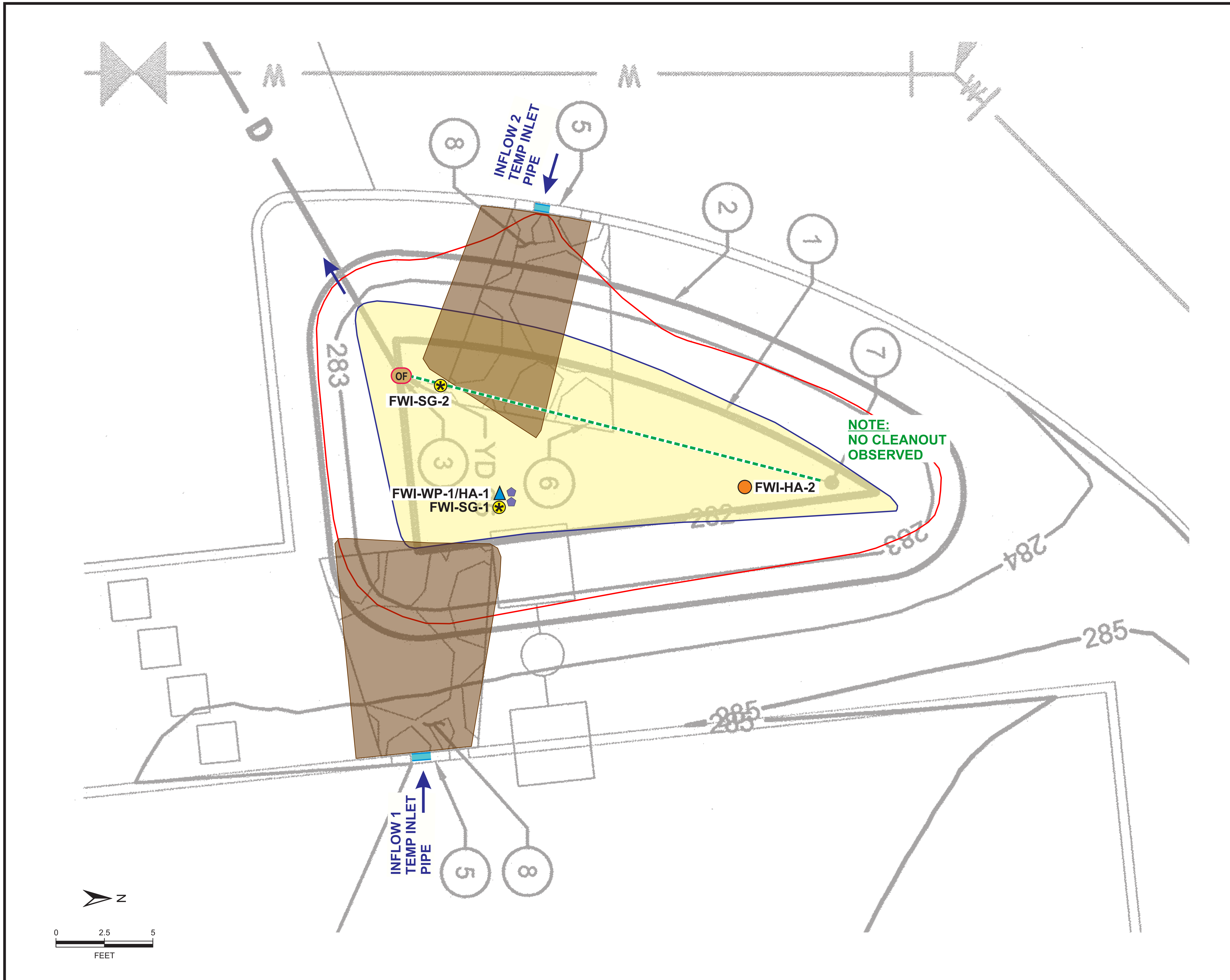
PROJ NO.	DATE:	FIGURE:
150387H007	3/19	FWI F1

DATA SOURCES / REFERENCES:
USGS: 7.5' SERIES TOPOGRAPHIC MAPS, ESRI/I-CUBED/NGS 2013
PIERCE CO: STREETS, CITY LIMITS, PARCELS 1/18

LOCATIONS AND DISTANCES SHOWN ARE APPROXIMATE

NOTE: BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION

Document Path: G:\GIS_Projects\aY15post0716\150387 Bioretention Hydro Performance Monitoring\mxd\PhaseII\Fig1s\150387H007 F1 VM_FWI.mxd



LEGEND:

HA HAND AUGER
WP WELL POINT
TEMPORARY STAFF GAUGE
BASE OF FACILITY
TOP OF FACILITY SLOPE
INFLOW / OVERFLOW DIRECTION
OF OVERFLOW GRATE - 12" PVC YARD DRAIN
PVC PONDING TUBE
UNDERDRAIN
CURB CUT
ENERGY DISSIPATER

CONTOUR INTERVAL = N/A

NOTE: LOCATION AND DISTANCES SHOWN ARE APPROXIMATE.

NOTES:
1. BASE MAP REFERENCE: AHBL, DLR GROUP, WAINWRIGHT INTERMEDIATE SCHOOL , TACOMA PUBLIC SCHOOLS, STORM DRAINAGE NOTES AND DETAILS, SHEET C4.3, 5/29/15

BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION.

associated earth sciences incorporated

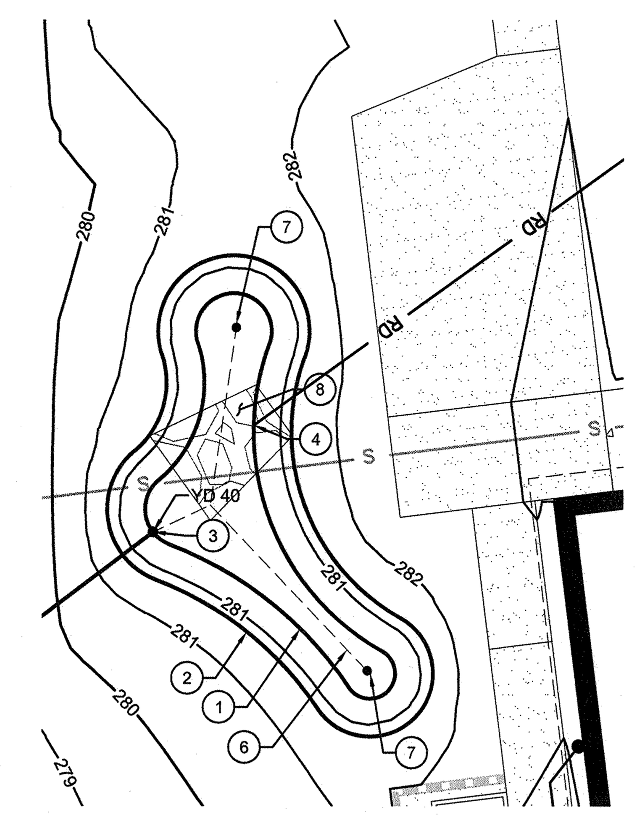
FACILITY AND EXPLORATION PLAN
FWI SITE
BIORETENTION HYDROLOGIC PERFORMANCE
TACOMA, WASHINGTON

PROJ NO.	DATE:	FIGURE:
150387H007	3/19	FWI F2

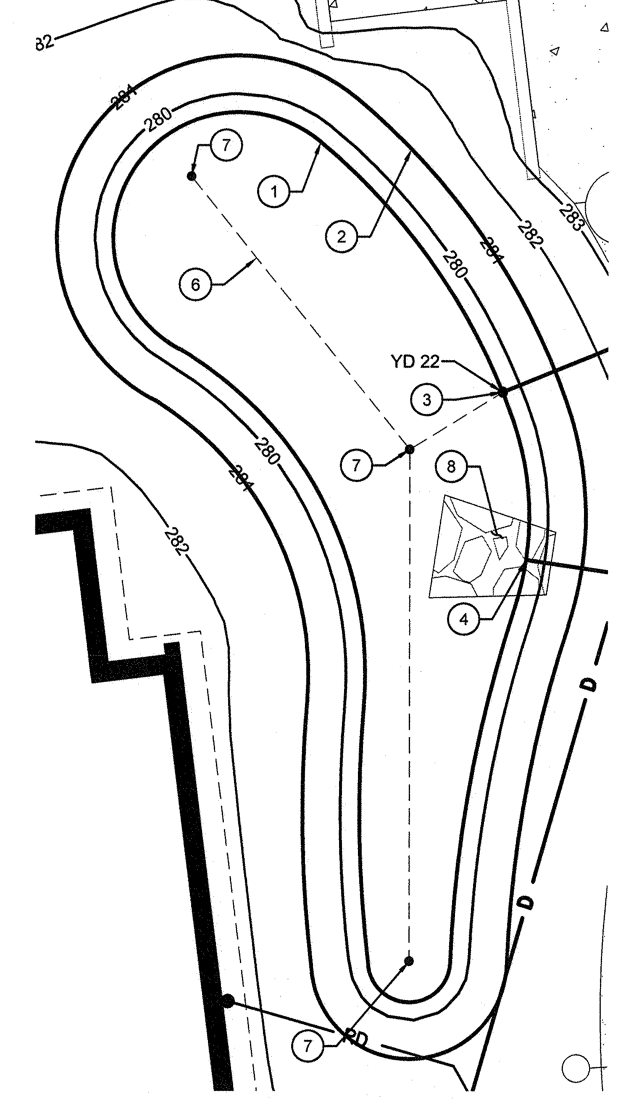
150387 BHPS MCCA \ 150387H007 Site-Expl ALL.cdr PAGE x: FWI F2

APPENDIX A

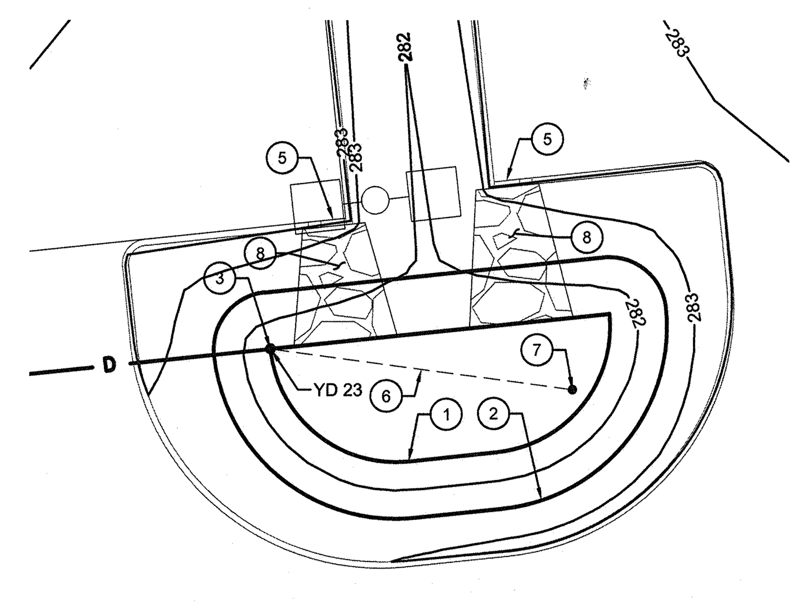
Project Civil Plans



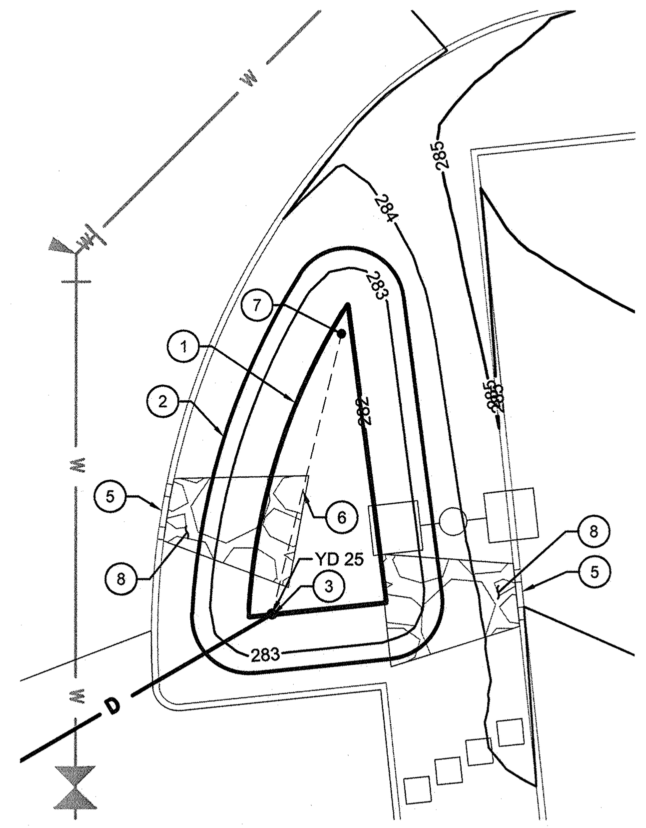
1 **BIORETENTION CELL 1**
SCALE: 1"=10'



2 **BIORETENTION CELL 2**
SCALE: 1"=10'



3 **BIORETENTION CELL 3**
SCALE: 1"=10'



4 **BIORETENTION CELL 4**
SCALE: 1"=10'

KEYNOTES

1. BOTTOM OF BIORETENTION CELL.
2. TOP OF BIORETENTION CELL.
3. OVERFLOW STRUCTURE. REFER TO SHEET C4.1.
4. END SECTION INLET.
5. CURB CUT INLET.
6. UNDERDRAIN PER BIORETENTION CELL DETAIL.
7. CLEANOUT. RIM SHALL MATCH BOTTOM OF BIORETENTION CELL. 6/C4.4
8. RIP RAP PAD SHALL CONSIST OF 6" STREAMBED COBBLES PER WSDOT STANDARD SPECIFICATION 9-03.11(2). THICKNESS OF PAD SHALL BE 8" (MIN). LAYOUT AS SHOWN ON DRAWINGS.

BIORETENTION CELL TABLE

CELL No.	MINIMUM BOTTOM AREA (SF)	BOTTOM ELEVATION (FT)	LIVE STORAGE DEPTH (FT)	OVERFLOW ELEVATION (FT)
1	178	280.30	0.5	280.80
2	1010	279.50	1.0	280.50
3	227	281.24	1.0	282.24
4	386	281.95	1.0	282.95

BIORETENTION CELL REQUIREMENTS:

INSPECTION #1 - TESC AND GRADING

1. BIORETENTION AREAS SHALL NOT BE USED AS SEDIMENT CONTROL FACILITIES AND SHALL BE PROTECTED FROM SILTATION AND COMPACTION DURING CONSTRUCTION. ALL DRAINAGE SHOULD BE DIRECTED AWAY FROM BIORETENTION AREAS AFTER INITIAL ROUGH GRADING; BLOCK CELL INLETS WITH TEMPORARY CONCRETE OR SAND BAGS DURING CONSTRUCTION. IF SITE CONSTRAINTS REQUIRE BIORETENTION AREAS TO BE USED FOR SEDIMENT CONTROL, INITIALLY EXCAVATE TO 6" ABOVE FINAL GRADE, AND WHEN OTHER EARTH DISTURBING WORK IS DONE THEN EXCAVATE DOWN TO FINAL GRADE AND INSTALL THE BIORETENTION FACILITIES AS DESIGNED.
2. TESC IS CORRECTLY INSTALLED.
3. ROUGH GRADING (VERIFY CONSTRUCTION STAKING) AND BIORETENTION DIMENSIONS ARE TO PLAN.

INSPECTION #2 - BIORETENTION SOIL MIX (BSM) AND BIORETENTION

1. PRIOR TO INSPECTION, APPLICANT MUST SUBMIT SOIL TEST VERIFICATION (LAB REPORT WITHIN PAST 30 DAYS) TO PW INSPECTOR PRIOR TO SOIL INSTALLATION. SOIL TEST VERIFICATION SHOULD INCLUDE INFILTRATION RATE (MUST MATCH DESIGN INFILTRATION RATE), SIEVE ANALYSIS (LESS THAN 5% FINES), AND ORGANIC MATTER CONTENT (4-8% BY DRY WEIGHT).
2. SUBGRADE SOIL IS FREE OF CONSTRUCTION RUNOFF FINES. IF SEDIMENT HAS ENTERED THE BIORETENTION AREA, REMOVE ENOUGH SUBGRADE SOIL TO REMOVE THE FINES AND REPLACE WITH BSM.
3. OVERFLOWS AND UNDER-DRAINS ARE AT PROPER LOCATIONS AND ELEVATIONS.
4. EXCAVATED CELL SUBGRADE IS NOT OVER-SATURATED, AND BSM IS NOT SATURATED WHEN PLACED.
5. WASHED ROCK BACKFILL FOR UNDERDRAINS IS FREE OF FINES. IF FINES ARE PRESENT, REMOVE TOP 6 INCHES OF BACKFILL AND REPLACE.

INSPECTION #3 - BSM PLACEMENT AND PRE-PLANTING

1. VERIFY THE BSM SOIL DELIVERED MEETS SOIL TEST VERIFICATION (LAB REPORT FROM INSPECTION #2) WITH A TRUCKLOAD TICKET OR OTHER DOCUMENTATION.
2. BSM DEPTH AND CELL SIDE SLOPES ARE PER PLAN.
3. VERIFY PLACEMENT & PLANTS PRIOR TO PLANT INSTALLATION. PLANTS SHALL NOT BE INSTALLED NEXT TO WATER METERS.
4. IF PLANTING WILL BE MORE THAN 30 DAYS OUT; MULCH MUST BE PLACED IMMEDIATELY AFTER BSM PLACEMENT (PREVENTS WEED ESTABLISHMENT).

INSPECTION #4 - POST PLANTING AND MULCH

1. PLANT QUANTITIES ARE PER PLAN.
2. MULCH & COARSE COMPOST TYPE AND DEPTH (2-3 INCHES). VERIFY ESC IS ADEQUATE, AND NO SEDIMENT HAS ACCUMULATED ON THE MULCH.
3. FINISHED CELL ELEVATION (INCLUDING MULCH) IS BELOW SIDEWALKS, CURBS, DRIVEWAYS, AND OTHER PAVEMENT PER PLAN.
4. NO EXCESSIVE WEED OR OTHER INVASIVE PLANT ESTABLISHMENT.
5. ALL PIPES, CULVERTS, CONVEYANCE SYSTEMS, FLOW CONTROL STRUCTURES, INLET SPILLWAYS (2-3' DROP) AND OUTLET OVERFLOWS ARE FREE AND CLEAR OF DEBRIS.
6. TEMPORARY WATERING PLAN IS IN PLACE (EITHER ON-SITE IRRIGATION OR OTHER PLAN).

INSPECTION #5 - FINAL (STARTS MAINTENANCE BOND PERIOD)

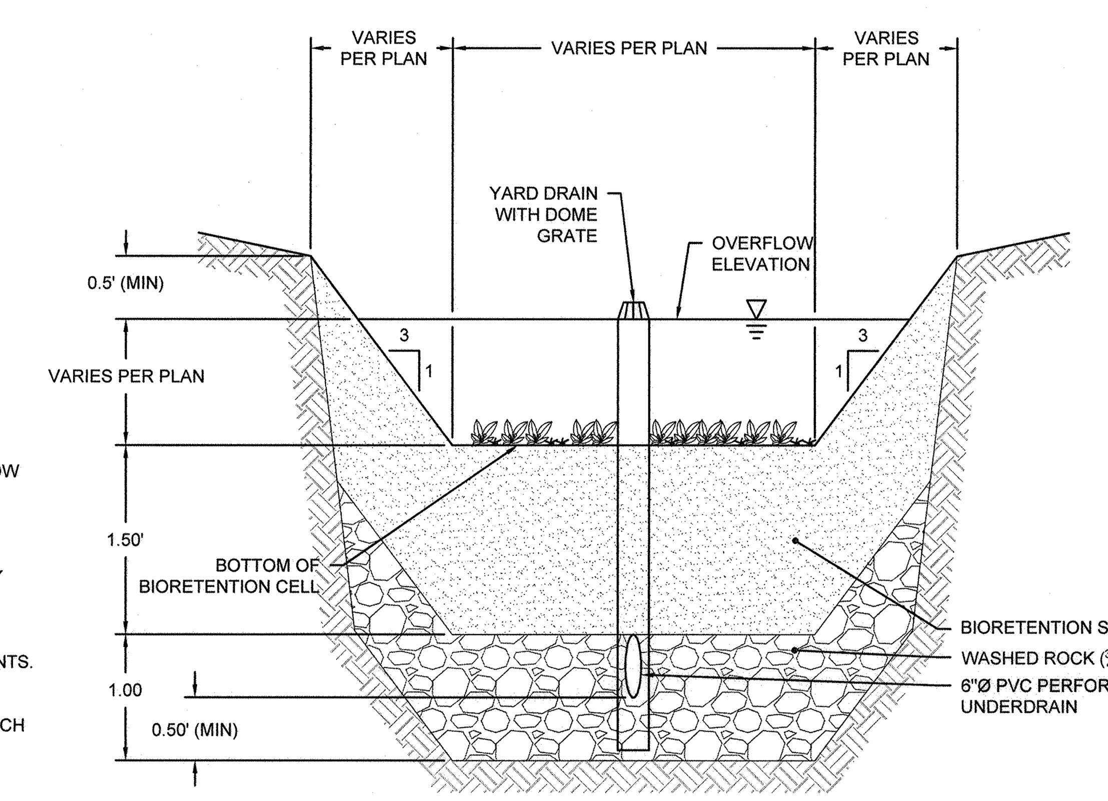
1. FINAL GRADE PER PLAN, INCLUDING LETTER OF APPROVAL FROM DESIGN ENGINEER FOR FINAL SURVEY OF CELL VOLUME AND CONTRIBUTING AREA SIZE.
2. BSM IS NOT CLOGGED AND INFILTRATION RATE IS ADEQUATE THROUGH VISUAL ASSESSMENT. NO PONDING FOLLOWING PRECIPITATION EVENTS.
3. REMOVAL OF TESC.
4. INSTALLATION OF ADDITIONAL SOIL WILL BE NEEDED ALONG THE EDGE OF CELLS 1 TO 2 MONTHS AFTER CELL CONSTRUCTION (DUE TO SETTLING).
5. 1 YEAR VERIFICATION WALK THROUGH IS REQUIRED DURING MAINTENANCE BOND PERIOD.
6. DUE TO PLANT SURVIVAL RATE REQUIRED, DEVELOPER/CONTRACTOR MUST MAKE PROVISIONS FOR A WATER TRUCK OR TEMPORARY IRRIGATION FROM EXISTING SERVICE ONSITE FOR THE FIRST 2 YEARS AFTER FINAL.

INSPECTION #6 - END OF MAINTENANCE BOND PERIOD

1. NO SEDIMENT ON TOP OF MULCH AND COARSE COMPOST.
2. BSM IS NOT CLOGGED AND INFILTRATION RATE IS ADEQUATE THROUGH VISUAL ASSESSMENT. DRAINS IN 24 TO 48 HOURS.
3. AERIAL PLANT COVER MUST BE AT LEAST 80% WITHIN 2 YEARS AFTER PLANT INSTALLATION.
4. OWNER RESPONSIBLE FOR CONTINUED IRRIGATION, AND PLANT REPLACEMENT IF NEEDED.

NOTES:

1. OVERFLOW SHALL BE AT LEAST 6" BELOW ANY ADJACENT PAVEMENT AREA.
2. PROVIDE MINIMUM SETBACK OF 5 FEET FROM TO OF BIORETENTION CELL TO BUILDING STRUCTURES AND PROPERTY LINES.
3. REFER TO LANDSCAPE ARCHITECTURE DRAWINGS FOR PLANTING REQUIREMENTS.
4. UNDERDRAIN SHALL BE PVC SLOTTED SUBSURFACE DRAIN PER ASTM D1785 SCH 40 WITH SLOTS FACING UPWARD.



5 **BIORETENTION CELL**
NOT TO SCALE

N
GRAPHIC SCALE
0 15 30 60
1" = 30 FEET

Know what's below. Call before you dig.

CITY OF FIRCREST
PUBLIC WORKS DEPARTMENT
ENGINEERING CONSTRUCTION DRAWINGS
APPROVED:
CITY ENGINEER DATE

AHBL
TACOMA · SEATTLE · SPOKANE · TRI-CITIES
2215 North 30th Street, Suite 300 Tacoma, WA 98403
253.383.2422 TEL 253.383.2572 FAX www.ahbl.com WEB
AHBL PROJECT NO.: 2140272.10

BID SET

130 Alameda Ave
Tacoma, WA 98466

STORM DRAINAGE NOTES AND DETAILS
WAINWRIGHT INTERMEDIATE SCHOOL
TACOMA PUBLIC SCHOOLS

C4.3
73-14167-00
05/29/2015

DLR Group
Architecture Engineering Planning Interiors

APPENDIX B

Current Study Exploration Logs and Laboratory Testing Data

Geologic & Monitoring Well Construction Log

associated earth sciences incorporated

Project Number	Well Number	Sheet
150387H007	FWI-HA-1/WP	1 of 1

Project Name: Bioretention Hydrologic Performance Study
Location: Fircrest, WA
Elevation (Top of Well Casing): 96 (Project Datum)
Surface Elevation (ft): 94.2 (Project Datum)
Water Level Elevation: Dry
Date Start/Finish: 10/2/18,10/2/18
Drilling/Equipment: Hand Auger
Hole Diameter (in): 4 inches
Hammer Weight/Drop: N/A

Depth (ft)	Water Level	WELL CONSTRUCTION	S T	Blows/ 6"	Graphic Symbol	DESCRIPTION
		Threaded steel pipe 1.25 inch I.D. with threaded and vented PVC cap -1.8 to 0.6 feet				**Bioretention Soil Mix**
		Bioretention soil mix 0 to 1 foot				Loose, dark brown, moist, medium SAND, some silt, trace gravel; organic rich; massive (SP-SM).
		Tape over well point screen 0.6 to 1.4 feet				
		Silica sand 1 to 1.9 feet				**Drain Rock with Bioretention Soil Mix** Loose, brownish gray, slightly moist, rounded GRAVEL (~0.5 inch), some sand, some silt (GP-GM).
		Driven into existing sediments 1.9 to 3.3 feet Stainless steel jacket over stainless steel #60 gauze, welded to perforated steel pipe 1.4 to 2.6 feet				Boring terminated at 1.9 feet Well completed at 3.3 feet on 10/2/18. Refusal in gravel. No seepage. Sloughing gravel 1.4 to 1.9 feet. Steel drive point placed in borehole and hand driven with slide hammer to depth of 3.3 feet.
		Threaded steel pipe 1.25 inches I.D. and drive point 2.6 to 3.3 feet				
		Note: ~4 inches of "dead space" below bottom of perforated openings and total inside depth. Total inside depth = 4.7 feet.				
5						

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample

M - Moisture
Water Level ()
Water Level at time of drilling (ATD)

Logged by: ADY
Approved by: JHS

associated earth sciences incorporated

Exploration Log

Project Number	Exploration Number	Sheet
150387H007	FWI-HA-2	1 of 1

Project Name	Bioretention Hydrologic Performance Study	Ground Surface Elevation (ft)	
Location	Fircrest, WA	Datum	N/A
Driller/Equipment	Hand Auger	Date Start/Finish	10/2/18,10/2/18
Hammer Weight/Drop	N/A	Hole Diameter (in)	4 inches

Depth (ft)	S T	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Water Level	Blows/6"	Blows/Foot 10 20 30 40	Other Tests
				Bioretention Soil Mix					
		S-1		Loose, dark brown, moist, medium SAND, some silt, trace gravel; organic rich; massive (SP-SM).					
		S-2							
				Drain Rock with Bioretention Soil Mix Loose, brownish gray, slightly moist, rounded GRAVEL (~0.5 inch), some sand, some silt (GP-GM).					
				Bottom of exploration boring at 1.6 feet. Refusal in gravel. No seepage. Sloughing gravel 1.4 to 1.6 feet.					
5									

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample
- M - Moisture
- Water Level ()
- Water Level at time of drilling (ATD)

Logged by: ADY
Approved by: JHS

associated earth sciences incorporated

Exploration Log

Project Number	Exploration Number	Sheet
150387H007	FWI-HA-3	1 of 1

Project Name: Bioretention Hydrologic Performance Study
Location: Fircrest, WA
Driller/Equipment: Hand Auger
Hammer Weight/Drop: N/A

Ground Surface Elevation (ft):
Datum: N/A
Date Start/Finish: 10/2/18,10/2/18
Hole Diameter (in): 4 inches

Depth (ft)	ST	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Water Level	Blows/6"	Blows/Foot (10 20 30 40)	Other Tests
				Bioretention Soil Mix					
		S-1							
				Loose, dark brown, moist, medium SAND, some silt, trace gravel; organic rich; massive (SP-SM).					
		S-2							
				Drain Rock with Bioretention Soil Mix - Loose, brownish gray, slightly moist, rounded GRAVEL (~0.5 inch), some sand, some silt (GP-GM).					
				Bottom of exploration boring at 2.5 feet. Refusal in gravel. No seepage. Sloughing gravel 2.4 to 2.5 feet.					
5									

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample
- M - Moisture
- Water Level ()
- Water Level at time of drilling (ATD)

Logged by: ADY
Approved by: JHS

associated earth sciences incorporated

Moisture, Ash, and Organic Matter of Peat and Other Organic Soils - ASTM 2974

Date Sampled	Project	Project No.		Soil Description
10/2/2018	Bioretention Hydrologic Performance Monitoring Study	150387 E007		Bioretention soil mix
Tested By	**Location**	**EB/EP No.**	**Depth**	
BN	Onsite- FWI			

Moisture Content

Sample ID	HA-1 (0.1'-0.5')	HA-2 (0.1'-0.5')	HA-3 (0.1'-0.5')
Wet Weight + Pan	1045.54	1010.73	1032.97
Dry Weight + Pan	993.98	938.71	964.23
Weight of Pan	516.95	422.18	434.66
Weight of Moisture	51.56	72.02	68.74
Dry Weight of Soil	477.03	516.53	529.57
% Moisture	9.8	12.2	11.5

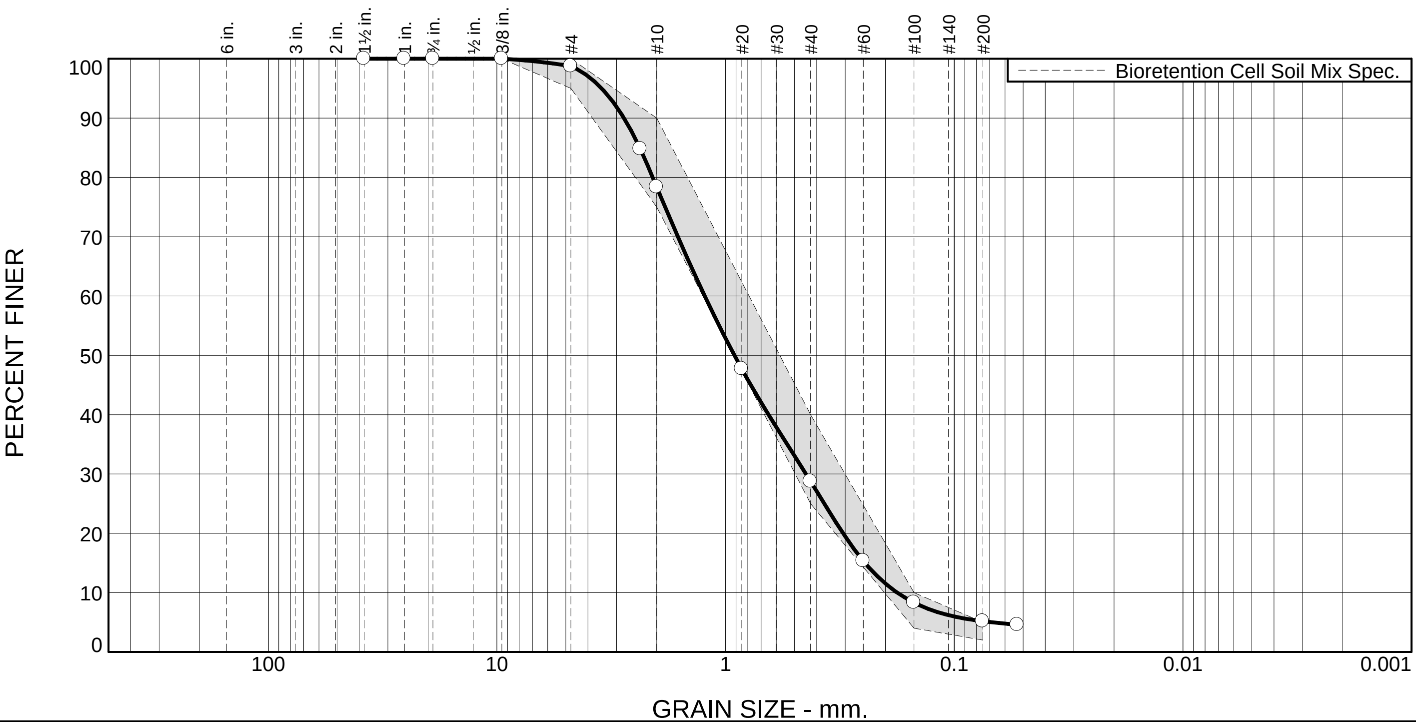
Organic Matter and Ash Content

Dry Soil Befor Burn + Pan	575.92	599.08	602.61
Dry Soil After Burn + Pan	564.55	588.64	585.37
Weight of Pan	357.92	391.93	357.92
Wt. Loss Due to Ignition	11.37	10.44	17.24
Actual Wt. Of Soil After Burr	206.63	196.71	227.45
% Organics	5.2	5.0	7.0

ASSOCIATED EARTH SCIENCES, INC.

911 5th Ave., Suite 100 Kirkland, WA 98033 425-827-7701 FAX 425-827-5424

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	1.2	20.5	49.6	23.5	5.2	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5	100.0		
1	100.0		
.75	100.0		
.375	100.0	100.0	
#4	98.8	95.0 - 100.0	
#8	84.8		
#10	78.3	75.0 - 90.0	
#20	47.7		
#40	28.7	25.0 - 40.0	
#60	15.3		
#100	8.3	4.0 - 10.0	
#200	5.2	2.0 - 5.0	X
#270	4.6		

* Bioretention Cell Soil Mix Spec.

Material Description

SAND, some silt, trace gravel

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP-SM **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 2.7831 D_{85}= 2.3741 D_{60}= 1.2336
D_{50}= 0.9154 D_{30}= 0.4454 D_{15}= 0.2458
D_{10}= 0.1777 C_u= 6.94 C_c= 0.91

Remarks

Collected by: ADY

Bioretention soil mix burned first per ASTM D2974 then sieved.

Date Received: 10/08/2018 **Date Tested:** 11/08/2018

Tested By: BN

Checked By: JHS

Title:

Source of Sample: (FWI) Fircrest- Wainwright Intermediate School **Depth:** 0.1'-0.5' **Date Sampled:** 10/02/2018

Sample Number: HA-1

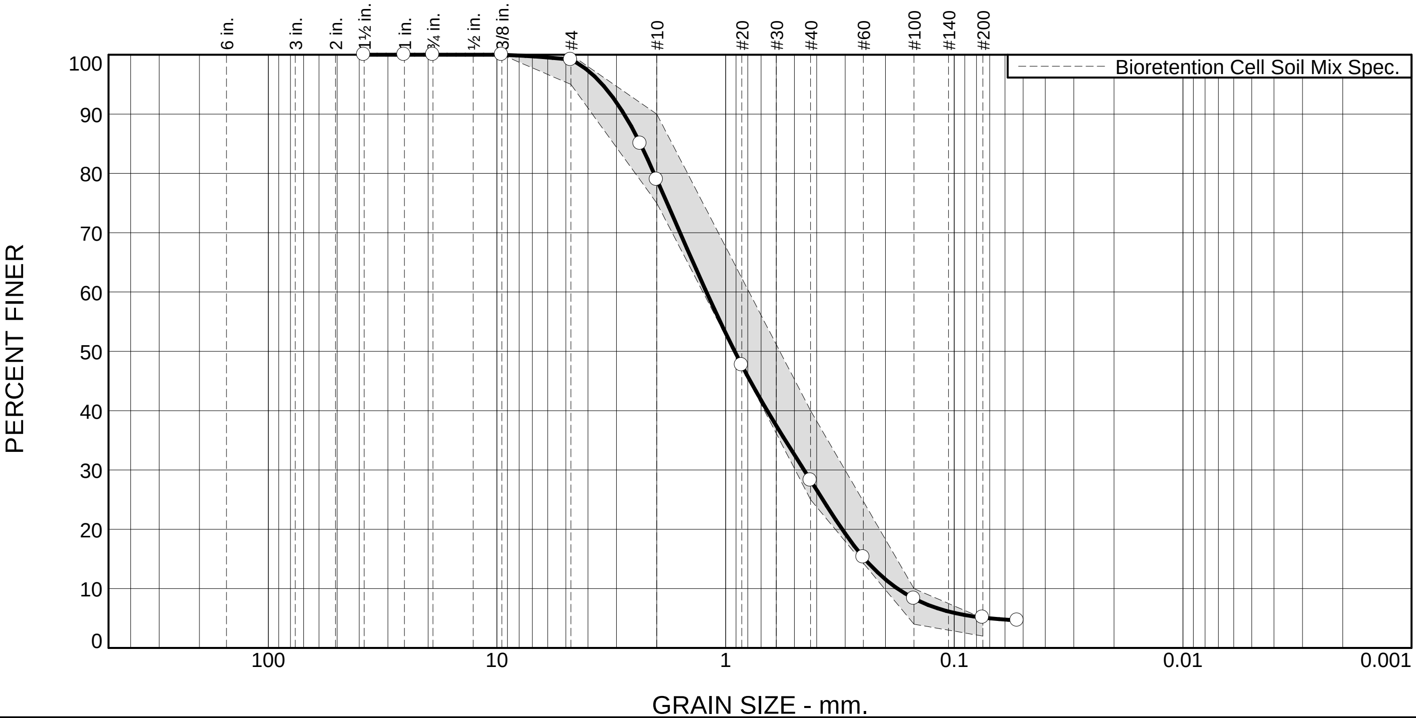
a s s o c i a t e d
e a r t h s c i e n c e s
i n c o r p o r a t e d

Client: Clear Creek Solutions

Project: Bioretention Hydrologic Performance Study

Project No: 150387 H004 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.8	20.2	50.8	23.1	5.1	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5	100.0		
1	100.0		
.75	100.0		
.375	100.0	100.0	
#4	99.2	95.0 - 100.0	
#8	85.0		
#10	79.0	75.0 - 90.0	
#20	47.7		
#40	28.2	25.0 - 40.0	
#60	15.3		
#100	8.3	4.0 - 10.0	
#200	5.1	2.0 - 5.0	X
#270	4.6		

* Bioretention Cell Soil Mix Spec.

Material Description

SAND, some silt, trace gravel

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP-SM **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 2.7791 D_{85}= 2.3597 D_{60}= 1.2132
D_{50}= 0.9128 D_{30}= 0.4541 D_{15}= 0.2463
D_{10}= 0.1771 C_u= 6.85 C_c= 0.96

Remarks

Collected by: ADY

Bioretention soil mix burned first per ASTM D2974 then sieved.

Date Received: 10/08/2018 **Date Tested:** 11/08/2018

Tested By: BN

Checked By: JHS

Title:

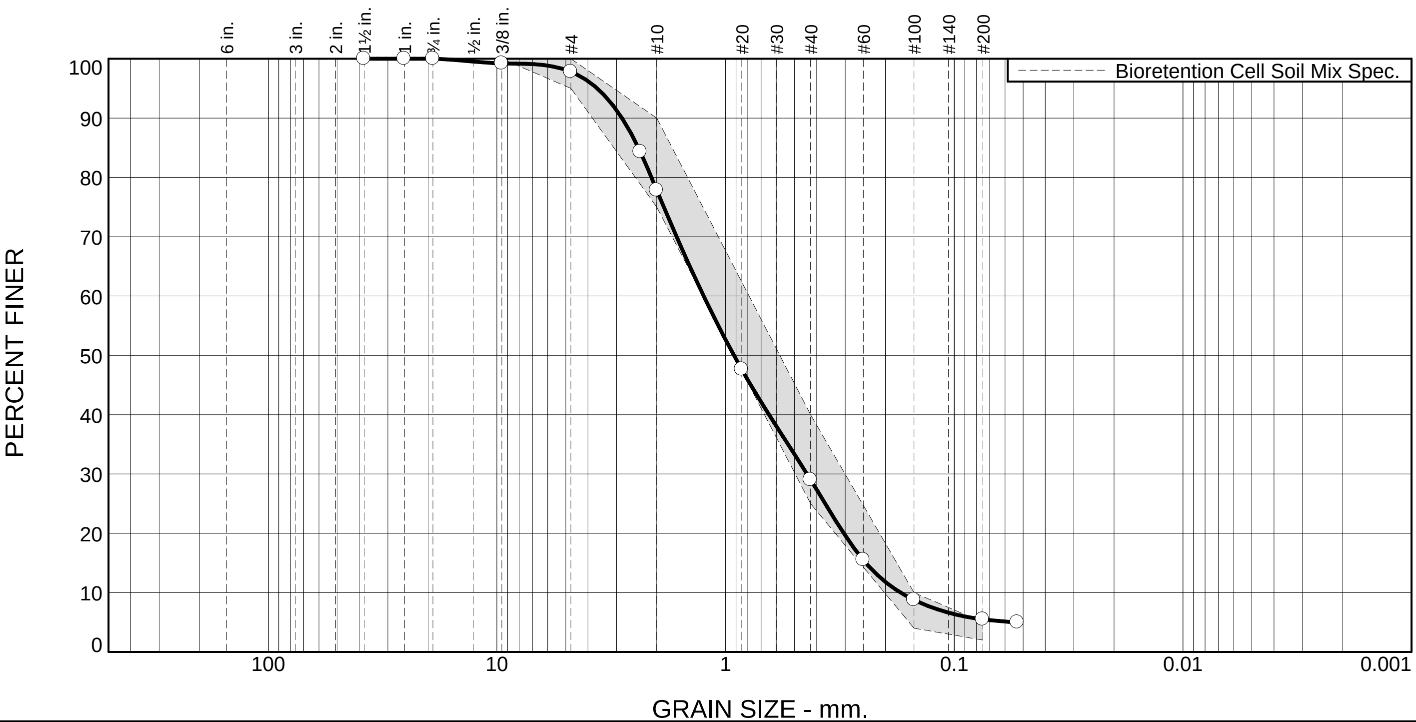
Source of Sample: (FWI) Fircrest- Wainwright Intermediate School **Depth:** 0.1'-0.5' **Date Sampled:** 10/02/2018
Sample Number: HA-2

associated earth sciences incorporated

Client: Clear Creek Solutions
Project: Bioretention Hydrologic Performance Study

Project No: 150387 H004 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	2.2	20.0	48.8	23.5	5.5	

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5	100.0		
1	100.0		
.75	100.0		
.375	99.2	100.0	X
#4	97.8	95.0 - 100.0	
#8	84.3		
#10	77.8	75.0 - 90.0	
#20	47.6		
#40	29.0	25.0 - 40.0	
#60	15.5		
#100	8.8	4.0 - 10.0	
#200	5.5	2.0 - 5.0	X
#270	5.0		

* Bioretention Cell Soil Mix Spec.

Material Description

SAND, some silt, trace gravel

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP-SM **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 2.8395 D_{85}= 2.4066 D_{60}= 1.2468
D_{50}= 0.9199 D_{30}= 0.4408 D_{15}= 0.2437
D_{10}= 0.1716 C_u= 7.27 C_c= 0.91

Remarks

Collected by: ADY

Bioretention soil mix burned first per ASTM D2974 then sieved.

Date Received: 10/08/2018 **Date Tested:** 11/08/2018

Tested By: BN

Checked By: JHS

Title:

Source of Sample: (FWI) Fircrest- Wainwright Intermediate School **Depth:** 0.1'-0.5' **Date Sampled:** 10/02
Sample Number: HA-3

associated earth sciences incorporated

Client: Clear Creek Solutions
Project: Bioretention Hydrologic Performance Study

Project No: 150387 H004 **Figure**

APPENDIX C

Background Soil, Geology, and Groundwater Data (Regional Maps, Previous Studies Exploration Logs and Laboratory Testing Data)

Soil Map—City of Tacoma, Washington, and Pierce County Area, Washington

Map Scale: 1:7,370 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 100 200 400 600

Feet: 0 350 700 1400 2100

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features

- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at scales ranging from 1:24,000 to 1:124,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: City of Tacoma, Washington
Survey Area Data: Version 2, Dec 5, 2013

Soil Survey Area: Pierce County Area, Washington
Survey Area Data: Version 14, Sep 10, 2018

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jul 8, 2014—Jul 15, 2014

MAP LEGEND

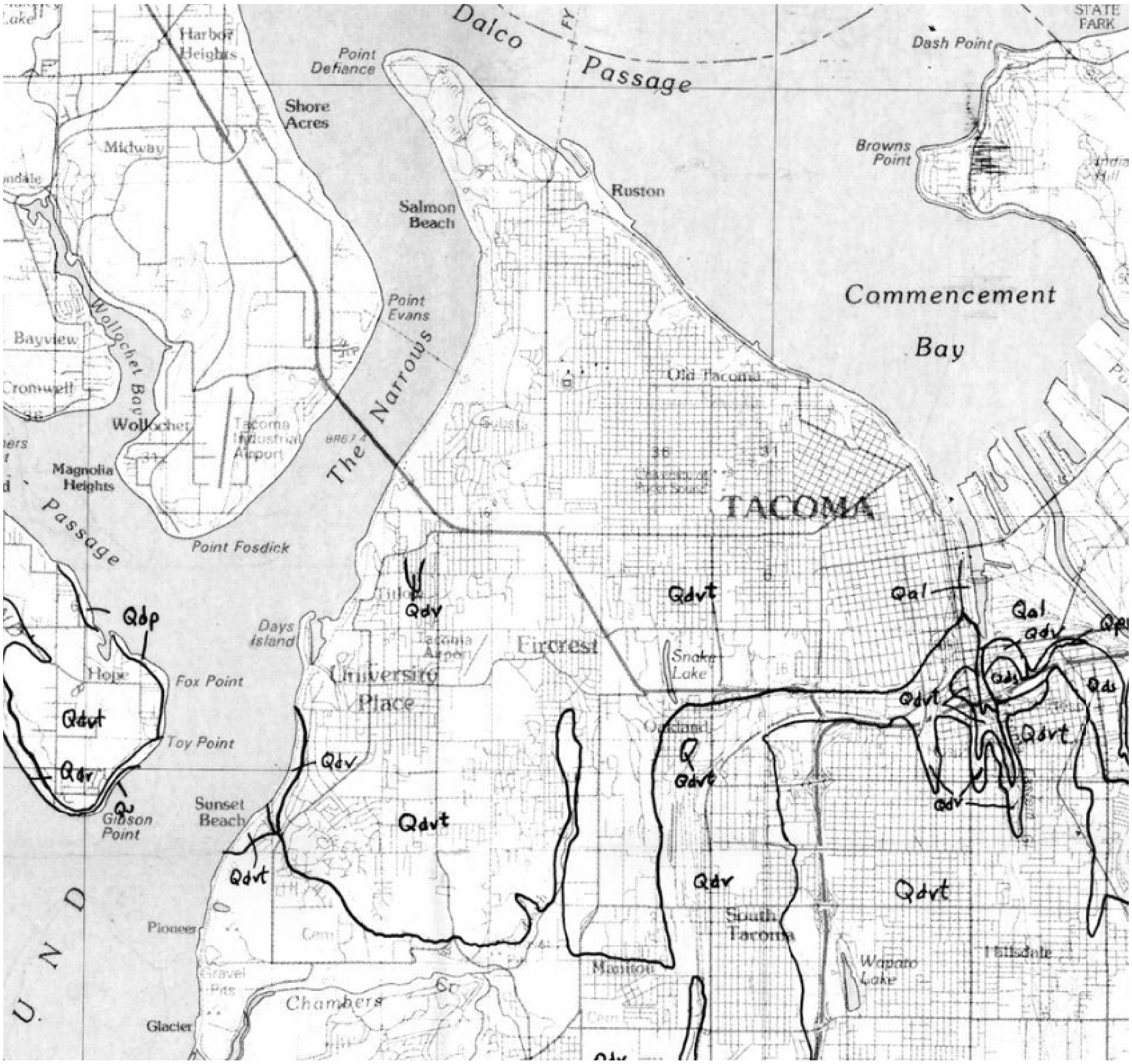
MAP INFORMATION

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

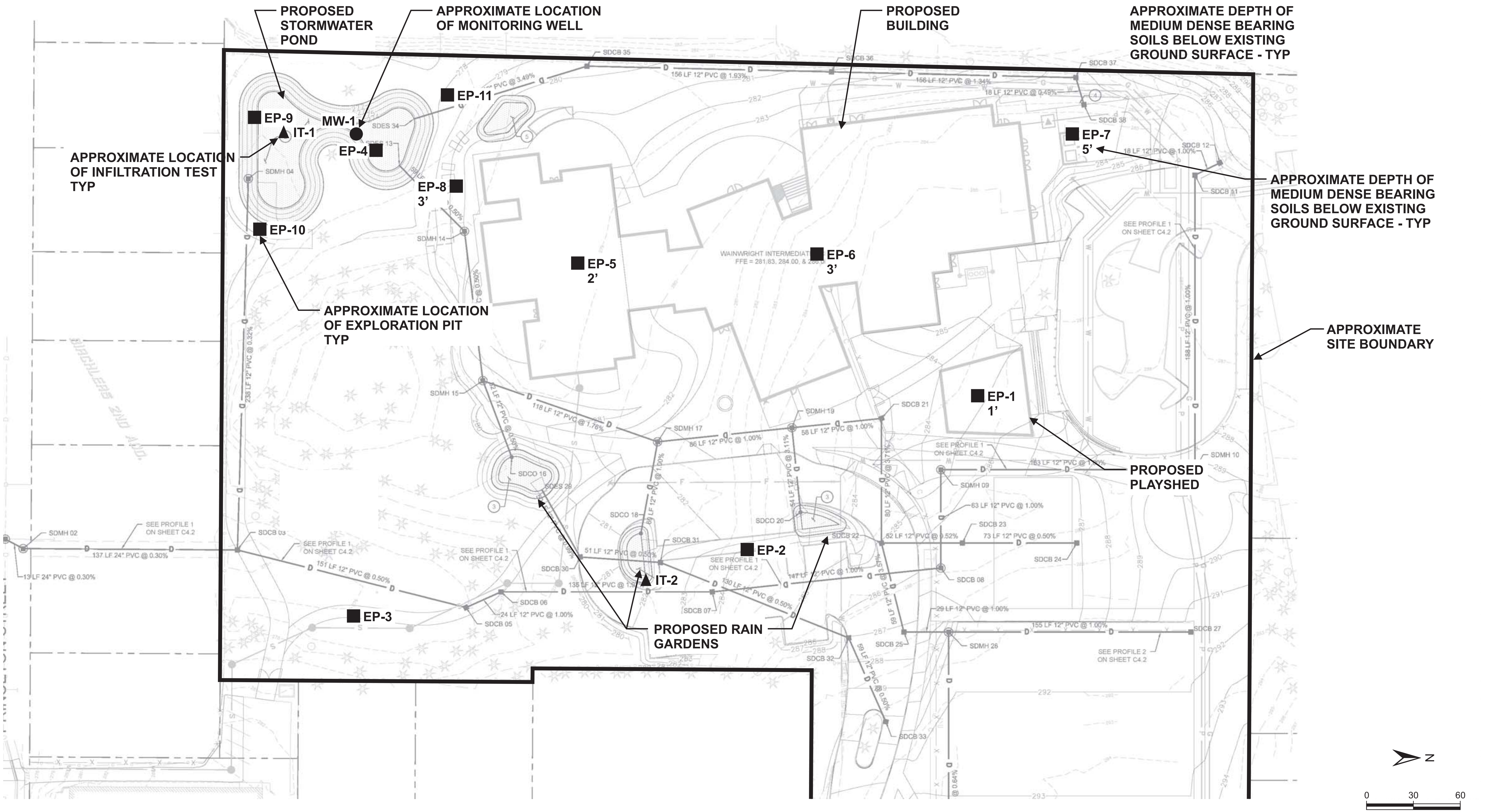
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
NOTCOM	No Digital Data Available	32.7	13.6%
Subtotals for Soil Survey Area		**32.7**	**13.6%**
Totals for Area of Interest		**239.9**	**100.0%**

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
1B	Alderwood gravelly sandy loam, 0 to 8 percent slopes	53.7	22.4%
1C	Alderwood gravelly sandy loam, 8 to 15 percent slopes	145.1	60.5%
1D	Alderwood gravelly sandy loam, 15 to 30 percent slopes	8.4	3.5%
Subtotals for Soil Survey Area		**207.2**	**86.4%**
Totals for Area of Interest		**239.9**	**100.0%**



Excerpt from:

Walsh, T. J., 1987, Geologic Map of the south half of the Tacoma quadrangle, Washington, Washington Division of Geology and Earth Resources, Open File Report 87-3, scale 1:100,000.



REFERENCE: AHBL

140513 Wainwright Elementary \ 140513 F2 Site and Exploration Plan 3-5-2014.cdr

associated earth sciences incorporated

SITE AND EXPLORATION PLAN

WAINWRIGHT ELEMENTARY SCHOOL RENOVATION
FIRCREST, WASHINGTON

FIGURE 2
DATE 3/15
PROJ. NO. TE140513A

LOG OF EXPLORATION PIT NO. EP-1

Depth (ft)

This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered.

DESCRIPTION

Gravel - 1 inch

Fill

Medium dense, slightly moist, dark gray brown, silty fine to medium SAND, trace gravel; unsorted (SM).

Vashon Recessional Outwash

Medium dense, dry to slightly moist, light orangish brown, fine to medium SAND, some gravel, trace silt; weakly stratified (SP).

Medium dense, dry to slightly moist, brown, fine to medium SAND, some gravel, trace silt; weakly stratified (SP).

Vashon Lodgement Till

Dense, dry, grayish brown, silty fine to medium SAND, some gravel; unsorted (SM).

Bottom of exploration pit at depth 9.5 feet
No seepage. No caving

Wainwright Elementary
Fircrest, WA

Logged by: LBK

Approved by: JMB

associated earth sciences incorporated

Project No. TE140513A

10/29/14

LOG OF EXPLORATION PIT NO. EP-2

Depth (ft)	DESCRIPTION
	This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered.
	Vashon Lodgement Till
1	Dense, slightly moist, grayish brown, silty fine to medium SAND, some gravel; unsorted (SP).
2	
3	Becomes very dense.
4	
5	
6	
7	Bottom of exploration pit at depth 6 feet No seepage. No caving
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	

Wainwright Elementary
Fircrest, WA

Logged by: LBK

Approved by: JMB

associated earth sciences incorporated

Project No. TE140513A

10/29/14

LOG OF EXPLORATION PIT NO. EP-3

Depth (ft)	DESCRIPTION
	This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered.
1	**Grass / Moss / Topsoil** Loose, moist, black, silty fine SAND, some gravel, abundant roots and organics (SM).
2	**Vashon Recessional Outwash** Loose, slightly moist, brown, silty fine SAND, some gravel, some roots and organics (SM).
3	Soft, very moist, grayish brown with heavy orange mottling, sandy SILT; massive; sand component chiefly fine sand (ML).
4	
5	
6	Loose to medium dense, moist, brown, gravelly fine to coarse SAND, trace silt; weakly stratified (SW).
7	Medium dense, moist, grayish brown, gravelly fine to medium SAND, some silt; silt stringers; stratified (SP).
8	Medium dense, moist, grayish brown, fine to medium SAND, some gravel, trace silt; discontinuous layers (1 to 4 inches thick) of gray with heavy orange mottling silt (SP/ML).
9	
10	
11	
12	**Weathered Vashon Lodgement Till (?)**
13	Very stiff to hard, slightly moist, grayish brown with orange mottling, sandy SILT, some gravel; unsorted (ML).
14	Medium dense, moist, grayish brown, silty fine to coarse SAND, some gravel; discontinuous layers of gray with heavy orange mottling silt (SM/ML).
15	
16	Bottom of exploration pit at depth 15 feet Slow seepage at 6 feet. Minor caving 0 to 7 feet.
17	
18	
19	
20	

Wainwright Elementary
Fircrest, WA

Logged by: LBK

Approved by: JMB

associated earth sciences incorporated

Project No. TE140513A

10/29/14

LOG OF EXPLORATION PIT NO. EP-4

Depth (ft)	This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered. **DESCRIPTION**
	Grass / Topsoil
1	Loose, moist, dark brown, silty fine SAND, trace gravel, abundant roots (SM).
	Vashon Recessional Outwash
2	Loose to medium dense, moist, brown, fine to medium SAND, some gravel, some silt, few roots (SM).
3	
4	Medium dense, slightly moist, grayish brown to brown, fine to medium SAND, some gravel, trace silt; weakly stratified (SP).
5	
6	Medium dense, slightly moist, grayish brown to brown, gravelly fine to coarse SAND, trace silt; stratified (SW).
7	
8	Medium dense, slightly moist, grayish brown to brown, fine to coarse SAND, some gravel, trace silt; massive (SW).
9	Increasing gravel.
10	Medium dense, slightly moist, grayish brown to brown, gravelly fine to coarse SAND, trace silt; weakly stratified (SW).
11	
12	
13	Bottom of exploration pit at depth 12 feet No seepage. No caving
14	
15	
16	
17	
18	
19	
20	

Wainwright Elementary
Fircrest, WA

Logged by: LBK

Approved by: JMB

associated earth sciences incorporated

Project No. TE140513A

10/29/14

LOG OF EXPLORATION PIT NO. EP-5

This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered.

Depth (ft)	DESCRIPTION
1	**Grass / Topsoil** Loose, moist, dark brown, silty fine to medium SAND, trace gravel, abundant roots (SM).
2	**Vashon Recessional Outwash** Loose to medium dense, moist, orangish brown, fine to medium SAND, some gravel, some silt; weakly stratified (SP).
3	Becomes medium dense and brown.
4	
5	**Vashon Lodgement Till** Dense, slightly moist, grayish brown, very silty fine to medium SAND, some gravel; unsorted (SM).
6	
7	Bottom of exploration pit at depth 6 feet No seepage. No caving
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	

KCTP3 140513.GPJ November 6, 2014

Wainwright Elementary
Fircrest, WA

Logged by: LBK

Approved by: JMB

associated earth sciences incorporated

Project No. TE140513A

10/29/14

LOG OF EXPLORATION PIT NO. EP-6

Depth (ft)	This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered. **DESCRIPTION**
0–1	**Grass / Topsoil** Loose, moist, dark brown, silty fine to medium SAND, trace gravel, abundant roots (SM).
1–3	**Vashon Recessional Outwash** Loose to medium dense, slightly moist, orangish brown, fine to medium SAND, some gravel, some silt, few roots; weakly stratified (SP).
3–4.5	**Weathered Vashon Lodgement Till** Medium dense to dense, slightly moist, grayish brown with orange mottling, silty fine to medium SAND, some coarse sand, some gravel; unsorted (SM).
4.5–6	**Vashon Lodgement Till** Dense, slightly moist, grayish brown, very silty fine to medium SAND, some gravel, trace cobbles; unsorted (SM).
6	Bottom of exploration pit at depth 6 feet No seepage. No caving

Depth scale: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

Wainwright Elementary
Fircrest, WA

Logged by: LBK

Approved by: JMB

associated earth sciences incorporated

Project No. TE140513A

10/29/14

LOG OF EXPLORATION PIT NO. EP-7

This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered.

Depth (ft)	DESCRIPTION
	Grass / Topsoil
1	Medium dense, moist, dark brown, silty fine to medium SAND, trace gravel, abundant roots (SM).
	Fill / Reworked Vashon Recessional Outwash
2	Medium dense, moist, brown to orangish brown, fine to medium SAND, some gravel, some silt (SP).
3	
4	
5	**Old Topsoil** Medium dense, slightly moist, black, silty fine to medium SAND, abundant organics (SM).
6	**Vashon Recessional Outwash** Medium dense, slightly moist, brown, fine to medium SAND, some gravel, trace silt; weakly stratified (SP).
7	**Vashon Advance Outwash**
8	Dense, slightly moist, grayish brown, fine to medium SAND, some coarse sand, some gravel, trace silt; stratified (SP).
9	
10	Dense, slightly moist, grayish brown, fine SAND, trace gravel, trace silt; stratified (SP).
11	
12	Bottom of exploration pit at depth 11 feet No seepage. No caving
13	
14	
15	
16	
17	
18	
19	
20	

Wainwright Elementary
Fircrest, WA

Logged by: LBK

Approved by: JMB

associated earth sciences incorporated

Project No. TE140513A

10/29/14

LOG OF EXPLORATION PIT NO. EP-8

This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered.

Depth (ft)	DESCRIPTION
	Grass / Topsoil
1	Loose, moist, dark brown, silty fine SAND, abundant roots (SM).
	Vashon Recessional Outwash
2	Medium dense, slightly moist, orangish brown, fine SAND, some silt, trace gravel, abundant roots (SP).
3	Medium dense, slightly moist, brown, fine to medium SAND, some gravel, trace silt; weakly stratified (SP).
4	
5	
6	
7	Medium dense, slightly moist, brown to grayish brown, gravelly fine to coarse SAND, trace silt; stratified (SW).
8	Becoming moist.
9	
10	
11	Bottom of exploration pit at depth 10 feet No seepage. No caving
12	
13	
14	
15	
16	
17	
18	
19	
20	

Wainwright Elementary
Fircrest, WA

Logged by: LBK

Approved by: JMB

associated earth sciences incorporated

Project No. TE140513A

10/29/14

LOG OF EXPLORATION PIT NO. EP-9

Depth (ft)	This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered. **DESCRIPTION**
	Grass / Topsoil
1	Loose, moist, dark brown, silty fine SAND, trace gravel, abundant roots (SM).
	Fill
2	Loose to medium dense, slightly moist, dark brown to brown, silty fine to medium SAND, some gravel, with zones of sandy fine to coarse GRAVEL, some silt, debris (i.e. glass bottles) (SM/GW).
3	**Vashon Recessional Outwash**
4	Medium dense, slightly moist, brown, gravelly fine to coarse SAND, trace silt; weakly stratified (SW).
5	
6	
7	
8	Medium dense, slightly moist, brown, very gravelly fine to coarse SAND, trace silt; stratified; some cemented zones (SW).
9	
10	
11	
12	Bottom of exploration pit at depth 11 feet No seepage. No caving
13	
14	
15	
16	
17	
18	
19	
20	

Wainwright Elementary
Fircrest, WA

Logged by: LBK

Approved by: JMB

associated earth sciences incorporated

Project No. TE140513A

10/29/14

LOG OF EXPLORATION PIT NO. EP-10

Depth (ft)	This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered. **DESCRIPTION**
	Grass / Topsoil
1	Loose to medium dense, slightly moist, dark brown, silty fine to medium SAND, trace gravel, abundant roots (SM).
	Vashon Recessional Outwash
2	Medium dense, slightly moist, orangish brown, fine to medium SAND, some gravel, some silt (SP).
3	Medium dense, slightly moist, brown, fine to medium SAND, some gravel, trace silt; weakly stratified (SP).
4	
5	
6	Medium dense, slightly moist, brown, gravelly fine to coarse SAND, trace silt; stratified (SW).
7	
8	
9	
10	Occasional cobbles.
11	
12	
13	Bottom of exploration pit at depth 12 feet No seepage. Minor caving 1 to 3 feet.
14	
15	
16	
17	
18	
19	
20	

Wainwright Elementary
Fircrest, WA

Logged by: LBK

Approved by: JMB

associated earth sciences incorporated

Project No. TE140513A

10/29/14

LOG OF EXPLORATION PIT NO. EP-11

This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered.

Depth (ft)	DESCRIPTION
	Grass / Topsoil
1	Loose, moist, dark brown, silty fine SAND, abundant roots (SM).
	Vashon Recessional Outwash
2	Loose, slightly moist, orangish brown, fine SAND, some silt, trace gravel; massive (SP).
3	
4	Loose to medium dense, slightly moist, brown, fine to medium SAND, trace gravel, trace silt; massive (SP).
5	Medium dense, slightly moist, brown, fine to coarse SAND, some gravel, trace silt; stratified (SW).
6	
7	
8	Becoming gravelly.
9	
10	Medium dense, slightly moist, brown, gravelly fine to coarse SAND, trace silt; stratified (SW).
11	
12	Bottom of exploration pit at depth 11.5 feet No seepage. No caving
13	
14	
15	
16	
17	
18	
19	
20	

KCTP3 140513.GPJ November 6, 2014

Wainwright Elementary
Fircrest, WA

Logged by: LBK

Approved by: JMB

associated earth sciences incorporated

Project No. TE140513A

10/29/14

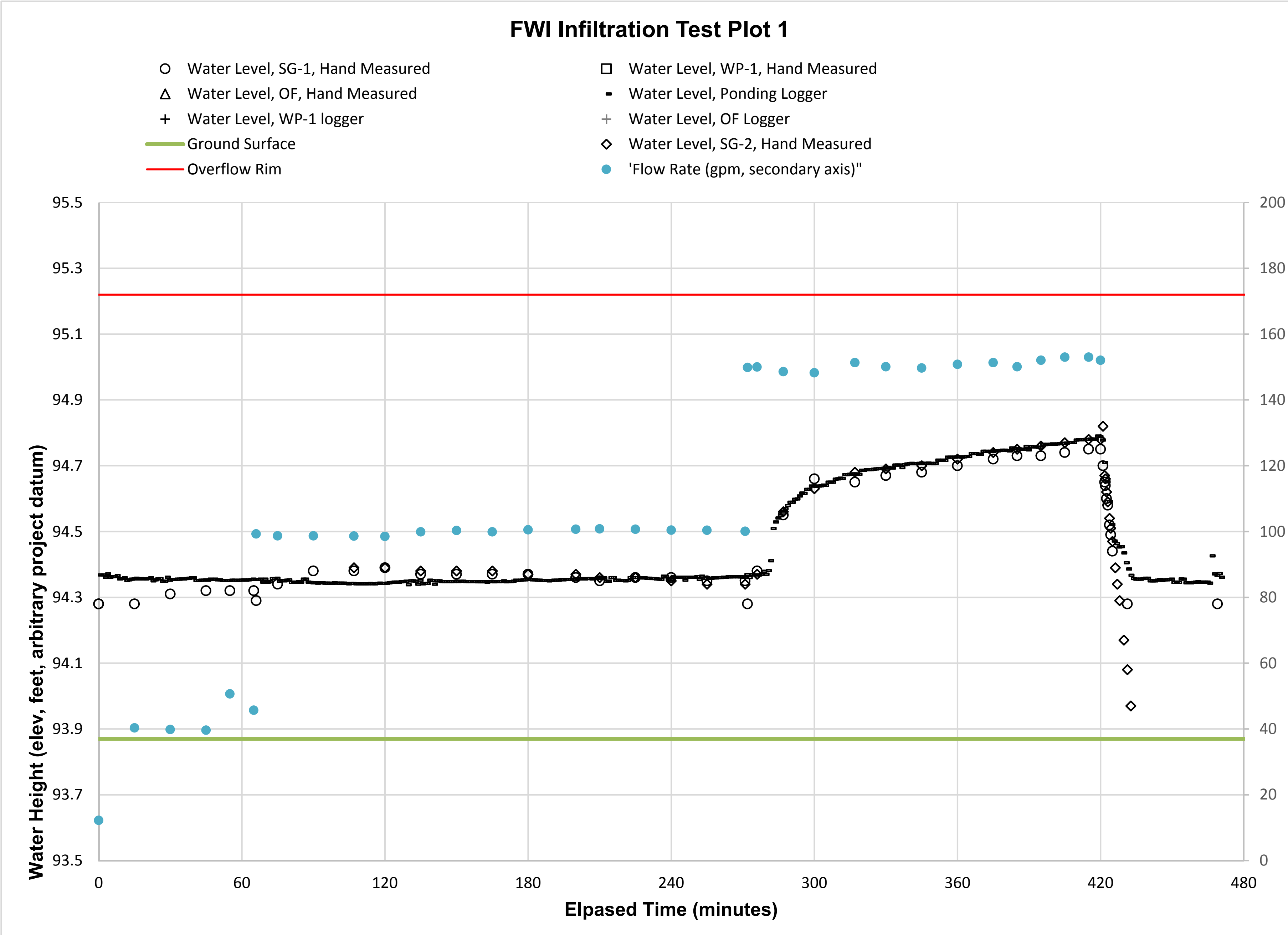
APPENDIX D

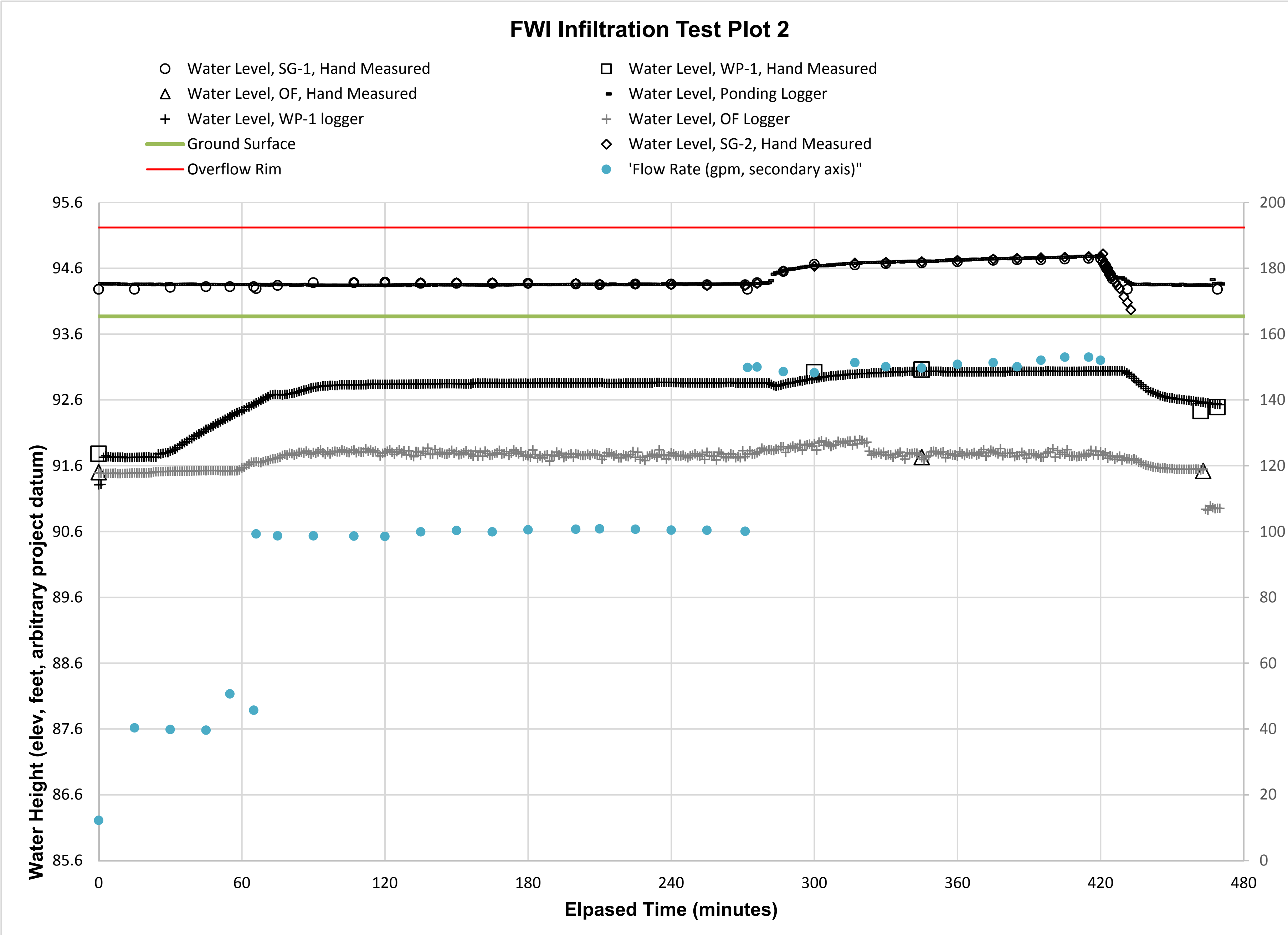
Soil Probe, Level Survey, and Field Infiltration Testing Data

Project Name:	BHPS	**Water Source:**	Hydrant
Project Number:	150387H007	**Meter:**	AESI FM5,6,7
Date:	10/25/2018	**Base Area (sq.ft.):**	NA
Weather:	Intermittent rain, 60's	**Ponded Area(sq.ft.):**	200.0
Test No.:	FWI	**Test Depth (feet):**	NA
Performed By:	ADY, SC	**Receptor Soils:**	Vashon lodgment till

Time (24-hr)	**Flow Rate (gpm)**	**Stage (feet)**	**Totalizer (gallons)**	**Comments**
8:38			0	
8:45	12.2	0	0	Flow on
9:00	40.3	0	178	Flow observed in underdrain at 09:10
9:15	39.8	0.03	769	
9:30	39.6	0.04	1365	Underdrain: visual estimate of 1-2 gpm flow
9:40	50.6	0.04	1768	
9:50	45.7	0.04	2221	Underdrain: visual estimate 40 gpm flow
9:51	99.3	0.01	2221	
10:00	98.7	0.06	3033	Underdrain: visual estimate 50 gpm flow
10:15	98.7	0.1	4579	Underdrain: visual estimate 100 gpm flow
10:32	98.6	0.1	6290	Installed SG-2 in facility deep point
10:45	98.5	0.11	7491	
11:00	99.9	0.09	9051	
11:15	100.3	0.09	10621	
11:30	99.9	0.09	12011	
11:45	100.5	0.09	13446	
12:05	100.7	0.08	15531	
12:15	100.8	0.07	16681	
12:30	100.7	0.08	18111	
12:45	100.4	0.08	19551	
13:00	100.4	0.07	21027	4.6ft from rim to water in OF cleanout sump in sidewalk.
13:16	100.1	0.07	22651	4.4ft to water behind weir in OF cleanout sump in sidewalk.
13:17	149.9		22651	Swap to FM7
13:21	150.0	0.1	23146	
13:32	148.6	0.27	24777	Weir in OF cleanout sump in sidewalk is backwatered
13:45	148.2	0.38	22651	
14:02	151.3	0.37	29309	
14:15	150.1	0.39	31263	
14:30	149.7	0.4	33481	
14:45	150.8	0.42	36561	
15:00	151.3	0.44	38013	
15:10	150.1	0.45	39519	
15:20	152.1	0.45	41082	
15:30	153.0	0.46	42566	
15:40	153.0	0.47		
15:45	152.1	0.47	44808	Flow off

15:46		0.42		
15:46		0.37		
15:47		0.36		
15:47		0.32		
15:48		0.3		
15:48		0.24		
15:49		0.21		
15:50		0.16		
15:51		0.1		
15:52		0.05		
15:53		dry		


FWI Infiltration Test Plot 1
Water Level, SG-1, Hand Measured
Water Level, OF, Hand Measured
Water Level, WP-1 logger
Ground Surface
Overflow Rim
Water Level, WP-1, Hand Measured
Water Level, Ponding Logger
Water Level, OF Logger
Water Level, SG-2, Hand Measured
'Flow Rate (gpm, secondary axis)"
Water Height (elev, feet, arbitrary project datum)
95.5
95.3
95.1
94.9
94.7
94.5
94.3
94.1
93.9
93.7
93.5
200
180
160
140
120
100
80
60
40
20
0
0
60
120
180
240
300
360
420
480
Elapsed Time (minutes)


FWI Infiltration Test Plot 2
Water Level, SG-1, Hand Measured
Water Level, OF, Hand Measured
Water Level, WP-1 logger
Ground Surface
Overflow Rim
Water Level, WP-1, Hand Measured
Water Level, Ponding Logger
Water Level, OF Logger
Water Level, SG-2, Hand Measured
'Flow Rate (gpm, secondary axis)"
Water Height (elev, feet, arbitrary project datum)
95.6
94.6
93.6
92.6
91.6
90.6
89.6
88.6
87.6
86.6
85.6
200
180
160
140
120
100
80
60
40
20
0
0
60
120
180
240
300
360
420
480
Elpased Time (minutes)

APPENDIX E

Site Photos

Cell FWI, curb cut inlet. Above photo is prior to install of weir. Lower photo is after weir install and during infiltration testing.

Above photo: FWI during infiltration testing. Overflow beehive not visible in vegetation, located in lower left. Lower Photo: overflow structure and staff gauges.

Technical Memorandum

Date:	June 11, 2019	**From:**	Anton Ypma Suzanne Cook, L.G.
To:	Clear Creek Solutions, Inc.	**Project Manager:**	Jennifer H. Saltonstall, L.G., L.Hg.
	15800 Village Green Drive #3 Mill Creek, Washington 98012	**Principal in Charge:**	Jennifer H. Saltonstall, L.G., L.Hg.
cc:	Eric Christensen	**Project Name:**	Bioretention Hydrologic Performance Study
Attn:	Doug Beyerlein, P.E.	**Project No:**	150387H007
Subject:	Deliverable Task 4.5, Site TWH, Geotechnical/Soils Assessment Design Data and Current Conditions, Wilson High School, Tacoma, Washington		

1.0 INTRODUCTION

This technical memorandum documents existing shallow soil and groundwater conditions in the raingarden of the Wilson High School Project, located in the city of Tacoma, Washington (Figure TWH F1). This memorandum was prepared in accordance with Task 4 of the contract scope of work. Associated Earth Sciences, Inc. (AESI) collected shallow soil and groundwater conditions data related to bioretention cell function, and documented the current condition of the facility relative to the as-built drawings and available background geotechnical information. The information will be used in the WWHM2012 modeling that will be conducted as part of Task 5 (Data Analysis). In Task 5, the team will compare the previously documented hydrologic design information with our field-collected information and will note where there are significant differences. The purpose of this technical memorandum is to document the collection of current and accurate geotechnical, geologic, and hydrogeologic site information for this later work.

The following summary of shallow soil and groundwater conditions integrates the observations made during the geotechnical assessment which included site visits on October 3, 2018, infiltration testing on November 11, 2018, and background geotechnical information.

This technical memorandum has been prepared for the exclusive use of Clear Creek Solutions and the City of Olympia and their agents for specific application to this project. Within the limitations of scope, schedule, and budget, our services have been performed in accordance with generally accepted hydrogeologic and geotechnical engineering practices in effect in this area at the time our document was prepared. No other warranty, express or implied, is made.

2.0 PURPOSE AND SCOPE

The purpose of our work was to perform a shallow soil and groundwater conditions assessment and provide baseline documentation data to assess effectiveness of bioretention hydrologic performance.

Specifically, our scope included the following activities:

- Review of project documents.
- Site reconnaissance.
- Visual condition assessment of erosion and deposition features near inlet and outlet.
- Review project plans relative to constructed facility, in particular, the number and location of inlets, energy dissipation devices, outlets, and other flow-related details.
- Survey elevations of inlet, outlet, well point rim, and other observation points relative to a project datum.
- Excavate shallow hand augers through the bioretention soil.
- Classify sediment according to the Unified Soil Classification System (USCS) and *American Society for Testing and Materials* (ASTM) D2488, "Standard Recommended Practice for Description of Soils."
- Collect samples for laboratory testing of: (1) particle size distribution in accordance with ASTM D422-63, "Standard Test Method for Particle-Size Analysis of Soils"; (2) organic matter content per ASTM D2974.
- Preparation of descriptive exploration logs for each exploration.
- Conduct qualitative assessment of soil compaction via T-probe.
- Conduct infiltration testing.
- Review of hydrologic monitoring data.
- Preparation of this summary document.

Existing facility features and the locations of hand-auger boreholes completed for this study are shown on Figure TWH F2, "Facility and Exploration Plan." Project civil plans are attached as Appendix A. Exploration logs and laboratory testing data conducted as part of this study are attached as Appendix B. Background soil, geology, and groundwater information are attached as Appendix C. Soil probe, level survey, and field infiltration testing data are attached as Appendix D. Site photos are attached as Appendix E.

3.0 SITE DESCRIPTION AND DESIGN BACKGROUND

The project site is the Wilson High School Project, located in Tacoma, Washington as shown on the attached "Vicinity Map" (Figure TWH F1). Wilson High School is located on four parcels, totaling 41.5 acres. The site is bordered by North 14th Street to the north, by North Orchard Street to the east, by North 11th Street to the south, and by North Highland Street to the west. Site topography generally slopes gently down to the south and east. No on-site surface water features are present.

As described in the Stormwater Site Plan (Sitts & Hill Engineers, Inc., 2014) the site is not located in an Aquifer Recharge Area. Our specific area of study for this project includes the raingarden located on the northern edge of campus next to the stormwater detention pond referred to as cell TWH for this study.

Details of the bioretention facility design and basis for design were presented in the following documents:

- "Limited Subsurface Exploration and Geotechnical Engineering Report, Wilson High School Field Renovation," Associated Earth Sciences, Inc., 2013.
- "Supplemental Subsurface Exploration and Infiltration Assessment, Wilson High School Athletic Field Upgrades," Associated Earth Sciences, Inc., 2014.
- "Supplemental Subsurface Exploration and Geotechnical Evaluation, Wilson High School Phase 2, Building, Pond, and Roadway Improvements, Associated Earth Sciences, Inc., 2014.
- "Western Playfield Infiltration Considerations," Technical Memorandum, Associated Earth Sciences, Inc., 2014.
- "Wilson High School Phase 2 - Stormwater Site Plan," Sitts and Hill Engineers, Inc., October 2014.
- Conformed Plan Set, Wilson High School, Sitts and Hill Engineers, Inc., December 3, 2015.

3.1 Summary of Facility Design

From our review of these documents, the bioretention facility design for cell TWH consists of an approximately rectangular-shaped bioretention cell with approximately 2,070 square feet of base area. The cell is shown on Figure TWH F2, "Facility and Exploration Plan." We understand that the site was developed under the 2012 City of Tacoma *Stormwater Management Manual* for design and construction of stormwater facilities and modeled using WWHM2012 with a design infiltration rate of 1.5 inches per hour (in/hr) for the bioretention soil. Land use within the drainage basin consisted of parking lot and associated drive lanes. Per plan sheet C3.14 (Sitts and Hill Engineers, Inc., December 3, 2015), the facility design includes mulch overlying 18 inches of bioretention soil mix overlying a minimum 8-foot-wide rock-filled trench. The rock-filled trench is separated from the overlying bioretention soil mix by a layer of Class A drainage geotextile fabric. The rock-filled trench contains three 6-inch-diameter perforated underdrain pipe bedded in approximately 1.5 feet of "¾-inch to 1½-inch washed rock" which overlies native soil. The three underdrain pipes run along the length of the facility and discharge into the overflow catch basin.

The facility is designed to infiltrate 91 percent of inflow into the subgrade. Stormwater enters the facility through two inlet pipes on the north end, one 12-inch and one 8-inch. The 8-inch pipe was observed in the field but is not marked on plan sheets. If water ponds up on the bioretention soil, the ponded water would discharge into a Type 2 48-inch Catch Basin (CB 203) with a beehive grate located near the southern edge of the cell, and then into the on-site stormwater system. The rim of the Type 2 Catch Basin was designed to be 1 foot higher than the cell base to create 1 foot of ponding depth. Based on review of historic aerial imagery, the facility was constructed after June 2016 and before May 2017.

4.0 SITE OBSERVATIONS

During AESI's site visits, we made notes regarding the physical construction of the bioretention facilities including documenting site inlet/outlet layout relative to site plans and qualitative bioretention soil thickness and compaction. These notes were used to indicate key features of the facility in Figure TWH F2, "Facility and Exploration Plan."

- Level Survey: AESI conducted an elevation survey of the cell using a Leitz C40 automatic level and a stadia rod. An arbitrary project datum was established for this survey, with the rim of the storm manhole south of the cell (CB 205) (identified on the "TWH Level Survey Data" map in Appendix D) defined as project datum elevation 100 feet. All other elevations measured by the survey are relative to this project datum. Key level data is summarized in Table 1. Additional data points are included in Appendix D to this document. This survey was not conducted by a licensed surveyor. Surveyed elevations are expected to be sufficiently accurate for this general assessment of facility construction, but may be inaccurate for purposes requiring greater precision.

- Inflow: Two inflow pipes are present on the eastern side of the northern end of cell TWH.
  - Primary: The primary inflow pipe (Inlet 1) to the facility is a 12-inch polyvinyl chloride (PVC) consistent with project plans, which discharges onto a quarry spall energy dissipation pad approximately 6 feet wide and 8 feet long, which began above the inlet and extended approximately 5 feet past the inlet. No water was discharging at the time of our site visit, but we observed moisture present in the pipe and minor leaf litter and garbage accumulation on the quarry spall.

  - Undocumented inflow: A second inflow pipe (Inlet 2) to the facility is an 8-inch concrete pipe, with a 5-foot-wide, 6-foot-long quarry spall pad which extends 4 feet past the inlet. AESI observed that this pipe is approximately 50 percent blocked with quarry spall, with approximately 1 inch of organic-rich silt present in the pipe. This pipe is not depicted on the project plan sheets. During our field visits, AESI was unable to determine the drainage area from which stormwater would enter this pipe.

- Overflow: The overflow consists of a Type 2 Catch Basin (CB 203) with a beehive grate. The rim of this grate was approximately flush with ground surface in the facility and set into the base of the slope on the southern end of the facility. AESI observed evidence of sediment entering the beehive grate.

- AESI investigated the loose bioretention soil thickness present in cell TWH using a geotechnical soil T-probe. This qualitative data was used in conjunction with the hand-auger observations to understand loose soil thickness and relative potential compactness of the bioretention soils at depth. AESI measured the depth of penetration of the soils probe at locations generally arranged in a 5-foot grid on the facility base.

Penetration of the T-probe generally ranged from approximately 1.1 to 1.7 feet, and averaged 1.5 feet. Probe penetration data is included in Appendix D to this document.

- AESI measured a base area of approximately 1,200 square feet, less than the 2,090 square feet described in the drainage report (Sitts and Hill Engineers, Inc., October 2014).

Table 1
Summary of Cell TWH
Level Survey Data

Location	Elevation (feet, project datum)
Overflow (OF) inner rim (@ outlet pipe)	96.31
OF outer rim corner (N)	96.37
OF outer rim corner (E)	96.33
OF outer rim corner (S)	96.44
OF outer rim corner (W)	96.46
GS @ Ponding tubes#2/ OF (N)	96.32
Ponding Tube TOC (DL#2, S)	97.64
Ponding Tube TOC (Baro#2, S)	97.58
TOC DL, in OF	95.84
TOC Baro, in OF	95.87
Inlet #1, 12", Top/end of green pipe	98.39
Inlet#2, Top/end green pipe	97.05
WP-1 TOC	98.83
WP-1, Ground surface	96.17 to 96.19
Ponding Tube TOC (DL#1, N)	97.48
Ponding Tube TOC (Baro#1, N)	97.44

TOC: top of casing; GS: ground surface. DL: Datalogger;

5.0 SITE SETTING

The text sections below describe our research findings in regards to the topographic, geologic, and hydrogeologic setting of the project site both from regional studies and background site-specific geotechnical and groundwater studies. Our sources of information included the following:

- Site-specific documents cited previously under "Project and Site Description."
- U.S. Geological Survey (USDA), 2006, *Draft Geologic Map for the Gig Harbor 7.5 Minute Quadrangle*.
- Natural Resource Conservation Service (NRCS), Web Soil Survey, United States Department of Agriculture (USDA), http://websoilsurvey.nrcs.usda.gov/, accessed February 2019.
- Griffin, W.C., Sceva, J.E., Swenson, H.A., and Mundroff, MJ., *Water Resources of the Tacoma Area, Washington*, United States Department of the Interior, Geological Survey, 1962.

5.1 Regional Topography and Project Grading

The project site is situated on an undulating upland. The nearest surface water feature is China Lake, approximately 1 mile south of the site. Elevations on the larger project site range from about 385 feet on the northern edge, to 358 feet on the southern edge of the property.

On a closer scale, the area near Cell TWH is at an elevation of 368 feet, with a previously constructed stormwater detention pond present immediately west of the cell, and parking lot to the east of the cell at an elevation of 371 feet, separated from the cell by a curb, slope, and fence. Tennis courts and fields roughly level with the cell are present to the south, and North 14th Street is present to the north, separated from the cell by a curb, slope, and fence.

The project site was previously developed as Wilson High School with associated sport fields. The nearby stormwater detention pond was added prior to the addition of the bioretention cell and involved excavation of approximately 10 feet. We understand that cell TWH was added later as part of a subsequent phase of work which involved minor cutting (about 3 feet) to achieve design bioretention cell grades based on a review of existing topography compared with built topography.

5.2 Regional Geology and Background Geotechnical Information

According to the current draft U.S. Geological Survey (USGS) *Geologic Map for the Gig Harbor 7.5 Minute Quadrangle* (USGS - Miscellaneous Field Investigation, 2006), the project site is underlain by Vashon lodgement till. Vashon lodgement till is deposited by and directly overridden by the advancing glacial ice sheet, which compacts it to a dense condition

- Vashon lodgement till (Qvt): The Vashon lodgment till was deposited directly from basal, debris-laden, glacial ice during the Vashon Stade of the Fraser Glaciation, approximately 12,500 to 15,000 years ago. The high relative density characteristic of the Vashon lodgement till is due to its consolidation by the massive weight of the glacial ice from which it was deposited.

Background geotechnical information includes exploration log EP-1 from within the footprint of cell TWH dated February 23, 2000, and reached depths of about 5 feet below current grades, and describe material generally consisting of medium dense to dense, gray, moist, sand with gravel and little silt ranging to silty with scattered cobbles with depth, interpreted as Vashon lodgement till. This interpretation is consistent with the geologic mapping in the area.

5.3 Regional Soils and Soil Data Used in Site Stormwater Model

Regional NRCS soils mapping is not available in the project area because it was urbanized prior to NRCS mapping.

As described in the Stormwater Site Plan (Sitts & Hill Engineers, Inc., 2014), the pre-developed condition was modeled as Type C, consistent with the Washington State Department of Ecology

(Ecology) 2014 *Stormwater Management Manual for Western Washington* (2014 Ecology Manual) recommendations for glacial till soils.

5.4 Regional Hydrogeology and Background Groundwater Data

Regional hydrogeology is described in *Water Resources of the Tacoma Area, Washington* (Griffin et al., 1962). Griffin et al. (1962) indicates that recessional and advance outwash are typically productive aquifers, while the Vashon lodgement till typically perches water.

As described in the stormwater site plan, the site is in the Leach Creek watershed. Leach Creek flows generally south, joins Chambers Creek, and ultimately discharges into the Puget Sound. Previous reports inferred based on subsurface exploration data that rainwater perches above the glacial till present at the site (AESI, 2014).

6.0 BIORETENTION CELL SUBSURFACE EXPLORATION

Limited information on subsurface conditions was obtained for this study from hand-auger samples and soil probe penetration measurements at about 2-foot increments in each hand-augered borehole. Four hand-auger borings were performed in the facility bottom and advanced through the bioretention soil and to the underlying aggregate rock, except for hand-auger boring 2 (TWH-HA-2) which was advanced into the underlying subgrade. Representative samples were collected, visually classified in the field, stored in water-tight containers, and transported to AESI's offices for additional classification, geotechnical testing, and study. At the conclusion of the excavation, the boreholes were immediately backfilled with the excavated material or completed as a well point for water level monitoring (described separately below).

The various types of sediments, as well as the depths where characteristics of the sediments changed, are indicated on the exploration logs presented in Appendix B. A detailed record of the observed bioretention soil, subsurface soil, geology, and groundwater conditions was made. The sediments were described by visual and textural examination using the soil classification in general accordance with ASTM D2488, "Standard Recommended Practice for Description of Soils." The depths indicated on the logs where conditions changed may represent gradational variations between sediment types in the field. The exploration logs in Appendix B are based on the field observations, inspection of the samples, and where applicable, laboratory grain-size analysis. Our explorations were approximately located in the field relative to known site features, and are shown on Figure TWH F2, "Facility and Exploration Plan." Global Positioning System (GPS) coordinates for the explorations were taken using a hand-held GPS, and are summarized in Appendix B.

The results presented in this document are based on the explorations completed for this study and review of background data. The number, locations, and depths of the explorations were completed within site and budgetary constraints. Because of the nature of exploratory work below ground, interpolation of subsurface conditions between field explorations is necessary. It should be noted that differing subsurface conditions may sometimes be present due to the random nature of deposition and the alteration of topography by past grading and/or filling.

6.1 Hand-Auger Borings

Hand-auger borings in cell TWH were completed on October 3, 2018. No rainfall was noted at the time of exploration.

Hand-auger boring number 1 (TWH-HA-1), which was completed in the northern portion of the cell, near the inflow, encountered approximately 0.1 feet of organic material and leaf litter, 1 foot of bioretention soil mix, and filter fabric overlying rounded drain rock. Hand-auger boring number 2 (TWH-HA-2), which was completed near the inlets on the edge of the cell, encountered 0.1 feet of organic material and leaf litter, 1.4 feet of bioretention soil mix, and sediments tentatively interpreted as fill to a total depth of 1.9 feet. Hand-auger borings 3 and 4 (THW-HA-3 and TWH-HA-4) encountered 1.4 and 1.3 feet of bioretention soil, respectively, overlying filter fabric. No seepage or caving were observed.

6.2 Well Points

A well point was installed in TWH-HA-1. Key well point dimensions are provided in Table 2, below.

Table 2
Summary of Cell TWH
Well Point Dimensions

Well Point	Exploration in which Well Point was Installed	Total Length of Casing (feet)	Interior Diameter	Stickup Height (feet)	Total Depth Inside Casing Below Ground Surface
TWH-HA-1/WP	TWH-HA-1/WP	7.2	1.25 inch nominal	2.7	4.5

7.0 LABORATORY ANALYSIS

Laboratory testing included mechanical grain-size distribution and percent organic matter by weight in accordance with the ASTM D422 and D2974, respectively. Bioretention soil was first tested for organic matter content and then the burned material was tested for grain-size distribution for comparison with the aggregate fraction of the bioretention soil mix guidance in the 2014 Ecology Manual. One sample of material interpreted as representative of the subgrade was tested for grain-size distribution. The data is summarized in Table 3.

Table 3
Summary of Cell TWH
Organic Content and Grain Size Data

Exploration Number	Depth (feet)	Soil Type	Organic Content (% by weight)	USCS Soil Description	Fines Content (% passing #200)	Cu	Cc	USDA Soil Texture*
TWH-HA-1	0.1-0.5	Bioretention Soil	6.8	SAND, trace silt, trace gravel (SP)	3.6	2.5	1	Sand
TWH-HA-2	1.4-1.9	Fill		Gravelly SAND, some silt (SP-SM)	11.6			Loamy Sand to Sandy Loam
TWH-HA-3	0.1-0.5	Bioretention Soil	8.0	SAND, trace silt, trace gravel (SP)	2.9	2.7	1	Sand

USCS: Unified Soil Classification System; Cu: coefficient of uniformity; Cc: coefficient of curvature; USDA: U.S. Dept. of Agriculture;
*No hydrometers were performed. USDA soil texture range assumes fines consist entirely of silt to entirely of clay.

7.1 Bioretention Soil Mix

We compared the organic content and burned fraction gradation against the general guidelines for the bioretention soil mix (Table 4).

The organic content of the tested bioretention soils ranged between 6.8 and 8 percent by weight. This meets the recommended organic content by weight of 5 to 8 percent in the 2014 Ecology Manual.

The grain-size analysis test results on the burned soil fraction indicate that the bioretention soils tested correlate to a “SAND” with trace silt and trace gravel based on ASTM D2487 Unified Soil Classification System (USCS). The respective fines content as measured on the No. 200 sieve was 2.9 to 3.6 percent, within the recommended range of 2 to 5 percent. The coefficient of uniformity ranged from 2.5 to 2.7, lower than the recommended value of equal to or greater than 4. The coefficient of curvature was approximately 1, at the low end of the recommended range of greater than or equal to 1 and less than or equal to 3. The soil mix was generally within the recommended ranges for the sand gradations. The tested bioretention soil was a poorly-graded sand.

7.2 Subgrade

In cell TWH, no samples of the subgrade could be obtained for this study due to the import gravel beneath the bioretention cell and difficulties hand auguring in this material. In TWH-HA-2, a sample was obtained from the lower side slope of the cell was sieved, interpreted tentatively identified as fill, was sieved. The tested material correlates to a gravelly SAND with some silt with 11.6 percent by weight of the material passing the No. 200 sieve.

The grain-size distribution data were also transformed to describe the United States Department of Agriculture (USDA) soil texture. The grain-size distributions were normalized to the No. 10 sieve—

i.e., the coarse sand and gravel fraction of the sample is discounted and the remainder is taken as 100 percent of the sample. The fines were assessed relative to the No. 270 sieve. The respective USDA fines content as measured on the No. 270 sieve after adjusting to remove the weight retained on the #10 sieve was 15.8 percent for the sieved material.

Table 4
General Guidelines for Bioretention Soil Mix (2014 Ecology Manual)
Compared to Averaged Cell TWH Site Data

Parameter	Recommended Range	Cell TWH
Organic Content (by weight)	5 to 8 percent	7.4percent by weight
Cu coefficient of uniformity	4 or greater	2.6
Cc coefficient of curvature	1 to 3	1
Sieve Size	**Percent Passing**	
3/8” (9.51 mm)	100	99.7
#4 (4.76 mm)	95 to 100	97.6
#10 (2.0 mm)	75 to 90	90.5
#40 (0.42 mm)	25 to 40	34
#100 (0.15 mm)	4 to 10	5
#200 (0.074 mm)	2 to 5	3

Note: The general guidelines for mineral aggregate gradation are from Table 7.4.1 of the 2014 Ecology Manual.
mm: millimeters.

8.0 INFILTRATION TESTING

8.1 General Infiltration Test Method

The infiltration test was conducted in general accordance with the 2014 Ecology Manual. The test was conducted by discharging water into the facility for a “soaking period,” to allow the receptor soils to become saturated. After completion of the soaking period, water was discharged into the cell at a rate sufficient to maintain a relatively constant head. This constitutes the “constant-head” phase of infiltration testing. Immediately following the constant-head phase of infiltration testing, flow into the facilities was discontinued, and the water level was monitored as it dropped. This constitutes the “falling-head” portion of the infiltration testing.

The water for testing was obtained from an on-site fire hydrant and a water truck, and conveyed to cell TWH with fire hoses. During infiltration testing, the water was conveyed into the bioretention cell via a digital flow meter with gallons per minute (gpm) and total gallon readouts, and discharged through a flow diffuser. Water levels were monitored using a temporary staff gauge (TWH-SG-1) marked in 0.01-foot increments installed adjacent to the well point, within the well point, and with digital pressure transducers. Data from the digital pressure transducers was compensated for barometric response using a separate digital barometer. The area of the pool was measured periodically during testing.

The infiltration test in cell TWH is discussed below, and results are presented in Table 5. Infiltration test data is included in Appendix D to this document.

8.2 Infiltration Test in Cell TWH

AESI performed infiltration testing on November 19, 2018. No rainfall was noted during testing, and no flow from the inflow pipes was present.

During this test, flow from the on-site fire hydrant was limited to 50 gpm, per City of Tacoma requirements. AESI supplemented the flow using a water truck with an approximate 4,000-gallon capacity. Inflow to the facility for the infiltration test was directed, through a diffuser, onto the cell. Flow from the on-site fire hydrant was maintained at approximately 50 gpm for the duration of the test. This 50 gpm initially wetted a portion of the cell totaling approximately 340 square feet in the vicinity of the inflow pipes and staff gauges. The water truck provided an additional approximately 91 gpm (total flow rate approximately 141 gpm average) from approximately 85 to 127 minutes into the test. This higher flow rate led to a total wetted area of approximately 790 square feet, however AESI observed that the wetted area was still growing as the water truck ran out of water, and the wetted area was therefore not stable. The water truck then left the site to refill, and then provided an additional approximately 60 gpm (total flow rate approximately 110 gpm average) from 275 to 345 minutes into the test. During this final period of inflow, the wetted area stabilized with a total wetted area of approximately 850 square feet. No flow into the overflow beehive was observed, however AESI observed that the underdrain pipes were active from approximately 80 minutes into the test, prior to supplemental flow from the water truck, until the end of testing. After approximately 5 and 3/4 hours, the water level in the wetted area was about 0.14 feet as measured on TWH-SG-1. The wetted pool area had been generally stable for about 20 minutes.

Water in the well point was monitored with a data logger during the infiltration test and responded to inflow. Initially, only trapped end-cap water was present in the well point. The water level in the well point responded to inflow within 10 minutes of the start of testing, and rose by up to approximately 0.6 feet during testing. AESI interprets this response to indicate that water from the infiltration test infiltrated rapidly through the bioretention soil and then mounded within the gravel base course beneath the facility, as it discharged primarily through the underdrains.

After about 5 and 3/4 hours, AESI shut off the flow and monitored water level as it fell. AESI observed that the pooled water in the base of the facility infiltrated over the course of approximately 4 minutes.

The constant-head test infiltration rate in Table 5 is calculated based on flow rate from the hoses for infiltration testing, and the wetted area of bioretention soil through which the water infiltrated, and represents the average infiltration rate of the bioretention soil in the wetted area. Infiltration rate calculations for cell TWH are based on the final period of steady discharge, when flow was being supplemented by the water truck to approximately 110 gpm. The falling head infiltration rate is a more localized infiltration rate because the wetted area shrank rapidly after the inflow ceased. AESI observed the discharge from the underdrains, and visually estimated that it was similar to the inflow to the facility during testing, indicating that the majority of inflow was leaving the facility via the underdrains and little to no inflow was infiltrating into the subgrade.

Table 5
Cell TWH
Infiltration Test Results

Test No.	Surface Area (square feet)	Discharge Time (minutes)	Total Volume Discharged (gallons)	Approximate Constant-Head Level (feet)	Field Infiltration Rates	
					Constant-Head Test (in/hr)	Falling-Head Test (in/hr)
TWH (bioretention soil)	850*	345	25,123	0.14	~11	25*
TWH (subgrade)	Perched water response in well point				Unknown, interpreted to be low based on the underdrain outflow	

in/hr: inches per hour
*The falling head infiltration rate is interpreted to represent a more localized area of the cell because the wetted area shrank rapidly once the inflow ceased. The constant head rate is interpreted to an average rate for the wetted are of the cell during testing.

9.0 CONCLUSIONS AND RECOMMENDATIONS

Cell TWH was generally inconsistent with the design shown on the civil plan sheets. Observations on site design, shallow soil and groundwater conditions are discussed below.

- Inflow: A second inflow, not indicated on plan sheets, was observed.
- The overflow is inconsistent with the plans. Site design documents indicate that the ponding level was designed as 1 foot. The overflow was installed approximately flush with ground surface. However, given the high infiltration rate of the bioretention soil and the distance of the overflow from the inflow, it is unlikely that frequent ponding will occur at the overflow.
- Bioretention soil:
  - Thickness: The apparent thickness of loose bioretention soil based on soil probe data was generally about 1.5 feet as indicated on the plan.
  - Composition: The soil tested generally met the recommended guidelines for organic content and grain size.
- Subgrade conditions: The subgrade is interpreted to consist of Vashon lodgement till, as documented in exploration pits prior to construction. Undocumented fill sediments may be present.

- Bioretention soil field infiltration rate:
    - Measured at about 11 to 25 in/hr.
    - Water readily soaked through the bioretention soil mix and the field rate is interpreted to represent the bioretention soil infiltration rate.

- Native subgrade infiltration rate: interpreted to be low. The majority of flow is interpreted to leave the cell via the underdrain.

10.0 CLOSURE

We appreciate the opportunity to be of continued service to you on this project. Should you have any questions regarding this document or other geotechnical/hydrogeologic aspects of the project, please call us at your earliest convenience.

Anton D. Ypma
Staff Geologist

Suzanne S. Cook, L.G.
Senior Project Geologist

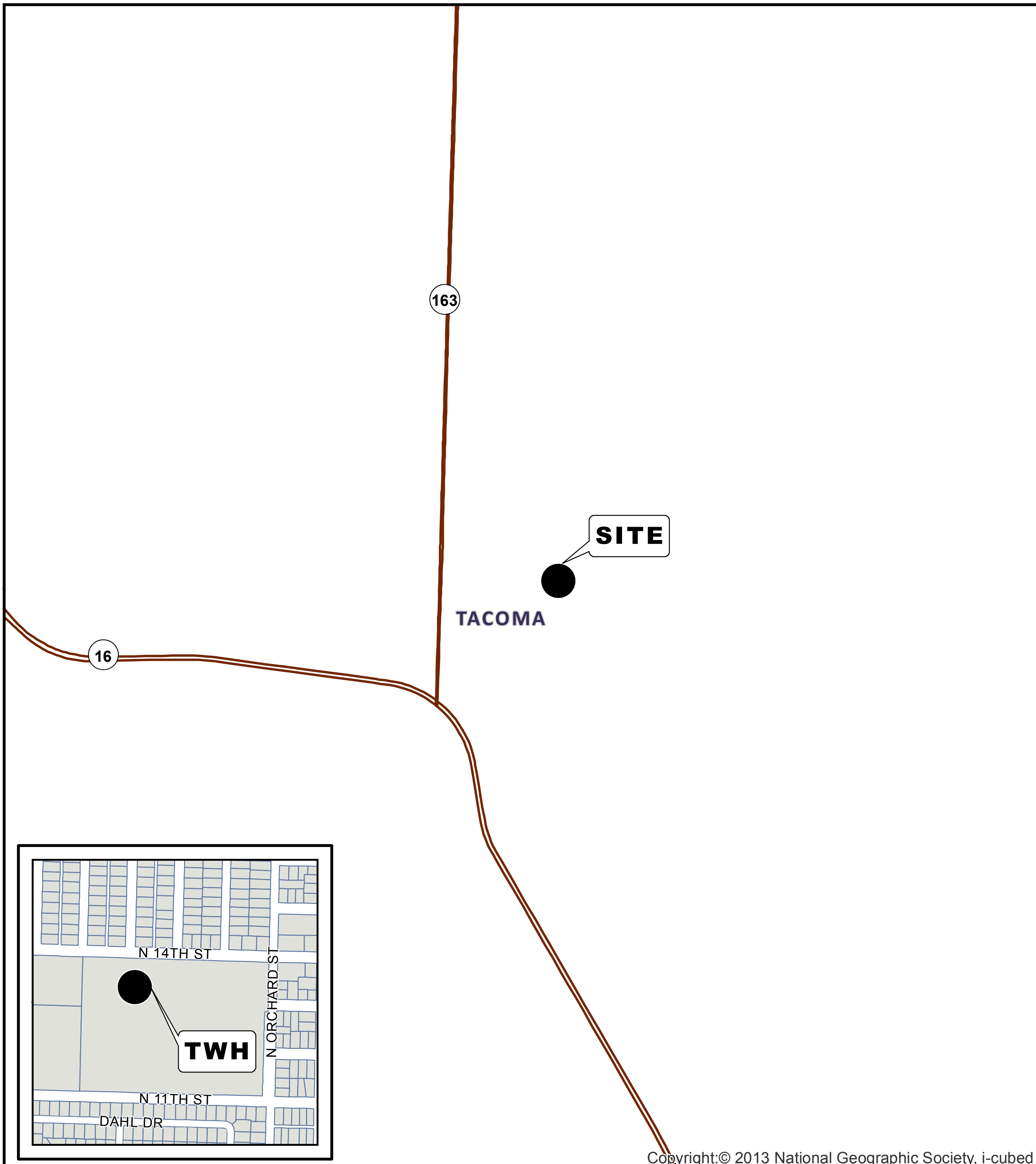
6/11/19

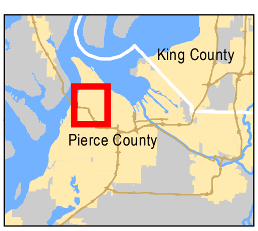
State of Washington
Hydrogeologist
2335
Licensed Geologist
Jennifer H. Saltonstall

Jennifer H. Saltonstall, L.G., L.Hg.
Principal Geologist/Hydrogeologist

Attachments:	Figure TWH F1:	Vicinity Map
	Figure TWH F2:	Facility and Exploration Plan
	Appendix A:	Project Civil Plans
	Appendix B:	Current Study Exploration Logs and Laboratory Testing Data
	Appendix C:	Background Soil, Geology, and Groundwater Data (Regional Maps, Previous Studies Exploration Logs and Laboratory Testing Data)
	Appendix D:	Soil Probe, Level Survey, and Field Infiltration Testing Data
	Appendix E:	Site Photos

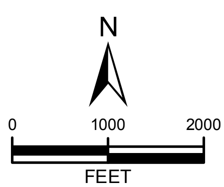
JHS/ld
150387H007-9
Projects\20150387\KH\WP





DATA SOURCES / REFERENCES:
USGS: 7.5' SERIES TOPOGRAPHIC MAPS, ESRI/I-CUBED/NGS 2013
PIERCE CO: STREETS, CITY LIMITS, PARCELS 1/18

LOCATIONS AND DISTANCES SHOWN ARE APPROXIMATE



NOTE: BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION

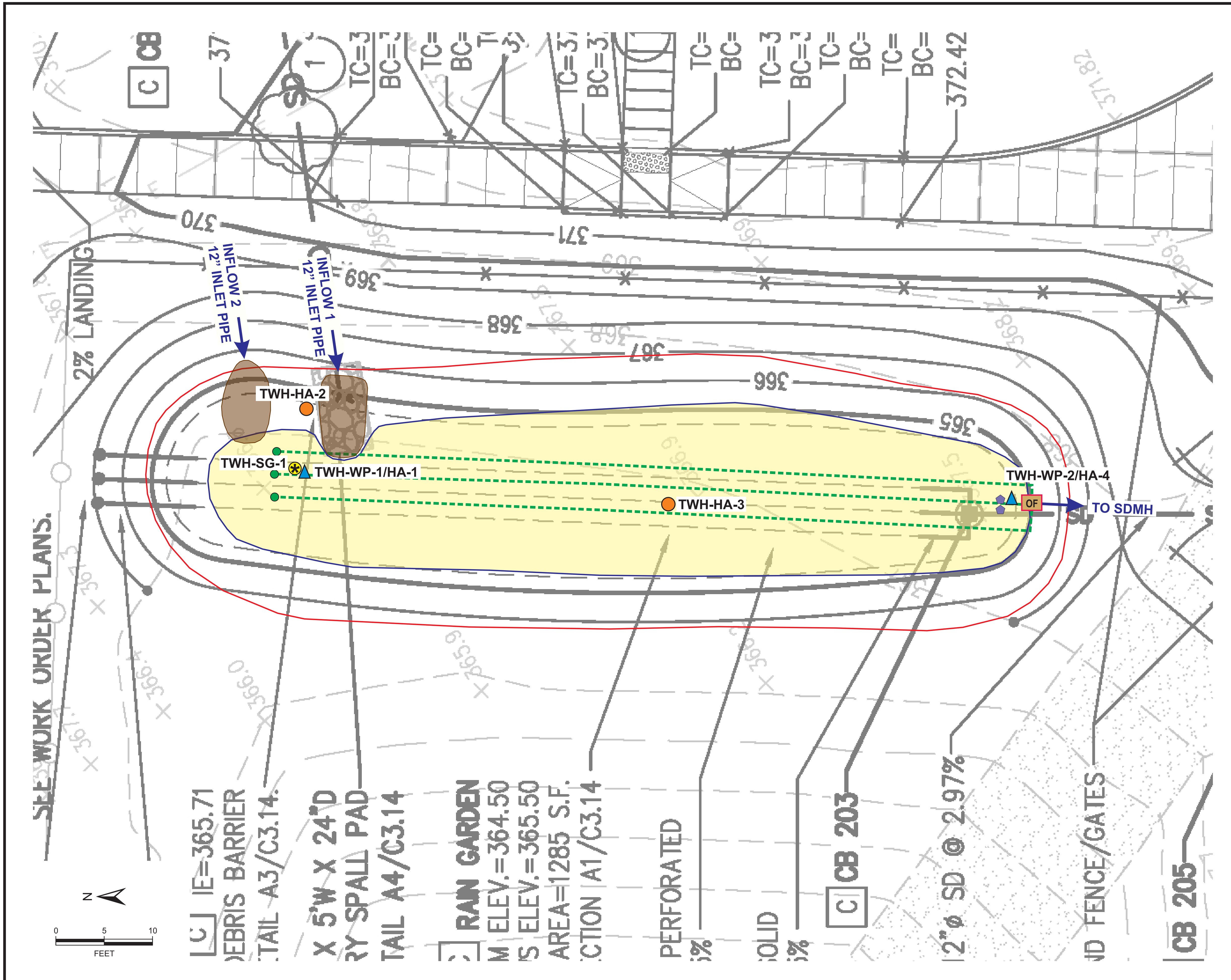
[redacted]

VICINITY MAP

BIORETENTION HYDROLOGIC PERFORMANCE STUDY, TWH SITE
TACOMA, WASHINGTON

PROJ NO.	DATE:	FIGURE:
150387H007	3/19	TWH F1

Document Path: G:\GIS_Projects\aY15post0716\150387 Bioretention Hydro Performance Monitoring\mxd\PhaseII\Fig1s\150387H007 F1 VM_TWH.mxd



LEGEND:

- HA — HAND AUGER
- WP — WELL POINT
- TEMPORARY STAFF GAUGE
- BASE OF FACILITY
- TOP OF FACILITY SLOPE
- INFLOW / OVERFLOW DIRECTION
- OF — OVERFLOW GRATE - 24" X 18"
- PVC PONDING TUBE
- UNDERDRAIN
- STORM DRAIN CLEANOUT
- ENERGY DISSIPATER

CONTOUR INTERVAL = N/A

NOTE: LOCATION AND DISTANCES SHOWN ARE APPROXIMATE.

NOTES:
1. BASE MAP REFERENCE: SITTS AND HILL ENGINEERING, INC., TACOMA SCHOOL DISTRICT, WILSON HIGH SCHOOL, GRADING AND DRAINAGE PLAN, SHEET C3.1, 12/10/15

associated earth sciences incorporated

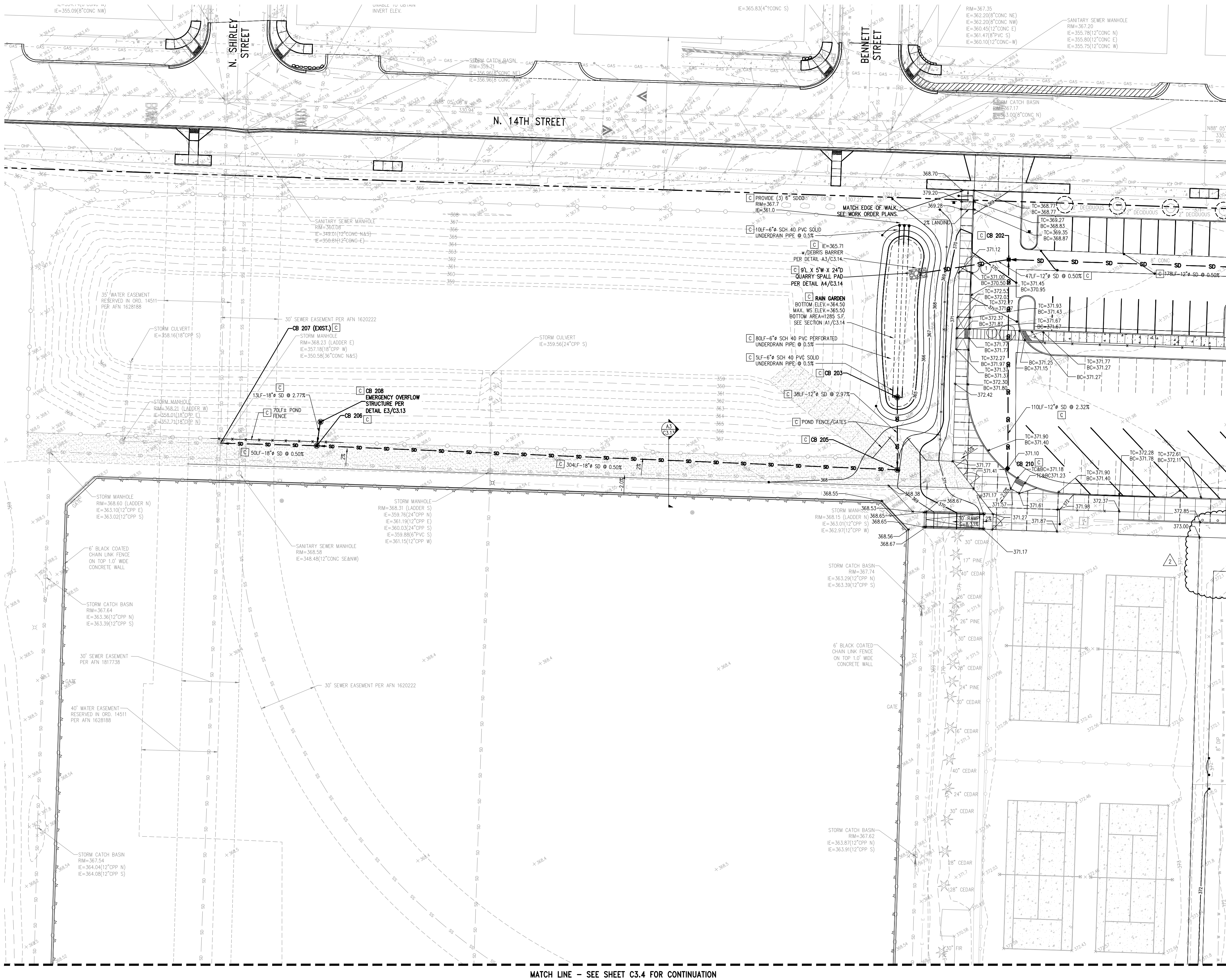
FACILITY AND EXPLORATION PLAN
TWH SITE
BIORETENTION HYDROLOGIC PERFORMANCE
TACOMA, WASHINGTON

PROJ NO.	DATE:	FIGURE:
150387H007	3/19	TWH F2

150387 BHPS MCCA \ 150387H007 Site-Expl ALL.cdr PAGE x: TWH F2

APPENDIX A

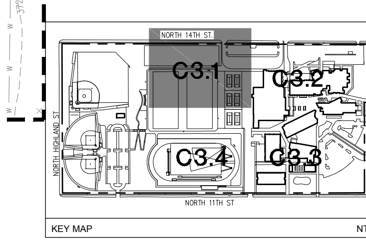
Project Civil Plans



NORTH

HORIZONTAL SCALE: 1"=20'

20 0 20 40



KEY MAP NTS

Call 2 Working Days Before You Dig

1-800-424-5555

Utilities Underground Location Center

GENERAL NOTES

1. COMPLY WITH NOTE REQUIREMENTS ON SHEET C3.12.

GRADING AND DRAINAGE KEY NOTES

1. COORDINATE WITH FIELD DRAWINGS FOR DETAILED FINISHED GRADE ELEVATION AND SURFACING SECTION REQUIREMENTS.
2. PROVIDE DROP TEE CONNECTION IN 15" SD FOR FIELD SUBDRAINAGE CONNECTIONS. COORDINATE LOCATION AND INSTALLATION REQUIREMENTS WITH FIELD CONTRACTOR AND DRAWINGS.

PROJECT PHASING KEY NOTES

WORK DESIGNATED ON THE PLANS SHALL BE INSTALLED DURING THE NOTED PHASE. COORDINATE PHASE TIMES AND DATES WITH PROJECT PHASING REQUIREMENTS.

- A PHASE A
- B PHASE B
- C PHASE C
- D PHASE D

REVISIONS

2 PERMIT REVISIONS 09-03-2015

CONFORMED SET

SITTS & HILL ENGINEERS, INC.

CIVIL ▪ STRUCTURAL ▪ SURVEYING

4815 CENTER STREET | TACOMA, WA. 98409

PHONE: (253) 474-9449 | FAX: (253) 474-0153

http://www.sitts-hill-engineers.com/

TACOMA SCHOOL DISTRICT

WILSON HIGH SCHOOL

1202 N. ORCHARD ST., TACOMA, WASHINGTON 98406

RICHARD C. HAND STATE OF WASHINGTON 26780 REGISTERED PROFESSIONAL ENGINEER 12/03/15

NAC | ARCHITECTURE

2025 FIRST AVE, SUITE 300 | SEATTLE, WA 98121-3131 | T:206.441.4522 | F:206.441.7917

WWW.NACARCHITECTURE.COM

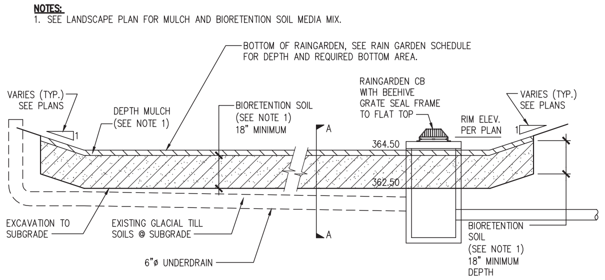
NAC NO	121-13009
DATE:	12-10-2015
DRAWN	JMW
CHECKED	RCH

BASE BID - GRADING AND DRAINAGE PLAN

GRADING AND DRAINAGE PLAN

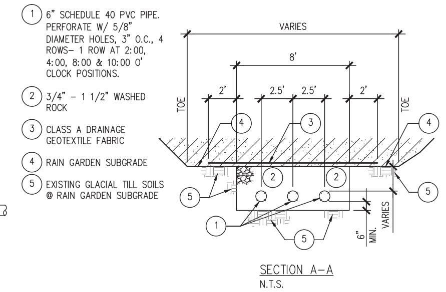
BASE BID

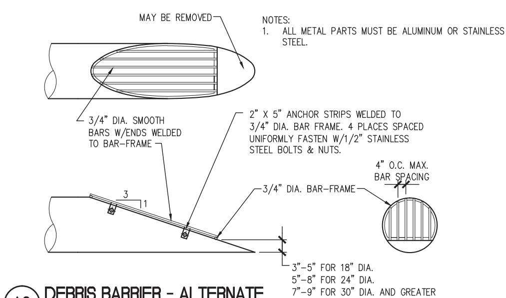
C3.1



A1 TYPICAL RAIN GARDEN CROSS SECTION - BASE BID

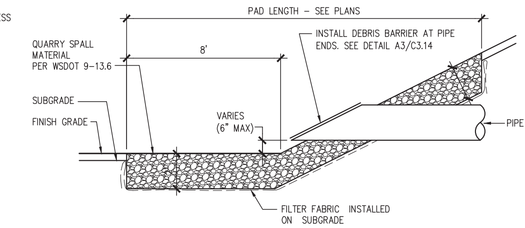
SCALE: N.T.S.





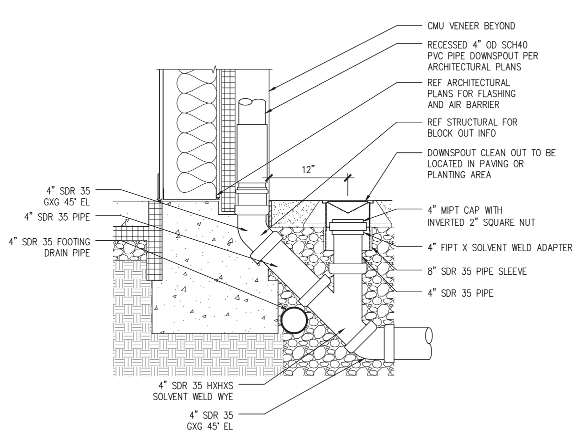
A3 DEBRIS BARRIER - ALTERNATE

SCALE: N.T.S.



A4 QUARRY SPALL PAD SECTION - BASE BID AND ALTERNATE

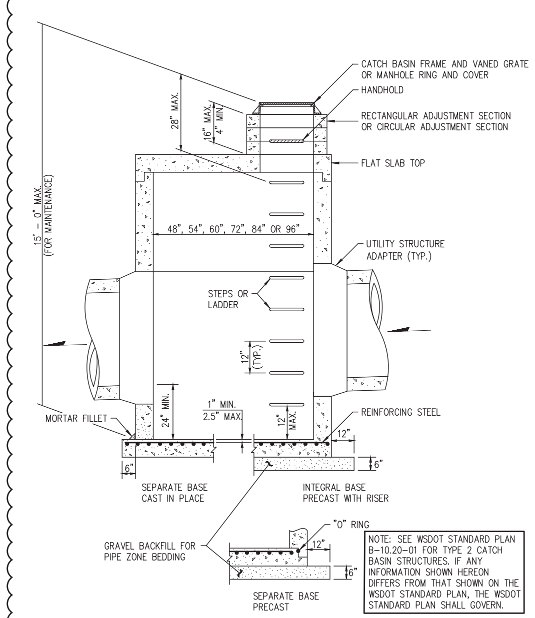
SCALE: N.T.S.



C1 RECESSED DOWNSPOUT AT FOOTING - BASE BID AND ALTERNATE

SCALE: N.T.S.

3



CATCH BASIN DIMENSIONS						
CATCH BASIN DIAMETER	WALL THICKNESS	BASE THICKNESS	MAXIMUM KNOCKOUT SIZE	MINIMUM DISTANCE BETWEEN KNOCKOUTS	BASE REINFORCING STEEL in^2 /ft IN EACH DIRECTION	
					INTEGRAL	SEPARATE
48"	4"	6"	36"	8"	0.15	0.23
54"	4.5"	8"	42"	8"	0.19	0.19
60"	5"	8"	48"	8"	0.25	0.25
72"	6"	8"	60"	12"	0.24	0.35
84"	8"	12"	72"	12"	0.29	0.39
96"	8"	12"	84"	12"	0.29	0.39

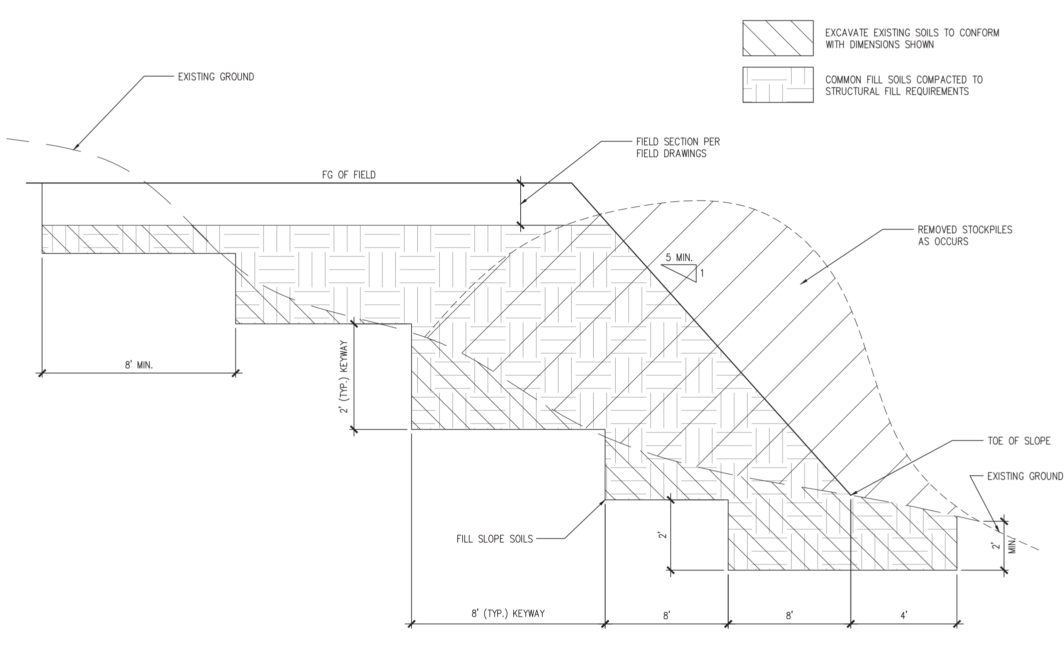
PIPE ALLOWANCES					
CATCH BASIN DIAMETER	PIPE MATERIAL WITH MAXIMUM INSIDE DIAMETER				
	CONCRETE	ALL METAL	CPSSP ①	SOLID WALL PVC ②	PROFILE WALL PVC ③
48"	24"	30"	24"	27"	30"
54"	30"	36"	30"	27"	36"
60"	36"	42"	36"	36"	42"
72"	42"	54"	42"	36"	48"
84"	54"	60"	54"	36"	48"
96"	60"	72"	60"	36"	48"

① CORRUGATED POLYETHYLENE STORM SEWER PIPE (Std. Spec. 9-05.20)
② (Std. Spec. 9-05.12(1))
③ (Std. Spec. 9-05.12(2))

C5 TYPE 2 CATCH BASIN - BASE BID AND ALTERNATE

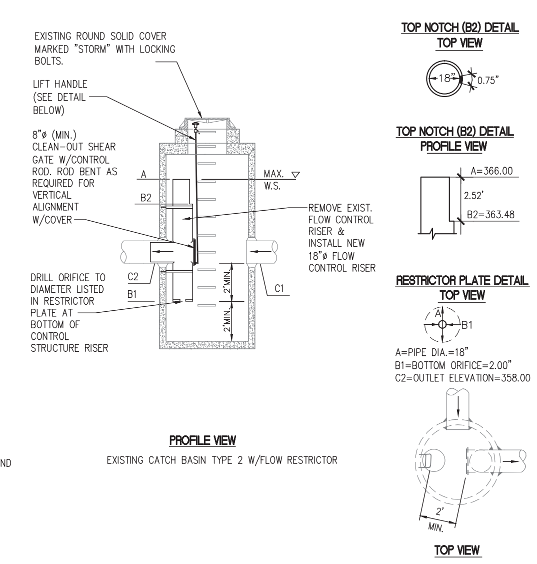
SCALE: N.T.S.

3



E1 EARTHWORK FILL SLOPE CONSTRUCTION - ALTERNATE 5 - FIELDS

SCALE: N.T.S.



CONTROL STRUCTURE										
LOCATION	D (IN.)	B1		B2		A		C1		C2	
		ELEV.	DIAM.	ELEV.		ELEV.	DIAM.	ELEV.	DIAM.	ELEV.	DIAM.
EX. OUTLET CONTROL STRUCTURE	60"	356.00	2"	363.48		366.00	18"	358.00	18"	358.00	18"

NOTES:
1. THE PIPE SUPPORTS AND THE CONTROL STRUCTURE RISER SHALL BE CONSTRUCTED OF THE SAME MATERIAL AND BE ANCHORED AT A MAXIMUM SPACING OF 36". ATTACH THE PIPE SUPPORTS TO THE MANHOLE WITH 5/8" STAINLESS STEEL EXPANSION BOLTS OR EMBED THE SUPPORTS INTO THE CATCH BASIN WALL 2".
2. THE CONTROL STRUCTURE RISER SHALL BE THE SAME DIAMETER AS THE HORIZONTAL OUTLET PIPE
3. THE FLOW RESTRICTOR SHALL BE FABRICATED FROM ONE OF THE FOLLOWING MATERIALS: 0.060" CORRUGATED ALUMINUM ALLOY DRAIN PIPE, 0.060" ALUMINUM ALLOY FLAT SHEET, IN ACCORDANCE WITH ASTM B 209, 5052 H32 OR EPS HIGH DENSITY POLYETHYLENE STORM SEWER PIPE.
5. RESTRICTOR PLATE WITH ORIFICE AS SPECIFIED. THE OPENING IS TO BE CUT ROUND AND SMOOTH.
6. THE SHEAR GATE SHALL BE MADE OF ALUMINUM ALLOY IN ACCORDANCE WITH ASTM B 26 AND ASTM B 275 DESIGNATION ZG32A OR CAST IRON IN ACCORDANCE WITH ASTM A48 CLASS 30B.

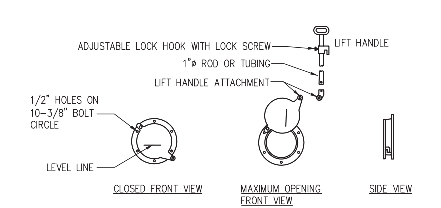
   THE LIFT HANDLE SHALL BE MADE OF A SIMILAR MATERIAL TO THE GATE (TO PREVENT GALVANIC CORROSION). IT MAY BE OF SOLID ROD OR HOLLOW TUBING WITH ADJUSTABLE HOOK AS REQUIRED.

   A NEOPREME RUBBER GASKET IS REQUIRED BETWEEN THE RISER MOUNTING FLANGE AND THE GATE FLANGE.

   INSTALL THE GATE SO THAT THE LEVEL-LINE MARK IS LEVEL WITH THE GATE IS CLOSED.

   THE MATING SURFACES OF THE LID AND THE BODY SHALL BE MACHINED FOR PROPER FIT.

   ALL SHEAR GATE BOLTS SHALL BE STAINLESS STEEL.
7. THE SHEAR GATE MAXIMUM OPENING SHALL BE CONTROLLED BY LIMITED HINGE MOVEMENT, A STOP TAB, OR SOME OTHER DEVICE.
8. ALTERNATIVE SHEAR GATE DESIGNS ARE ACCEPTABLE IF MATERIAL SPECIFICATIONS ARE MET AND FLANGE BOLT PATTERN MATCHES.



SHEAR GATE DETAILS

E3 CONTROL STRUCTURE - ALTERNATE 5 - FIELDS

SCALE: N.T.S.

DETAILS
BASE BID AND ALTERNATES

REVISIONS
3 PR003 MUSIC BUILDING ALTERNATE ACCEPTED

CONFORMED SET

SITTS & HILL ENGINEERS, INC.
CIVIL • STRUCTURAL • SURVEYING
4815 CENTER STREET | TACOMA, WA 98409
PHONE: (253) 474-9449 | FAX: (253) 474-0153
http://www.sitts-hill-engineers.com/

TACOMA SCHOOL DISTRICT
WILSON HIGH SCHOOL
1202 N. ORCHARD ST., TACOMA, WASHINGTON 98406

NAC | ARCHITECTURE

NAC NO.	121-13009
DATE	12-10-2015
DRAWN	JMW
CHECKED	RCH

BASE BID & ALTERNATE - GRADING AND DRAINAGE DETAILS

ALT
C3.14

APPENDIX B

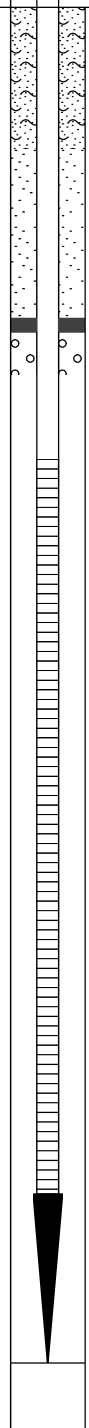
Current Study Exploration Logs and Laboratory Testing Data

associated earth sciences incorporated

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
150387H007	TWH-HA-1/WP	1 of 1

Project Name	Bioretention Hydrologic Performance Study	Location	Tacoma, WA
Elevation (Top of Well Casing)	98.8 (Project Datum)	Surface Elevation (ft)	96.1 (Project Datum)
Water Level Elevation	Dry	Date Start/Finish	10/3/18,10/3/18
Drilling/Equipment	Hand Auger	Hole Diameter (in)	4 inches
Hammer Weight/Drop	N/A		



Depth (ft)	Water Level	WELL CONSTRUCTION	S T	Blows/ 6"	Graphic Symbol	DESCRIPTION
		Organic material and leaf litter 0 to 0.1 feet				**Organic Material and Leaf Litter**
		Bioretention soil mix 0.1 to 0.5 feet Silica sand 0.5 to 1.1 feet Threaded steel pipe 1.25-inches I.D. with threaded and vented PVC cap -2.7 to 1.6 feet				**Bioretention Soil Mix** Loose, moist, dark brown, medium SAND, trace silt, trace gravel; massive (SP).
		Layer of filter fabric with extra filter fabric wrapped around well point at 1.1 feet				Layer of filter fabric at 1.1 feet
		Rounded gravel 1.1 to 1.3 feet				**Rounded Drain Rock** Loose, slightly moist, rounded GRAVEL, trace silt (GP).
						Boring terminated at 1.3 feet Well completed at 4.1 feet on 10/3/18. Refusal in gravel. No seepage. Sloughing in gravel. Steel drive point placed in borehole and hand driven with slide hammer to depth of 4.8 feet.
		Stainless steel jacket over stainless steel #60 gauze, welded to perforated steel pipe 1.6 to 4.2 feet				
		Threaded steel pipe 1.25-inches I.D. and drive point 4.2 to 4.8 feet				
5		Note: ~4 inches of "dead space" below bottom of perforated openings and total inside depth. Total inside depth = 7.2 feet.				

Sampler Type (ST):

2" OD Split Spoon Sampler (SPT)	No Recovery	M - Moisture	**Logged by:** ADY
3" OD Split Spoon Sampler (D & M)	Ring Sample	Water Level ()	**Approved by:** JHS
Grab Sample	Shelby Tube Sample	Water Level at time of drilling (ATD)	

associated earth sciences incorporated

Exploration Log

Project Number	Exploration Number	Sheet
150387H007	TWH-HA-2	1 of 1

Project Name: Bioretention Hydrologic Performance Study
Location: Tacoma, WA
Driller/Equipment: Hand Auger
Hammer Weight/Drop: N/A
Ground Surface Elevation (ft):
Datum: N/A
Date Start/Finish: 10/3/18,10/3/18
Hole Diameter (in): 4 inches

Depth (ft)	ST	Samples	DESCRIPTION	Well Completion	Water Level	Blows/6"	Blows/Foot (10 20 30 40)	Other Tests
			Organic Material and Leaf Litter					
		S-1	**Bioretention Soil Mix** Loose, moist, dark brown, medium SAND, trace silt, trace gravel; massive (SP).					
		S-2	**Fill ?** Medium dense, moist, brownish gray, silty, gravelly, fine SAND (SM).					
			Bottom of exploration boring at 1.9 feet. No seepage. No caving.					
5								

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample
- M - Moisture
- Water Level ()
- Water Level at time of drilling (ATD)

Logged by: ADY
Approved by: JHS

Exploration Log

associated earth sciences incorporated

Project Number	Exploration Number	Sheet
150387H007	TWH-HA-3	1 of 1

Project Name	Bioretention Hydrologic Performance Study	Ground Surface Elevation (ft)	
Location	Tacoma, WA	Datum	N/A
Driller/Equipment	Hand Auger	Date Start/Finish	10/3/18,10/3/18
Hammer Weight/Drop	N/A	Hole Diameter (in)	4 inches

Depth (ft)	S T	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Water Level	Blows/6"	Blows/Foot (10 20 30 40)	Other Tests
				Bioretention Soil Mix					
		S-1		Loose, moist, dark brown, medium SAND, trace silt, trace gravel; massive (SP). Filter fabric over rounded drain rock at 1.4 feet.					
				Bottom of exploration boring at 1.4 feet. No seepage. No caving.					
5									

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample
- M - Moisture
- Water Level ()
- Water Level at time of drilling (ATD)

Logged by: ADY
Approved by: JHS

associated earth sciences incorporated

Exploration Log

Project Number	Exploration Number	Sheet
150387H007	TWH-HA-4	1 of 1

Project Name: Bioretention Hydrologic Performance Study
Location: Tacoma, WA
Driller/Equipment: Hand Auger
Hammer Weight/Drop: N/A
Ground Surface Elevation (ft):
Datum: N/A
Date Start/Finish: 10/3/18,10/3/18
Hole Diameter (in): 4 inches

Depth (ft)	S T	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Water Level	Blows/6"	Blows/Foot 10 20 30 40	Other Tests
		S-1		**Bioretention Soil Mix** Loose, moist, dark brown, medium SAND, trace silt, trace gravel; massive (SP). Filter fabric over rounded drain rock at 1.3 feet.					
				Bottom of exploration boring at 1.3 feet. No seepage. No caving.					
5									

Sampler Type (ST):
- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample
- M - Moisture
- Water Level ()
- Water Level at time of drilling (ATD)

Logged by: ADY
Approved by: JHS

associated earth sciences incorporated

Moisture, Ash, and Organic Matter of Peat and Other Organic Soils - ASTM 2974

Date Sampled	Project	Project No.		Soil Description
10/3/2018	Bioretention Hydrologic Performance Monitoring Study	150387 E007		Bioretention soil mix
Tested By	**Location**	**EB/EP No.**	**Depth**	
BN	Onsite- TWH			

Moisture Content

Sample ID	HA-1 (0.1'-0.5')	HA-3 (0.1'-0.5')
Wet Weight + Pan	1034.28	926.99
Dry Weight + Pan	962.62	892.96
Weight of Pan	467.41	426.30
Weight of Moisture	71.66	34.03
Dry Weight of Soil	495.21	466.66
% Moisture	12.6	6.8

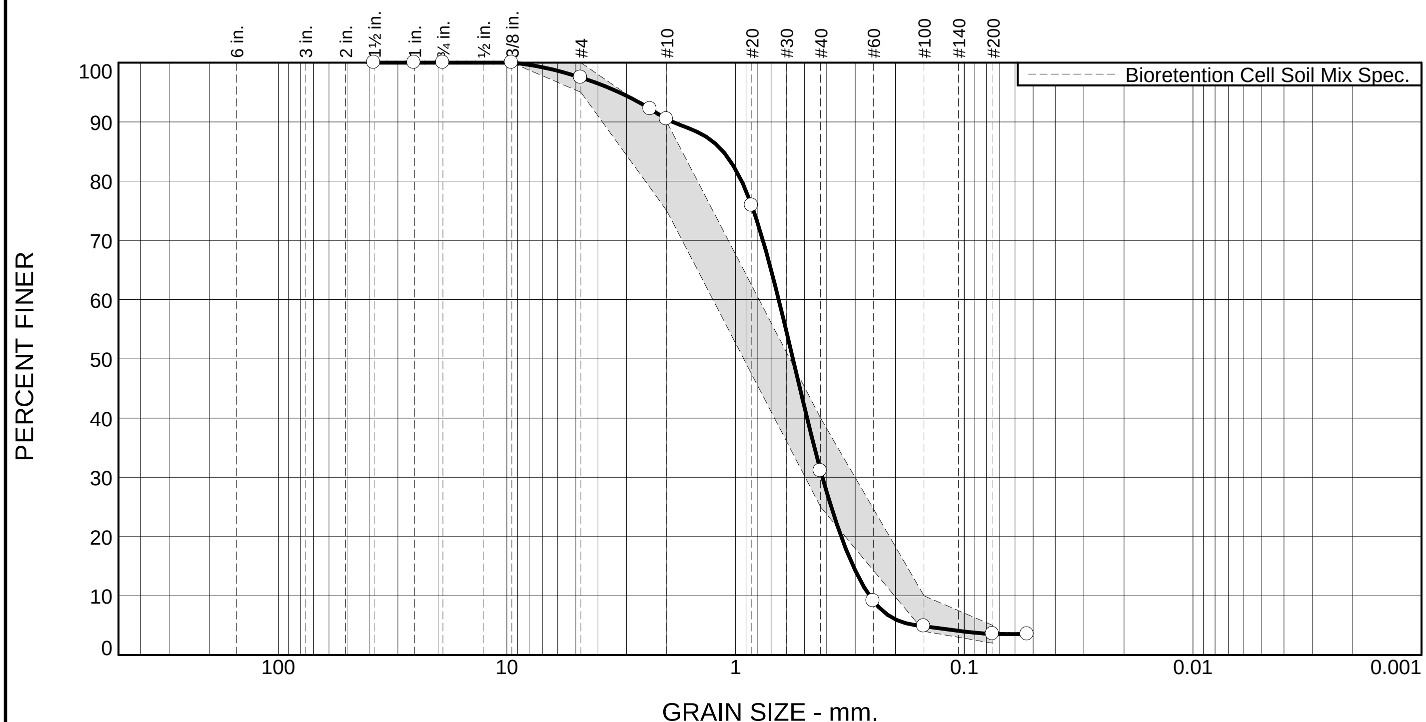
Organic Matter and Ash Content

Dry Soil Befor Burn + Pan	614.75	588.28
Dry Soil After Burn + Pan	599.50	569.91
Weight of Pan	391.92	357.91
Wt. Loss Due to Ignition	15.25	18.37
Actual Wt. Of Soil After Burr	207.58	212.00
% Organics	6.8	8.0

ASSOCIATED EARTH SCIENCES, INC.

911 5th Ave., Suite 100 Kirkland, WA 98033 425-827-7701 FAX 425-827-5424

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	2.5	7.0	59.4	27.5	3.6	

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5	100.0		
1	100.0		
.75	100.0		
.375	100.0	100.0	
#4	97.5	95.0 - 100.0	
#8	92.2		
#10	90.5	75.0 - 90.0	X
#20	75.9		
#40	31.1	25.0 - 40.0	
#60	9.1		
#100	4.9	4.0 - 10.0	
#200	3.6	2.0 - 5.0	
#270	3.5		

* Bioretention Cell Soil Mix Spec.

Material Description

SAND, trace silt, trace gravel

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 1.8867 D_{85}= 1.1338 D_{60}= 0.6482
D_{50}= 0.5616 D_{30}= 0.4173 D_{15}= 0.3059
D_{10}= 0.2596 C_u= 2.50 C_c= 1.04

Remarks

Collected by: ADY

Bioretention soil mix burned first per ASTM D2974 then sieved.

Date Received: 10/03/2018 **Date Tested:** 11/01/2018

Tested By: BN

Checked By: JHS

Title:

Source of Sample: (TWH) Tacoma-Wilson High SChool **Depth:** 0.1'-0.5' **Date Sampled:** 10/03/2018

Sample Number: HA-1

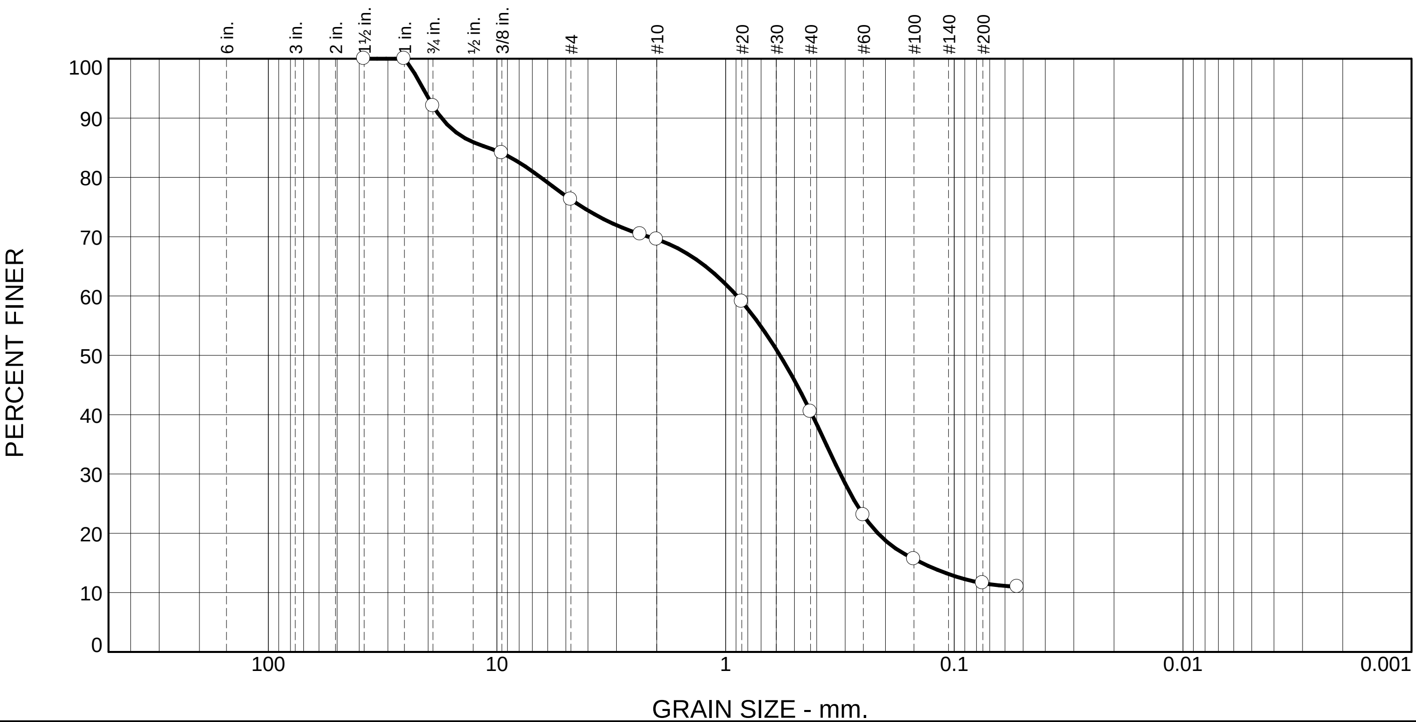
associated earth sciences incorporated

Client: Clear Creek Solutions

Project: Bioretention Hydrologic Performance Study

Project No: 150387 H004 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	8.0	15.7	6.7	29.1	28.9	11.6	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5	100.0		
1	100.0		
.75	92.0		
.375	84.1		
#4	76.3		
#8	70.4		
#10	69.6		
#20	59.1		
#40	40.5		
#60	23.1		
#100	15.7		
#200	11.6		
#270	11.0		

* (no specification provided)

Material Description

gravelly SAND, some silt

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP-SM **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 17.4752 D_{85}= 10.9462 D_{60}= 0.8927
D_{50}= 0.5788 D_{30}= 0.3150 D_{15}= 0.1385
D_{10}= C_u= C_c=

Remarks

Collected by: ADY

Date Received: 12/06/2018 **Date Tested:** 12/11/2018

Tested By: BN

Checked By: JHS

Title:

Source of Sample: (TWH) Tacoma-Wilson High SChool **Depth:** 1.4'-1.9' **Date Sampled:** 10/03/2018

Sample Number: HA-2

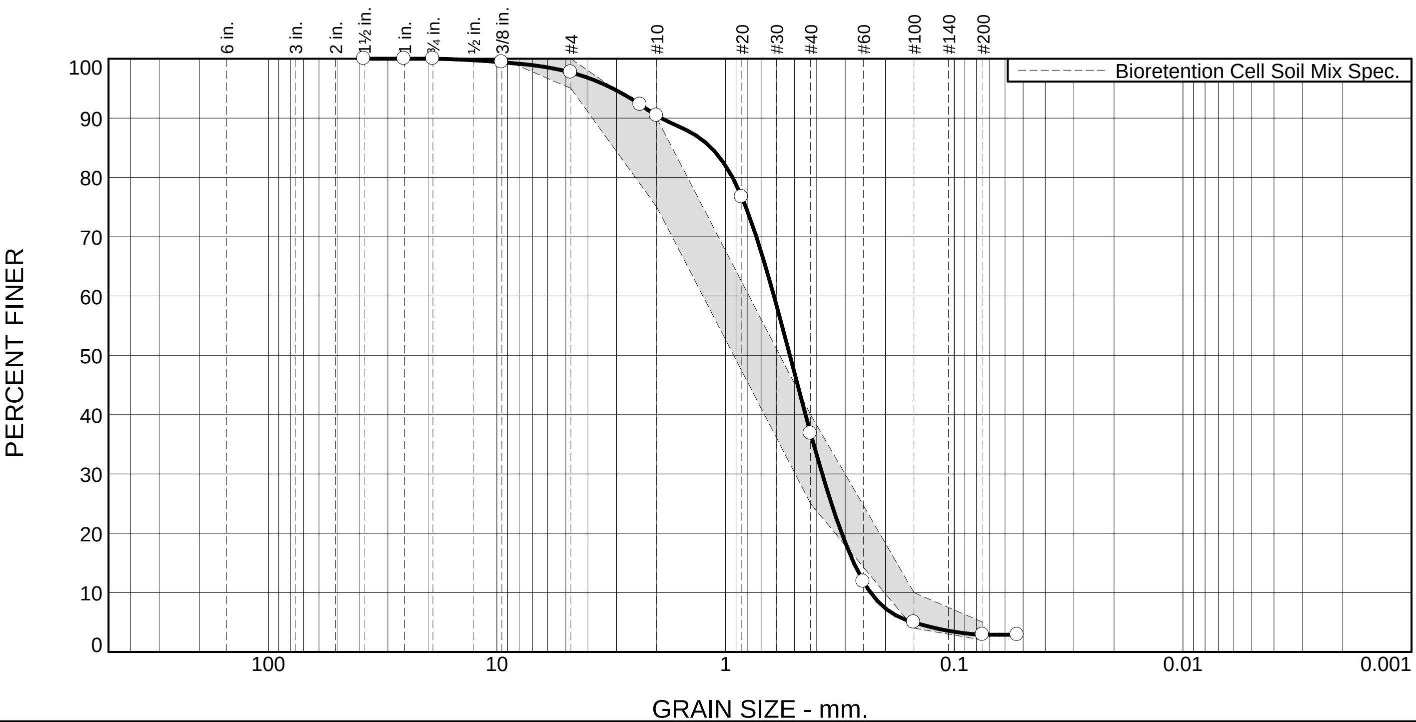
a s s o c i a t e d
e a r t h s c i e n c e s
i n c o r p o r a t e d

Client: Clear Creek Solutions

Project: Bioretention Hydrologic Performance Study

Project No: 150387 H004 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	2.3	7.3	53.5	34.0	2.9	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5	100.0		
1	100.0		
.75	100.0		
.375	99.4	100.0	X
#4	97.7	95.0 - 100.0	
#8	92.3		
#10	90.4	75.0 - 90.0	X
#20	76.7		
#40	36.9	25.0 - 40.0	
#60	11.9		
#100	5.0	4.0 - 10.0	
#200	2.9	2.0 - 5.0	
#270	2.9		

* Bioretention Cell Soil Mix Spec.

Material Description

SAND, trace silt, trace gravel

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 1.9169 D_{85}= 1.1553 D_{60}= 0.6147
D_{50}= 0.5238 D_{30}= 0.3780 D_{15}= 0.2749
D_{10}= 0.2323 C_u= 2.65 C_c= 1.00

Remarks

Collected by: ADY

Bioretention soil mix burned first per ASTM D2974 then sieved.

Date Received: 10/03/2018 **Date Tested:** 11/01/2018

Tested By: BN

Checked By: JHS

Title:

Source of Sample: (TWH) Tacoma-Wilson High SChool **Depth:** 0.1'-0.5' **Date Sampled:** 10/03/2018

Sample Number: HA-3

associated earth sciences incorporated

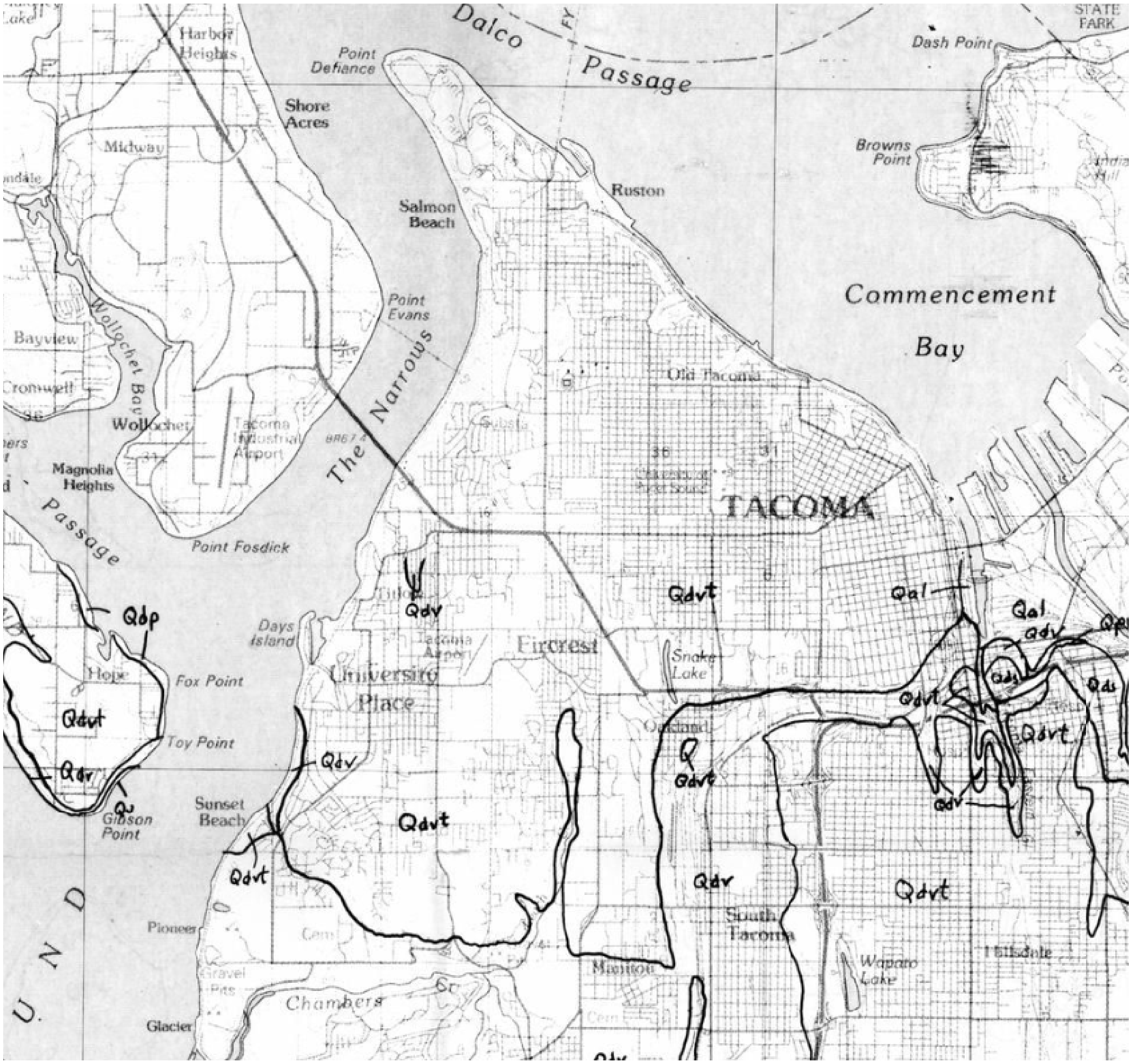
Client: Clear Creek Solutions

Project: Bioretention Hydrologic Performance Study

Project No: 150387 H004 **Figure**

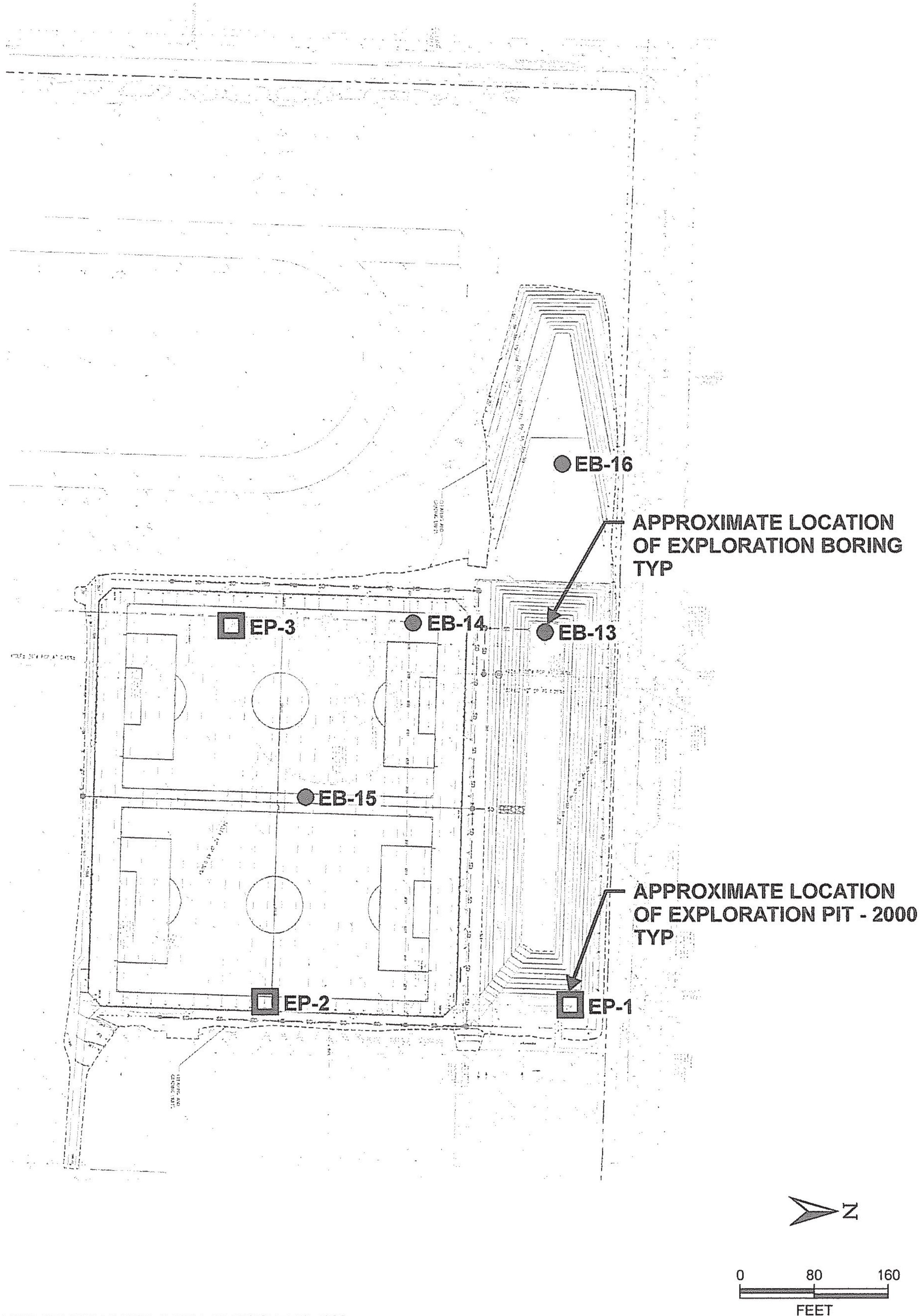
APPENDIX C

Background Soil, Geology, and Groundwater Data (Regional Maps, Previous Studies Exploration Logs and Laboratory Testing Data)



Excerpt from:

Walsh, T. J., 1987, Geologic Map of the south half of the Tacoma quadrangle, Washington, Washington Division of Geology and Earth Resources, Open File Report 87-3, scale 1:100,000.



REFERENCE: NAC ARCHITECTURE / SITTS & HILL ENGINEERS, INC.

Associated Earth Sciences, Inc.

SITE AND EXPLORATION PLAN

WILSON HIGH SCHOOL FIELD RENOVATIONS
TACOMA, WASHINGTON

FIGURE 2

DATE 7/13

PROJ. NO. TE130259A

130259 Wilson HS Field Renovations \ 130259 Site and Explr.cdr

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

Terms Describing Relative Density and Consistency

	Density	SPT (2) blows/foot
Coarse-Grained Soils	Very Loose	0 to 4
	Loose	4 to 10
	Medium Dense	10 to 30
	Dense	30 to 50
	Very Dense	>50

	Consistency	SPT (2) blows/foot
Fine-Grained Soils	Very Soft	0 to 2
	Soft	2 to 4
	Medium Stiff	4 to 8
	Stiff	8 to 15
	Very Stiff	15 to 30
	Hard	>30

Test Symbols

G = Grain Size
M = Moisture Content
A = Atterberg Limits
C = Chemical
DD = Dry Density
K = Permeability

Component Definitions

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

(3) Estimated Percentage

Component	Percentage by Weight
Trace	<5
Few	5 to 10
Little	15 to 25
With	- Non-primary coarse constituents: ≥ 15% - Fines content between 5% and 15%

Moisture Content

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

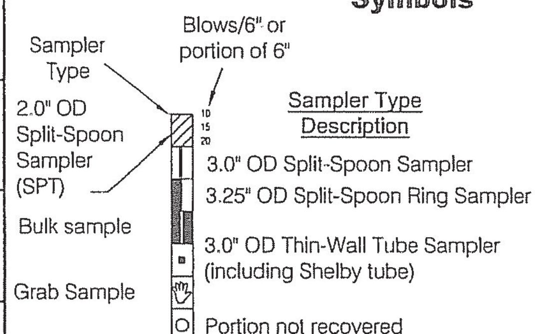
Slightly Moist - Perceptible moisture

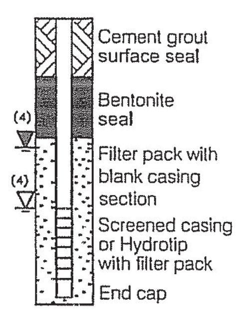
Moist - Damp but no visible water

Very Moist - Water visible but not free draining

Wet - Visible free water, usually from below water table

Symbols





(1) Percentage by dry weight
(2) (SPT) Standard Penetration Test (ASTM D-1586)
(3) In General Accordance with Standard Practice for Description and Identification of Soils (ASTM D-2488)
(4) Depth of ground water
▼ ATD = At time of drilling
▽ Static water level (date)
(5) Combined USCS symbols used for fines between 5% and 15%

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

blockslog_key.dwg LAYOUT: Layout2

Associated Earth Sciences, Inc.

EXPLORATION LOG KEY

FIGURE A1

LOG OF EXPLORATION PIT NO. EP-1

Depth, ft	This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplification of actual conditions encountered. DESCRIPTION
	Sod
1	**Lodgement Till** Medium dense to dense, gray, moist, SAND with GRAVEL, little silt (SP); becomes very dense and SILTY with scattered cobbles below 3 1/2' (SM).
2	
3	
4	
5	
6	
7	
8	
9	Bottom of exploration pit at depth 8 feet No seepage, no caving.
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	

KCTP3 00077.GPJ February 23, 2000

Wilson High School
Tacoma, Washington

Logged by: TJP
Approved by: TJP

ASSOCIATED EARTH SCIENCES, INC

Project No. KE00077G
Feb 23, 2000

LOG OF EXPLORATION PIT NO. EP-2

This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplification of actual conditions encountered.

Depth, ft	DESCRIPTION
	Sod
	Lodgement Till
1	Dense, moist, gray SILTY SAND with GRAVEL (SM); contains scattered cobbles, becomes very dense below 4'.
2	
3	
4	
5	
6	
7	
8	
9	Bottom of exploration pit at depth 8 feet No seepage, no caving.
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	

Wilson High School
Tacoma, Washington

Logged by: TJP

Approved by: TJP

ASSOCIATED EARTH SCIENCES, INC

Project No. KE00077G

Feb 23, 2000

LOG OF EXPLORATION PIT NO. EP-3

Depth, ft	This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplification of actual conditions encountered. DESCRIPTION
	Sod
	Fill
1	Medium dense, very moist, brown, SILTY SAND with GRAVEL (SM); contains abundant sticks and branches.
2	
3	**Weathered Recessional Outwash**
4	Loose, wet, brown, SILTY SAND, little gravel (SM); contains roots.
5	**Recessional Outwash**
	Stiff, gray with rust mottling, SILT, little fine sand, low plasticity (ML); contains abundant rootlets.
6	**Lodgement Till**
7	Very dense, moist, grayish-brown, SILTY SAND with GRAVEL (SM).
8	
9	Bottom of exploration pit at depth 8 feet Slow seepage 3'-5', no caving.
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	

KCTF3 00077.GPJ February 23, 2000

Wilson High School
Tacoma, Washington

Logged by: TJP
Approved by: TJP

ASSOCIATED EARTH SCIENCES, INC

Project No. KE00077G
Feb 23, 2000

Associated Earth Sciences, Inc.

Exploration Log

Project Number	Exploration Number	Sheet
TE130259A	EB-13	1 of 1

Project Name	Wilson High School Field Renovations	Ground Surface Elevation (ft)	370
Location	Tacoma, WA	Datum	N/A
Driller/Equipment	Geologic Drill / Mini-Track Rig	Date Start/Finish	6/27/13,6/27/13
Hammer Weight/Drop	140# / 30"	Hole Diameter (in)	6 inches

Depth (ft)	Samples	DESCRIPTION	Blows/6"	Blows/Foot
		Sod		
		Fill		
		Loose, moist, gray to brown, fine to medium SAND, with fine gravel, trace silt (SM).		
	S-1	Medium dense, moist, gray to brown, fine to medium SAND, with fine gravel, few silt, rootlets and moderate organics (SM).	7 10 10	20
5	S-2	Loose, moist, brown, fine to medium SAND, with silt, few gravel, abundant organics (SM).	5 3 4	7
		Old Topsoil Horizon		
		Loose, moist, brown to dark brown, fine to medium SAND, with silt, few gravel, moderate rootlets (SM).		
		Vashon Recessional Outwash		
	S-3	Soft, moist to very moist, brown to gray, SILT, few fine sand; weathered (ML).	3 2 2	4
10	S-4	Medium dense, moist, gray, fine to medium SAND, trace silt; stratified (SM).	7 8 9	17
		Vashon Lodgement Till		
		Harder drilling.		
15	S-5	Very dense, moist, gray, fine to medium SAND, with silt and gravel (SM).	22 50/6"	72/12"
		Bottom of exploration boring at 16 5 feet No ground water encountered.		

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample
- M - Moisture
- Water Level ()
- Water Level at time of drilling (ATD)

Logged by: MIL
Approved by:

Associated Earth Sciences, Inc.

Exploration Log

Project Number	Exploration Number	Sheet
TE130259A	EB-14	1 of 1

Project Name	Wilson High School Field Renovations	Ground Surface Elevation (ft)	370
Location	Tacoma, WA	Datum	N/A
Driller/Equipment	Geologic Drill / Mini-Track Rig	Date Start/Finish	6/27/13,6/27/13
Hammer Weight/Drop	140# / 30"	Hole Diameter (in)	6 inches

Depth (ft)	Samples	DESCRIPTION	Blows/6"	Blows/Foot
		Sod		
		Fill		
		Loose, moist, gray to brown, fine to medium SAND, with fine gravel, trace silt (SM).		
	S-1	Loose to medium dense, moist, brown to dark brown, fine to medium SAND, few silt, trace gravel, moderate rootlets and organics (SM).	12 8 5	13
5		**Old Topsoil Horizon**		
	S-2	Loose, moist, brown, fine to medium SAND, with fine gravel, few silt, minor rootlets (SM).	4 9 14	23
		Vashon Lodgement Till		
		Medium dense, moist, gray, fine to medium SAND, with silt (SM). Cobbles.		
	S-3	Dense, moist, gray, fine to medium SAND, with silt and gravel, trace cobbles; blowcounts overstated due to obstruction (SM).	50/6"	50/6"
10	S-4	Dense, moist, gray, fine to medium SAND, with silt and gravel, trace cobbles (SM).	9 19 26	45
		Bottom of exploration boring at 11 5 feet No ground water encountered		
15				

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample
- M - Moisture
- Water Level ()
- Water Level at time of drilling (ATD)

Logged by: MIL
Approved by:

Associated Earth Sciences, Inc.	Exploration Log		
	Project Number TE130259A	Exploration Number EB-15	Sheet 1 of 1

Project Name	Wilson High School Field Renovations	Ground Surface Elevation (ft)	370
Location	Tacoma, WA	Datum	N/A
Driller/Equipment	Geologic Drill / Mini-Track Rig	Date Start/Finish	6/27/13,6/27/13
Hammer Weight/Drop	140# / 30"	Hole Diameter (in)	6 inches

Depth (ft)	S T	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Water Level	Blows/6"	Blows/Foot (10 20 30 40)	Other Tests
				Sod					
				Fill					
				Loose, moist, gray to brown, fine to medium SAND, with fine gravel, trace silt (SM).					
				Medium dense, moist, gray, fine to medium SAND, with silt, few gravel (SM).					
		S-1					9 10 11	21	
				Rootlets.					
5				Medium dense, moist, orang brown to gray, fine to medium SAND, with silt and gravel, minor organics (SM).					
		S-2					3 3 7	10	
				Vashon Lodgement Till					
				Harder drilling. Very dense, moist, gray, fine to medium SAND, with silt and gravel (SM).					
		S-3					28 30 29	59	
				Bottom of exploration boring at 9 feet No ground water encountered					
10									
15									

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample
- M - Moisture
- Water Level ()
- Water Level at time of drilling (ATD)

Logged by: MIL
Approved by:

Associated Earth Sciences, Inc.

Exploration Log

Project Number	Exploration Number	Sheet
TE130259A	EB-16	1 of 1

Project Name	Wilson High School Field Renovations	Ground Surface Elevation (ft)	382
Location	Tacoma, WA	Datum	N/A
Driller/Equipment	Geologic Drill / Mini-Track Rig	Date Start/Finish	6/27/13,6/27/13
Hammer Weight/Drop	140# / 30"	Hole Diameter (in)	6 inches

Depth (ft)	S T	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Water Level	Blows/6"	Blows/Foot (10 20 30 40)	Other Tests
				Fill					
				Medium dense, moist, brown, fine to medium SAND, with fine gravel, trace silt (SM).					
				Medium dense, moist, brown, fine to medium SAND, with gravel, few cobbles and silt (SM).					
				Vashon Lodgement Till					
		S-1		Dense, moist, gray, fine to medium SAND, with silt and gravel (SM).			3 18 26	▲44	
5				Very dense, moist, gray, fine to medium SAND, with silt and gravel (SM).					
		S-2					9 25 34	▲59	
		S-3		Very dense, moist, gray, fine to medium SAND, with silt and gravel, few cobbles; blowcount overstated due to cobbles (SM).			50/6"	▲50/6"	
				Bottom of exploration boring at 9 feet No ground water encountered					
10									
15									

Sampler Type (ST):

2" OD Split Spoon Sampler (SPT) | No Recovery | M - Moisture | **Logged by:** MIL

3" OD Split Spoon Sampler (D & M) | Ring Sample | Water Level () | **Approved by:**

Grab Sample | Shelby Tube Sample | Water Level at time of drilling (ATD)

APPENDIX D

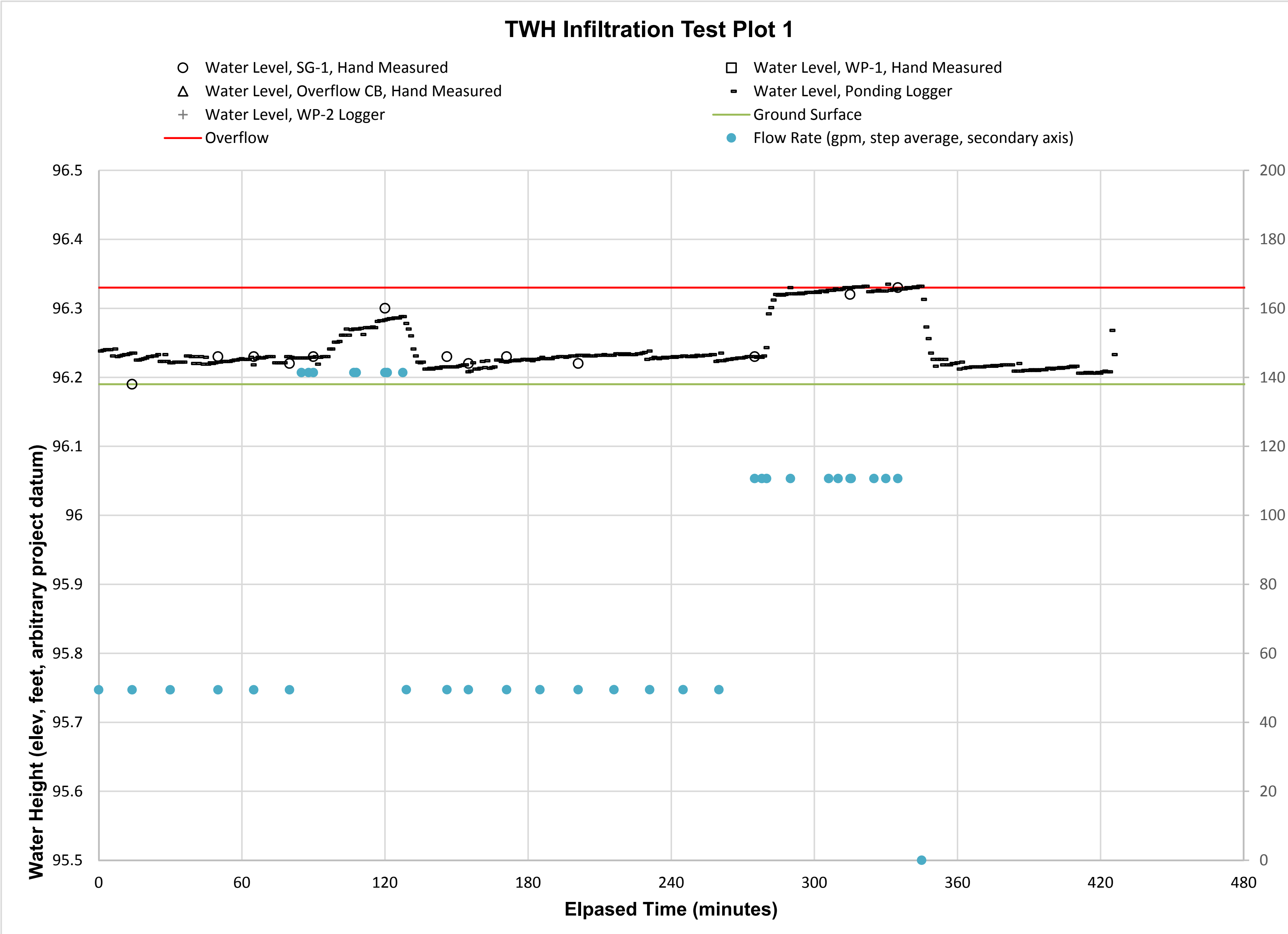
Soil Probe, Level Survey, and Field Infiltration Testing Data

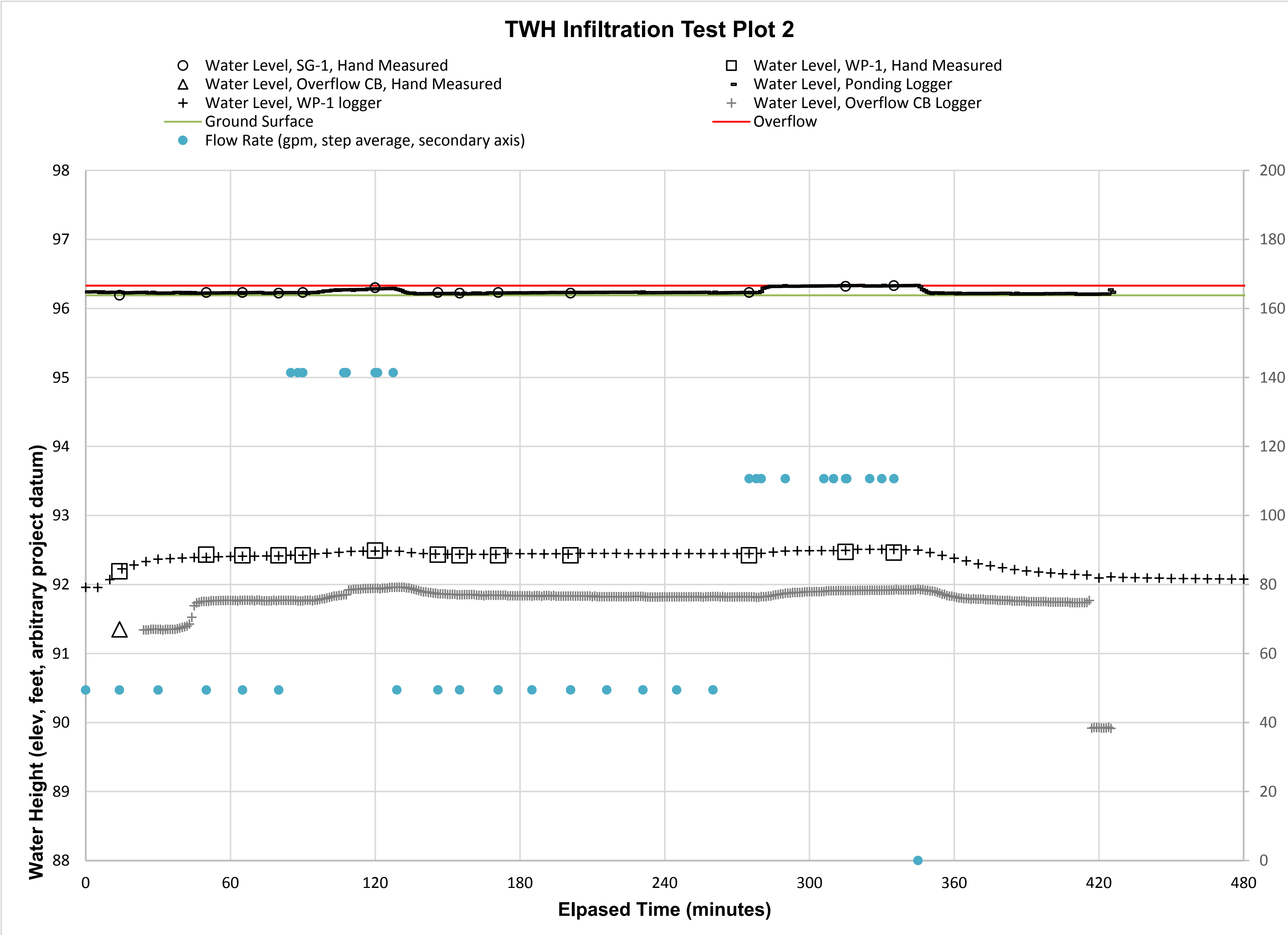
Project Name:	BHPS	**Water Source:**	Hydrant
Project Number:	150387H007	**Meter:**	AESI FM5, 9
Date:	11/19/2018	**Base Area (sq.ft.):**	NA
Weather:	Partly cloudy, 60's	**Ponded Area(sq.ft.):**	850.0
Test No.:	TWH	**Test Depth (feet):**	NA
Performed By:	ADY, SC	**Receptor Soils:**	Vashon lodgment till

Time (24-hr)	**Flow Rate (gpm)**	**Stage (feet)**	**Totalizer (gallons)**	**Comments**
8:55	49.7	0	0	Flow on from hydrant.
9:09	49.3	0	693.86	
9:25	49.3	0	1458	FM9 discharge located by SG-1/WP-1
9:45	49.4	0.04	2460	
10:00	49.5	0.04	3220	
10:15	49.2	0.03	3936	Flow observed from underdrain pipes.
10:20	135.7			Flow on FM5 from water truck at approx 98 gpm, discharge near center of facility.
10:23	147.1			No observed discharge into detention pond.
10:25		0.04		
10:42		0.05		
10:43				
10:55		0.11		
10:56				
11:02				Water truck empty. Leaves site to refill.
11:04	49.4	0.09		
11:21	49.2	0.04		
11:30	49.7	0.03		
11:46	49.5	0.04		
12:00	49.5	0.03		Only West underdrain pipe active.
12:16	49.2	0.03		
12:31	49.6	0.04		
12:46	49.4	0.04		
13:00	49.6	0.04		
13:15	49.5	0.04		
13:30		0.04	17547	Water truck returned, flow on from water truck at approx 60 gpm. Discharge near SG-1/WP-1.
13:33	108.9			
13:35	109.4			
13:45	112.5	0.08		No observed flow into detention pond.
14:01	111.7	0.13		

14:05				
14:10	111.2	0.13		
14:10				
14:20	110.9	0.14	22979	
14:25	110.4	0.14	23544	
14:30	110.3	0.14	24137	
14:35		0.14		No observed flow into detention pond.
14:40	0.0	0.14	25123	Water truck empty. All flow off.
14:40:20		0.11		
14:40:45		0.1		
14:41:00		0.09		
14:41:15		0.08		
14:41:35		0.07		
14:41:50		0.06		
14:42:20		0.05		
14:43:30		0.02		
14:44:30		dry		
15:01:00				
15:51:00				
15:57:00				

Average Infiltration Rate (in/hr) during last hour of inflow:	11
Average Infiltration Rate (in/hr) during falling head:	25


TWH Infiltration Test Plot 1
Water Level, SG-1, Hand Measured
Water Level, Overflow CB, Hand Measured
Water Level, WP-2 Logger
Overflow
Water Level, WP-1, Hand Measured
Water Level, Ponding Logger
Ground Surface
Flow Rate (gpm, step average, secondary axis)
Water Height (elev, feet, arbitrary project datum)
Elpased Time (minutes)
96.5
96.4
96.3
96.2
96.1
96
95.9
95.8
95.7
95.6
95.5
0
60
120
180
240
300
360
420
480
200
180
160
140
120
100
80
60
40
20
0


TWH Infiltration Test Plot 2
Water Level, SG-1, Hand Measured
Water Level, Overflow CB, Hand Measured
Water Level, WP-1 logger
Ground Surface
Flow Rate (gpm, step average, secondary axis)
Water Level, WP-1, Hand Measured
Water Level, Ponding Logger
Water Level, Overflow CB Logger
Overflow
Water Height (elev, feet, arbitrary project datum)
98
97
96
95
94
93
92
91
90
89
88
200
180
160
140
120
100
80
60
40
20
0
0
60
120
180
240
300
360
420
480
Elpased Time (minutes)

APPENDIX E

Site Photos

Above photo is overview of cell TWH prior to start of infiltration test.
Lower photo shows the energy dispersion pads for the two inlets and the well point.

Above photo: TWH, underdrain cleanouts and well point.
Lower Photo: overflow structure.

associated earth sciences incorporated

Technical Memorandum

Date:	June 14, 2019	**From:**	Anton Ympa Suzanne Cook, L.G.
To:	Clear Creek Solutions, Inc.	**Project Manager:**	Jennifer H. Saltonstall, L.G., L.Hg.
	15800 Village Green Drive #3 Mill Creek, Washington 98012	**Principal in Charge:**	Jennifer H. Saltonstall, L.G., L.Hg.
cc:	Eric Christensen	**Project Name:**	Bioretention Hydrologic Performance Study
Attn:	Doug Beyerlein, P.E.	**Project No:**	150387H007
Subject:	Deliverable Task 4.5, Site M1C, Geotechnical/Soils Assessment Design Data and Current Conditions, 1st Street Low Impact Development Project, Marysville, Washington		

1.0 INTRODUCTION

This technical memorandum documents existing shallow soil and groundwater conditions in cell S-1 of the City of Marysville, 1st Street Low Impact Development Project , located in the city of Marysville, Washington (Figure M1C F1). This memorandum was prepared in accordance with Task 4 of the contract scope of work. Associated Earth Sciences, Inc. (AESI) collected shallow soil and groundwater conditions data related to bioretention cell function, and documented the current condition of the facility relative to the as-built drawings and available background geotechnical information. The information will be used in the WWHM2012 modeling that will be conducted as part of Task 5 (Data Analysis). In Task 5, the team will compare the previously documented hydrologic design information with our field-collected information and will note where there are significant differences. The purpose of this technical memorandum is to document the collection of current and accurate geotechnical, geologic, and hydrogeologic site information for this later work.

The following summary of shallow soil and groundwater conditions integrates the observations made during the geotechnical assessment which included site visits on October 18, 2018, infiltration testing on November 20, 2018, provisional results of hydrologic monitoring, and background geotechnical information.

This technical memorandum has been prepared for the exclusive use of Clear Creek Solutions and the City of Olympia and their agents for specific application to this project. Within the limitations of scope, schedule, and budget, our services have been performed in accordance with generally accepted hydrogeologic and geotechnical engineering practices in effect in this area at the time our document was prepared. No other warranty, express or implied, is made.

2.0 PURPOSE AND SCOPE

The purpose of our work was to perform a shallow soil and groundwater conditions assessment and provide baseline documentation data to assess effectiveness of bioretention hydrologic performance.

Specifically, our scope included the following activities:

- Review of project documents.
- Site reconnaissance.
- Visual condition assessment of erosion and deposition features near inlet and outlet.
- Review project plans relative to constructed facility, in particular, the number and location of inlets, energy dissipation devices, outlets, and other flow-related details.
- Survey elevations of inlet, outlet, well point rim, and other observation points relative to a project datum.
- Excavate shallow hand augers through the bioretention soil.
- Classify sediment according to the Unified Soil Classification System (USCS) and *American Society for Testing and Materials* (ASTM) D2488, "Standard Recommended Practice for Description of Soils."
- Collect samples for laboratory testing of: (1) particle size distribution in accordance with ASTM D422-63, "Standard Test Method for Particle-Size Analysis of Soils"; (2) organic matter content per ASTM D2974.
- Preparation of descriptive exploration logs for each exploration.
- Conduct qualitative assessment of soil compaction via T-probe.
- Conduct infiltration testing.
- Review of hydrologic monitoring data.
- Preparation of this summary document.

Existing facility features and the locations of hand-auger boreholes completed for this study are shown on Figure M1C F2, "Facility and Exploration Plan." Project civil plans are attached as Appendix A. Exploration logs and laboratory testing data conducted as part of this study are attached as Appendix B. Background soil, geology, and groundwater information are attached as Appendix C. Soil probe, level survey, and field infiltration testing data are attached as Appendix D. Site photos are attached as Appendix E.

3.0 SITE DESCRIPTION AND DESIGN BACKGROUND

The project site is the City of Marysville, 1st Street Low Impact Development Project, located in Marysville, Washington as shown on the attached "Vicinity Map" (Figure M1C F1). The site is bordered by undeveloped City property and Ebey Slough to the south and commercial buildings to the north. Site topography is generally flat. The site is located about 65 feet north of Ebey Slough, a tributary of the Snohomish River system that discharges directly to Puget Sound to the west. Per the Washington State Source Water Assessment Program Mapping Application, the site is not located within a time of travel zone for any Group A water system.

Our specific area of study for this project includes bioretention facility Cell S-1. Cell S-1 is located along the south side of 1st Street, east of Cedar Avenue, referred to as cell M1C for this study. The cell was relocated approximately 100 feet east from predesign plans (Gray & Osborne, Inc. [G&O], 2014) to the 2017 plans (G&O, 2017) and the built condition. The attached "Facility and Exploration Plan" (Figure M1C F2) illustrates the cell area and some of the surrounding site features and utilities from the 2017 plans and the built condition.

Details of the bioretention facility design and basis for design were presented in the following documents:

- "Geotechnical Report First and Third Street Retrofit, Marysville, Washington, G&O IPN #13587," Prepared by PanGEO, Inc. for Gray & Osborne, Inc., dated March 4, 2014.
- "Geotechnical Design Recommendations 3rd Street Retrofit," Marysville, Washington, PanGEO, Inc., December 31, 2013.
- "City of Marysville, 1st and 3rd Stormwater Retrofit Project Predesign Report", prepared by Gray & Osborne, Inc., January 2014.
- "City of Marysville, 1st Street Low Impact Development Project," Gray & Osborne, Inc., June 2017 (plan set).

3.1 Summary of Facility Design

From our review of these documents, the bioretention facility design for cell M1C consists of a rectangular-shaped bioretention cell with approximately 130 square feet of base area surrounded by bioretention barrier curb set in a concrete sidewalk, as shown on Figure M1C F2, "Facility and Exploration Plan." We understand that the site was developed under the Washington State Department of Ecology (Ecology) 2014 *Stormwater Management Manual for Western Washington* (2014 Ecology Manual) for design and construction of stormwater facilities and modeled using WWHM2012 with a design infiltration rate of 2 inches per hour (in/hr) in the native subgrade. Land use within the drainage basin is primarily roadway, sidewalk, and commercial rooftops and pavement. Per "1st Street Low Impact Development Project, Road and Storm Plan and Profile," Sheet 18 of 25 (G&O, 2017), the facility design includes 2 inches of mulch overlying 18 inches of bioretention soil mix overlying existing native soil.

The facility is designed to infiltrate 100 percent of inflow into the native subgrade. Stormwater enters the facility through one curbcut from 1st Street and four small sidewalk curb notches. If water ponds up on the bioretention soil, the ponded water would discharge into an 8-inch polyvinyl chloride (PVC) overflow riser with an 8-inch Nyloplast dome grate located near the center of the cell, and then into an 8-inch lateral PVC overflow pipe. The rim of the overflow riser was designed to be 6 inches higher than the cell base to create 6 inches of ponding depth. The facility was constructed spring 2018.

4.0 SITE OBSERVATIONS

During AESI's site visits, we made notes regarding the physical construction of the bioretention facility including documenting site inlet/outlet layout relative to site plans and qualitative bioretention soil thickness and compaction. These notes were used to indicate key features of the facility in Figure M1C F2, "Facility and Exploration Plan."

- Level Survey: AESI conducted an elevation survey of the cell using a Leitz C40 automatic level and a stadia rod. An arbitrary project datum was established for this survey, with the southwest curb corner of cell S-1 defined as project datum elevation 100 feet. All other elevations measured by the survey are relative to this project datum. Key level data is summarized in Table 1. Additional data points are included in Appendix D to this document. This survey was not conducted by a licensed surveyor. Surveyed elevations are expected to be sufficiently accurate for this general assessment of facility construction, but may be inaccurate for purposes requiring greater precision.

- Inflow: One curbcut from 1st Street and four sidewalk curb notches.
    - The primary curbcut to the facility is a 24-inch curbcut consistent with project plans, which discharges onto a concrete pad approximately 1 foot long by 2 feet wide. Quarry spall splash pads surrounding the concrete pad indicated on plans were not observed.

    - Four small curb notches on the south side of the facility drain runoff from the sidewalk to the facility. The notches are approximately 4 inches wide, are consistent with project plans, and each discharge onto a 1-foot by 2-feet concrete pad.

- Overflow: The overflow consists of an 8-inch PVC overflow riser with an 8-inch Nyloplast dome grate. The rim of this grate was approximately 6.4 to 6.6 inches above the base of the facility. The overflow riser conveys water to an 8-inch lateral overflow pipe that connects to additional bioretention cells in a line to the east, and then ties into existing storm catch basin.

- AESI investigated the loose bioretention soil thickness present in cell M1C using a geotechnical soil T-probe. This qualitative data was used in conjunction with the hand-auger observations to understand loose soil thickness and relative potential compactness of the bioretention soils at depth. AESI measured the depth of penetration of the soils probe at locations generally arranged in a 2-foot to 4-foot grid on the facility base. Penetration of the T-probe generally ranged from approximately 1.3 to 1.8 feet, and averaged 1.7 feet. Probe penetration data is included in Appendix D to this document.

Table 1
Summary of Cell M1C
Level Survey Data

Location	Elevation (feet, project datum)
Bioretention barrier curb top SW corner	100.00
Bioretention barrier curb top NW corner	100.03
Bioretention barrier curb top NE corner	99.78
Bioretention barrier curb top SE corner	99.71
Curb notch (W)	99.66
Curb notch (center west)	99.57
Curb notch (center east)	99.48
Curb notch (E)	99.38
Curbcut Inlet (W)	98.96
Curbcut Inlet (center)	98.98
Curbcut Inlet (E)	98.95
WP-1 TOC	99.58
WP-2 TOC	99.28
Ponding tube TOC (DL)	98.45
Top/end 8" temporary inlet pipe	99.18
8" PVC overflow rim	98.38

WP: well point; TOC: top of casing; PVC: polyvinyl chloride; DL: datalogger

5.0 SITE SETTING

The text sections below describe our research findings in regard to the topographic, geologic, and hydrogeologic setting of the project site both from regional studies and background site-specific geotechnical and groundwater studies. Our sources of information included the following:

- Site-specific documents cited previously under “Project and Site Description.”
- Minard, J.P., 1985, *Geologic Map of the Marysville Quadrangle, Snohomish County, Washington*: U.S. Geological Survey, Miscellaneous Field Studies Map MF-1743, scale 1:24,000.
- Natural Resources Conservation Service (NRCS), Web Soil Survey, United States Department of Agriculture (USDA), http://websoilsurvey.nrcs.usda.gov/, accessed January 2019.
- *Soil Survey of Snohomish County Area, Washington*, United States Department of Agriculture (USDA), Natural Resource Conservation Service (NRCS), in cooperation with Washington Agricultural Experiment Station, 1983.
- Newcomb, R.C., 1952, *Ground-water Resources of Snohomish County, Washington*: U.S. Geological Survey, Water-Supply Paper 1135, scale 1:62,500.

5.1 Regional Topography and Project Grading

The project site is situated at low-lying topography along the Ebey Slough, part of the Snohomish River flats. The Snohomish River and Ebey Slough empty into Possession Sound approximately 2 miles southwest of the project. Elevations on the larger project site range from about 10 to 30 feet.

On a closer scale, the area near cell M1C is relatively level, situated on an outwash plain at about elevation 15 to 20 feet. Cell M1C is located about 65 feet north of Ebey Slough, which is below 10 feet elevation. Relatively level pavement of 1st Street and sidewalks surround the cell. A curb separates the paved surfaces from the cell. A gentle slope rises on the west toward Cedar Avenue and railroad tracks.

The project site was previously undeveloped right-of-way adjacent to a boat storage/marina (since removed). The right-of-way improvements included new pavements, curbs, sidewalks and the bioretention elements. Various utilities are present in the vicinity of the site, including a buried water main. Minor cutting of less than 5 feet were needed to achieve design bioretention cell grades based on a review of existing topography compared with built topography.

5.2 Regional Geology and Background Geotechnical Information

According to a regional geology map (Minard, 1985), the site vicinity is underlain by Vashon recessional outwash. Recessional outwash sediments in the project area are described on the referenced map to consist of outwash sand with some fine gravel and beds of silt and clay deposited from meltwater streams (Minard, 1985), which is consistent with our observations and interpretations of subsurface materials encountered in our explorations for this project.

- <u>Vashon Recessional Outwash (Qvr)</u>: This unit is composed of stratified to massive outwash sand with some fine gravel and beds of silt and clay. Recessional outwash in the project area was deposited by glacial meltwater streams during ice retreat (Minard, 1985) and has not been glacially overridden.

Background geotechnical information includes exploration logs B-1 and B-2 within 135 feet and 235 feet, respectively, of cell M1C dated November 25, 2013. Borings B-1 and B-2 reached depths of about 14 feet below current grades, and describe material generally consisting of loose to medium dense, laminated, silty sand to sand with trace to some silt interpreted to be recessional outwash (PanGEO, Inc., 2014), which is consistent with the geologic mapping in the area. Shallow fill soils were encountered to depths of up to 7 feet.

5.3 Regional Soils and Soil Data Used in Site Stormwater Model

AESI reviewed the soil survey (Natural Resources Conservation Service [NRCS], 1983) and soils mapping from the NRCS web portal (NRCS, 2018). The soil survey identifies different soil map units based on parent material, climate, topography (slope), organisms (biota), and time. The soils in the study area formed mostly from young glacial deposits and have not had time to develop the deep weathering profiles present in soils in unglaciated terrains. Instead, they exhibit a direct relationship to the underlying parent material, local climate, topography, and vegetation.

Mapped soils in the project area consist of Ragnar fine sandy loam (NRCS, 2018). This very deep, well-drained soil is situated on outwash plains and formed in glacial outwash. NRCS describes the permeability as moderately rapid (NRCS, 1983).

As described in the predesign report (G&O, 2014), the pre-developed condition was modeled as 100 percent impervious (roads, flat), consistent with the existing drainage area condition and background geotechnical data.

5.4 Regional Hydrogeology and Background Groundwater Data

Regional hydrogeology is described by Newcomb (1952). The coastal lowlands often represent hundreds of feet of glacial and alluvial deposits backfilled into ancestral drainage systems. Outwash sands below the local water table carry large quantities of groundwater and alluvial materials in river valleys are good aquifers in the lower Snohomish Valley (Newcomb, 1952).

Within the vicinity of cell M1C, groundwater was encountered within sediments identified as Vashon recessional outwash (PanGEO, Inc., 2014). The shallow aquifer identified is interpreted to be in hydraulic conductivity locally with river valley aquifers of the Snohomish River and Ebey Slough. Limited background groundwater level data was collected at B-1 and B-2; groundwater ranged from approximately 4 to 8 feet below ground surface between November 2013 and January 2014 (PanGEO, Inc., 2014). Hydrographs are included in Appendix C.

6.0 BIORETENTION CELL SUBSURFACE EXPLORATION

Limited information on subsurface conditions was obtained for this study from hand-auger samples and soil probe penetration measurements at about 2-foot increments in each hand-augered borehole. Three hand-auger borings were performed in the facility bottom and advanced through the bioretention soil and either to refusal in underlying fill (M1C-HA-2 and M1C-HA-3) or into native Vashon recessional outwash (M1C-HA-1). Representative samples were collected, visually classified in the field, stored in water-tight containers, and transported to AESI's offices for additional classification, geotechnical testing, and study. At the conclusion of the excavation, the boreholes were immediately backfilled with the excavated material or completed as a well point for water level monitoring (described separately below).

The various types of sediments, as well as the depths where characteristics of the sediments changed, are indicated on the exploration logs presented in Appendix B. A detailed record of the observed bioretention soil, subsurface soil, geology, and groundwater conditions was made. The sediments were described by visual and textural examination using the soil classification in general accordance with ASTM D2488, "Standard Recommended Practice for Description of Soils." The depths indicated on the logs where conditions changed may represent gradational variations between sediment types in the field. The exploration logs in Appendix B are based on the field observations, inspection of the samples, and where applicable, laboratory grain-size analysis. Our explorations were approximately located in the field relative to known site features, and are shown on Figure M1C F2, "Facility and Exploration Plan."

The results presented in this document are based on the explorations completed for this study and review of background data. The number, locations, and depths of the explorations were completed within site and budgetary constraints. Because of the nature of exploratory work below ground, interpolation of subsurface conditions between field explorations is necessary. It should be noted that differing subsurface conditions may sometimes be present due to the random nature of deposition and the alteration of topography by past grading and/or filling.

6.1 Hand-Auger Borings

Hand-auger borings in cell M1C were completed on October 18, 2018. No rainfall was noted at the time of exploration.

Hand-auger boring locations are presented on Figure M1C F2. The hand-auger borings encountered a thin layer of fine wood mulch overlying bioretention soil to a depth of 1.6 feet to 1.8 feet, overlying fill. Borings M1C-HA-2 and M1C-HA-3 were terminated on gravel within fill at 1.8 to 1.9 feet. Boring M1C-HA-1 encountered native Vashon recessional outwash below fill from 2.9 to the boring terminal depth of 5.9 feet). Bioretention soil thickness was 1.4 to 1.6 feet in the borings. No seepage or caving was observed.

6.2 Well Points

Well points were installed in M1C-HA-1 (WP-1) and M1C-HA-2 (WP-2). Key well point dimensions are provided in Table 2, below. WP-1 was installed to a depth of 9.4 feet to measure groundwater in the shallow aquifer below the bioretention soil. WP-2 was installed to a depth of 2.2 feet, and screened primarily within the bioretention soil.

Table 2
Summary of Cell M1C
Well Point Dimensions

Well Point	Exploration in which Well Point was Installed	Total Length of Casing (feet)	Interior Diameter	Stickup Height (feet)	Total Depth Inside Casing Below Ground Surface
M1C-WP-1	M1C-HA-1	11.2	1.25 inch nominal	1.8	9.4
M1C-WP-2	M1C-HA-2	3.6	1.25 inch nominal	1.4	2.2

7.0 LABORATORY ANALYSIS

Laboratory testing included mechanical grain-size distribution and percent organic matter by weight in accordance with the ASTM D422 and D2974, respectively. Bioretention soil was first tested for organic matter content and then the burned material was tested for grain-size distribution for comparison with the aggregate fraction of the bioretention soil mix guidance in the 2014 Ecology *Stormwater Management Manual for Western Washington* (2014 Ecology Manual). Two samples of material interpreted as representative of the bioretention soil were tested for grain-size distribution. The data is summarized in Table 3.

Table 3
Summary of Cell M1C
Organic Content and Grain Size Data

Exploration Number	Depth (feet)	Soil Type	Organic Content (% by weight)	USCS Soil Description	Fines Content (% passing #200)	Cu	Cc	USDA Soil Texture*
M1C-HA-1	0.3-0.5	Bioretention Soil	5.6	SAND, trace silt, trace gravel (SP)	3.9	3.1	1.1	Sand
M1C-HA-3	0.2-0.6	Bioretention Soil	6.2	SAND, trace silt, trace gravel (SP)	3.8	3.2	1.1	Sand
MC1C-HA-1	3-3.9	Recessional Outwash	Not tested	SAND, some silt, some gravel (SP-SM)	11.8			Sand to Loamy Sand

USCS: Unified Soil Classification System; Cu: coefficient of uniformity; Cc: coefficient of curvature; USDA: U.S. Dept. of Agriculture;
*No hydrometers were performed. USDA soil texture range assumes fines consist entirely of silt to entirely of clay.

7.1 Bioretention Soil Mix

We compared the organic content and burned fraction gradation against the general guidelines for the bioretention soil mix (Table 4).

The organic content of the tested bioretention soils ranged between 5.6 and 6.2 percent by weight. This meets the recommended organic content by weight of 5 to 8 percent in the 2014 Ecology Manual.

The grain-size analysis test results on the burned soil fraction indicate that the bioretention soils tested correlate to a “SAND” with trace silt and trace gravel based on ASTM D2487 USCS. The respective fines content as measured on the No. 200 sieve was 3.8 to 3.9 percent within the recommended range of 2 to 5 percent. The coefficient of uniformity ranged from 3.1 to 3.2, less than the recommended value of equal to or greater than 4. The coefficient of curvature was 1.1, within the recommended range of greater than or equal to 1 and less than or equal to 3. The soil mix contained less than the recommended range of coarse sand and slightly more than the recommended range of fine sand. The tested bioretention soil was a poorly-graded sand.

Table 4
General Guidelines for Bioretention Soil Mix (2014 Ecology Manual)
Compared to Averaged Cell M1C Site Data

Parameter	Recommended Range	Cell M1C
Organic Content (by weight)	5 to 8 percent	5.9 percent by weight
Cu coefficient of uniformity	4 or greater	3.1
Cc coefficient of curvature	1 to 3	1.1
Sieve Size	**Percent Passing**	
3/8” (9.51 mm)	100	100
#4 (4.76 mm)	95 to 100	98.2
#10 (2.0 mm)	75 to 90	92.3
#40 (0.42 mm)	25 to 40	47.3
#100 (0.15 mm)	4 to 10	8.5
#200 (0.074 mm)	2 to 5	3.9

Note: The general guidelines for mineral aggregate gradation are from Table 7.4.1 of the 2014 Ecology Manual.
mm: millimeters.

7.2 Subgrade

In cell M1C, a sample of native recessional outwash was sieved. The tested material correlates to a SAND with some silt and some gravel with 11.8 percent by weight of the material passing the No. 200 sieve. A layer of sand fill was observed in the hand-auger borings below the bioretention soil and above the native soil. The sand fill was up to 1.3 feet thick and classified as gravelly SAND, some silt (SP-SM).

8.0 INFILTRATION TESTING

8.1 General Infiltration Test Method

The infiltration test was conducted in general accordance with the 2014 Ecology Manual. The test was conducted by discharging water into the facility for a “soaking period,” to allow the receptor soils to become saturated. After completion of the soaking period, water was discharged into the cell at a rate sufficient to maintain a relatively constant head. This constitutes the “constant-head” phase of infiltration testing. Immediately following the constant-head phase of infiltration testing, flow into the facilities was discontinued, and the water level was monitored as it dropped. This constitutes the “falling-head” portion of the infiltration testing.

The water for testing was obtained from an on-site City water line blow off tap and conveyed to cell M1C with fire hoses. During infiltration testing, the water was conveyed into the bioretention cell via a digital flow meter with gallons per minute (gpm) and total gallon readouts, and discharged through a flow diffuser. Ponded water levels within the cell were monitored using a temporary staff gauge (M1C-SG-1) marked in 0.01-foot increments installed adjacent to M1C-WP-1 and within a piezometer (“ponding tube”) with a digital water level tape, and with digital pressure transducers for the duration of the test. The water level at the base of the bioretention soil and the shallow groundwater table were monitored in well point M1C-WP-2 and M1C-WP-1, respectively, with a digital water level tape, and with digital pressure transducers. Data from the digital pressure transducers were compensated for barometric response using a separate digital barometer. The area of the pool was measured periodically during testing.

The infiltration test in cell M1C is discussed below, and results are presented in Table 5. Infiltration test data is included in Appendix D to this document.

8.2 Infiltration Test in Cell M1C

AESI performed infiltration testing on November 20, 2018. Light, intermittent rainfall was noted during testing, and no flow from the inflow pipes was present.

During this test, flow was initially adjusted between about 10 and 35 gpm to fill the cell bottom and stabilize the wetted area, then maintained at about 24 gpm for the duration of test. Inflow to the facility for the infiltration test was directed, through a diffuser, into the cell. The entire cell base was wetted after about 2 hours and a water level of about 0.5 feet was maintained as measured on M1C-SG-1. The wetted pool area was generally stable throughout most of the soaking and testing period covering the entire cell base of approximately 130 square feet. Approximately 10,600 gallons of water were used.

Ponded water in the bioretention cell was monitored in well point M1C-WP-2 with a data logger during the infiltration test and responded rapidly to inflow. Groundwater was not observed within the bioretention soil prior to the start of inflow. The water level in the well point responded to inflow within several minutes, and rose to near ground surface at the well point. AESI interprets this response to indicate that water from the infiltration test infiltrated relatively rapidly through the bioretention soil and then mounded on the native finer-grained recessional outwash. The rate of infiltration was such that the water level in the bioretention soil remained lower than the ponded water in the bioretention soil. The shallow subsurface ponded water level mirrored the surface water ponding level.

The shallow groundwater table was monitored in well point M1C-WP-1 using a data logger during the infiltration test and slowly rose during testing. Groundwater was present at about 5.7 feet beneath the bioretention cell prior to the start of inflow and represents the shallow groundwater level in native sediments. The water level in the M1C-WP-1 began to rise after about 40 minutes and rose approximately 2.2 feet (from 5.7 feet below ground surface to 3.5 feet below ground surface) during testing.

After about 7 hours (at 2:40 pm), AESI shut off the flow and monitored the ponded water level as it fell. AESI observed that the pooled water in the base of the facility infiltrated over the course of approximately 26 minutes. The ponded subsurface water in the bioretention cell also dissipated. However, the shallow groundwater table beneath the facility continued to rise, and was 3.5 feet below the cell ground surface, when the data logger was removed 30 minutes after the end of inflow. This may be due to rising tidal response of Ebey Slough. On the date infiltration testing was done, high tide for Quilceda Creek (near the mouth of Ebey Slough) was measured as approximately 10.8 feet at 2:30 pm, about 6.6 feet higher than low tide at 8:54 am. (https://tidesandcurrents.noaa.gov/gmap3/index.shtml?id=TWC1125).

The constant-head test infiltration rate in Table 5 is calculated based on flow rate from the hose for infiltration testing, and the wetted area of bioretention soil through which the water infiltrated and represents the infiltration rate of the native subgrade.

Table 5
Cell M1C
Infiltration Test Results

Test No.	Surface Area (square feet)	Discharge Time (minutes)	Total Volume Discharged (gallons)	Approximate Constant-Head Level (feet)	Field Infiltration Rates	
					Constant-Head Test (in/hr)	Falling Head Test (in/hr)
M1C (bioretention soil)	130	420	10,644	0.50	greater than native soil infiltration rate	
M1C (subgrade)	Interpreted to be similar to wetted area				17	15

in/hr: inches per hour.

9.0 CONCLUSIONS AND RECOMMENDATIONS

Cell M1C was generally consistent with the design shown on the 2017 civil plan sheets (G&O, 2017). Observations on site design, shallow soil and groundwater conditions are discussed below.

- The overflow is consistent with the plans. Site design documents indicate that the ponding level was designed as 6 inches.
- Cell design: Quarry spall splash pads surrounding the concrete pad indicated on plans were not observed.
- Bioretention soil:
    - Thickness: The apparent thickness of loose bioretention soil based on soil probe data was generally about 1.7 feet, plans indicated 1.5 feet.
    - Composition: The soil tested generally within the recommended guidelines for organic content and sand gradation, although the soil mix contained less than the recommended range of coarse sand and slightly more than the recommended range of fine sand. The coefficient of uniformity was below the recommended range.

- Subgrade conditions: The subgrade is interpreted to consist of a sand fill layer (up to 1.3 feet thick) over native Vashon recessional outwash, consistent with previous studies for this project (PanGEO, Inc., 2013 and 2014).

- During infiltration testing, water readily soaked through the bioretention soil mix. Water was observed in the shallow well point (screened at the base of the bioretention soil), demonstrating that water accumulated on the underlying subgrade. The native fine sand is interpreted to have a lower permeability than the overlying bioretention soil. The shallow subsurface ponded water level mirrored the surface water ponding level.

- Subgrade infiltration rate: Measured at about 17 in/hr.

- Bioretention soil field infiltration rate:
    - Greater than the measured field rate of 17 in/hr
    - Water readily soaked through the bioretention soil mix and the field rate is interpreted to represent the native subgrade infiltration rate.

- A shallow groundwater table is present in the location of the M1C facility as measured in M1C-WP-1 and previous studies for this project (PanGEO, Inc., 2014). The groundwater response during testing may have been influenced by the tidal response of Ebey Slough since the water table continued to rise 30 minutes after the end of inflow.

- The effects of shallow groundwater mounding will increase during the wetter winter months, and will reduce the effective infiltration rate by reducing the vertical gradient. The ongoing monitoring data will be reviewed for groundwater and tidal influence on facility infiltration performance.

10.0 CLOSURE

We appreciate the opportunity to be of continued service to you on this project. Should you have any questions regarding this document or other geotechnical/hydrogeologic aspects of the project, please call us at your earliest convenience.

State of Washington
Hydrogeologist
2335
Licensed Geologist
Jennifer H. Saltonstall
6/14/19

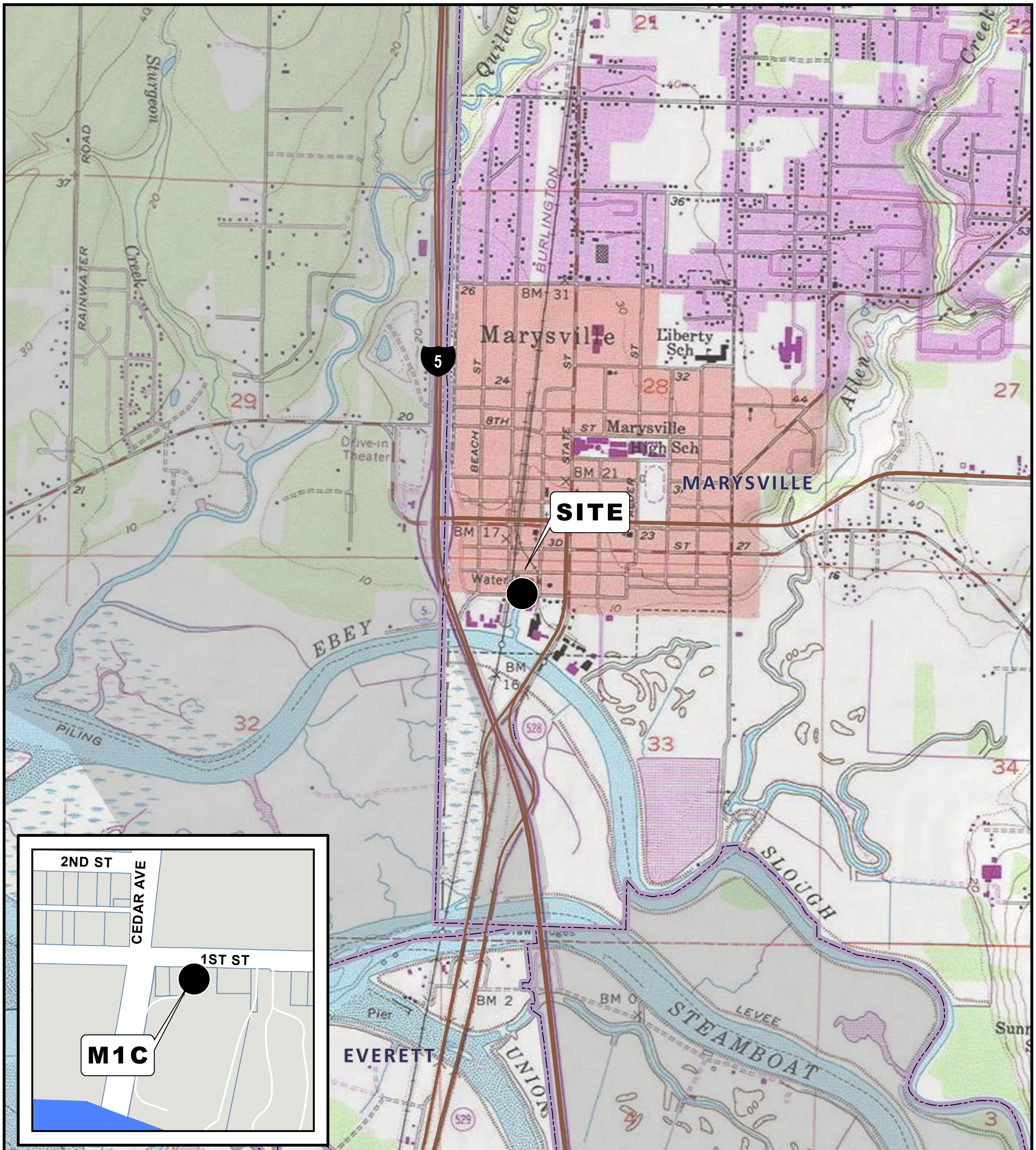
Suzanne S. Cook, L.G.
Senior Project Geologist

Anton D. Ypma
Staff Geologist

Jennifer H. Saltonstall, L.G., L.Hg.
Principal Geologist/Hydrogeologist

Attachments:	Figure M1C F1:	Vicinity Map
	Figure M1C F2:	Facility and Exploration Plan
	Appendix A:	Project Civil Plans
	Appendix B:	Current Study Exploration Logs and Laboratory Testing Data
	Appendix C:	Background Soil, Geology, and Groundwater Data (Regional Maps, Previous Studies Exploration Logs and Laboratory Testing Data)
	Appendix D:	Soil Probe, Level Survey, and Field Infiltration Testing Data
	Appendix E:	Site Photos

JHS/ld
150387H007-4
Projects\20150387\KH\WP



DATA SOURCES / REFERENCES:
USGS: 7.5' SERIES TOPOGRAPHIC MAPS, ESRI/I-CUBED/NATIONAL GEOGRAPHIC SOCIETY 2013
SNOHOMISH CO: STREETS, CITY LIMITS, PARCELS, 1/18
LOCATIONS AND DISTANCES SHOWN ARE APPROXIMATE

N

0 1000 2000
FEET

NOTE: BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION

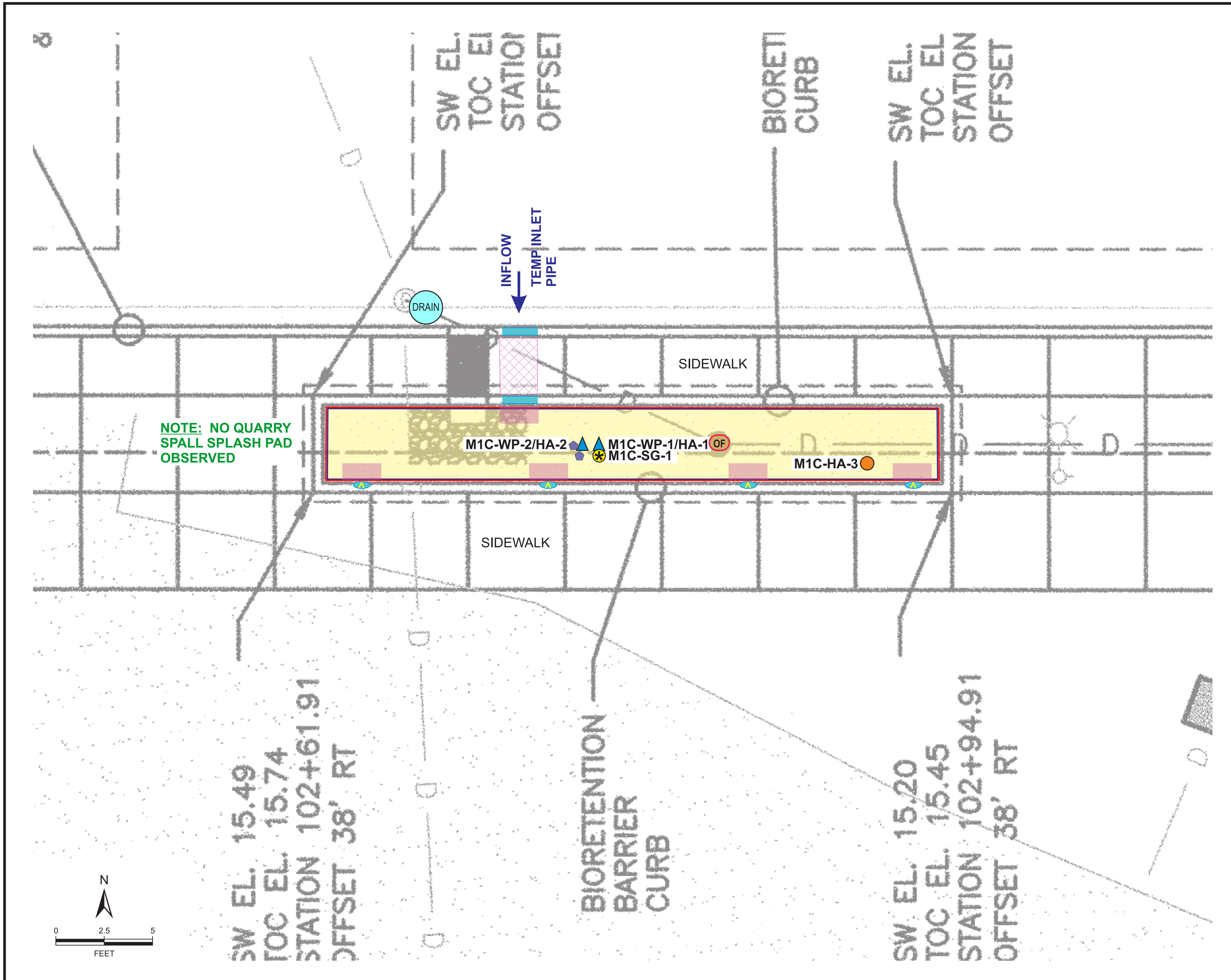
associated earth sciences incorporated

VICINITY MAP

BIORETENTION HYDROLOGIC PERFORMANCE STUDY, M1C SITE
MARYSVILLE, WASHINGTON

PROJ NO.	DATE:	FIGURE:
150387H007	3/19	M1C F1

Document Path: G:\GIS_Projects\aY15post0716\150387 Bioretention Hydro Performance Monitoring\mxd\PhaseII\Fig1s\150387H007 F1 VM_M1C.mxd



LEGEND:

HA	HAND AUGER
WP	WELL POINT
	TEMPORARY STAFF GAUGE
	BASE OF FACILITY
	TOP OF FACILITY SLOPE
	INFLOW / OVERFLOW DIRECTION
OF	OVERFLOW - 8" PVC
	PVC PONDING TUBE
	CURB CUT
	CONCRETE SPLASH PAD
	METAL GRATE
	SMALL CURB NOTCH

CONTOUR INTERVAL = N/A

NOTE: LOCATION AND DISTANCES SHOWN ARE APPROXIMATE.

NOTES:
1. BASE MAP REFERENCE: GRAY AND OSBORNE, INC., CITY OF MARYSVILLE, 1ST STREET LOW IMPACT DEVELOPMENT, BIORETENTION PLAN, SHEET 14 OF 25 6/19/17

associated earth sciences incorporated

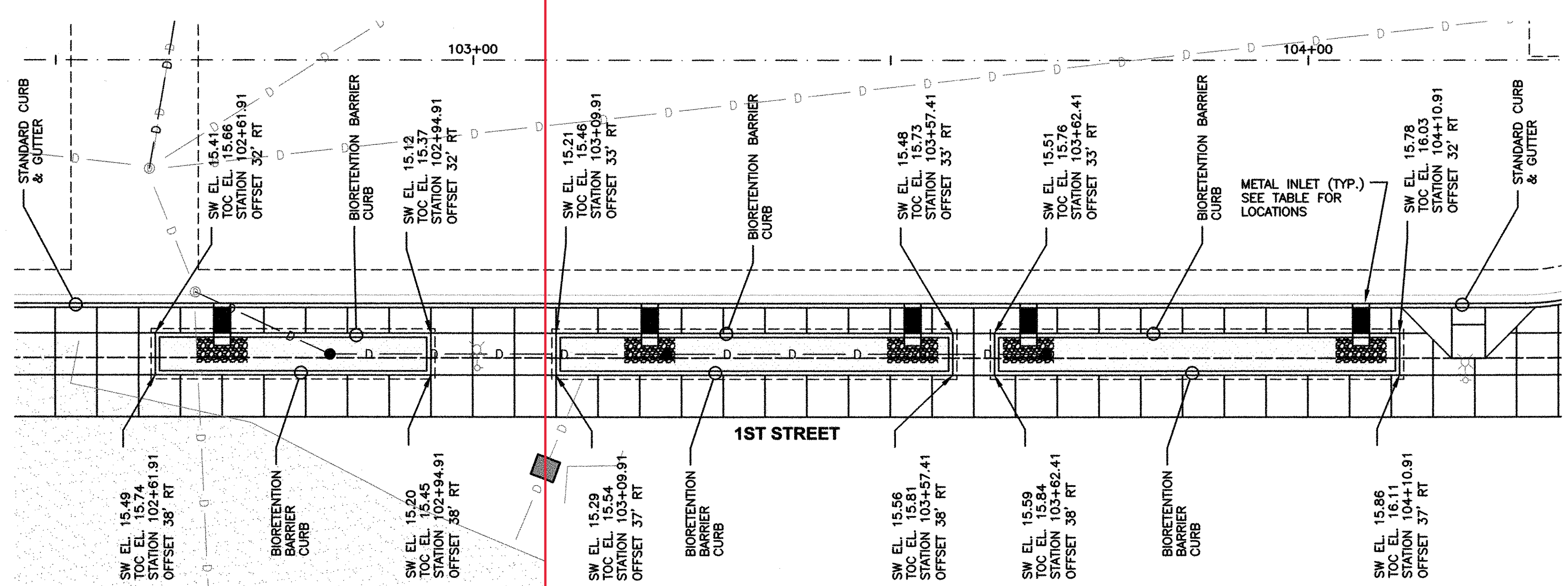
FACILITY AND EXPLORATION PLAN
M1C SITE
BIORETENTION HYDROLOGIC PERFORMANCE
MARYSVILLE, WASHINGTON

PROJ NO.	DATE:	FIGURE:
150387H007	3/19	M1C F2

150387 BHPS MCCA \ 150387H007 Site-Expl ALL.cdr PAGE x: M1C F2

APPENDIX A

Project Civil Plans



20' 10' 0 20' 40'
SCALE: 1"=20'

N

BIORETENTION AREA S-1
STATION 102+62 TO STATION 102+95
AREA EL.= 12.4' (±)
OVERFLOW ELEV.= 12.9' (±)

BIORETENTION AREA S-2
STATION 103+10 TO STATION 103+57
AREA EL.= 12.5' (±)
OVERFLOW ELEV.= 13.0' (±)

BIORETENTION AREA S-3
STATION 103+62 TO STATION 104+11
AREA EL.= 12.9' (±)
OVERFLOW ELEV.= 13.4' (±)

METAL INLET LOCATION TABLES

BIORETENTION AREA S-1
102+70.80

SEE NOTE 1

BIORETENTION AREA S-2
103+20.78
103+52.23

SEE NOTE 1

BIORETENTION AREA S-3
103+65.75
104+05.81

SEE NOTE 1

NOTES:

1. SEE BIORETENTION AREA CURB INLET DETAILS, SHEETS 18 – 19.
2. FOR PLAN CLARITY, ONLY EXISTING AND PROPOSED STORM DRAINAGE FACILITIES ARE SHOWN. SEE PLAN AND PROFILE SHEETS FOR ADDITIONAL UTILITY INFORMATION.
3. CONTRACTOR SHALL FURNISH AND INSTALL A 2' WIDE X 1' DEEP QUARRY SPALL SLASH PAD AROUND THE CONC PAD. SEE DETAILS, SHEETS 18 – 19.

Gray & Osborne, Inc.
CONSULTING ENGINEERS
3710 168TH STREET NE, BLDG. B, SUITE 210
ARLINGTON, WA 98223 • (360) 454-5490

DATE: JUNE 2017
SCALE: NOTED
DRAWN: C.J.B.
CHECKED: S.A.C.
APPROVED: K.W.B.

No.	REVISION	DATE	APPD

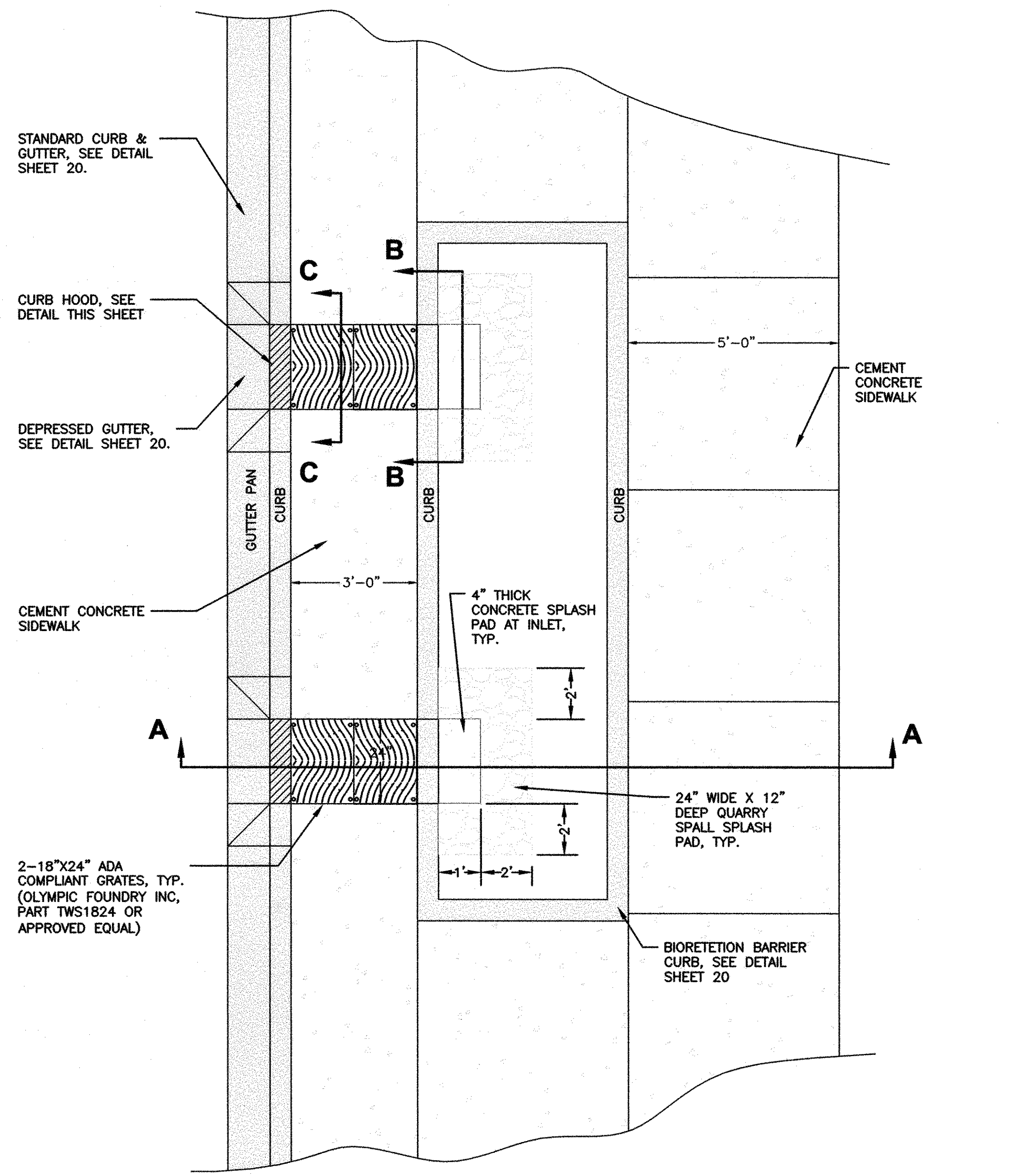
STACEY ANN CLEAR — STATE OF WASHINGTON — 38311 — REGISTERED PROFESSIONAL ENGINEER

KEVIN W. BROWN — STATE OF WASHINGTON — PROFESSIONAL ENGINEER — 6/16/17

CITY OF MARYSVILLE
SNOHOMISH COUNTY WASHINGTON
1ST STREET LOW IMPACT DEVELOPMENT PROJECT
BIORETENTION PLAN

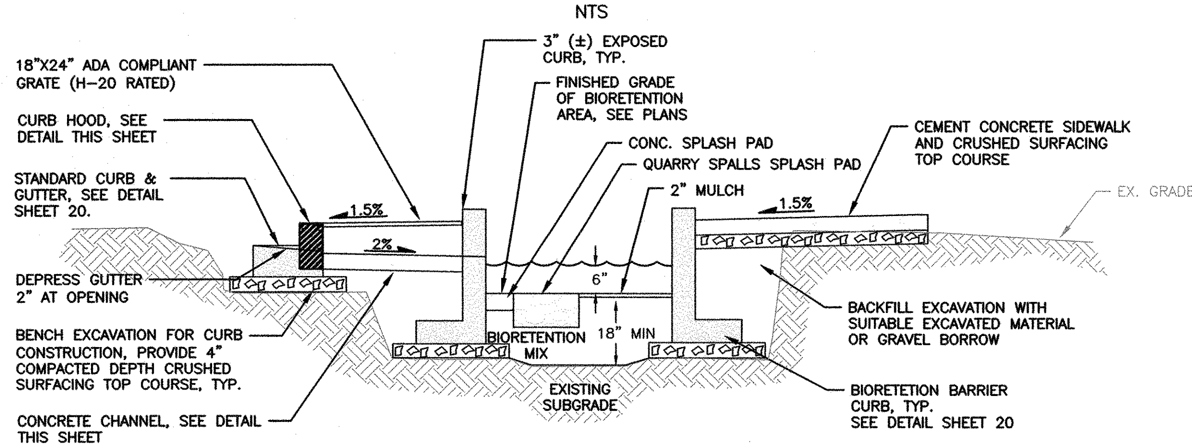
SHEET: 14
OF: 25

JOB NO.: 13587.00
DWG: RETENTION PLANS



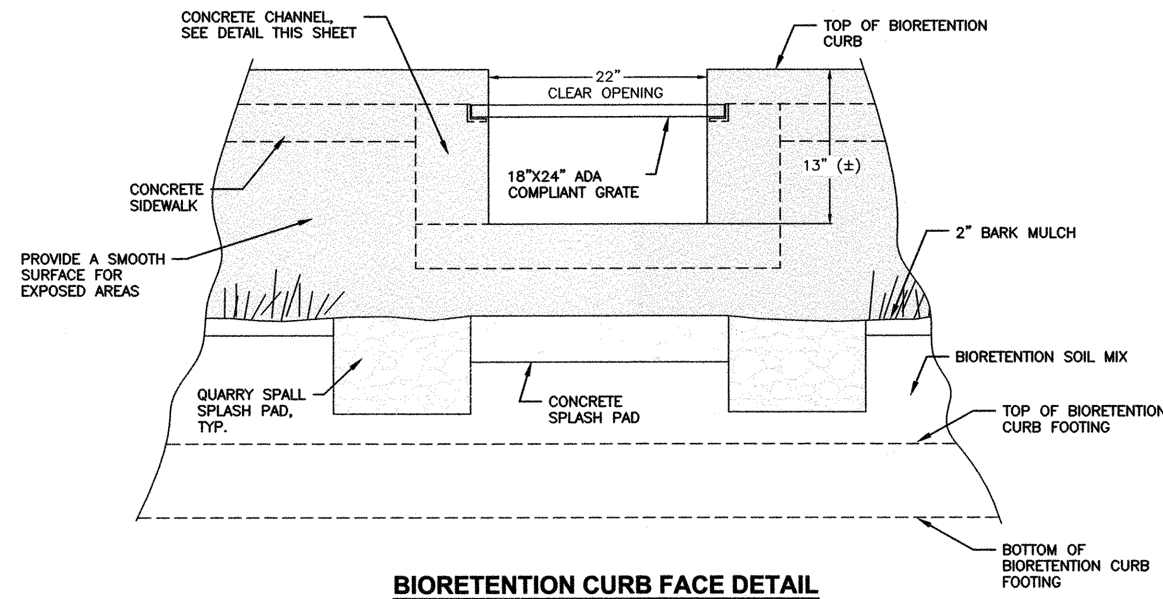
TYPICAL BIORETENTION AREA PLAN VIEW (SOUTH SIDE)

NTS



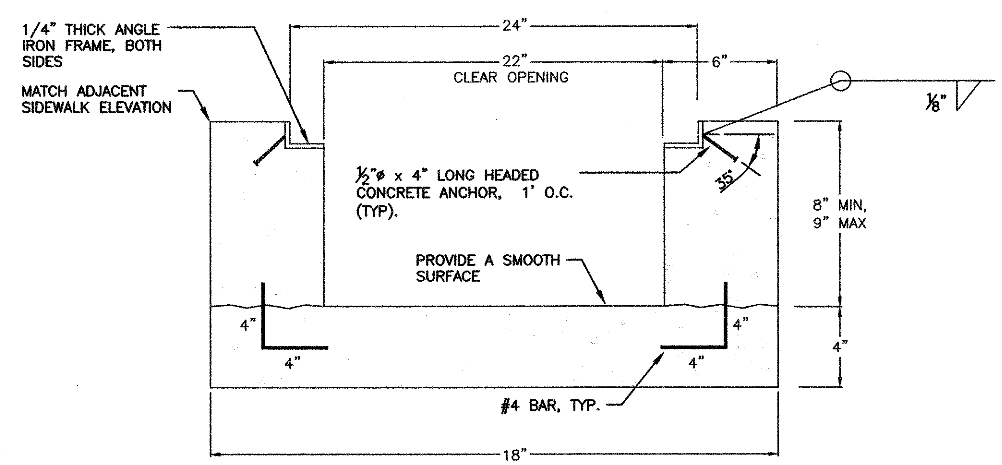
TYPICAL BIORETENTION AREA CROSS SECTION A-A

NTS



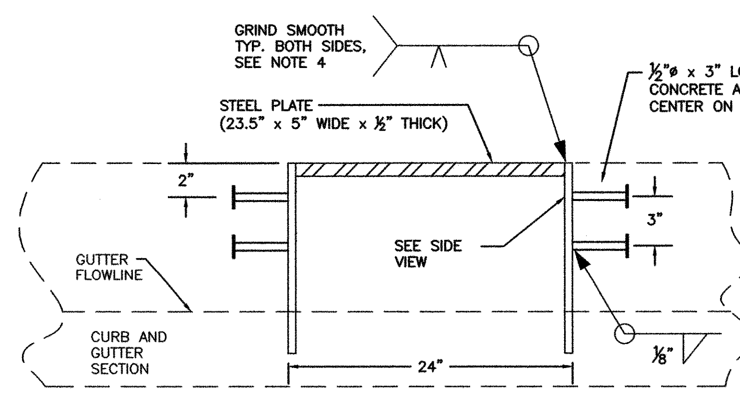
BIORETENTION CURB FACE DETAIL SECTION B-B

NTS



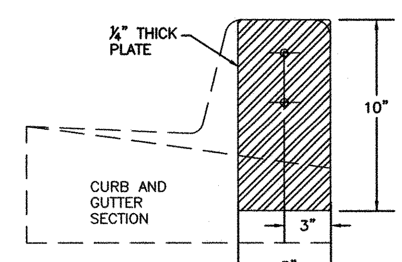
CONCRETE CHANNEL DETAIL SECTION C-C

NTS



CURB HOOD (FRONT VIEW)

NTS



CURB HOOD (SIDE VIEW)

NTS

CURB HOOD NOTES

1. HEADED CONCRETE ANCHORS SHALL MEET THE REQUIREMENTS OF ASTM A-108.
2. ALL PLATES SHALL MEET THE REQUIREMENTS OF ASTM A-36
3. ENTIRE ASSEMBLY SHALL BE HOT-DIP GALVANIZED IN ACCORDANCE WITH ASTM A-123.
4. SINGLE BEVEL GROOVE WELD.

CURB HOOD DETAIL

NTS

Gray & Osborne, Inc.
CONSULTING ENGINEERS
3710 168TH STREET NE, BLDG. B, SUITE 210
ARLINGTON, WA 98223 • (360) 454-5490

DATE: JUNE 2017
SCALE: NOTED
DRAWN: C.J.B.
CHECKED: S.A.C.
APPROVED: K.W.B.

No.	REVISION	DATE	APPD

CITY OF MARYSVILLE
SNOHOMISH COUNTY WASHINGTON
1ST STREET LOW IMPACT DEVELOPMENT PROJECT
DETAILS

SHEET: 18
OF: 25

JOB NO.: 13587.00
DWG: DETAILS

APPENDIX B

Current Study Exploration Logs and Laboratory Testing Data

Geologic & Monitoring Well Construction Log

associated earth sciences incorporated

Project Number	Well Number	Sheet
150387H007	M1C-HA-1/WP	1 of 2

Project Name: Bioretention Hydrologic Performance Study
Elevation (Top of Well Casing): 99.6 (Project Datum)
Water Level Elevation: Dry
Drilling/Equipment: Hand Auger
Hammer Weight/Drop: N/A

Location: Marysville, WA
Surface Elevation (ft): 97.8 (Project Datum)
Date Start/Finish: 10/18/18,10/18/18
Hole Diameter (in): 4 inches

Depth (ft)	Water Level	WELL CONSTRUCTION	S T	Blows/ 6"	Graphic Symbol	DESCRIPTION
		Fine wood mulch 0 to 0.2 feet				**Fine Wood Mulch**
		Bioretention soil mix 0.2 to 1.6 feet				**Bioretention Soil Mix** Loose, moist, dark brown, fine to medium SAND, trace silt, trace gravel; organic rich; massive (SP).
		Threaded steel pipe 1.25-inch I.D. with threaded vented PVC cap -1.8 to 6.5 feet				
		Bentonite chips 1.6 to 3.6 feet				**Fill** Loose, moist, brown, gravelly, fine to medium SAND, some silt; massive (SP-SM).
						Vashon Recessional Outwash Medium dense, moist, oxidized reddish brown, fine SAND, some silt, some gravel (SP-SM).
5		Excavated Recessional Outwash sands 3.6 to 5.9 feet				Becomes very moist, less oxidized, and silt decreases. Occasional wood fragments observed

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample

M - Moisture
Water Level ()
Water Level at time of drilling (ATD)

Logged by: ADY
Approved by: JHS

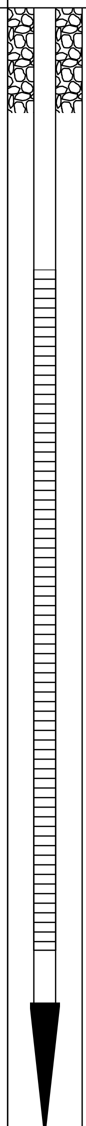
associated earth sciences incorporated

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
150387H007	M1C-HA-1/WP	2 of 2

Project Name	Bioretention Hydrologic Performance Study	Location	Marysville, WA
Elevation (Top of Well Casing)	99.6 (Project Datum)	Surface Elevation (ft)	97.8 (Project Datum)
Water Level Elevation	Dry	Date Start/Finish	10/18/18,10/18/18
Drilling/Equipment	Hand Auger	Hole Diameter (in)	4 inches
Hammer Weight/Drop	N/A		

Depth (ft)	Water Level	WELL CONSTRUCTION	S T	Blows/ 6"	Graphic Symbol	DESCRIPTION
						Boring terminated at 5.9 feet Well completed at 9.8 feet on 10/18/18. Refusal on gravel. No seepage. No caving. Steel drive point placed in borehole and hand driven with slide hammer to depth of 9.8 feet.
		Driven into existing sediments 5.9 to 9.8 feet				
		Stainless steel jacket over stainless steel #60 gauze, welded to perforated steel pipe 6.5 to 9.1 feet				
		Threaded steel pipe 1.25-inch I.D. and drive point 9.1 to 9.8 feet				
10		Note: ~4 inches of "dead space" below bottom of perforated openings and total inside depth. Total inside depth = 11.2 feet.				



Sampler Type (ST):

2" OD Split Spoon Sampler (SPT)	No Recovery	M - Moisture	**Logged by:** ADY
3" OD Split Spoon Sampler (D & M)	Ring Sample	Water Level ()	**Approved by:** JHS
Grab Sample	Shelby Tube Sample	Water Level at time of drilling (ATD)	

Geologic & Monitoring Well Construction Log

associated earth sciences incorporated

Project Number	Well Number	Sheet
150387H007	M1C-HA-2/WP	1 of 1

Project Name	Bioretention Hydrologic Performance Study	Location	Marysville, WA
Elevation (Top of Well Casing)	99.3 (Project Datum)	Surface Elevation (ft)	97.9 (Project Datum)
Water Level Elevation	Dry	Date Start/Finish	10/18/18,10/18/18
Drilling/Equipment	Hand Auger	Hole Diameter (in)	4 inches
Hammer Weight/Drop	N/A		

Depth (ft)	Water Level	WELL CONSTRUCTION	S T	Blows/ 6"	Graphic Symbol	DESCRIPTION
		Fine wood mulch 0 to 0.2 feet				**Fine Wood Mulch**
		Threaded steel pipe 1.25-inch I.D. wtih threaded PVC cap -1.4 to 0.2 feet Tape over well point screen 0.2 to 0.7 feet Bioretention soil mix 0.2 to 1.8 feet				**Bioretention Soil Mix** Loose, moist, dark brown, fine to medium SAND, trace silt, trace gravel; organic rich; massive (SP).
		Stainless steel jacket over stainless steel #60 gauze, welded to perforated steel pipe 0.7 to 1.9				
						At 1.7 feet: Fill - Loose, moist, brown, gravelly, fine to medium SAND, some silt; massive (SP-SM).
						Boring terminated at 1.8 feet Well completed at 2.6 feet on 10/18/18. Refusal on gravel. No seepage. No caving. Steel drive point placed in borehole and driven with slide hammer to depth of 2.6 feet.
		Threaded steel pipe 1.25-inch I.D. and drive point 1.9 to 2.6 feet				
		Note: ~4 inches of "dead space" below bottom of perforated openings and total inside depth. Total inside depth = 3.6 feet.				
5						

Sampler Type (ST):

2" OD Split Spoon Sampler (SPT)	No Recovery	M - Moisture	**Logged by:** ADY
3" OD Split Spoon Sampler (D & M)	Ring Sample	Water Level ()	**Approved by:** JHS
Grab Sample	Shelby Tube Sample	Water Level at time of drilling (ATD)	

associated earth sciences incorporated

Exploration Log

Project Number	Exploration Number	Sheet
150387H007	M1C-HA-3	1 of 1

Project Name	Bioretention Hydrologic Performance Study	Ground Surface Elevation (ft)	
Location	Marysville, WA	Datum	N/A
Driller/Equipment	Hand Auger	Date Start/Finish	10/18/18,10/18/18
Hammer Weight/Drop	N/A	Hole Diameter (in)	4 inches

Depth (ft)	S T	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Water Level	Blows/6"	Blows/Foot 10 20 30 40	Other Tests
				Fine Wood Mulch					
		S-1		**Bioretention Soil Mix** Loose, moist, dark brown, fine to medium SAND, trace silt, trace gravel; organic rich; massive (SP).					
		S-2		**At 1.8 feet: Fill** Loose, moist, brown, gravelly, fine to medium SAND, some silt; massive (SP-SM). Bottom of exploration boring at 1.9 feet. Refusal on gravel. No seepage. No caving.					
5									

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample
- M - Moisture
- Water Level ()
- Water Level at time of drilling (ATD)

Logged by: ADY
Approved by: JHS

a s s o c i a t e d
e a r t h s c i e n c e s
i n c o r p o r a t e d

Moisture, Ash, and Organic Matter of Peat and Other Organic Soils - ASTM 2974

Date Sampled	Project	Project No.		Soil Description
10/18/2018	Bioretention Hydrologic Performance Monitoring Study	150387 E007		Bioretention soil mix
Tested By	**Location**	**EB/EP No.**	**Depth**	
BN	Onsite- M1C			

Moisture Content

Sample ID	HA-1 (0.3'-0.5')	HA-3 (0.2'-0.6')
Wet Weight + Pan	963.55	925.72
Dry Weight + Pan	887.34	847.94
Weight of Pan	536.16	421.73
Weight of Moisture	76.21	77.78
Dry Weight of Soil	351.18	426.21
% Moisture	17.8	15.4

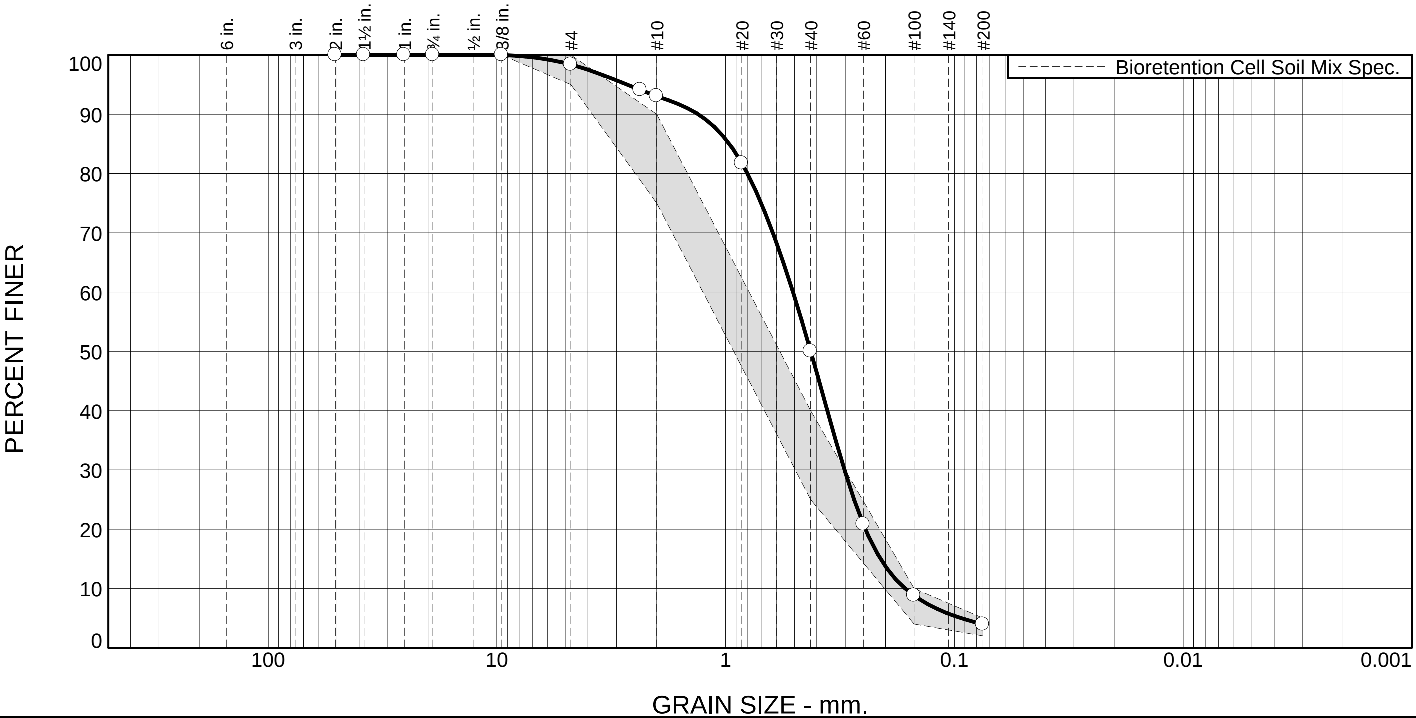
Organic Matter and Ash Content

Dry Soil Befor Burn + Pan	599.89	573.01
Dry Soil After Burn + Pan	588.21	559.60
Weight of Pan	391.92	357.93
Wt. Loss Due to Ignition	11.68	13.41
Actual Wt. Of Soil After Burr	196.29	201.67
% Organics	5.6	6.2

ASSOCIATED EARTH SCIENCES, INC.

911 5th Ave., Suite 100 Kirkland, WA 98033 425-827-7701 FAX 425-827-5424

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	1.6	5.3	43.1	46.1	3.9	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
2	100.0		
1.5	100.0		
1	100.0		
.75	100.0		
.375	100.0	100.0	
#4	98.4	95.0 - 100.0	
#8	94.1		
#10	93.1	75.0 - 90.0	X
#20	81.8		
#40	50.0	25.0 - 40.0	X
#60	20.8		
#100	8.8	4.0 - 10.0	
#200	3.9	2.0 - 5.0	

* Bioretention Cell Soil Mix Spec.

Material Description

SAND, trace silt, trace gravel

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 1.3181 D_{85}= 0.9641 D_{60}= 0.5077
D_{50}= 0.4247 D_{30}= 0.3021 D_{15}= 0.2104
D_{10}= 0.1641 C_u= 3.09 C_c= 1.10

Remarks

Collected by: ADY

Bioretention soil mix burned first per ASTM D2974 then sieved.

Date Received: 10/19/2018 **Date Tested:** 11/08/2018

Tested By: BN

Checked By: JHS

Title:

Source of Sample: (M1C) Marysville- 1st Street LID **Depth:** 0.3'-0.5' **Date Sampled:** 10/18/2018

Sample Number: HA-1

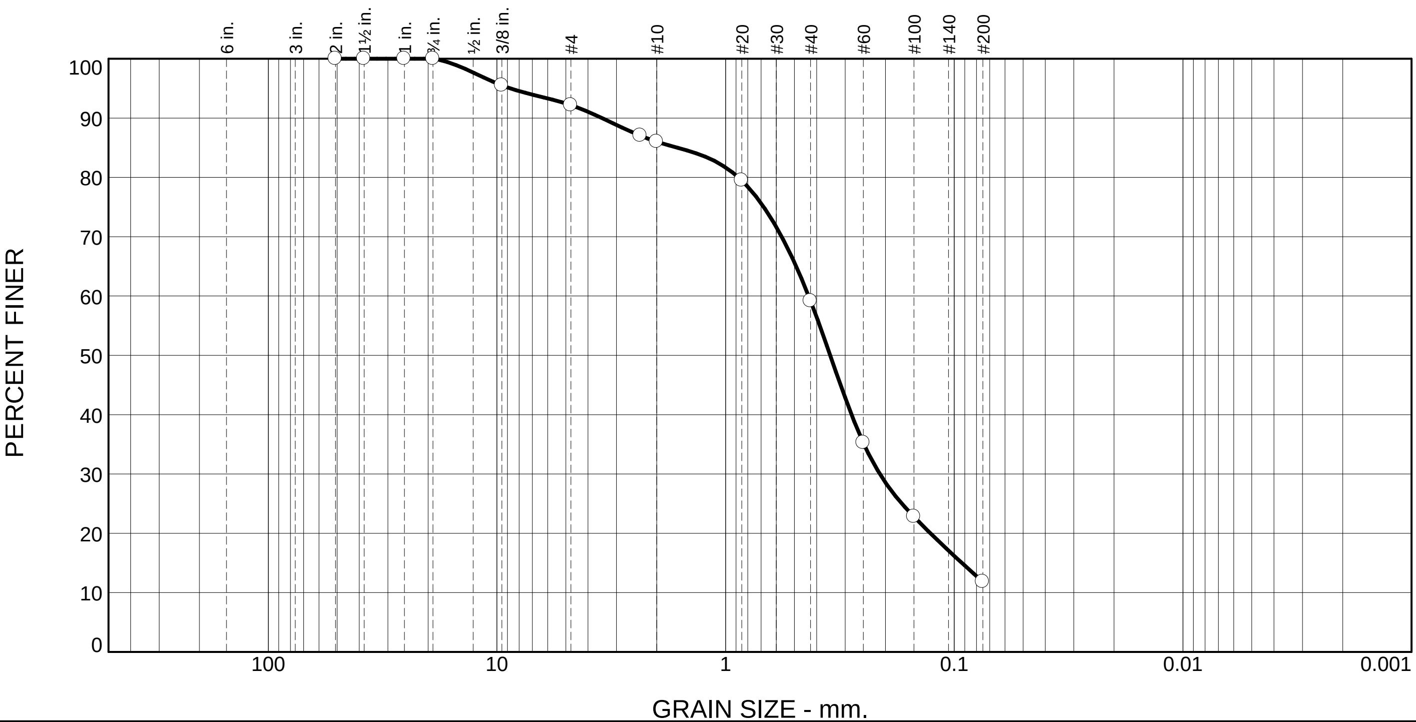
associated earth sciences incorporated

Client: Clear Creek Solutions

Project: Bioretention Hydrologic Performance Study

Project No: 150387 H004 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	7.8	6.2	26.8	47.4	11.8	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
2	100.0		
1.5	100.0		
1	100.0		
.75	100.0		
.375	95.5		
#4	92.2		
#8	87.0		
#10	86.0		
#20	79.5		
#40	59.2		
#60	35.2		
#100	22.8		
#200	11.8		

* (no specification provided)

Material Description

SAND, some silt, some gravel

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP-SM **AASHTO (M 145)=** A-2-4(0)

Coefficients

D_{90}= 3.4746 D_{85}= 1.6260 D_{60}= 0.4335
D_{50}= 0.3489 D_{30}= 0.2117 D_{15}= 0.0926
D_{10}= C_u= C_c=

Remarks

Collected by: ADY

Date Received: 10/19/2018 **Date Tested:** 11/08/2018

Tested By: BN

Checked By: JHS

Title:

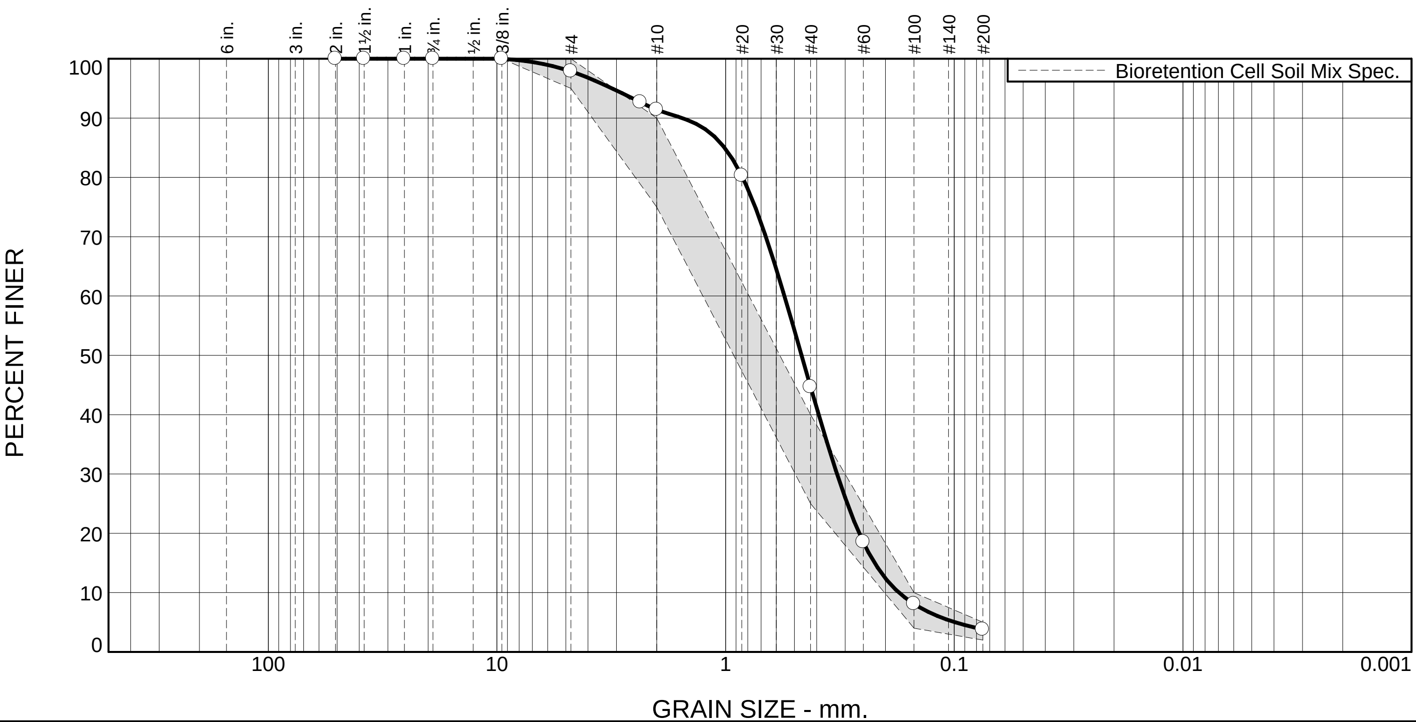
Source of Sample: (M1C) Marysville- 1st Street LID **Depth:** 3'-3.9' **Date Sampled:** 10/19/2018
Sample Number: HA-1

associated earth sciences incorporated

Client: Clear Creek Solutions
Project: Bioretention Hydrologic Performance Study

Project No: 150387 H004 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	2.1	6.5	46.7	40.9	3.8	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
2	100.0		
1.5	100.0		
1	100.0		
.75	100.0		
.375	100.0	100.0	
#4	97.9	95.0 - 100.0	
#8	92.7		
#10	91.4	75.0 - 90.0	X
#20	80.3		
#40	44.7	25.0 - 40.0	X
#60	18.5		
#100	8.1	4.0 - 10.0	
#200	3.8	2.0 - 5.0	

* Bioretention Cell Soil Mix Spec.

Material Description

SAND, trace silt, trace gravel

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 1.5479 D_{85}= 1.0107 D_{60}= 0.5532
D_{50}= 0.4655 D_{30}= 0.3256 D_{15}= 0.2231
D_{10}= 0.1746 C_u= 3.17 C_c= 1.10

Remarks

Collected by: ADY

Bioretention soil mix burned first per ASTM D2974 then sieved.

Date Received: 10/19/2018 **Date Tested:** 11/08/2018

Tested By: BN

Checked By: JHS

Title:

Source of Sample: (M1C) Marysville- 1st Street LID **Depth:** 0.2'-0.6' **Date Sampled:** 10/18/2018

Sample Number: HA-3

associated earth sciences incorporated

Client: Clear Creek Solutions

Project: Bioretention Hydrologic Performance Study

Project No: 150387 H004 **Figure**

APPENDIX C

Background Soil, Geology, and Groundwater Data (Regional Maps, Previous Studies Exploration Logs and Laboratory Testing Data)

Site Unit: Qvrm: Vashon Recessional Outwash, Marysville Member

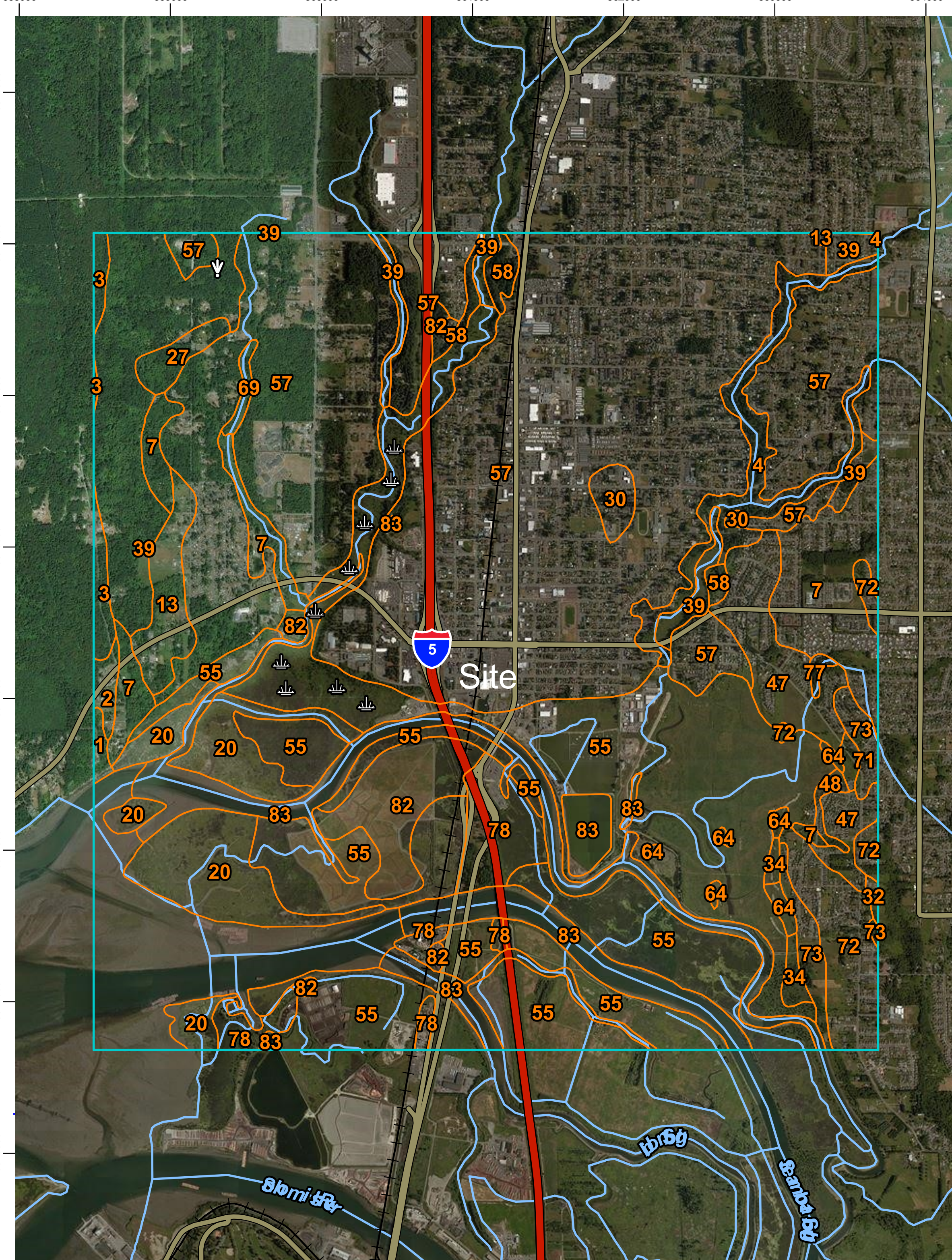
Source:
Geologic map of the Marysville quadrangle, Snohomish County, Washington
Author(s): Minard, J.P.
Publishing Organization: U.S. Geological Survey
Series and Number: Miscellaneous Field Studies Map MF-1743
Publication Date: 1985
Map Scale: 1:24,000

Soil Map—Snohomish County Area, Washington

122° 13' 17" W | 122° 8' 15" W

558000 559000 560000 561000 562000 563000 564000

48° 5' 21" N | 48° 5' 21" N



5326000 5325000 5324000 5323000 5322000 5321000 5320000 5319000

48° 0' 53" N | 48° 0' 53" N

559000 560000 561000 562000 563000 564000

122° 13' 17" W | 122° 8' 15" W

Map Scale: 1:40,200 if printed on A portrait (8.5" x 11") sheet.

Meters: 0 500 1000 2000 3000

Feet: 0 1500 3000 6000 9000

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
1	Alderwood gravelly sandy loam, 0 to 8 percent slopes	10.0	0.1%
2	Alderwood gravelly sandy loam, 8 to 15 percent slopes	17.5	0.3%
3	Alderwood gravelly sandy loam, 15 to 30 percent slopes	39.3	0.6%
4	Alderwood-Everett gravelly sandy loams, 25 to 70 percent slopes	133.3	1.9%
7	Bellingham silty clay loam	276.3	4.0%
13	Custer fine sandy loam	79.6	1.1%
20	Fluvaquents, tidal	296.5	4.3%
27	Kitsap silt loam, 0 to 8 percent slopes	31.0	0.4%
30	Lynnwood loamy sand, 0 to 3 percent slopes	30.3	0.4%
32	McKenna gravelly silt loam, 0 to 8 percent slopes	4.3	0.1%
34	Mukilteo muck	18.8	0.3%
39	Norma loam	367.5	5.3%
47	Pastik silt loam, 0 to 8 percent slopes	169.0	2.4%
48	Pastik silt loam, 8 to 25 percent slopes	11.2	0.2%
55	Puget silty clay loam	1,511.0	21.8%
57	Ragnar fine sandy loam, 0 to 8 percent slopes	2,616.5	37.7%
58	Ragnar fine sandy loam, 8 to 15 percent slopes	44.5	0.6%
64	Snohomish silt loam	22.2	0.3%
69	Terric Medisaprists, nearly level	11.0	0.2%
71	Tokul silt loam, 8 to 15 percent slopes	8.8	0.1%
72	Tokul gravelly medial loam, 0 to 8 percent slopes	143.4	2.1%
73	Tokul gravelly medial loam, 8 to 15 percent slopes	61.8	0.9%
77	Tokul-Winston gravelly loams, 25 to 65 percent slopes	5.3	0.1%
78	Urban land	138.2	2.0%
82	Xerorthents, nearly level	150.5	2.2%

Legend:

B-1 Approx. Borehole Location (PanGEO)

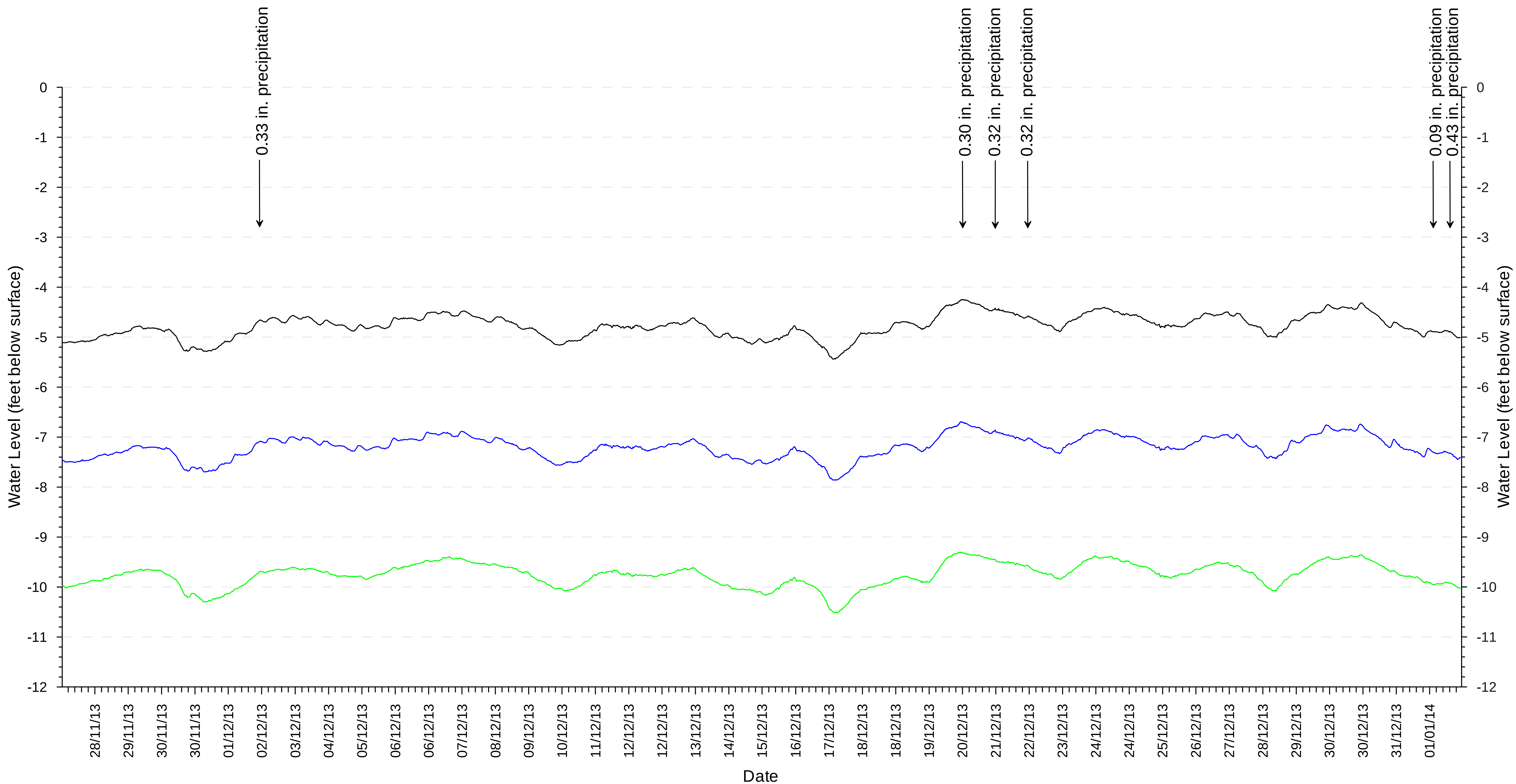
Core #1 Approx. Pavement Core Location (City of Marysville)

Approx. Scale
1" = 60'

Note: Base map modified from Aerial Map provided by City of Marysville.

PanGEO INCORPORATED	1st & 3rd Streets Retrofit Marysville, WA	SITE AND EXPLORATION PLAN 1ST STREET BETWEEN CEDAR AVENUE AND STATE AVENUE
		Project No. 13-239 / Figure No. 2A

file.grf w/ file.dat 1/30/14 (11:29) TEA2



Legend:

B-1 Water Depth (feet)
B-2 Water Depth (feet)
B-4 Water Depth (feet)

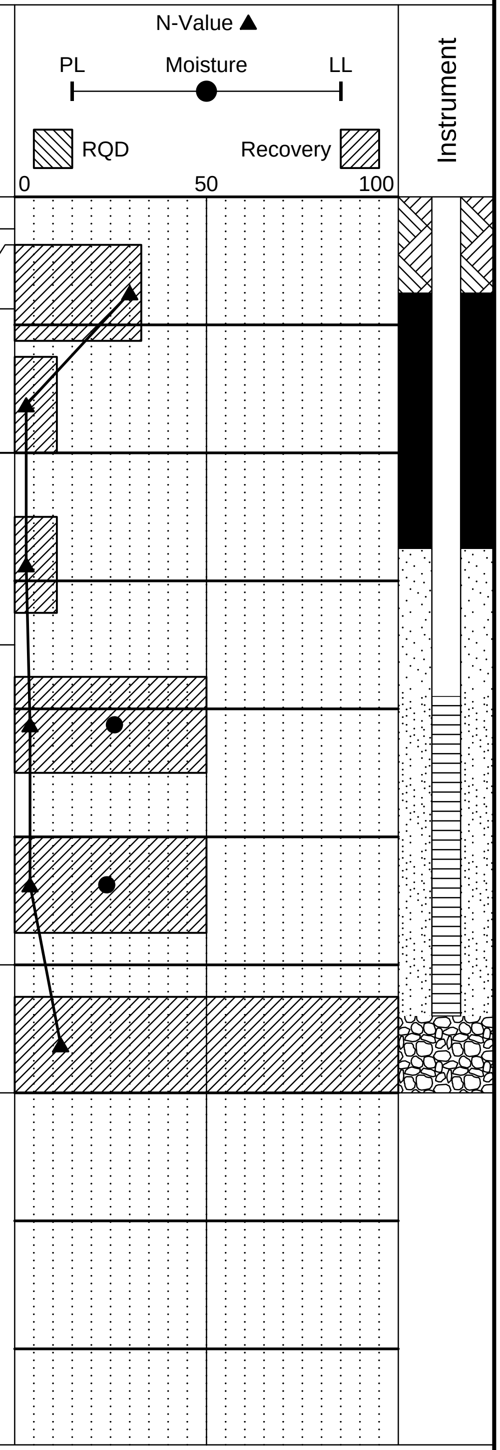
Note: Monitoring well in B-7 was dry after drilling.
Rainfall data from Stanwood.

PanGEO INCORPORATED	1st & 3rd Streets Retrofit Marysville, Washington	SUMMARY GROUNDWATER LEVEL BETWEEN NOVEMBER 27, 2013 AND JANUARY 8, 2014
		Project No. 13-239 / Figure No. 3

Pump Test Results 11-8-13.grf 2/3/14 (9:07) SHE

Project:	1st & 3rd Street Retrofit	Surface Elevation:	
Job Number:	13-239	Top of Casing Elev.:	
Location:	1st and 3rd Streets, Marysville, WA	Drilling Method:	HSA
Coordinates:	Northing: , Easting:	Sampling Method:	SPT

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0						6 inches Asphalt.
						3 inches chip seal or similar.
	S-1		27, 20, 10			Approximately 12 inches of sand and gravel (Road Base).
2						Loose, brown, silty, fine to coarse SAND with gravel: moist, sub-angular gravel. (Fill).
	S-2		4, 2, 1			
4						Very loose, brown, fine to coarse SAND with silt: moist, abundant red cedar debris, non-plastic, poorly graded.
6	S-3		1, 1, 2			
						Loose, brown-gray, fine to medium SAND with some silt: wet, poorly graded, non-plastic, laminated. (Recessional Outwash).
8	S-4		1, 1, 3	GS		
10	S-5		2, 1, 3	GS		Becoming fine to coarse SAND, some silt.
12						Loose to medium dense, brown gray, silty, fine to medium SAND: wet, poorly graded, non-plastic, rapid dilatancy, homogeneous, laminated. (Recessional Outwash).
	S-6		3, 5, 7			
14						Boring terminated at about 14 feet below the surface. Groundwater was measured at about 7.6 feet below the surface on November 26, 2013.
16						
18						



Completion Depth:	14.0ft	Remarks: Groundwater measured in well installation on 11/26/13 at 12:31. Well was then developed by pumping with a down-hole pump until return water was nearly clear, about 5 minutes. Data logger installed in well following development. Logging was programed to begin at 12:00 noon, 11/27/13.
Date Borehole Started:	11/25/13	
Date Borehole Completed:	11/25/13	
Logged By:	S. Evans	
Drilling Company:	Bore Tec Drilling	

PanGEO INCORPORATED

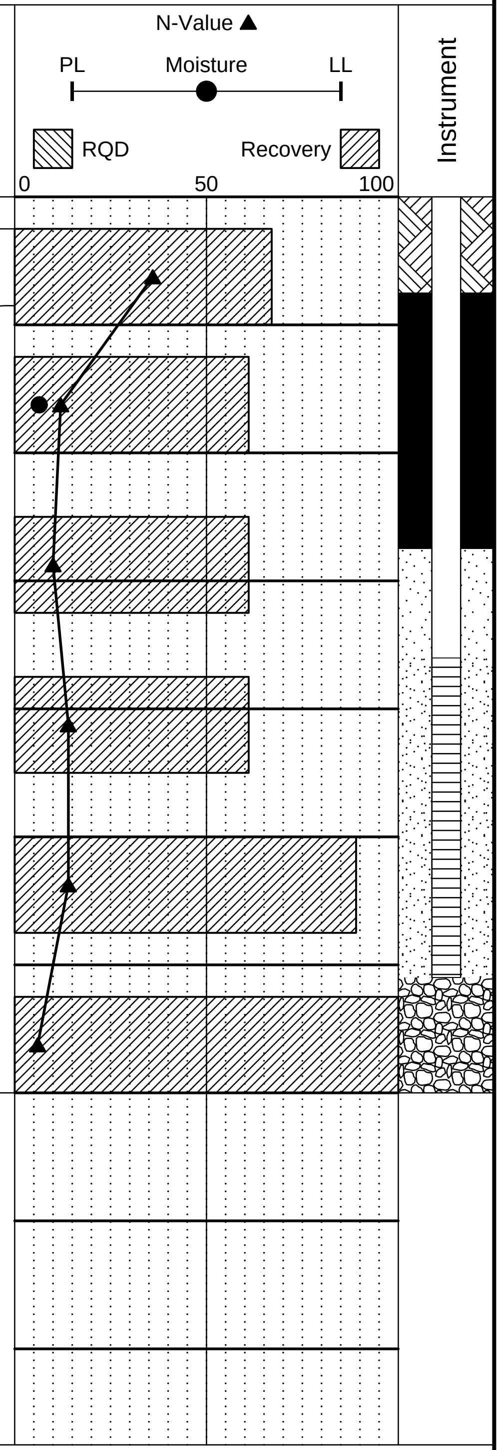
LOG OF TEST BORING B-1

Figure A-2

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

Project:	1st & 3rd Street Retrofit	Surface Elevation:	
Job Number:	13-239	Top of Casing Elev.:	
Location:	1st and 3rd Streets, Marysville, WA	Drilling Method:	HSA
Coordinates:	Northing: , Easting:	Sampling Method:	SPT

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0						6 inches of Asphalt.
	S-1		18 24 12			16 inches of Ballast/Base sand and gravel. Dense, brown and white, gravelly, fine to coarse SAND: moist some silt, layered, sub-rounded to sub-angular (Road Base).
2						Medium dense, brown to gray, fine to medium SAND: moist becoming wet, trace to some silt, well and poorly graded, non-plastic fines, occasional organic material or woody debris, homogeneous, laminated. (Recessional Outwash).
	S-2		5 6 6	GS		
4						
	S-3		4 5 5			Becoming wet.
6						
8	S-4		5 7 7			Some woody debris, occasional gravel.
10	S-5		4 7 7			Becoming fine to medium.
12	S-6		2 2 4			Laminated with one brown silt laminae.
14						Boring terminated at about 14 feet below the surface. Groundwater was measured at about 5.3 feet below the surface on November 26, 2013.
16						
18						



Completion Depth:	14.0ft
Date Borehole Started:	11/25/13
Date Borehole Completed:	11/25/13
Logged By:	S. Evans
Drilling Company:	Bore Tec Drilling

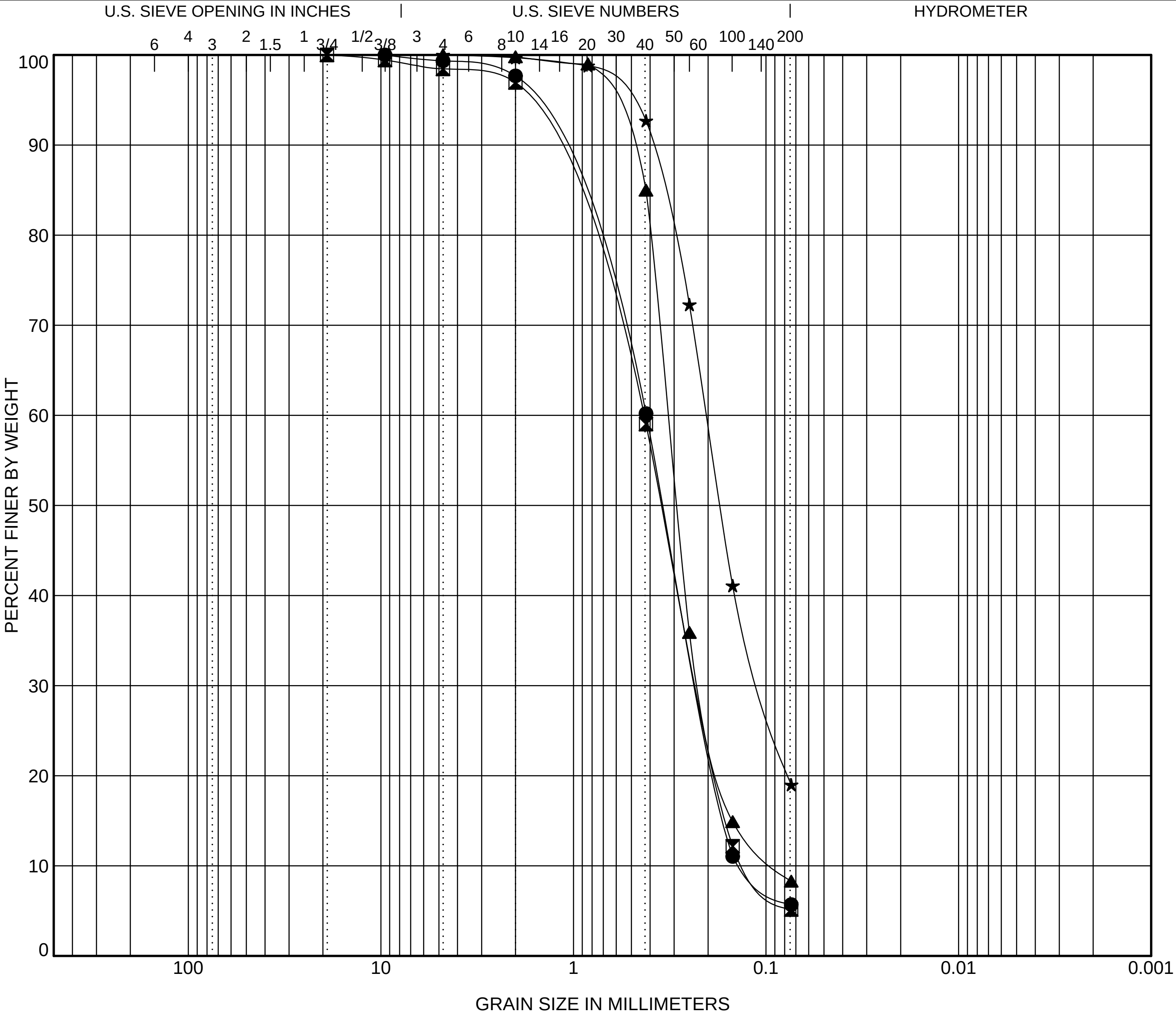
Remarks: Groundwater measured in well installation on 11/26/13 at 12:52. Well was then developed by pumping with a down-hole pump until return water was nearly clear, about 5 minutes. Data logger and barometric pressure logger installed in well following development. Logging was programed to begin at 12:00 noon, 11/27/13.

PanGEO INCORPORATED

LOG OF TEST BORING B-2

Figure A-3

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



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	B-1	@ 7.5 ft.	Browm-gray, fine to medium SAND, some silt				0.91	3.22
⧗	B-1	@ 10.0 ft.	Brown-gray, fine to coarse SAND, some silt				0.93	3.64
▲	B-2	@ 2.5 ft.	Brown-gray, fine to medium SAND, some silt				1.64	3.64
★	B-3	@ 2.5 ft.	Dark gray-yellowish brown, silty fine SAND					

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	B-1	7.5	9.52	0.418	0.222	0.13	0.7	93.5	5.8	
⧗	B-1	10.0	19.05	0.437	0.221	0.12	1.6	93.2	5.3	
▲	B-2	2.5	4.76	0.322	0.216	0.089	0.0	91.6	8.4	
★	B-3	2.5	4.76	0.204	0.105		0.0	80.6	19.4	

GRAIN SIZE DISTRIBUTION

PanGEO INCORPORATED
Phone: 206.262.0370

Project: 1st & 3rd Street Retrofit
Job Number: 13-239
Location: 1st and 3rd Streets, Marysville, WA

Figure B-1

APPENDIX D

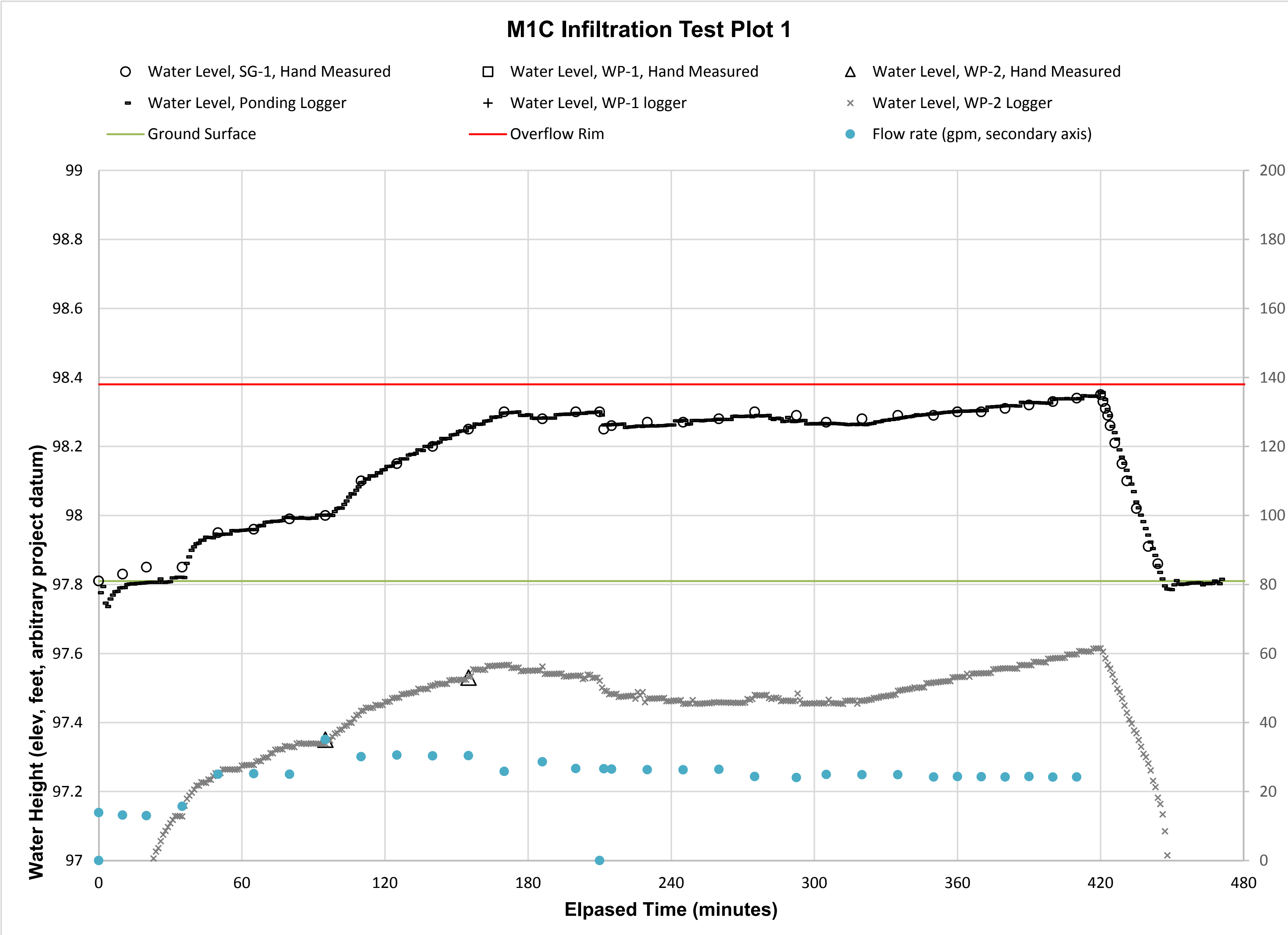
Field Infiltration Testing Data

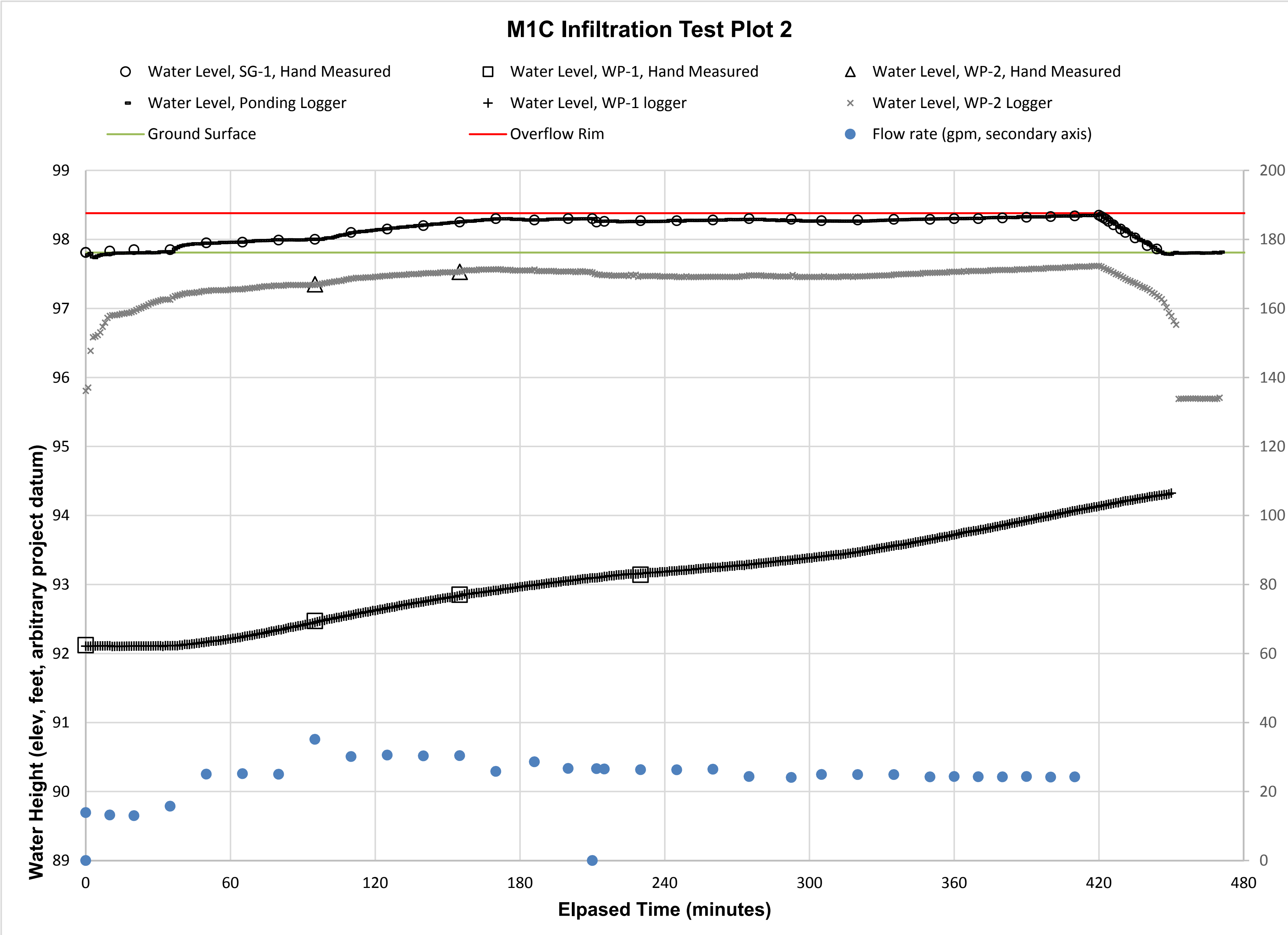
Project Name:	BHPS	**Water Source:**	Hydrant
Project Number:	150387H007	**Meter:**	AESI FM5
Date:	11/20/2018	**Base Area (sq.ft.):**	NA
Weather:	Intermittent rain, 60's	**Ponded Area(sq.ft.):**	130.0
Test No.:	M1C	**Test Depth (feet):**	NA
Performed By:	ADY, KRB	**Receptor Soils:**	Recessional Outwash

Time (24-hr)	Flow Rate (gpm)	Stage (feet)	Totalizer (gallons)	Comments
7:36				
7:40	13.89	0	0	Flow on
7:50	13.17	0.02	135.9	
8:00	13	0.04	262	
8:15	15.72	0.04	460	
8:30	25.01	0.14	830	
8:45	25.17	0.15	1210	
9:00	25	0.18	1590	
9:15	35.11	0.19	1962	
9:30	30.11	0.29	2474	
9:45	30.56	0.34	2925	
10:00	30.33	0.39	3406	
10:15	30.39	0.44	3837	
10:30	25.83	0.49	4306	
10:46	28.61	0.47	4725	
11:00	26.67	0.49	5122	Approx 0.5 gpm leaking through pipe joint into overflow
11:10	0	0.49		Flow off, flow meter calibration check.
11:11	26.61	0.44		Flow resumed.
11:15	26.5	0.45	5519	
11:30	26.33	0.46	5900	
11:45	26.29	0.46	6296	
12:00	26.44	0.47	6691	
12:15	24.33	0.49	7106	At 12:15, reduced flow rate from 26.4 to 24.3
12:32	24.06	0.48	7523	
12:45	24.94	0.46	7843	Water level meter not reading well point water levels - likely low salinity water
13:00	24.89	0.47	8200	
13:15	24.89	0.48	8583	
13:30	24.22	0.48	8943	
13:40	24.33	0.49	9185	
13:50	24.28	0.49	9437	
14:00	24.22	0.5	9675	
14:10	24.33	0.51	9913	
14:20	24.17	0.52	10177	
14:30	24.22	0.53	10408	14:39: observed flow overtop overflow grate, <0.5 gpm entered grate for approx 1 minute.
14:40	0	0.54	10644	Flow off
14:41		0.52		
14:42		0.5		
14:43		0.48		

14:44		0.45		
14:46		0.4		
14:49		0.34		
14:51		0.29		
14:55		0.21		
15:00		0.1		
15:02		0.08		
15:04		0.05		
15:07		dry		
15:10				
15:20				

	Average Infiltration Rate (in/hr) during last hour of inflow:	17.4
	Average Infiltration Rate (in/hr) during falling head:	14.7


M1C Infiltration Test Plot 1
Water Level, SG-1, Hand Measured
Water Level, WP-1, Hand Measured
Water Level, WP-2, Hand Measured
Water Level, Ponding Logger
Water Level, WP-1 logger
Water Level, WP-2 Logger
Ground Surface
Overflow Rim
Flow rate (gpm, secondary axis)
Water Height (elev, feet, arbitrary project datum)
99
98.8
98.6
98.4
98.2
98
97.8
97.6
97.4
97.2
97
200
180
160
140
120
100
80
60
40
20
0
0
60
120
180
240
300
360
420
480
Elpased Time (minutes)


M1C Infiltration Test Plot 2
Water Level, SG-1, Hand Measured
Water Level, WP-1, Hand Measured
Water Level, WP-2, Hand Measured
Water Level, Ponding Logger
Water Level, WP-1 logger
Water Level, WP-2 Logger
Ground Surface
Overflow Rim
Flow rate (gpm, secondary axis)
Water Height (elev, feet, arbitrary project datum)
Elpased Time (minutes)
99
98
97
96
95
94
93
92
91
90
89
0
60
120
180
240
300
360
420
480
200
180
160
140
120
100
80
60
40
20
0

APPENDIX E

Site Photos

Above photo: Cell M1C, overview of cell.

Lower photo: Cell M1C, note surface water in top of photo, tidally influenced.

Above photo: M1C primary inlet.
Lower Photo: close up of overflow structure.

Technical Memorandum

Date:	June 14, 2019	**From:**	Anton Ympa Suzanne Cook, L.G.
To:	Clear Creek Solutions, Inc.	**Project Manager:**	Jennifer H. Saltonstall, L.G., L.Hg.
	15800 Village Green Drive #3 Mill Creek, Washington 98012	**Principal in Charge:**	Jennifer H. Saltonstall, L.G., L.Hg.
cc:	Eric Christensen	**Project Name:**	Bioretention Hydrologic Performance Study
Attn:	Doug Beyerlein, P.E.	**Project No:**	150387H007
Subject:	Deliverable Task 4.5, Site M3Q, Geotechnical/Soils Assessment Design Data and Current Conditions, 3rd Street Low Impact Development, Marysville, Washington		

1.0 INTRODUCTION

This technical memorandum documents existing shallow soil and groundwater conditions in bioretention cell #2 at the intersection of Quinn Avenue and 3rd Street, north side of the city of Marysville, 3rd Street Low Impact Development and Roadway Improvement Project, located in the city of Marysville, Washington (Figure M3Q F1). This memorandum was prepared in accordance with Task 4 of the contract scope of work. Associated Earth Sciences, Inc. (AESI) collected shallow soil and groundwater conditions data related to bioretention cell function, and documented the current condition of the facility relative to the as-built drawings and available background geotechnical information. The information will be used in the WWHM2012 modeling that will be conducted as part of Task 5 (Data Analysis). In Task 5, the team will compare the previously documented hydrologic design information with our field-collected information and will note where there are significant differences. The purpose of this technical memorandum is to document the collection of current and accurate geotechnical, geologic, and hydrogeologic site information for this later work.

The following summary of shallow soil and groundwater conditions integrates the observations made during the geotechnical assessment which included site visits on October 4, 2018, infiltration testing on October 30, 2018, provisional results of hydrologic monitoring, and background geotechnical information.

This technical memorandum has been prepared for the exclusive use of Clear Creek Solutions and the City of Olympia and their agents for specific application to this project. Within the limitations of scope, schedule, and budget, our services have been performed in accordance with generally accepted hydrogeologic and geotechnical engineering practices in effect in this area at the time our document was prepared. No other warranty, express or implied, is made.

2.0 PURPOSE AND SCOPE

The purpose of our work was to perform a shallow soil and groundwater conditions assessment and provide baseline documentation data to assess effectiveness of bioretention hydrologic performance.

Specifically, our scope included the following activities:

- Review of project documents.
- Site reconnaissance.
- Visual condition assessment of erosion and deposition features near inlet and outlet.
- Review project plans relative to constructed facility, in particular, the number and location of inlets, energy dissipation devices, outlets, and other flow-related details.
- Survey elevations of inlet, outlet, well point rim, and other observation points relative to a project datum.
- Excavate shallow hand augers through the bioretention soil.
- Classify sediment according to the Unified Soil Classification System (USCS) and *American Society for Testing and Materials* (ASTM) D2488, "Standard Recommended Practice for Description of Soils."
- Collect samples for laboratory testing of: (1) particle size distribution in accordance with ASTM D422-63, "Standard Test Method for Particle-Size Analysis of Soils"; (2) organic matter content per ASTM D2974.
- Preparation of descriptive exploration logs for each exploration.
- Conduct qualitative assessment of soil compaction via T-probe.
- Conduct infiltration testing.
- Review of hydrologic monitoring data.
- Preparation of this summary document.

Existing facility features and the locations of hand-auger boreholes completed for this study are shown on Figure M3Q F2, "Facility and Exploration Plan." Project civil plans are attached as Appendix A. Exploration logs and laboratory testing data conducted as part of this study are attached as Appendix B. Background soil, geology, and groundwater information are attached as Appendix C. Soil probe, level survey, and field infiltration testing data are attached as Appendix D. Site photos are attached as Appendix E.

3.0 SITE DESCRIPTION AND DESIGN BACKGROUND

The project site is the City of Marysville, 3rd Street Low Impact Development and Roadway Improvement Project, located in Marysville, Washington as shown on the attached "Vicinity Map" (Figure M3Q F1). The site is bordered by roadways and sidewalks along a residential street with small areas of grass. Site topography is generally flat. The site is located approximately ½ mile north of Ebey Slough, a tributary of the Snohomish River system that discharges directly to Puget Sound.

Per the Washington State Source Water Assessment Program Mapping Application, the site is not located within a time of travel zone for any Group A water system.

Our specific area of study for this project includes bioretention facility cell #2 located on the northeast corner of the intersection of Quinn Avenue and 3rd Street, on the east side of Quinn Avenue, referred to as cell M3Q for this study. The attached "Facility and Exploration Plan" (Figure M3Q F2) illustrates the cell area and some of the surrounding site features and utilities.

Details of the bioretention facility design and basis for design were presented in the following documents:

- "Geotechnical Report First and Third Street Retrofit," Marysville, Washington, PanGEO, Inc., March 4, 2014.
- "Geotechnical Design Recommendations 3rd Street Retrofit," Marysville, Washington, PanGEO, Inc., December 31, 2013.
- "City of Marysville, 1st and 3rd Stormwater Retrofit Project Predesign Report," prepared by Gray & Osborne, Inc., January 2014.
- City of Marysville, 3rd Street Low Impact Development and Roadway Improvement Project," prepared by Gray & Osborne, Inc., August 2016 (plan set).

3.1 Summary of Facility Design

From our review of these documents, the bioretention facility design for cell M3Q consists of an approximately square-shaped bioretention cell with approximately 200 square feet of base area surrounded by bioretention barrier curb set in a concrete sidewalk, as shown on Figure M3Q F2, "Facility and Exploration Plan." We understand that the site was developed under the Washington State Department of Ecology (Ecology) 2014 *Stormwater Management Manual for Western Washington* (2014 Ecology Manual) for design and construction of stormwater facilities and modeled using WWHM2012 with a design infiltration rate of 2 inches per hour (in/hr) in the native subgrade. Land use within the drainage basin is primarily residential roadway and sidewalk with some residential lawn and rooftops. Per "3rd Street Low Impact Development Project, Road and Storm Plan and Profile," Sheet 18 of 25 (Gray & Osborne, Inc. [G&O], August 2016), the facility design includes 2 inches of mulch overlying 18 inches of bioretention soil mix overlying existing subgrade (native soil).

The facility is designed to infiltrate 100 percent of inflow into the subgrade. Stormwater is designed to enter the facility through one curbcut located on Quinn Avenue and 4-inch sidewalk curb notches placed on 10-foot centers. If water ponds up on the bioretention soil, the ponded water would discharge into an 8-inch polyvinyl chloride (PVC) overflow riser with an 8-inch Nyloplast dome grate located near the south-center of the cell, and then into an 8-inch lateral PVC overflow pipe. The rim of the overflow riser was designed to be 12 inches higher than the cell base to create 12 inches of ponding depth. The facility was constructed during fall 2016.

4.0 SITE OBSERVATIONS

During AESI's site visits, we made notes regarding the physical construction of the bioretention facility including documenting site inlet/outlet layout relative to site plans and qualitative bioretention soil thickness and compaction. These notes were used to indicate key features of the facility in Figure M3Q F2, "Facility and Exploration Plan."

- Level Survey: AESI conducted an elevation survey of the cell using a Leitz C40 automatic level and a stadia rod. An arbitrary project datum was established for this survey, with the light utility box cover defined as project datum elevation 100 feet. All other elevations measured by the survey are relative to this project datum. Key level data is summarized in Table 1. Additional data points are included in Appendix D to this document. This survey was not conducted by a licensed surveyor. Surveyed elevations are expected to be sufficiently accurate for this general assessment of facility construction, but may be inaccurate for purposes requiring greater precision.

- Inflow: One curb cut from Quinn Avenue and no sidewalk curb notches.
    - The only inlet to the facility is a 12-inch curbcut consistent with project plans (with a 2-inch depressed gutter allowing flow into the cell), which discharges onto a concrete pad approximately 1 foot long by 2 feet wide. Quarry spall splash pads surrounding the concrete pad indicated on plans were not observed.

    - Small curb notches (4-inch width on 10-foot centers) are called out in the design; however, no curb notches were installed along the sidewalk side of facility. Instead, sidewalk runoff flows south and west against the cell barrier curbs to the enter Quinn Avenue road, then flow into the cell street via the curbcut.

- Overflow: The overflow consists of an 8-inch PVC overflow riser (cleanout) with an 8-inch Nyloplast dome grate. The rim of this grate was approximately 0.95 feet above the base of the facility. The overflow riser conveys water to an 8-inch lateral overflow pipe that connects to cell #4 at a new catch basin (CB #9) and then ties into an existing storm catch basin on the west side of Quinn Avenue.

- AESI investigated the loose bioretention soil thickness present in cell M3Q using a geotechnical soil T-probe. This qualitative data was used in conjunction with the hand-auger observations to understand loose soil thickness and relative potential compactness of the bioretention soils at depth. AESI measured the depth of penetration of the soils probe at locations generally arranged in a 3-foot to 3-foot grid on the facility base. Penetration of the T-probe generally ranged from approximately 0.4 feet to 2.0 feet, and averaged 1.0 feet. Probe penetration data is included in Appendix D to this document.

- The observed cell base area, of 200 square feet, was similar to the design of about 208 square feet. We note that the north curb was placed about approximately a foot south of design.

Table 1
Summary of Cell M3Q
Level Survey Data

Location	Elevation (feet, project datum)
Light utility box cover (center)	100.00
Bioretention barrier curb top NW corner	100.10
Bioretention barrier curb top SW corner	99.83
Bioretention barrier curb top NE corner	100.40
Bioretention barrier curb top SW corner	100.11
Temporary staff gauge	97.80
Curbcut Inlet (center)	99.34
WP-1 TOC	98.74
WP-2 TOC	99.11
Ponding tube TOC (DL)	99.32
Top/end 8" temporary inlet pipe	99.37
8" PVC overflow rim	98.75
Overflow cleanout data logger PVC TOC	98.81

WP: well point; TOC: top of Casing;
PVC: polyvinyl chloride; DL: datalogger;

5.0 SITE SETTING

The text sections below describe our research findings in regard to the topographic, geologic, and hydrogeologic setting of the project site both from regional studies and background site-specific geotechnical and groundwater studies. Our sources of information included the following:

- Site-specific documents cited previously under “Project and Site Description.”
- Minard, J.P., 1985, *Geologic Map of the Marysville Quadrangle, Snohomish County, Washington*: U.S. Geological Survey (USGS), Miscellaneous Field Studies Map MF-1743, scale 1:24,000.
- Natural Resources Conservation Service (NRSC), Web Soil Survey, United States Department of Agriculture (USDA), http://websoilsurvey.nrcs.usda.gov/, accessed January 2019.
- *Soil Survey of Snohomish County Area, Washington*, United States Department of Agriculture (USDA), Natural Resource Conservation Service (NRCS), in cooperation with Washington Agricultural Experiment Station, 1983.
- Newcomb, R.C., 1952, *Ground-water Resources of Snohomish County, Washington*: U.S. Geological Survey (USGS), Water-Supply Paper 1135, scale 1:62,500.

5.1 Regional Topography and Project Grading

The project site is situated at low-lying topography at the south margin of the Marysville Trough recessional plain, near Ebey Slough, part of the Snohomish River flats. The Snohomish River and Ebey Slough empty into Possession Sound approximately 2 miles southwest of the project. Elevations on the larger project site range from about 20 to 30 feet.

On a closer scale, the area near cell M3Q is relatively level, situated on an outwash plain at about elevation 30 feet. The site is located about ½ mile north of Ebey Slough, which is below 10 feet elevation. Relatively level Quinn Avenue and sidewalks surround the cell on the west, south, and east, and lawn to the north. A curb separates the paved surfaces and lawn from the cell.

Bioretention cell M3Q and the surrounding sidewalk were added to the existing Quinn Avenue and 3rd Street. The right-of-way area previously was grass lawn area and areas with evergreen trees. Various utilities are present in the vicinity of the site, including buried water and sewer mains. Cuts on the order of 5 feet were needed to achieve design bioretention cell grades based on a review of existing topography compared with built topography.

5.2 Regional Geology and Background Geotechnical Information

According to a regional geology map (Minard, 1985), the site vicinity is underlain by Vashon recessional outwash. Recessional outwash sediments in the project area are described on the referenced map to consist of outwash sand with some fine gravel and beds of silt and clay deposited from meltwater streams (Minard, 1985), which is consistent with our observations and interpretations of subsurface materials encountered in our explorations for this project.

- Vashon Recessional Outwash (Qvr): This unit is composed of stratified to massive outwash sand with some fine gravel and beds of silt and clay. Recessional outwash in the project area was deposited by glacial meltwater streams during ice retreat (Minard, 1985) and has not been glacially overridden.

Background geotechnical information includes exploration logs B-5, B-6 and B-7 within 100 feet (B-5) and 450 feet (B-6 and B-7) of cell M3Q dated November 25 and 26, 2013. Borings B-5 to B-7 reached depths of about 14 to 16.5 feet below current grades, and describe material generally consisting of an upper few feet of loose to medium dense, laminated, silty sand and grading to a clean, somewhat coarser sand with trace to some silt and trace gravel interpreted to be recessional outwash (PanGEO, Inc., 2014), which is consistent with the geologic mapping in the area. Shallow fill soils were encountered to depths of up to 1 feet. Groundwater was encountered between 12 (B-5) and 16 feet (B-7) at the time of drilling. Groundwater was not encountered before the terminal depth of 14 feet in B-6.

5.3 Regional Soils and Soil Data Used in Site Stormwater Model

AESI reviewed the soil survey (Natural Resources Conservation Service [NRCS], 1983) and soils mapping from the NRCS web portal (NRCS, 2018). The soil survey identifies different soil map units based on parent material, climate, topography (slope), organisms (biota), and time. The soils in the study area formed mostly from young glacial deposits and have not had time to develop the deep weathering profiles present in soils in unglaciated terrains. Instead, they exhibit a direct relationship to the underlying parent material, local climate, topography, and vegetation.

Mapped soils in the project area consist of Ragnar fine sandy loam (NRCS, 2018). This very deep, well-drained soil is situated on outwash plains and formed in glacial outwash. NRCS describes the permeability as moderately rapid (NRCS, 1983).

As described in the predesign report (G&O, 2014), the pre-developed condition was modeled as 100 percent impervious (roads, flat), consistent with the existing drainage area condition and background geotechnical data.

5.4 Regional Hydrogeology and Background Groundwater Data

Regional hydrogeology is described by Newcomb (1952). The coastal lowlands often represent hundreds of feet of glacial and alluvial deposits backfilled into ancestral drainage systems (Newcomb, 1952). Outwash sands below the local water table carry large quantities of groundwater and alluvial materials in river valleys are good aquifers in the lower Snohomish Valley.

Within the vicinity of cell M3Q, groundwater was encountered within sediments identified as Vashon recessional outwash (PanGEO, Inc., 2014). The shallow aquifer identified is interpreted to be in hydraulic conductivity locally with river valley aquifers of the Snohomish River and Ebey Slough to the south/southwest. Groundwater was encountered during drilling in the vicinity of cell M3Q between 12 feet (B-5) and 16 feet (B-7) below grade. Groundwater was not encountered before the terminal depth of 14 feet in B-6 (PanGEO, Inc., 2014).

6.0 BIORETENTION CELL SUBSURFACE EXPLORATION

Limited information on subsurface conditions was obtained for this study from hand-auger samples and soil probe penetration measurements at about 2-foot increments in each hand-augered borehole. Three hand-auger borings were performed in the facility bottom and advanced through the bioretention soil and to refusal in the underlying fill (M3Q-HA-3 or into the native Vashon recessional outwash M3Q-HA-1 and M3Q-HA-2). Representative samples were collected, visually classified in the field, stored in water-tight containers, and transported to AESI’s offices for additional classification, geotechnical testing, and study. At the conclusion of the excavation, the boreholes were immediately backfilled with the excavated material or completed as a well point for water level monitoring (described separately below).

The various types of sediments, as well as the depths where characteristics of the sediments changed, are indicated on the exploration logs presented in Appendix B. A detailed record of the observed bioretention soil, subsurface soil, geology, and groundwater conditions was made. The sediments were described by visual and textural examination using the soil classification in general accordance with ASTM D2488, “Standard Recommended Practice for Description of Soils.” The depths indicated on the logs where conditions changed may represent gradational variations between sediment types in the field. The exploration logs in Appendix B are based on the field observations, inspection of the samples, and where applicable, laboratory grain-size analysis. Our explorations were approximately located in the field relative to known site features, and are shown on Figure M3Q F2, "Facility and Exploration Plan."

The results presented in this document are based on the explorations completed for this study and review of background data. The number, locations, and depths of the explorations were completed within site and budgetary constraints. Because of the nature of exploratory work below ground, interpolation of subsurface conditions between field explorations is necessary. It should be noted that differing subsurface conditions may sometimes be present due to the random nature of deposition and the alteration of topography by past grading and/or filling.

6.1 Hand-Auger Borings

Hand-auger borings in cell M3Q were completed on October 4, 2018. No rainfall was noted at the time of exploration.

Hand-auger boring locations are presented on Figure M3Q-F2. The hand-auger borings, encountered a thin layer of mulch overlying bioretention soil to a depth of 0.8 to 1.1 feet, overlying a mix of backfill and native recessional outwash (M3Q-HA-2 and M3Q-HA-3) and/or native recessional outwash (M3Q-HA-1 and M3Q-HA-2). Bioretention soil thickness was between 0.6 feet to 1.0 feet in each boring. No seepage or caving was observed.

6.2 Well Points

Two well points were installed in cell M3Q, one within M3Q-HA-1 (WP-1) and one driven without a hand-auger exploration (WP-2). Key well point dimensions are provided in Table 2, below. WP-1 was installed to a depth of 6.4 feet to measure groundwater in the shallow aquifer below the bioretention soil. WP-2 was installed to a depth of 1.4 feet, and screened primarily within the bioretention soil.

Table 2
Summary of Cell M3Q
Well Point Dimensions

Well Point	Exploration in which Well Point was Installed	Total Length of Casing (feet)	Interior Diameter	Stickup Height (feet)	Total Depth Inside Casing Below Ground Surface
M3Q -WP-1	M3Q -HA-1	7.4	1.25 inch nominal	0.8	6.6
M3Q -WP-2	None	2.6	1.25 inch nominal	1.2	1.4

7.0 LABORATORY ANALYSIS

Laboratory testing included mechanical grain-size distribution and percent organic matter by weight in accordance with the ASTM D422 and D2974, respectively. Bioretention soil was first tested for organic matter content and then the burned material was tested for grain-size distribution for comparison with the aggregate fraction of the bioretention soil mix guidance in the 2014 Ecology *Stormwater Management Manual for Western Washington* (2014 Ecology Manual). Three samples of material interpreted as representative of the bioretention soil was tested for grain-size distribution. The data is summarized in Table 3.

Table 3
Summary of Cell M3Q
Organic Content and Grain Size Data

Exploration Number	Depth (feet)	Soil Type	Organic Content (% by weight)	USCS Soil Description	Fines Content (% passing #200)	Cu	Cc	USDA Soil Texture*
M3Q-HA-1	0.2-0.5	Bioretention Soil	6.6	SAND, some gravel, trace silt (SP)	4.5	3.4	1.1	Sand
M3Q-HA-2	0.1-0.5	Bioretention Soil	6.0	SAND, trace silt, trace gravel (SP)	4.0	2.9	1.0	Sand
M3Q-HA-3	0.2-0.8	Bioretention Soil	6.4	SAND, some gravel, trace silt (SP)	4.5	3.0	1.0	Sand

USCS: Unified Soil Classification System; Cu: coefficient of uniformity; Cc: coefficient of curvature; USDA: U.S. Dept. of Agriculture;
*No hydrometers were performed. USDA soil texture range assumes fines consist entirely of silt to entirely of clay.

7.1 Bioretention Soil Mix

We compared the organic content and burned fraction gradation against the general guidelines for the bioretention soil mix (Table 4).

The organic content of the tested bioretention soils ranged between 6.0 to 6.6 percent by weight. This meets the recommended organic content by weight of 5 to 8 percent in the 2014 Ecology Manual.

The grain-size analysis test results on the burned soil fraction indicate that the bioretention soils tested correlate to a "SAND" with trace silt and trace to some gravel based on ASTM D2487 USCS. The respective fines content as measured on the No. 200 sieve was 4.0 to 4.5 percent within the recommended range of 2 to 5 percent. The coefficient of uniformity ranged from 2.9 to 3.4, below the recommended value of equal to or greater than 4. The coefficient of curvature ranged from 1.0 to 1.1, within the recommended range of greater than or equal to 1 and less than or equal to 3. The soil mix met the recommended guidelines for grain size distribution. The tested bioretention soil was a poorly-graded sand.

Table 4
General Guidelines for Bioretention Soil Mix (2014 Ecology Manual)
Compared to Averaged Cell M3Q Site Data

Parameter	Recommended Range	Cell M3Q
Organic Content (by weight)	5 to 8 percent	6.3 percent by weight
Cu coefficient of uniformity	4 or greater	3.1
Cc coefficient of curvature	1 to 3	1.0
Sieve Size	**Percent Passing**	
3/8" (9.51 mm)	100	98.9
#4 (4.76 mm)	95 to 100	94.8
#10 (2.0 mm)	75 to 90	87.2
#40 (0.42 mm)	25 to 40	35.8
#100 (0.15 mm)	4 to 10	6.5
#200 (0.074 mm)	2 to 5	4.3

Note: The general guidelines for mineral aggregate gradation are from Table 7.4.1 of the 2014 Ecology Manual.
mm: millimeters.

7.2 Subgrade

In cell M3Q, the native material is recessional outwash, visually classified as a SAND with trace silt (SP).

8.0 INFILTRATION TESTING

8.1 General Infiltration Test Method

The infiltration test was conducted in general accordance with the 2014 Ecology Manual. The test was conducted by discharging water into the facility for a "soaking period," to allow the receptor soils to become saturated. After completion of the soaking period, water was discharged into the cell at a rate sufficient to maintain a relatively constant head. This constitutes the "constant-head" phase of infiltration testing. Immediately following the constant-head phase of infiltration testing, flow into the facility was discontinued, and the water level was monitored as it dropped. This constitutes the "falling head" portion of the infiltration testing.

The water for testing was obtained from an on-site fire hydrant and conveyed to cell M3Q with fire hoses. During infiltration testing, the water was conveyed into the bioretention cell via a digital flow meter with gallons per minute (gpm) and total gallon readouts and discharged through a flow diffuser. Ponded water levels within the cell were monitored using a temporary staff gauge (M3Q-SG-1) marked in 0.01-foot increments installed adjacent the overflow riser and within a piezometer ("ponding tube") with a digital water level tape, and with digital pressure transducers for the duration of the test. The water level at the base of the bioretention soil and deeper in the subsurface were monitored in well point M3Q-WP-2 and M3Q-WP-1, respectively, with a digital water level tape, and with digital pressure transducers. Data from the digital pressure transducers was compensated for barometric response using a separate digital barometer. The area of the pool was measured periodically during testing.

The infiltration test in cell M3Q is discussed below, and results are presented in Table 5. Infiltration test data is included in Appendix D to this document.

8.2 Infiltration Test in Cell M3Q

AESI performed infiltration testing on October 30, 2018. No rainfall was noted during testing; however, a minor leak in the test hoses on the sidewalk contributed less than 0.1 gpm inflow entering via curbcut.

During this test, flow was initially adjusted between about 10 and 65 gpm to fill the cell bottom and stabilize the wetted area, then maintained at about 32 gpm for the duration of test. Inflow to the facility for the infiltration test was directed, through a diffuser, onto the cell. The entire cell base was wetted after about 50 minutes and a water level of about 0.9 feet was maintained as measured on M3Q-SG-1. The wetted pool area was generally stable through most of the soaking and testing period covering an area of about 200 square feet. Approximately 15,400 gallons of water were used.

Ponded water in the bioretention cell was monitored in well point M3Q-WP-2 with a data logger during the infiltration test and responded rapidly to inflow. Groundwater was not observed within the bioretention soil prior to the start of inflow. The water level in the well point responded to inflow within several minutes, and rose to near ground surface at the well point. AESI interprets this response to indicate that water from the infiltration test infiltrated relatively rapidly through the bioretention soil and then mounded on the native finer-grained recessional outwash. The shallow subsurface ponded water level mirrored the surface water ponding level.

Groundwater was monitored in the well point M3Q-WP-1 using a data logger during the infiltration test and responded to inflow. Groundwater was not measured beneath the bioretention cell prior to the start of inflow (to the bottom depth of well point M3Q-WP-1 of 7 feet), however a shallow groundwater aquifer is expected to exist in the native sediments at a depth of about 12 to 16 feet. The water level in well point M3Q-WP-1 responded to inflow after about 50 minutes, and rose about 3.4 feet (from greater than 7 feet below ground surface to 3.6 feet below ground surface) during testing. AESI interprets this response to indicate that water from the infiltration test infiltrated relatively rapidly through the bioretention soil and native sediments, then mounded on the shallow groundwater present beneath the facility.

After about 7 hours, AESI shut off the flow and monitored the water level as it fell. AESI observed that the pooled water in the base of the facility and the ponded subsurface water in the bioretention cell infiltrated over the course of approximately 40 minutes. The groundwater mound immediately decreased after test inflow ended and was about 6.2 feet below the ground surface 50 minutes after inflow ended.

The constant-head test infiltration rate in Table 5 is calculated based on flow rate from the hose for infiltration testing, and the wetted area of bioretention soil through which the water infiltrated, and represents the infiltration rate of the native subgrade.

Table 5
Cell M3Q
Infiltration Test Results

Test No.	Surface Area (square feet)	Discharge Time (minutes)	Total Volume Discharged (gallons)	Approximate Constant-Head Level (feet)	Field Infiltration Rates	
					Constant-Head Test (in/hr)	Falling-Head Test (in/hr)
M3Q (bioretention soil)	200	420	15,420	0.92	greater than native soil infiltration rate	
M3Q (subgrade)	interpreted to be similar to wetted area				15	14

in/hr: inches per hour.

9.0 CONCLUSIONS AND RECOMMENDATIONS

Cell M3Q was generally consistent with the design shown on the civil plan sheets. Observations on site design, shallow soil, and groundwater conditions are discussed below.

- The overflow is generally consistent with the plans. Site design documents indicate that the ponding level was designed as 12 inches, the overflow rim was observed to be 11.4 inches above the ground surface.

- Cell Design: The curbed area was slightly smaller than plans (G&O, 2016). The sidewalk curb notches were not installed, however sidewalk runoff flows into the curbcut.

- Bioretention soil:
    - Thickness: The apparent thickness of loose bioretention soil based on soil probe data was generally about 1.0-foot; less than plans which indicated 1.5 feet.
    - Composition: The soil tested in generally the recommended guidelines for organic content and sand gradation. The coefficient of uniformity was below the recommended range.

- Subgrade conditions: The subgrade is interpreted to consist of Vashon recessional outwash, as documented by previous studies for this project (PanGEO, Inc., 2013 and 2014).

- During infiltration testing, water readily soaked through the bioretention soil mix. Water was observed in the shallow well point (screened at the base of the bioretention soil), demonstrating that water accumulated on the underlying subgrade. The native fine sand is interpreted to have a lower permeability than the overlying bioretention soil. The shallow subsurface ponded water level mirrored the surface water ponding level.

- Subgrade infiltration rate: Measured at about 15 in/hr.

- Bioretention soil field infiltration rate:
  - Greater than the measured field rate of 15 in/hr.
  - Water readily soaked through the bioretention soil mix and the field rate is interpreted to represent the native subgrade infiltration rate.

- Shallow groundwater is expected to be present in the location of the M3Q facility as measured in M3Q-WP-1 during testing and previous studies for this project (PanGEO, Inc., 2014). AESI interprets that the infiltration test water soaked readily through the bioretention soil and native subgrade, and mounded on the underlying shallow water table, then dissipated both laterally and vertically as shallow groundwater flow. During testing, the lag time in response to start of inflow and stop of inflow was approximately 50 minutes.

- The effects of shallow groundwater mounding will increase during the wetter winter months, and if significantly mounded, could reduce the effective infiltration rate by reducing the vertical gradient. The ongoing monitoring data will be reviewed for groundwater influence.

10.0 CLOSURE

We appreciate the opportunity to be of continued service to you on this project. Should you have any questions regarding this document or other geotechnical/hydrogeologic aspects of the project, please call us at your earliest convenience.

State of Washington
Hydrogeologist
2335
Licensed Geologist
Jennifer H. Saltonstall

6/14/19

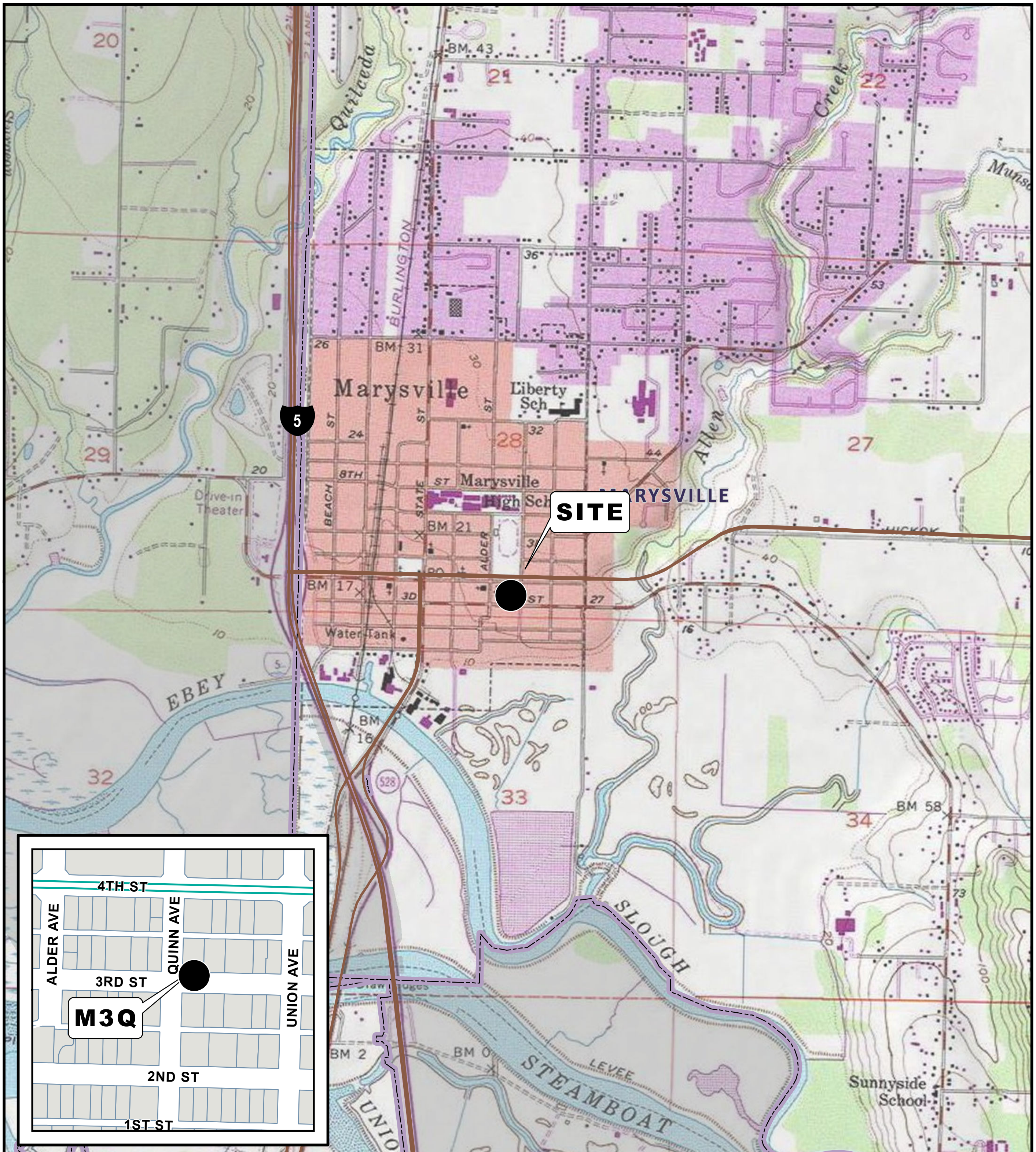
Suzanne S. Cook, L.G.
Senior Project Geologist

Anton D. Ypma
Staff Geologist

Jennifer H. Saltonstall, L.G., L.Hg.
Principal Geologist/Hydrogeologist

Attachments:	Figure M3Q F1:	Vicinity Map
	Figure M3Q F2:	Facility and Exploration Plan
	Appendix A:	Project Civil Plans
	Appendix B:	Current Study Exploration Logs and Laboratory Testing Data
	Appendix C:	Background Soil, Geology, and Groundwater Data (Regional Maps, Previous Studies Exploration Logs and Laboratory Testing Data)
	Appendix D:	Soil Probe, Level Survey, and Field Infiltration Testing Data
	Appendix E:	Site Photos

JHS/ld
150387H007-5
Projects\20150387\KH\WP



N

0 1000 2000
FEET

DATA SOURCES / REFERENCES:
USGS: 7.5' SERIES TOPOGRAPHIC MAPS, ESRI/I-CUBED/NATIONAL GEOGRAPHIC SOCIETY 2013
SNOHOMISH CO: STREETS, CITY LIMITS, PARCELS, 1/18
LOCATIONS AND DISTANCES SHOWN ARE APPROXIMATE

NOTE: BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION

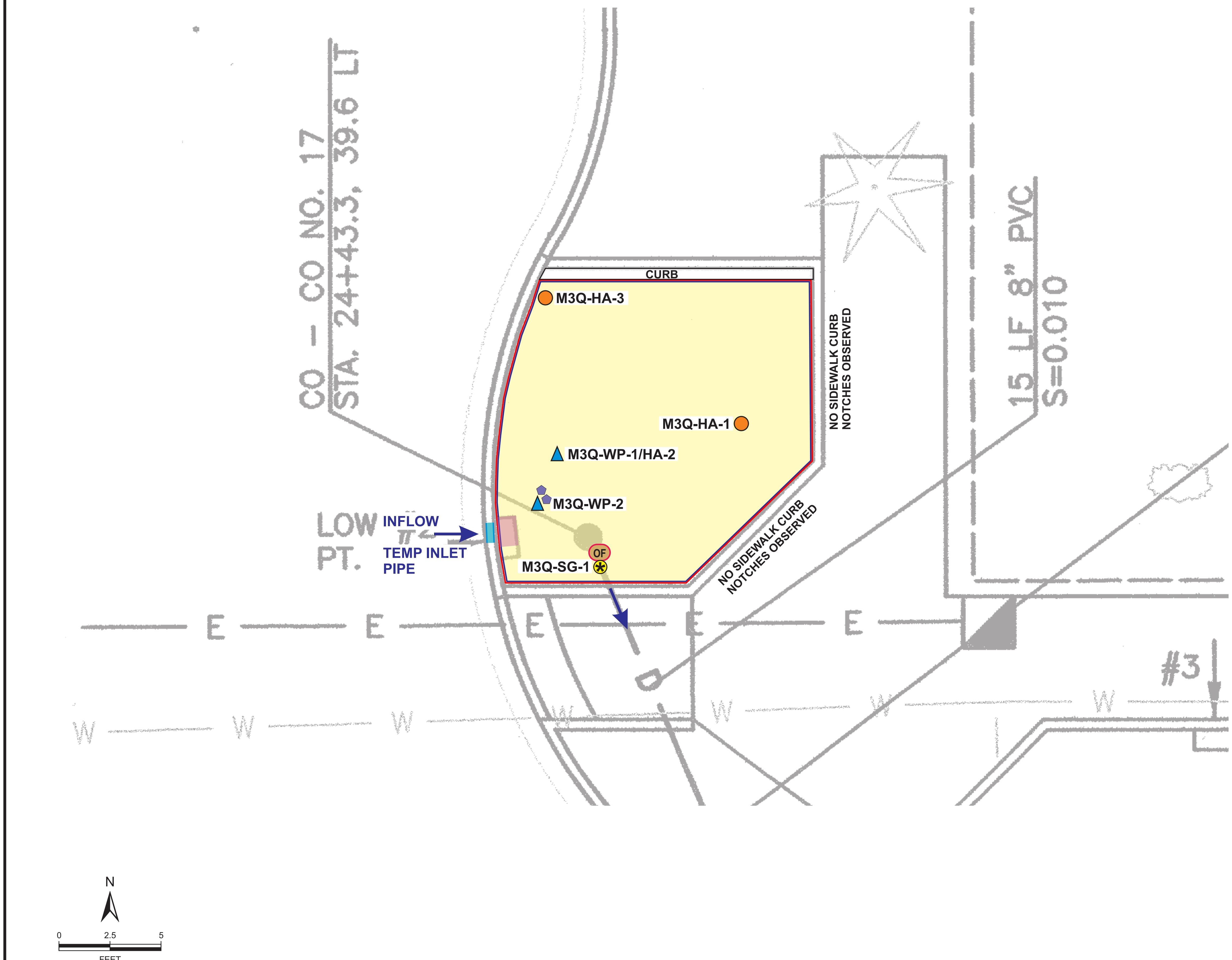
associated earth sciences incorporated

VICINITY MAP

BIORETENTION HYDROLOGIC PERFORMANCE STUDY, M3Q SITE
MARYSVILLE, WASHINGTON

PROJ NO.	DATE:	FIGURE:
150387H007	3/19	M3Q F1

Document Path: G:\GIS_Projects\aY15post0716\150387 Bioretention Hydro Performance Monitoring\mxd\PhaseII\Fig1s\150387H007 F1 VM_M3Q.mxd



LEGEND:

- HA — HAND AUGER
- WP — WELL POINT
- TEMPORARY STAFF GAUGE
- BASE OF FACILITY
- TOP OF FACILITY SLOPE
- INFLOW / OVERFLOW DIRECTION
- OF — OVERFLOW - 8" PVC
- PVC PONDING TUBE
- CURB CUT
- CONCRETE SPLASH PAD

CONTOUR INTERVAL = N/A

NOTE: LOCATION AND DISTANCES SHOWN ARE APPROXIMATE.

NOTES:
1. BASE MAP REFERENCE: GRAY AND OSBORNE, INC., CITY OF MARYSVILLE 3RD STREET LOW IMPACT DEVELOPMENT AND ROADWAY IMPROVEMENT PROJECT, STORMWATER PLAN AND PROFILE, SHEET 21 OF 68, 8/12/16

BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION.

associated earth sciences incorporated

FACILITY AND EXPLORATION PLAN
M3Q SITE
BIORETENTION HYDROLOGIC PERFORMANCE
MARYSVILLE, WASHINGTON

PROJ NO.	DATE:	FIGURE:
150387H007	3/19	M3Q F2

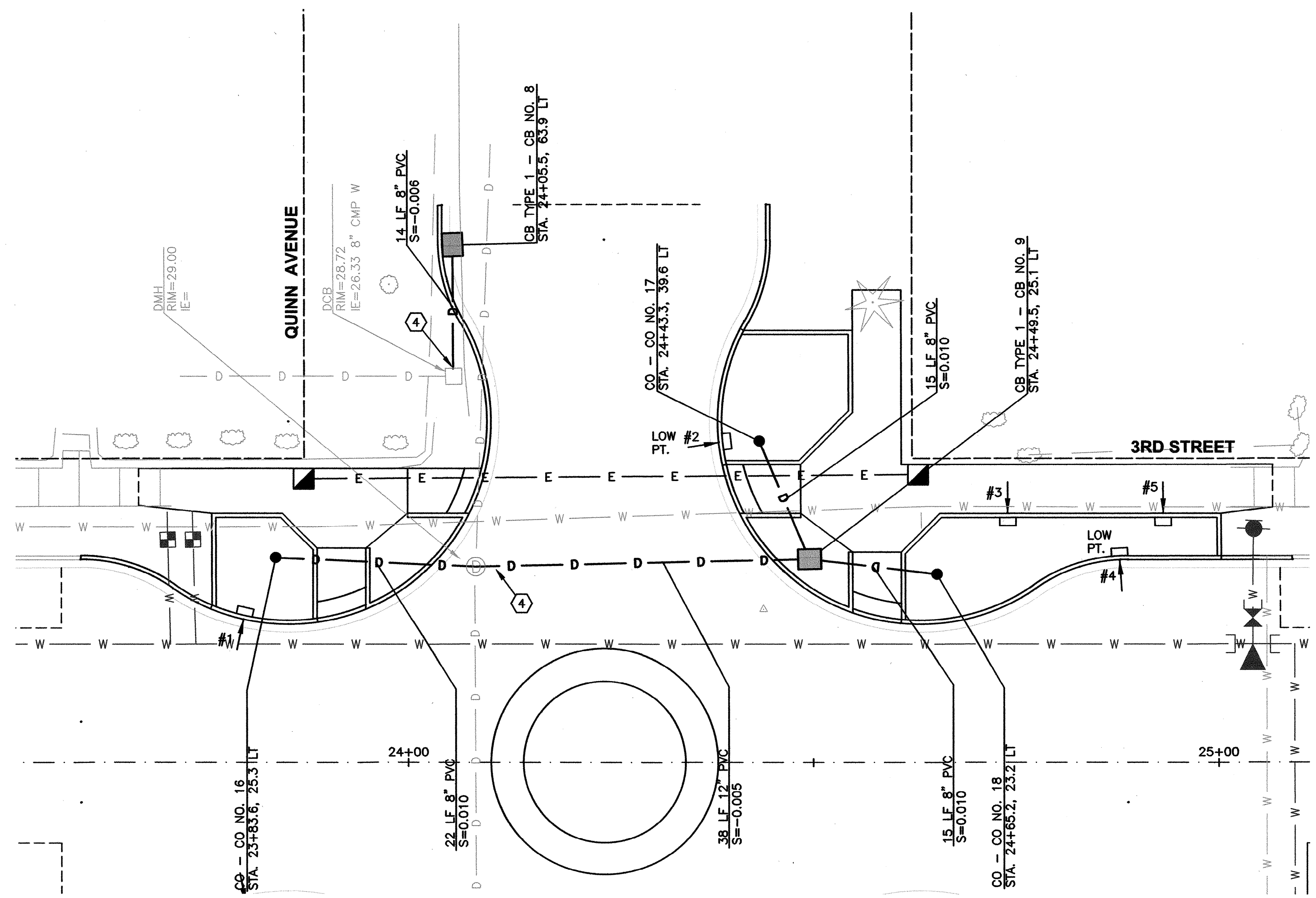
150387 BHPS MCCA \ 150387H007 Site-Explr ALL.cdr PAGE x: M3Q F2

APPENDIX A

Project Civil Plans

QUINN AVENUE/3RD STREET INTERSECTION - NORTH SIDE

10' 5' 0 10' 20'
SCALE: 1"=10'



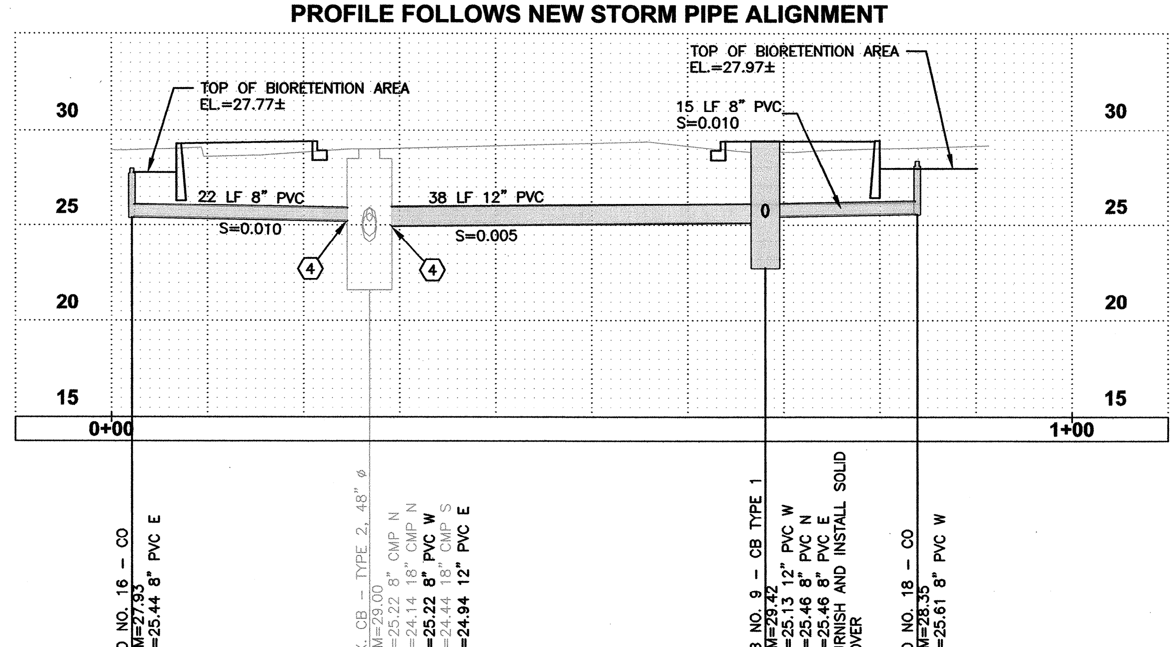
CURB CUT TABLE				
NUMBER	STATION	OFFSET	FLOWLINE ELEVATION (±)	SIDEWALK ELEVATION (±)
1	23+79.63	17.63 LT	28.60	---
2	24+38.32	39.49 LT	28.66	---
3	24+73.94	30.72 LT	---	29.62
4	24+87.86	24.98 LT	28.80	---
5	24+93.14	30.72 LT	---	29.53

SEE CURB CUT DETAIL, SHEET 27

BIORETENTION & STORM DRAINAGE NOTES

1. CAUTION: POTENTIAL UTILITY CONFLICT. CONTRACTOR TO FIELD VERIFY (POTHOLE) EXACT LOCATION AND DEPTH OF EXISTING UTILITY. SEE ORDER OF WORK IN THE SPECIFICATIONS.
2. CONTRACTOR SHALL POTHOLE EXISTING STORM PIPE TO VERIFY EXACT PIPE MATERIAL, LOCATION AND DEPTH PRIOR TO INSTALLING AND CONNECTING NEW CATCH BASIN.
3. CONTRACTOR SHALL PROTECT EXISTING UTILITY POLE, CURB AND/OR, SIDEWALK DURING CONSTRUCTION.
4. CONTRACTOR SHALL CONNECT NEW STORM PIPE TO EXISTING CATCH BASIN (CORE DRILL IF KNOCKOUT IS NOT PRESENT). SEE DETAIL SHEET 31.
5. EXISTING UTILITY TO BE REMOVED/RELOCATED BY OTHERS. CONTRACTOR TO COORDINATE. SEE GENERAL NOTE 2, SHEET 2.

PROFILE FOLLOWS NEW STORM PIPE ALIGNMENT



Gray & Osborne, Inc.
CONSULTING ENGINEERS
3710 168TH STREET NE, BLDG. B, SUITE 210
ARLINGTON, WA 98223 • (360) 454-5490

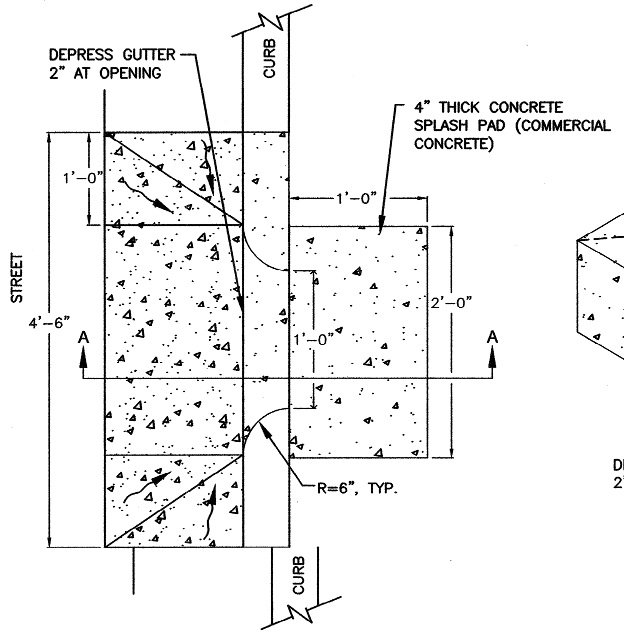
DATE: AUG 2016
SCALE: NOTED
DRAWN: A.A.J.
CHECKED: K.W.B.
APPROVED: S.A.C.

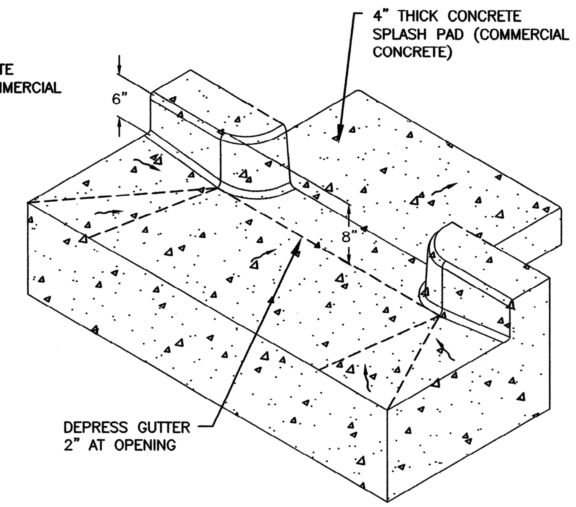
No.	REVISION	DATE	APP'D

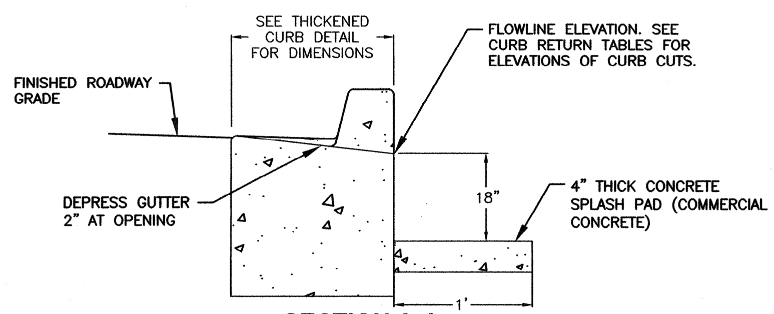
STACEY ANN CLEAR — STATE OF WASHINGTON — REGISTERED PROFESSIONAL ENGINEER
KEVIN W. BROWN — STATE OF WASHINGTON — REGISTERED PROFESSIONAL ENGINEER

CITY OF MARYSVILLE
SNOHOMISH COUNTY WASHINGTON
3RD STREET LOW IMPACT DEVELOPMENT AND ROADWAY IMPROVEMENT PROJECT
STORMWATER PLAN AND PROFILE

SHEET: 21
OF: 68
JOB NO.: 13587.00
DWG: INTER



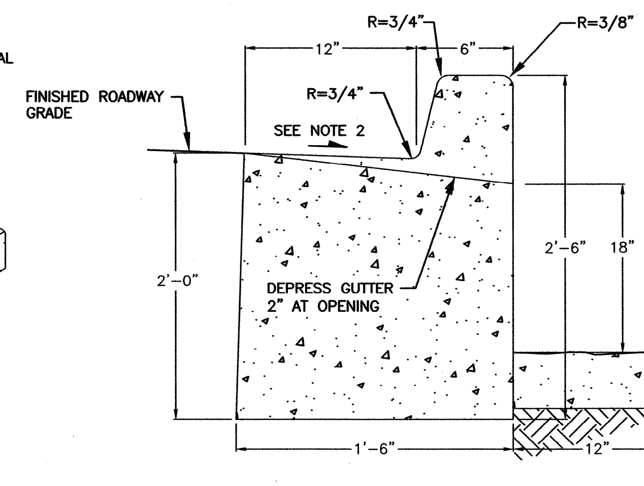




SECTION A-A

BIORETENTION AREA CURB INLET DETAIL

NTS

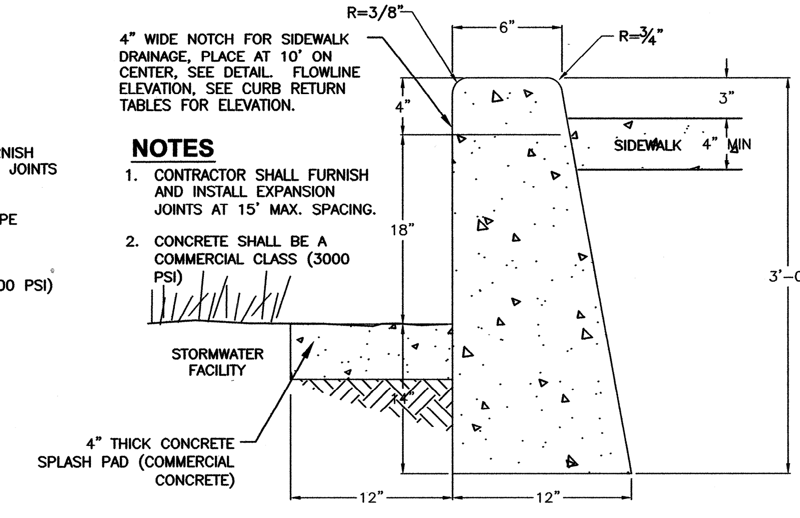


NOTES

1. CONTRACTOR SHALL FURNISH AND INSTALL EXPANSION JOINTS AT 15' MAX. SPACING.
2. GUTTER PAN SHALL SLOPE BETWEEN 2% AND 6%.
3. CONCRETE SHALL BE A COMMERCIAL CLASS (3000 PSI)

THICKENED CURB & GUTTER DETAIL

NTS

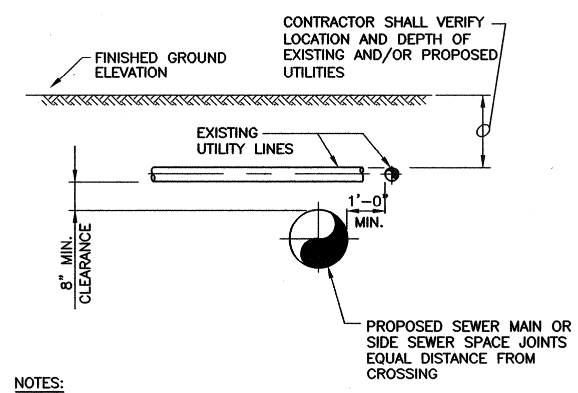


NOTES

1. CONTRACTOR SHALL FURNISH AND INSTALL EXPANSION JOINTS AT 15' MAX. SPACING.
2. CONCRETE SHALL BE A COMMERCIAL CLASS (3000 PSI)

BIORETENTION BARRIER CURB DETAIL

NTS

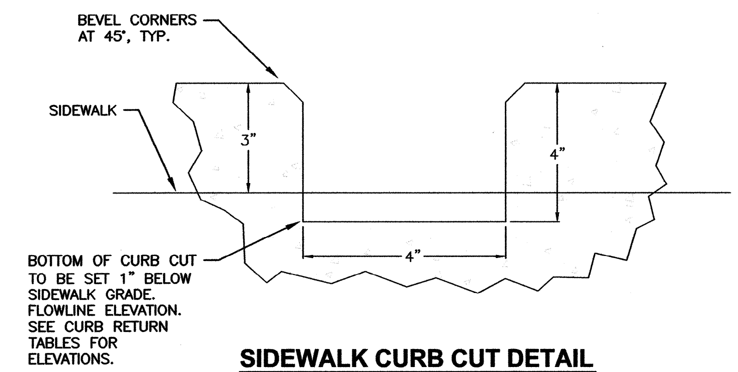


NOTES:

1. ALL SEWER SHALL HAVE A MINIMUM CLEARANCE OF 18" UNDER WATER LINES. MINIMUM CLEARANCE FOR OTHER UTILITIES SHALL BE 8".
2. BACKFILL ANY CROSSING WITH LESS THAN 18" CLEARANCE WITH CDF.

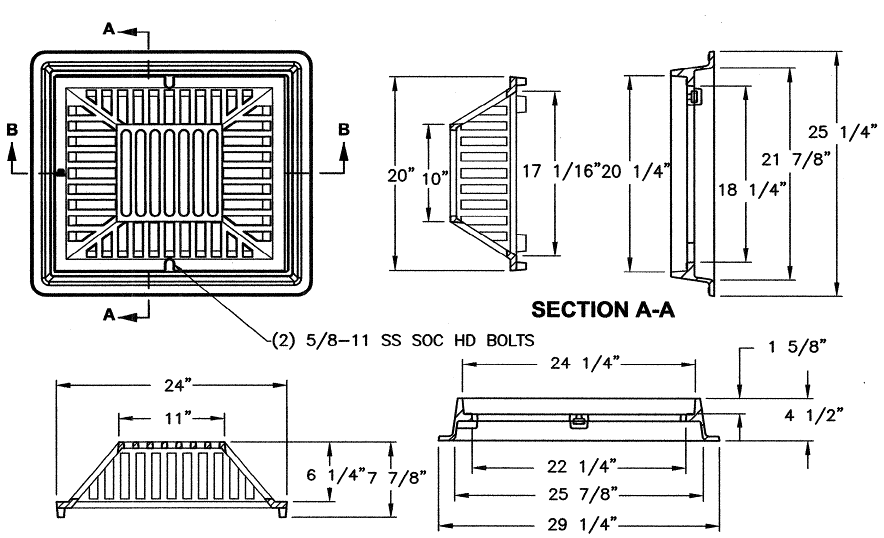
TYPICAL UTILITY CROSSING

NTS



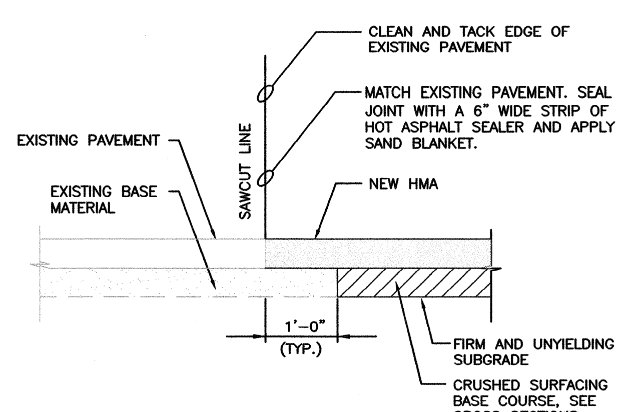
SIDEWALK CURB CUT DETAIL

NTS



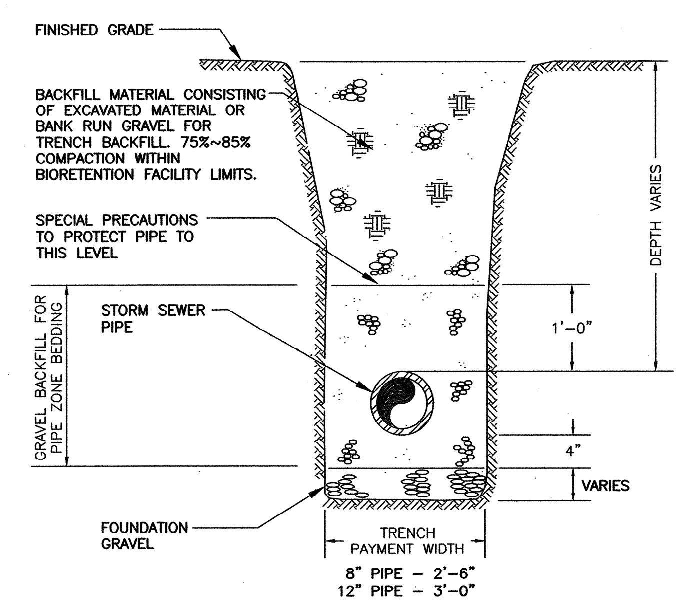
BEEHIVE FRAME AND GRATE DETAIL

NTS



BUTT JOINT DETAIL

NTS



STORM DRAIN PIPE TYPICAL TRENCH SECTION

NTS

Gray & Osborne, Inc.
CONSULTING ENGINEERS
3710 168TH STREET NE, BLDG. B, SUITE 210
ARLINGTON, WA 98223 • (360) 454-5490

DATE:	AUG 2016
SCALE:	NOTED
DRAWN:	A.A.J.
CHECKED:	K.W.B.
APPROVED:	S.A.C.

No.	REVISION	DATE	APP'D

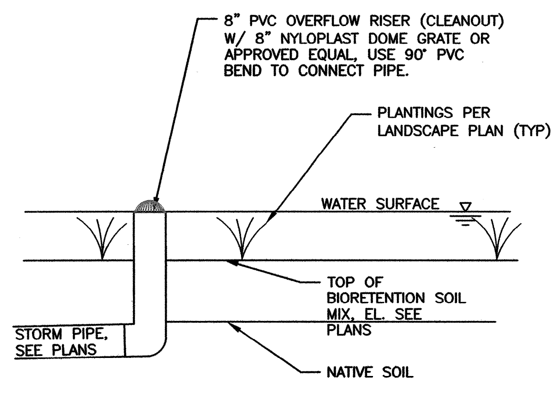
STACEY ANN CLEAR, STATE OF WASHINGTON, REGISTERED PROFESSIONAL ENGINEER

KEVIN W. BROWN, STATE OF WASHINGTON, REGISTERED PROFESSIONAL ENGINEER

CITY OF MARYSVILLE
SNOHOMISH COUNTY WASHINGTON
3RD STREET LOW IMPACT DEVELOPMENT AND ROADWAY IMPROVEMENT PROJECT
STORM DETAILS

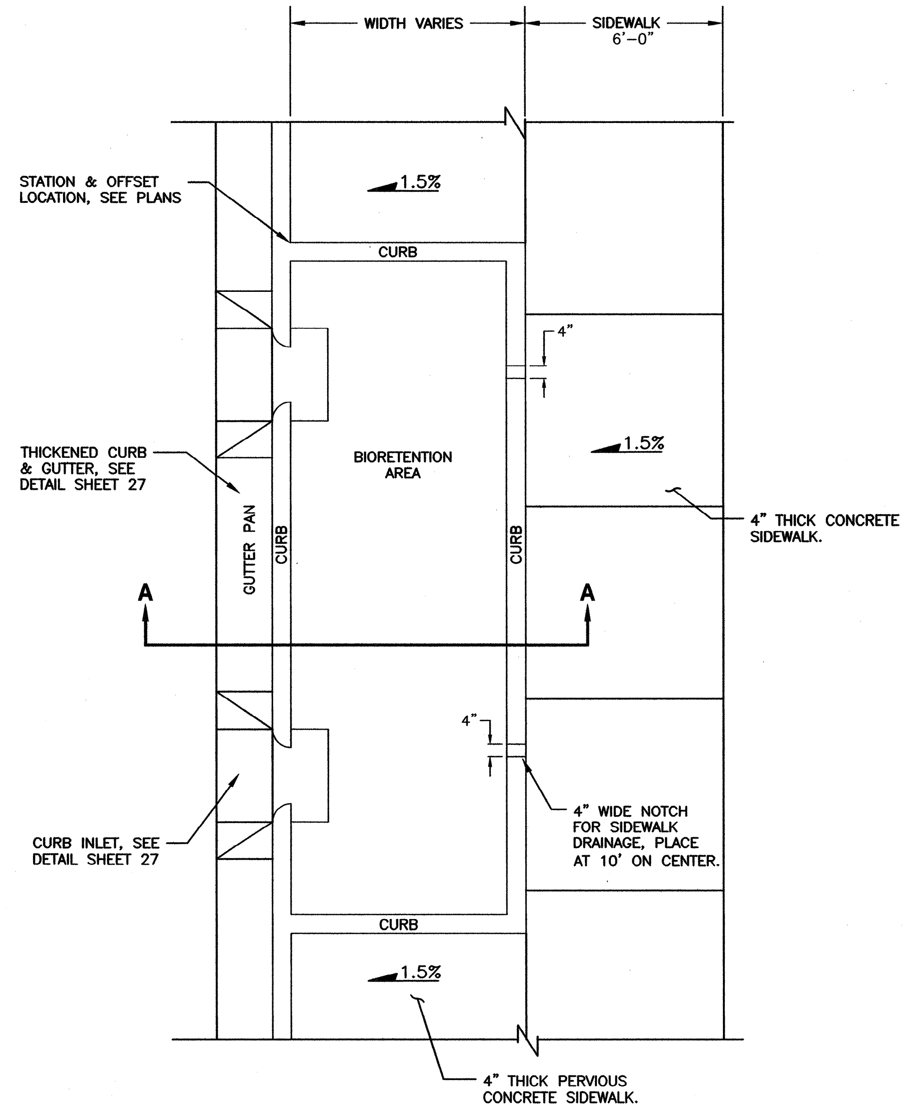
SHEET: 27
OF: 68

JOB NO.: 13587.00
DWG: DETAILS

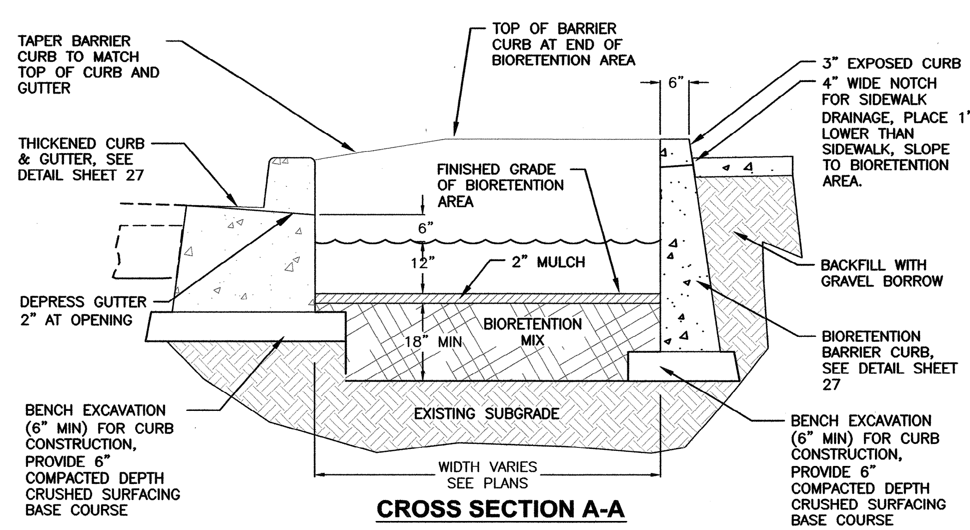


BIORETENTION AREA CLEANOUT DETAIL

NTS



PLAN VIEW



CROSS SECTION A-A

BIORETENTION AREA DETAIL (ADJACENT TO CURB & GUTTER)

NTS

GENERAL LOW IMPACT DEVELOPMENT FACILITY NOTES

1. ALL LOW IMPACT DEVELOPMENT (LID) AREAS (BIORETENTION AND PERMEABLE PAVEMENT) SHALL BE FULLY PROTECTED FROM SEDIMENT INTRUSION BY SILT FENCE OR CONSTRUCTION FENCING. THE CONTRIBUTING DRAINAGE AREA SHALL BE STABILIZED PRIOR TO DIRECTING WATER TO THE AREA.
2. LID AREAS SHALL REMAIN OUTSIDE THE LIMIT OF DISTURBANCE DURING CONSTRUCTION TO PREVENT SOIL COMPACTION BY HEAVY EQUIPMENT. THE AREAS SHALL BE CLEARLY MARKED. TO PREVENT SOIL COMPACTION, HEAVY VEHICULAR AND FOOT TRAFFIC SHALL BE KEPT OUT OF LID AREAS DURING AND IMMEDIATELY AFTER CONSTRUCTION.
3. DURING CONSTRUCTION, CARE SHALL BE TAKEN TO AVOID TRACKING SEDIMENTS ONTO ANY LID SURFACE TO AVOID CLOGGING.
4. STORE MATERIALS IN A PROTECTED AREA TO KEEP THEM FREE FROM MUD, DIRT, AND OTHER FOREIGN MATERIALS.
5. ANY AREA OF THE SITE INTENDED ULTIMATELY TO BE AN LID FACILITY SHALL GENERALLY NOT BE USED AS THE SITE OF A TEMPORARY SEDIMENT BASIN. WHERE LOCATING A SEDIMENT BASIN ON AN AREA INTENDED FOR AN LID FACILITY IS UNAVOIDABLE, THE INVERT OF THE SEDIMENT BASIN MUST BE A MINIMUM OF 2 FEET ABOVE THE FINAL DESIGN ELEVATION OF THE BOTTOM OF THE BIORETENTION SOIL MIX OR AGGREGATE RESERVOIR COURSE. ALL SEDIMENT DEPOSITS IN THE EXCAVATED AREA SHALL BE CAREFULLY REMOVED PRIOR TO INSTALLING THE SUBBASE, BASE AND SURFACE MATERIALS.

LOW IMPACT DEVELOPMENT FACILITY CONSTRUCTION SEQUENCE:

1. CONSTRUCTION OF THE LID FACILITIES SHALL ONLY BEGIN AFTER THE ENTIRE CONTRIBUTING DRAINAGE AREA HAS BEEN STABILIZED. THE SITE SHALL BE CHECKED FOR EXISTING UTILITIES PRIOR TO ANY EXCAVATION. THE CONTRACTOR SHALL NOT INSTALL THE SYSTEM IN RAIN OR SNOW, NOR INSTALL FROZEN BEDDING MATERIALS.
2. INSTALL TEMPORARY EROSION AND SEDIMENT CONTROLS TO DIVERT STORMWATER AWAY FROM THE LID FACILITY AREA UNTIL IT IS COMPLETED. SPECIAL PROTECTION MEASURES SUCH AS EROSION CONTROL FABRICS MAY BE NEEDED TO PROTECT VULNERABLE SIDE SLOPES FROM EROSION DURING THE EXCAVATION PROCESS. THE PROPOSED LID FACILITY AREA MUST BE KEPT FREE FROM SEDIMENT DURING THE ENTIRE CONSTRUCTION PROCESS. CONSTRUCTION MATERIALS THAT ARE CONTAMINATED BY SEDIMENTS MUST BE REMOVED AND REPLACED WITH CLEAN MATERIALS.
3. WHERE POSSIBLE, EXCAVATORS OR BACKHOES SHALL WORK FROM THE SIDES TO EXCAVATE THE BIORETENTION SOIL MIX OR RESERVOIR AGGREGATE LAYER TO THE DESIGN DEPTH AND DIMENSIONS SHOWN ON THE PLANS. FOR MICRO-SCALE AND SMALL-SCALE PAVEMENT APPLICATIONS, EXCAVATING EQUIPMENT SHALL HAVE ARMS WITH ADEQUATE EXTENSION SO THEY DO NOT HAVE TO WORK INSIDE THE FOOTPRINT OF THE LID FACILITY AREA (TO AVOID COMPACTION). CONTRACTORS CAN UTILIZE A CELL CONSTRUCTION APPROACH, WHEREBY THE PROPOSED PERMEABLE PAVEMENT AREA IS SPLIT INTO 500 TO 1000 SQ. FT. TEMPORARY CELLS WITH A 10 TO 15 FOOT EARTH BRIDGE IN BETWEEN, SO THAT CELLS CAN BE EXCAVATED FROM THE SIDE. EXCAVATED MATERIAL SHALL BE PLACED AWAY FROM THE OPEN EXCAVATION SO AS TO NOT JEOPARDIZE THE STABILITY OF THE SIDE WALLS. AS ANOTHER ALTERNATIVE, 6" OF MATERIAL MAY BE LEFT ABOVE THE SUBGRADE DURING OTHER WORK AND REMOVED JUST PRIOR TO PLACING THE FINAL LID MATERIAL (BIORETENTION SOIL MIX/AGGREGATE COURSE).
4. THE NATIVE SOILS ALONG THE BOTTOM AND SIDES OF THE LID FACILITY SHALL BE SCARIFIED OR TILLED TO A DEPTH OF 3 TO 4 INCHES PRIOR TO THE PLACEMENT OF THE BOTTOM SOIL OR AGGREGATE LAYER OF THE LID FACILITY.
5. IF FILTER FABRIC IS SHOWN ON THE PLANS (TO PREVENT AGGREGATE FROM SINKING INTO NATIVE SOIL), IT SHALL BE INSTALLED ON THE BOTTOM AND THE SIDES OF THE PAVEMENT SECTION. FILTER FABRIC STRIPS SHALL OVERLAP DOWN-SLOPE BY A MINIMUM OF 2 FEET, AND BE SECURED A MINIMUM OF 4 FEET BEYOND THE EDGE OF THE EXCAVATION. WHERE THE FILTER LAYER EXTENDS BEYOND THE EDGE OF THE PAVEMENT (TO CONVEY RUNOFF TO THE RESERVOIR LAYER), INSTALL AN ADDITIONAL LAYER OF FILTER FABRIC 1 FOOT BELOW THE SURFACE TO PREVENT SEDIMENTS FROM ENTERING INTO THE RESERVOIR LAYER. EXCESS FILTER FABRIC SHALL NOT BE TRIMMED UNTIL THE SITE IS FULLY STABILIZED.
6. PAVING AND BIORETENTION MATERIALS SHALL BE INSTALLED IN ACCORDANCE WITH THE SPECIFICATIONS.

Gray & Osborne, Inc.
CONSULTING ENGINEERS
3710 168TH STREET NE, BLDG. B, SUITE 210
ARLINGTON, WA 98223 • (360) 454-5490

DATE: AUG 2016
SCALE: NOTED
DRAWN: A.A.J.
CHECKED: K.W.B.
APPROVED: S.A.C.

No.	REVISION	DATE	APPD

STACEY ANN CLEAR — STATE OF WASHINGTON — REGISTERED PROFESSIONAL ENGINEER
KEVIN W. BROWN — STATE OF WASHINGTON — REGISTERED PROFESSIONAL ENGINEER

CITY OF MARYSVILLE
SNOHOMISH COUNTY WASHINGTON
3RD STREET LOW IMPACT DEVELOPMENT AND ROADWAY IMPROVEMENT PROJECT
STORM DETAILS

SHEET: 28
OF: 68
JOB NO.: 13587.00
DWG: DETAILS

APPENDIX B

Current Study Exploration Logs and Laboratory Testing Data

Geologic & Monitoring Well Construction Log

associated earth sciences incorporated

Project Number	Well Number	Sheet
150387H007	M3Q-HA-1/WP	1 of 2

Project Name: Bioretention Hydrologic Performance Study
Location: Marysville, WA
Elevation (Top of Well Casing): 98.7 (Project Datum)
Surface Elevation (ft): 97.9 (Project Datum)
Water Level Elevation: Dry
Date Start/Finish: 10/4/18,10/4/18
Drilling/Equipment: Hand Auger
Hole Diameter (in): 4 inches
Hammer Weight/Drop: N/A

Depth (ft)	Water Level	WELL CONSTRUCTION	S T	Blows/ 6"	Graphic Symbol	DESCRIPTION
		Coarse mulch 0 to 0.1 feet				**Coarse Mulch**
		Bioretention soil mix 0.1 to 1.5 feet				**Bioretention Soil Mix** Loose, moist, dark brown, medium SAND, trace to some gravel, trace silt; organic rich; massive (SP).
		Threaded steel pipe 1.25-inch I.D. with threaded, vented PVC cap -0.8 to 3.9 feet				**Vashon Recessional Outwash** Loose, slightly moist, brown, fine to medium SAND, trace silt; stratified (SP).
		Bentonite chips 1.2 to 3.2 feet				
		Vashon Recessional Outwash 1.1 to 6.7 feet				
						Layer (0.25 to 0.5 inch thick) of brown silt to sandy silt at 4.5 feet.
5		Stainless steel jacket over				

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample

M - Moisture
Water Level ()
Water Level at time of drilling (ATD)

Logged by: ADY
Approved by: JHS

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
150387H007	M3Q-HA-1/WP	2 of 2

Project Name	Bioretention Hydrologic Performance Study	Location	Marysville, WA
Elevation (Top of Well Casing)	98.7 (Project Datum)	Surface Elevation (ft)	97.9 (Project Datum)
Water Level Elevation	Dry	Date Start/Finish	10/4/18,10/4/18
Drilling/Equipment	Hand Auger	Hole Diameter (in)	4 inches
Hammer Weight/Drop	N/A		

Depth (ft)	Water Level	WELL CONSTRUCTION	S T	Blows/ 6"	Graphic Symbol	DESCRIPTION
		stainless steel #60 gauze, welded to perforated steel pipe 3.9 to 6.3 feet				Grades to grayish brown at 5.5 ft.
		Threaded steel pipe 1.25-inch I.D. and drive point 6.3 to 6.9 feet				Boring terminated at 6.7 feet Well completed at 6.9 feet on 10/4/18. Refusal on gravel. No seepage. No caving. Steel drive point placed in borehole and hand driven with slide hammer to 6.9 feet.
		Note: ~4 inches of "dead space" below bottom of perforated openings and total inside depth. Total inside depth = 7.4 feet.				
10						

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample

M - Moisture
Water Level ()
Water Level at time of drilling (ATD)

Logged by: ADY
Approved by: JHS

associated earth sciences incorporated

Exploration Log

Project Number	Exploration Number	Sheet
150387H007	M3Q-HA-2	1 of 1

Project Name: Bioretention Hydrologic Performance Study
Location: Marysville, WA
Driller/Equipment: Hand Auger
Hammer Weight/Drop: N/A

Ground Surface Elevation (ft):
Datum: N/A
Date Start/Finish: 10/4/18,10/4/18
Hole Diameter (in): 4 inches

Depth (ft)	S T	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Water Level	Blows/6"	Blows/Foot 10 20 30 40	Other Tests
				Coarse Mulch					
		S-1		**Bioretention Soil Mix** Loose, moist, dark brown, medium SAND, trace to some gravel, trace silt; organic rich; massive (SP).					
				At 0.9 feet: Mix of Wall Backfill and Native Sand - Medium dense, slightly moist, gray, angular coarse SAND, fine gravel (GP) and brown fine to medium SAND to sandy, SILT (SP/SP-ML).					
				Vashon Recessional Outwash - Loose, slightly moist, brown, fine to medium SAND, trace silt; stratified (SP).					
				Bottom of exploration boring at 1.2 feet. No seepage. No caving.					
5									

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample
- M - Moisture
- Water Level ()
- Water Level at time of drilling (ATD)

Logged by: ADY
Approved by: JHS

associated earth sciences incorporated

Exploration Log

Project Number	Exploration Number	Sheet
150387H007	M3Q-HA-3	1 of 1

Project Name: Bioretention Hydrologic Performance Study
Location: Marysville, WA
Driller/Equipment: Hand Auger
Hammer Weight/Drop: N/A
Ground Surface Elevation (ft):
Datum: N/A
Date Start/Finish: 10/4/18,10/4/18
Hole Diameter (in): 4 inches

Depth (ft)	S T	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Water Level	Blows/6"	Blows/Foot 10 20 30 40	Other Tests
				Coarse Mulch					
		S-1		**Bioretention Soil Mix** Loose, moist, dark brown, medium SAND, trace to some gravel, trace silt; organic rich; massive (SP).					
				Mix of Wall Backfill and Native Sand Loose, slightly moist, gray, angular GRAVEL (GP), and brown, fine to medium SAND, trace to some silt (SP/SP-SM); concrete debris present.					
				Bottom of exploration boring at 1 feet. No seepage. No caving.					
5									

Sampler Type (ST):

2" OD Split Spoon Sampler (SPT)
3" OD Split Spoon Sampler (D & M)
Grab Sample
No Recovery
Ring Sample
Shelby Tube Sample
M - Moisture
Water Level ()
Water Level at time of drilling (ATD)

Logged by: ADY
Approved by: JHS

Geologic & Monitoring Well Construction Log

associated earth sciences incorporated

Project Number	Well Number	Sheet
150387H007	M3Q-WP-2	1 of 1

Project Name	Bioretention Hydrologic Performance Study	Location	Marysville, WA
Elevation (Top of Well Casing)	99.1 (Project Datum)	Surface Elevation (ft)	97.9 (Project Datum)
Water Level Elevation	Dry	Date Start/Finish	10/19/18,10/19/18
Drilling/Equipment	Hand Auger	Hole Diameter (in)	4 inches
Hammer Weight/Drop	N/A		

Depth (ft)	Water Level	WELL CONSTRUCTION	S T	Blows/ 6"	Graphic Symbol	DESCRIPTION
		Threaded steel pipe with threaded, vented PVC cap 1.25-inch I.D. -1.2 to -0.9 feet Tape over well point screen -0.9 to 0.4 feet Existing sediments 0 to 1.7 feet				Boring terminated at 0 feet Well completed at 1.7 feet on 10/19/18. Well point only. No exploration was completed. Stel drive point hand drien with slide hammer to depth of 1.7 feet.
		Stainless steel jacket over stainless steel #60 gauze, welded to perforated steel pipe 0.4 to 1.1 feet Threaded steel pipe 1.25-inch I.D. and drive point 1.1 to 1.7 feet				No exploration; well point driven into existing sediments.
		Note: ~4 inches of "dead space" below bottom of perforated openings and total inside depth. Total inside depth = 2.6 feet.				
5						

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample
- M - Moisture
- Water Level ()
- Water Level at time of drilling (ATD)

Logged by: ADY
Approved by: JHS

a s s o c i a t e d earth sciences incorporated

Moisture, Ash, and Organic Matter of Peat and Other Organic Soils - ASTM 2974

Date Sampled	Project	Project No.		Soil Description
10/4/2018	Bioretention Hydrologic Performance Monitoring Study	150387 E007		Bioretention soil mix
Tested By	**Location**	**EB/EP No.**	**Depth**	
BN	Onsite- M3Q			

Moisture Content

Sample ID	HA-2 (0.2'-0.5')	HA-1 (0.2'-0.8')	HA-3 (0.1'-0.5')
Wet Weight + Pan	1024.38	957.44	1006.98
Dry Weight + Pan	946.10	912.32	922.80
Weight of Pan	517.21	449.60	470.00
Weight of Moisture	78.28	45.12	84.18
Dry Weight of Soil	428.89	462.72	452.80
% Moisture	15.4	8.9	15.7

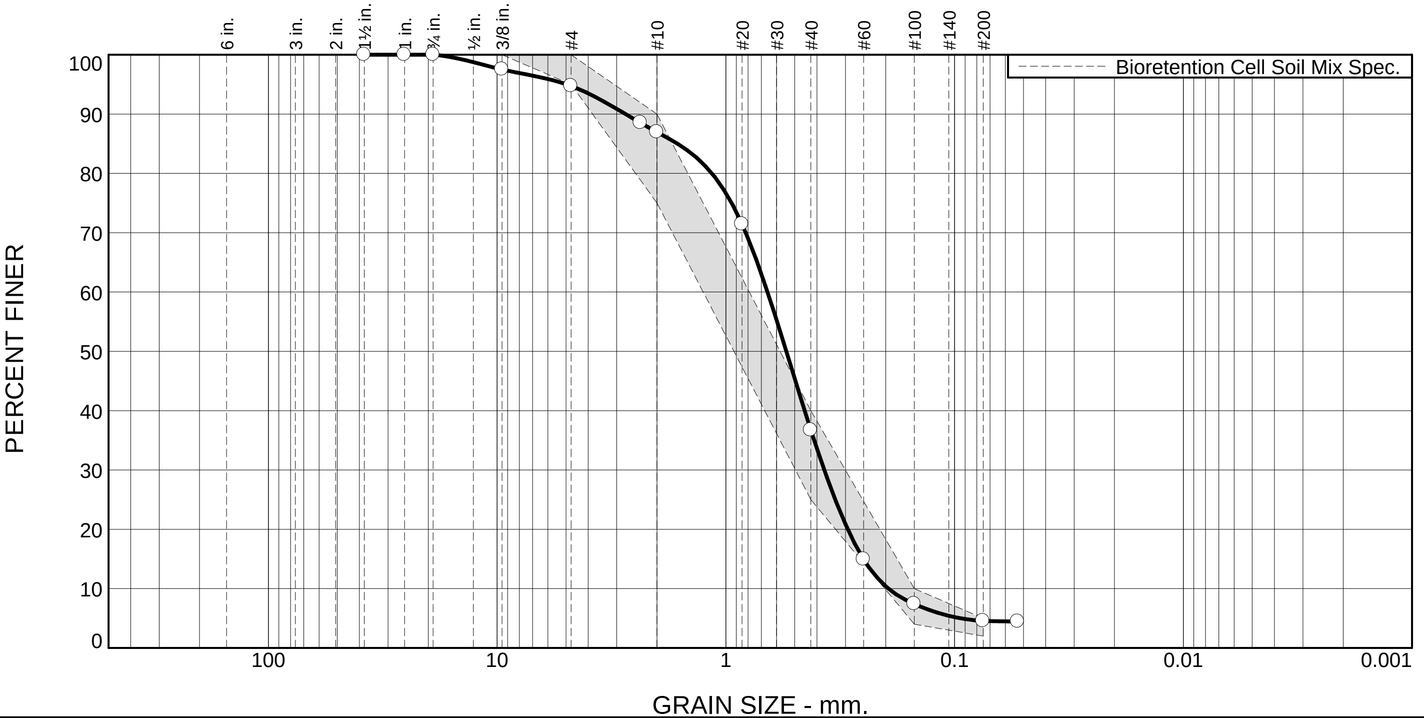
Organic Matter and Ash Content

Dry Soil Befor Burn + Pan	398.50	576.62	594.36
Dry Soil After Burn + Pan	388.44	562.58	582.14
Weight of Pan	247.07	357.93	391.93
Wt. Loss Due to Ignition	10.06	14.04	12.22
Actual Wt. Of Soil After Burr	141.37	204.65	190.21
% Organics	6.6	6.4	6.0

ASSOCIATED EARTH SCIENCES, INC.

911 5th Ave., Suite 100 Kirkland, WA 98033 425-827-7701 FAX 425-827-5424

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	5.3	7.8	50.2	32.2	4.5	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5	100.0		
1	100.0		
.75	100.0		
.375	97.5	100.0	X
#4	94.7	95.0 - 100.0	X
#8	88.5		
#10	86.9	75.0 - 90.0	
#20	71.4		
#40	36.7	25.0 - 40.0	
#60	14.9		
#100	7.4	4.0 - 10.0	
#200	4.5	2.0 - 5.0	
#270	4.5		

* Bioretention Cell Soil Mix Spec.

Material Description

SAND, some gravel, trace silt

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 2.7447 D_{85}= 1.6280 D_{60}= 0.6578
D_{50}= 0.5443 D_{30}= 0.3713 D_{15}= 0.2506
D_{10}= 0.1947 C_u= 3.38 C_c= 1.08

Remarks

Collected by: ADY

Bioretention soil mix burned first per ASTM D2974 then sieved.

Date Received: 10/04/2018 **Date Tested:** 11/08/2018

Tested By: BN

Checked By: JHS

Title:

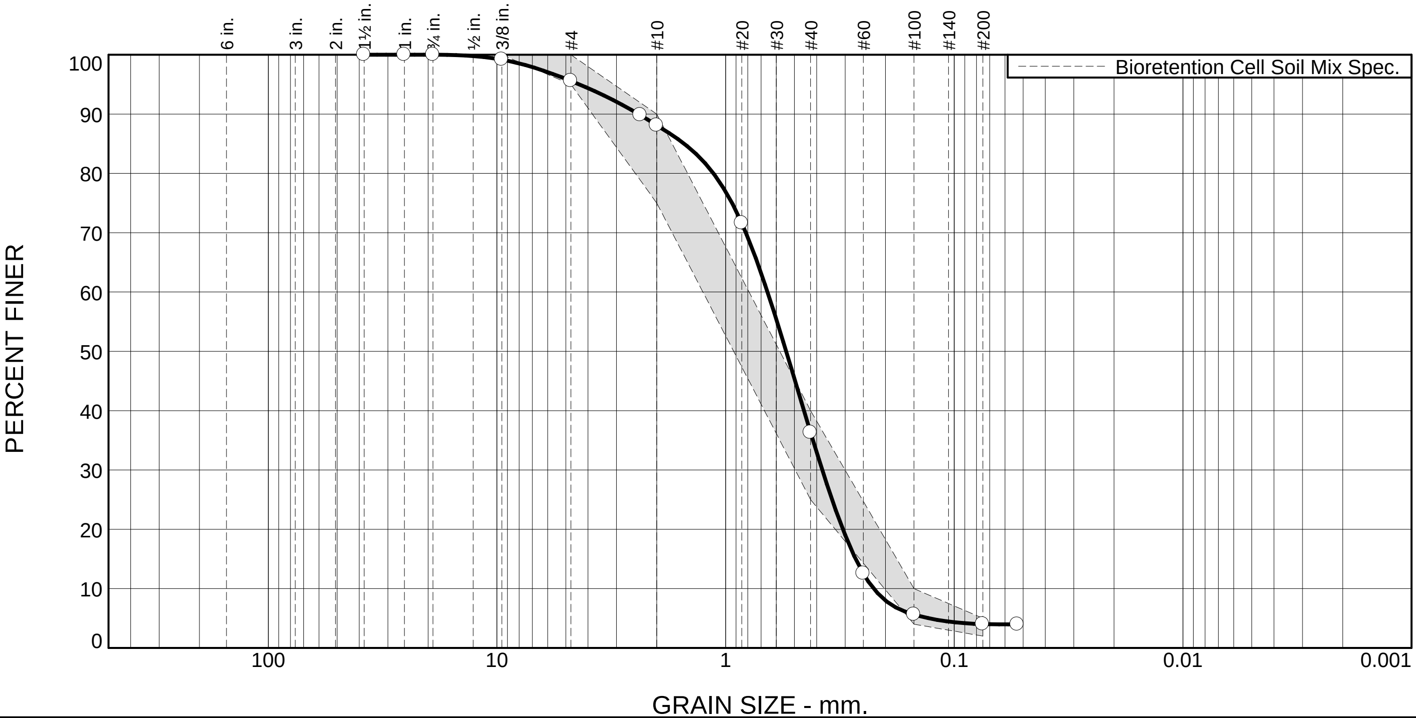
Source of Sample: (M3Q) Marysville- 3rd Street LID **Depth:** 0.2'-0.5'
Sample Number: HA-1 **Date Sampled:** 10/04/2018

associated earth sciences incorporated

Client: Clear Creek Solutions
Project: Bioretention Hydrologic Performance Study

Project No: 150387 H004 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	4.4	7.5	51.8	32.3	4.0	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5	100.0		
1	100.0		
.75	100.0		
.375	99.2	100.0	X
#4	95.6	95.0 - 100.0	
#8	89.8		
#10	88.1	75.0 - 90.0	
#20	71.6		
#40	36.3	25.0 - 40.0	
#60	12.6		
#100	5.6	4.0 - 10.0	
#200	4.0	2.0 - 5.0	
#270	4.0		

* Bioretention Cell Soil Mix Spec.

Material Description

SAND, trace silt, trace gravel

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 2.4034 D_{85}= 1.5172 D_{60}= 0.6557
D_{50}= 0.5435 D_{30}= 0.3778 D_{15}= 0.2701
D_{10}= 0.2253 C_u= 2.91 C_c= 0.97

Remarks

Collected by: ADY

Bioretention soil mix burned first per ASTM D2974 then sieved.

Date Received: 10/04/2018 **Date Tested:** 10/29/2018

Tested By: BN

Checked By: JHS

Title:

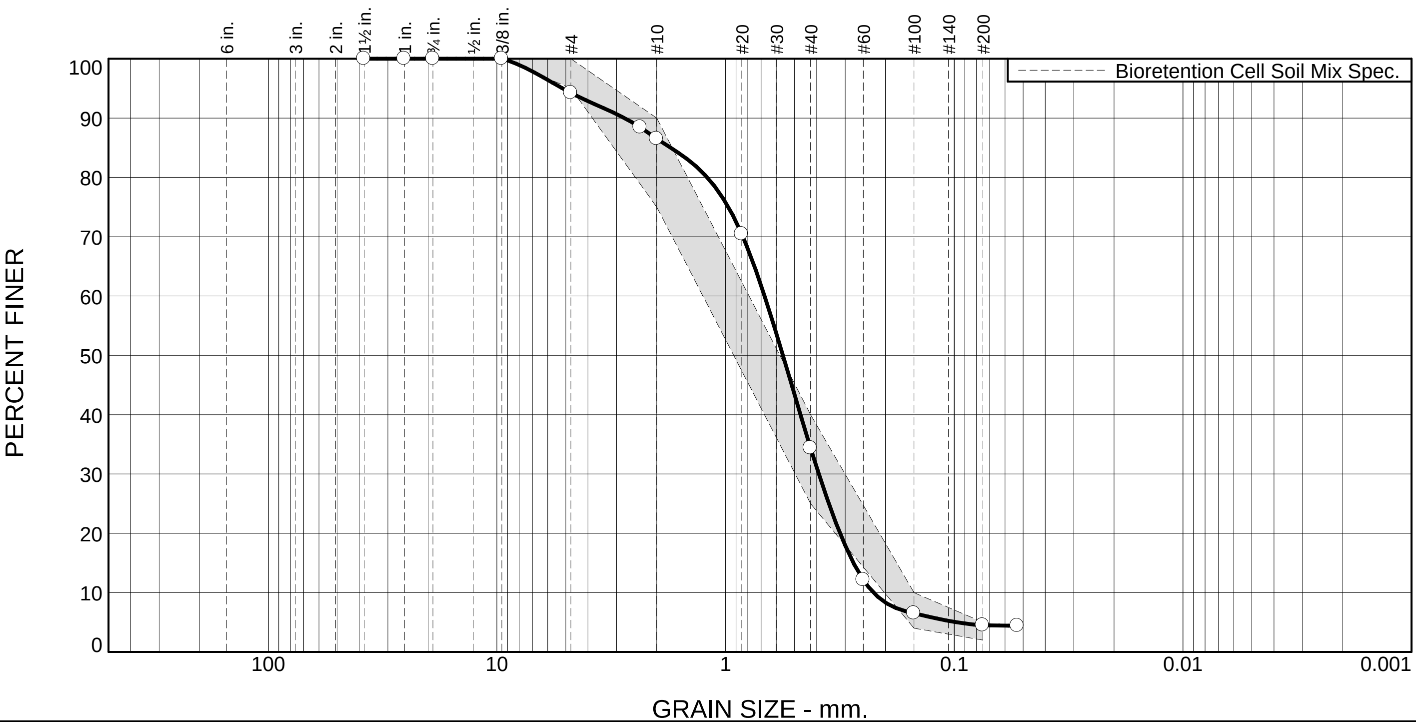
Source of Sample: (M3Q) Marysville- 3rd Street LID **Depth:** 0.1'-0.5' **Date Sampled:** 10/04/2018
Sample Number: HA-2

a s s o c i a t e d
e a r t h s c i e n c e s
i n c o r p o r a t e d

Client: Clear Creek Solutions
Project: Bioretention Hydrologic Performance Study

Project No: 150387 H004 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	5.8	7.7	52.1	29.9	4.5	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5	100.0		
1	100.0		
.75	100.0		
.375	100.0	100.0	
#4	94.2	95.0 - 100.0	X
#8	88.4		
#10	86.5	75.0 - 90.0	
#20	70.4		
#40	34.4	25.0 - 40.0	
#60	12.2		
#100	6.5	4.0 - 10.0	
#200	4.5	2.0 - 5.0	
#270	4.4		

* Bioretention Cell Soil Mix Spec.

Material Description

SAND, some gravel, trace silt

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 2.7737 D_{85}= 1.7389 D_{60}= 0.6755
D_{50}= 0.5616 D_{30}= 0.3912 D_{15}= 0.2759
D_{10}= 0.2257 C_u= 2.99 C_c= 1.00

Remarks

Collected by: ADY

Bioretention soil mix burned first per ASTM D2974 then sieved.

Date Received: 10/04/2018 **Date Tested:** 10/29/2018

Tested By: BN

Checked By: JHS

Title:

Source of Sample: (M3Q) Marysville- 3rd Street LID **Depth:** 0.2'-0.8' **Date Sampled:** 10/04/2018
Sample Number: HA-3

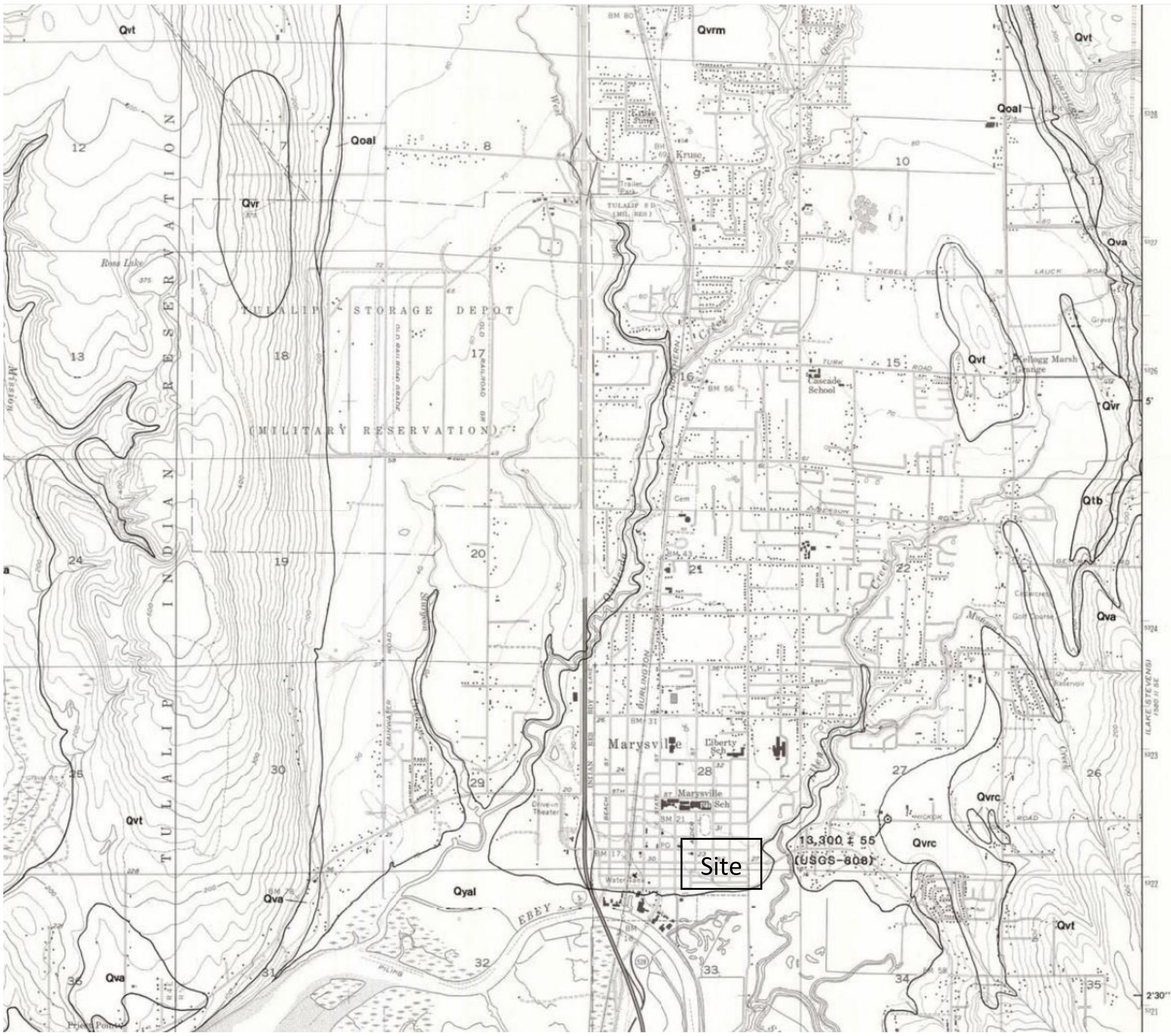
a s s o c i a t e d
e a r t h s c i e n c e s
i n c o r p o r a t e d

Client: Clear Creek Solutions
Project: Bioretention Hydrologic Performance Study

Project No: 150387 H004 **Figure**

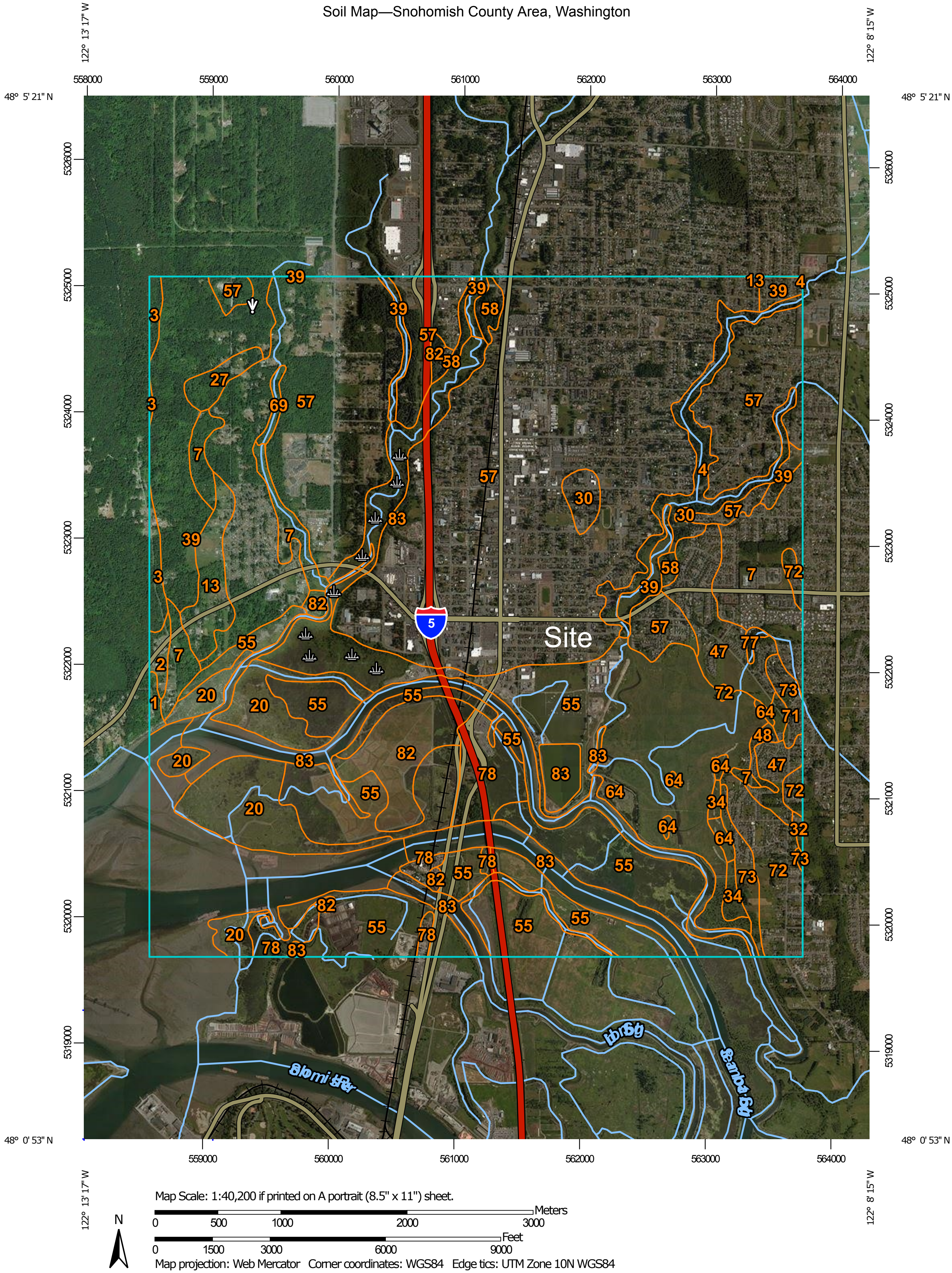
APPENDIX C

Background Soil, Geology, and Groundwater Data (Regional Maps, Previous Studies Exploration Logs and Laboratory Testing Data)



Site Unit: Qvrm: Vashon Recessional Outwash, Marysville Member

Source:
Geologic map of the Marysville quadrangle, Snohomish County, Washington
Author(s): Minard, J.P.
Publishing Organization: U.S. Geological Survey
Series and Number: Miscellaneous Field Studies Map MF-1743
Publication Date: 1985
Map Scale: 1:24,000



122° 13' 17" W
122° 8' 15" W
48° 5' 21" N
48° 0' 53" N
558000
559000
560000
561000
562000
563000
564000
5326000
5325000
5324000
5323000
5322000
5321000
5320000
5319000
Site
5
Map Scale: 1:40,200 if printed on A portrait (8.5" x 11") sheet.
Meters
0 500 1000 2000 3000
Feet
0 1500 3000 6000 9000
N
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
1	Alderwood gravelly sandy loam, 0 to 8 percent slopes	10.0	0.1%
2	Alderwood gravelly sandy loam, 8 to 15 percent slopes	17.5	0.3%
3	Alderwood gravelly sandy loam, 15 to 30 percent slopes	39.3	0.6%
4	Alderwood-Everett gravelly sandy loams, 25 to 70 percent slopes	133.3	1.9%
7	Bellingham silty clay loam	276.3	4.0%
13	Custer fine sandy loam	79.6	1.1%
20	Fluvaquents, tidal	296.5	4.3%
27	Kitsap silt loam, 0 to 8 percent slopes	31.0	0.4%
30	Lynnwood loamy sand, 0 to 3 percent slopes	30.3	0.4%
32	McKenna gravelly silt loam, 0 to 8 percent slopes	4.3	0.1%
34	Mukilteo muck	18.8	0.3%
39	Norma loam	367.5	5.3%
47	Pastik silt loam, 0 to 8 percent slopes	169.0	2.4%
48	Pastik silt loam, 8 to 25 percent slopes	11.2	0.2%
55	Puget silty clay loam	1,511.0	21.8%
57	Ragnar fine sandy loam, 0 to 8 percent slopes	2,616.5	37.7%
58	Ragnar fine sandy loam, 8 to 15 percent slopes	44.5	0.6%
64	Snohomish silt loam	22.2	0.3%
69	Terric Medisaprists, nearly level	11.0	0.2%
71	Tokul silt loam, 8 to 15 percent slopes	8.8	0.1%
72	Tokul gravelly medial loam, 0 to 8 percent slopes	143.4	2.1%
73	Tokul gravelly medial loam, 8 to 15 percent slopes	61.8	0.9%
77	Tokul-Winston gravelly loams, 25 to 65 percent slopes	5.3	0.1%
78	Urban land	138.2	2.0%
82	Xerorthents, nearly level	150.5	2.2%

Note: Base map modified from Aerial Map provided by City of Marysville.

Legend:

B-1 Approx. Borehole Location (PanGEO)

Core #3 Approx. Pavement Core Location (City of Marysville)

PanGEO INCORPORATED

1st and 3rd Streets Retrofit
Marysville, WA

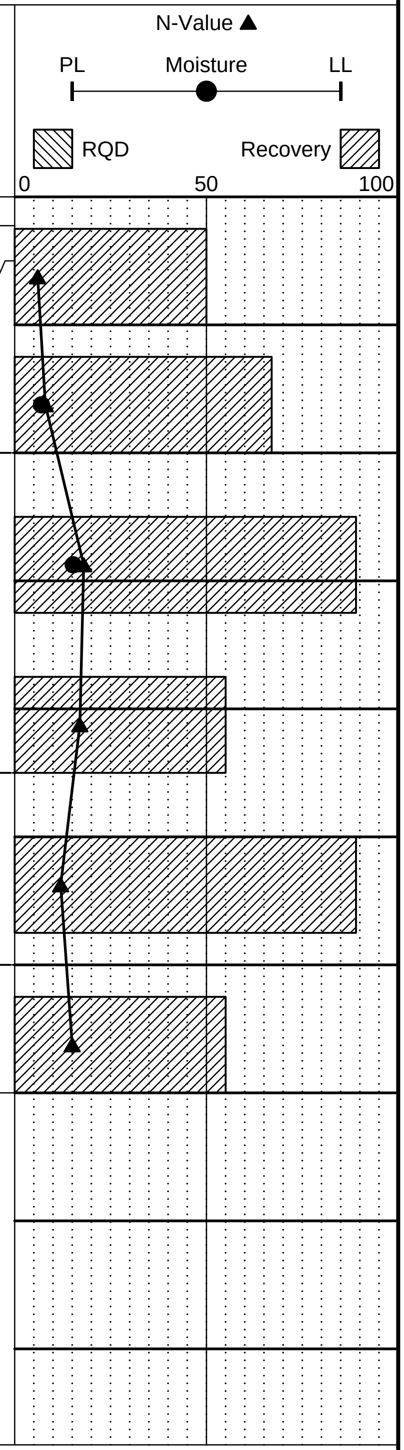
SITE AND EXPLORATION PLAN
3RD STREET BETWEEN
COLUMBIA AVENUE AND 47TH AVENUE NE

Project No.	Figure No.
13-239	2B

file.grf w/ file.dat 1/30/14 (11:33) TEA2

Project:	1st & 3rd Street Retrofit	Surface Elevation:	
Job Number:	13-239	Top of Casing Elev.:	
Location:	1st and 3rd Streets, Marysville, WA	Drilling Method:	HSA
Coordinates:	Northing: , Easting:	Sampling Method:	SPT

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0						5 inches of ASPHALT in two layers.
	S-1		4 4 2			6 inches of base. Medium dense, brown gray, silty, fine to coarse SAND with some gravel.
2						Loose, red brown to brown, fine SAND: moist, poorly graded, some silt, non-plastic fines, laminated with occasional rusty laminae, scattered charcoal organics. (Recessional Outwash).
	S-2		2 3 5	GS		
4						Medium dense, light gray, silty, fine to coarse SAND: moist, well graded, homogeneous, laminated with occasional rusty laminae, occasional fine gravel.
6	S-3		7 9 9	GS		
8	S-4		6 9 8			Grading to interbedded, light brown gray, silty, fine to medium SAND and fine to coarse SAND beds, laminated with occasional rusty laminae.
10						Medium dense, light brown, SILT with fine sand interbeds: very moist, non-plastic, laminated and fine bedded.
	S-5		4 5 7			
12	S-6		6 7 8			<medium dense, brown gray, fine to medium SAND with silt: wet, poorly graded, occasional fine to coarse sand interbed, homogeneous, laminated.
14						Boring terminated at about 14 feet below the surface. Groundwater was estimated based on the soil sample moisture on November 26, 2013.
16						
18						



Completion Depth:	14.0ft
Date Borehole Started:	11/26/13
Date Borehole Completed:	11/26/13
Logged By:	S. Evans
Drilling Company:	Bore Tec Drilling

Remarks: Groundwater observed in sample S-6 during drilling.

PanGEO INCORPORATED

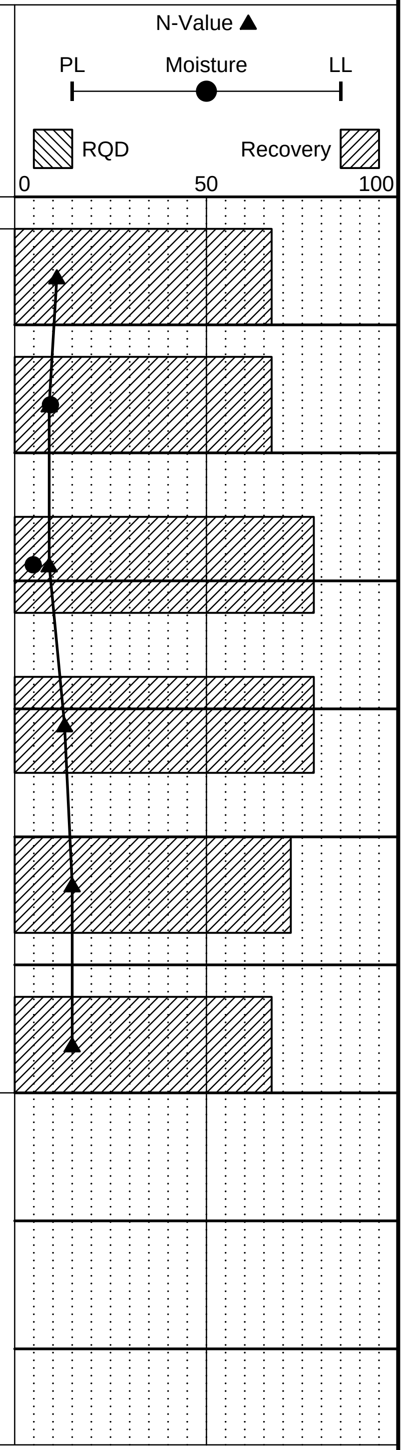
LOG OF TEST BORING B-5

Figure A-6

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

Project:	1st & 3rd Street Retrofit	Surface Elevation:	
Job Number:	13-239	Top of Casing Elev.:	
Location:	1st and 3rd Streets, Marysville, WA	Drilling Method:	HSA
Coordinates:	Northing: , Easting:	Sampling Method:	SPT

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0						6 inches of Asphalt, thin road base (<2 inches).
	S-1		6 6 5			Loose to medium dense, yellow brown, silty, fine SAND to fine to medium SAND with silt: moist, poorly graded, non-plastic fines, trace gravel and organics at top, homogeneous, laminated. (Recessional Outwash).
2	S-2		4 5 4	GS		Grading to silty, fine to medium SAND, light brown gray.
4						
6	S-3		2 5 4	GS		Grading to light gray, fine to medium SAND, some silt, occasional rusty laminae, finer and coarser beds.
8	S-4		4 5 8			Interbedded fine to coarse SAND, silty fine SAND and fine to medium SAND with silt, rusty laminae, finer beds brown, coarser are gray.
10	S-5		7 7 8			Homogeneous, fine to medium SAND, moist, trace silt, occasional rusty laminae.
12	S-6		6 7 8			Light gray, fine to medium SAND, moist, some silt, laminated to massive.
14						Boring terminated at about 14 feet below the surface. Groundwater was not observed during drilling.
16						
18						



Completion Depth:	14.0ft
Date Borehole Started:	11/25/13
Date Borehole Completed:	11/25/13
Logged By:	S. Evans
Drilling Company:	Bore Tec Drilling

Remarks: Groundwater not observed in SPT samples.

PanGEO INCORPORATED

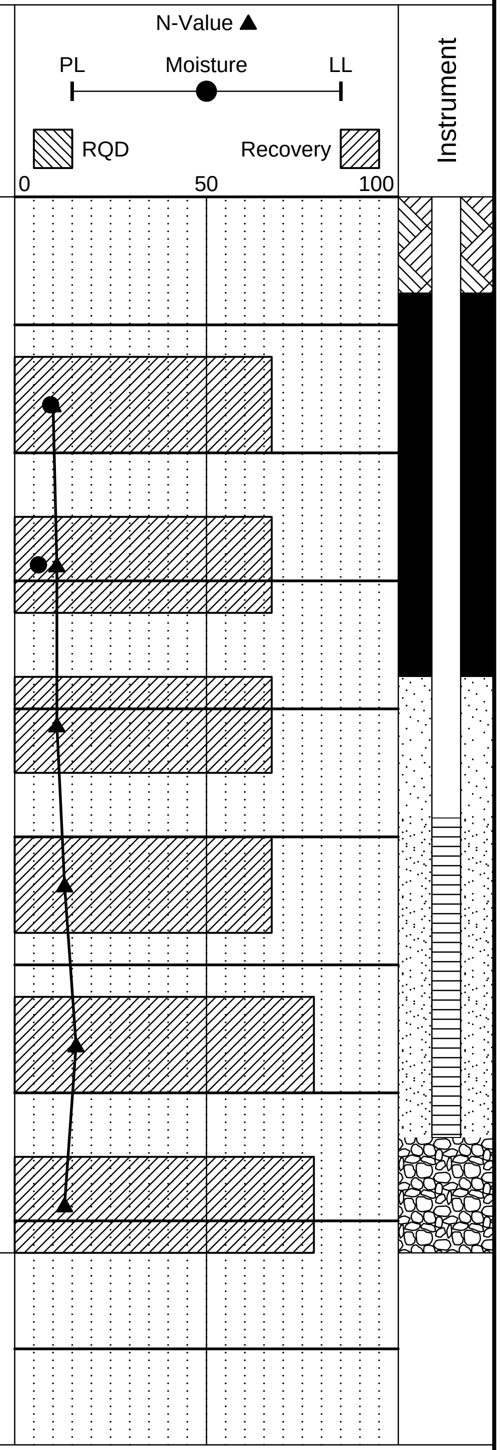
LOG OF TEST BORING B-6

Figure A-7

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

Project:	1st & 3rd Street Retrofit	Surface Elevation:	
Job Number:	13-239	Top of Casing Elev.:	
Location:	1st and 3rd Streets, Marysville, WA	Drilling Method:	HSA
Coordinates:	Northing: , Easting:	Sampling Method:	SPT

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0						Medium dense, light gray, fine to medium SAND: moist, some silt, poorly graded, homogeneous, massive to laminated, occasional orange pockets. (Recessional Outwash).
2						
	S-1		3 5 5	GS		Occasional organics.
4						
	S-2		5 5 6	GS		Trace to some silt.
6						
8	S-3		5 5 6			
10						
	S-4		4 6 7			Laminated with occasional brown laminae.
12						
	S-5		5 8 8			Grading to light gray, fine SAND with silt.
14						
	S-6		5 6 7			Grading to fine to medium SAND with silt.
16						
						Boring terminated at about 16.5 feet below the surface. Groundwater was estimated based on the soil sample moisture on November 26, 2013.
18						



Completion Depth:	16.5ft
Date Borehole Started:	11/25/13
Date Borehole Completed:	11/25/13
Logged By:	S. Evans
Drilling Company:	Bore Tec Drilling

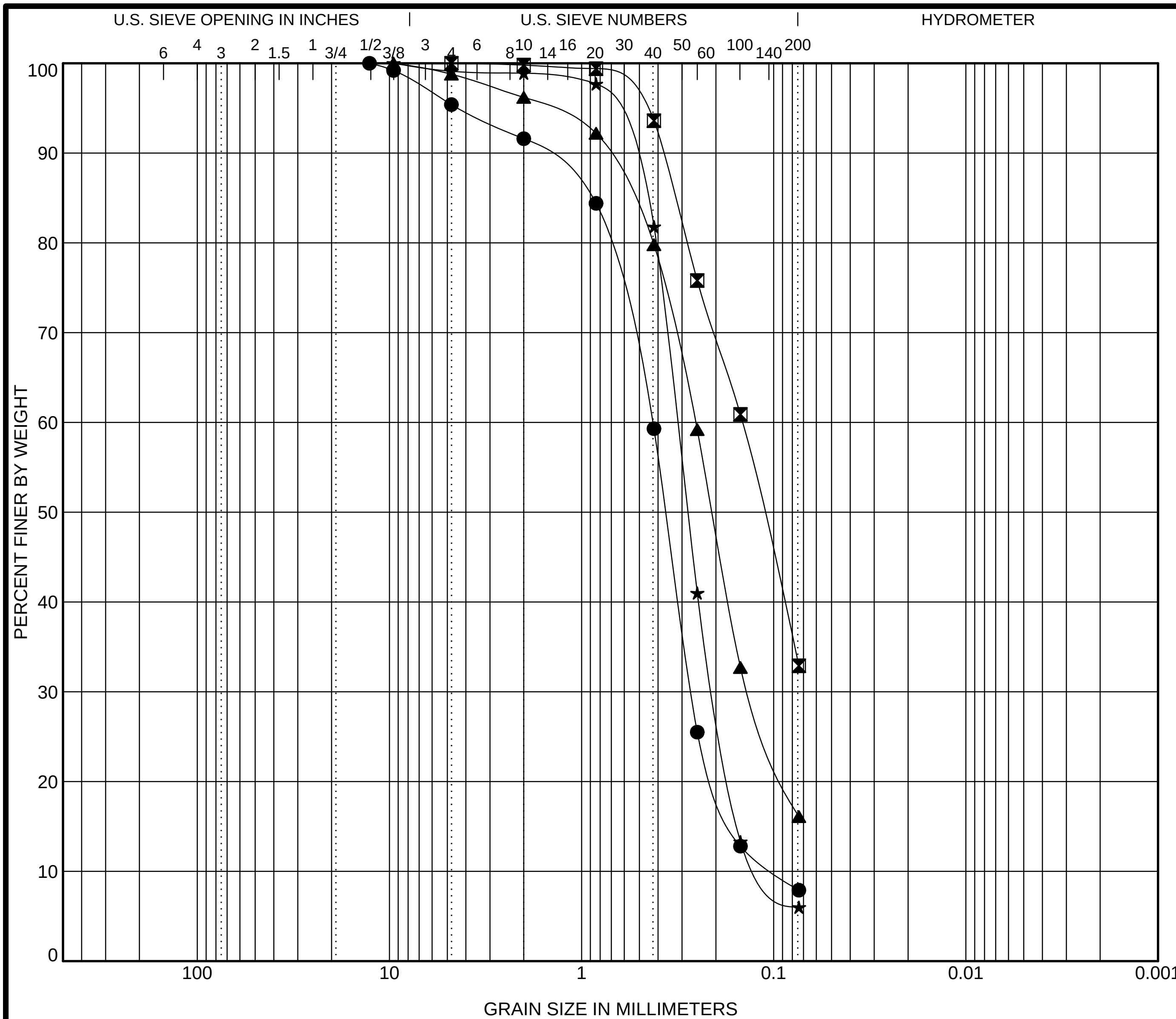
Remarks: Well dry when measured on 11/26/13. Groundwater estimated from SPT sample S-6 from 15 to 16.5 feet.

PanGEO INCORPORATED

LOG OF TEST BORING B-7

Figure A-8

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



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	B-5	@ 2.5 ft.	**Red brown-brown, fine SAND, some silt**				1.68	4.29
⊠	B-5	@ 5.0 ft.	**Light gray, silty fine to medium SAND**					
▲	B-6	@ 2.5 ft.	**Yellow brown, silty fine to medium SAND**					
★	B-6	@ 5.0 ft.	**Light gray, fine to medium SAND, some silt**				1.20	2.93

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	B-5	2.5	12.7	0.428	0.268	0.1	4.6	87.4	8.0	
⊠	B-5	5.0	4.76	0.146			0.0	66.6	33.4	
▲	B-6	2.5	9.52	0.255	0.133		1.2	82.4	16.4	
★	B-6	5.0	9.52	0.318	0.204	0.109	0.9	93.0	6.1	

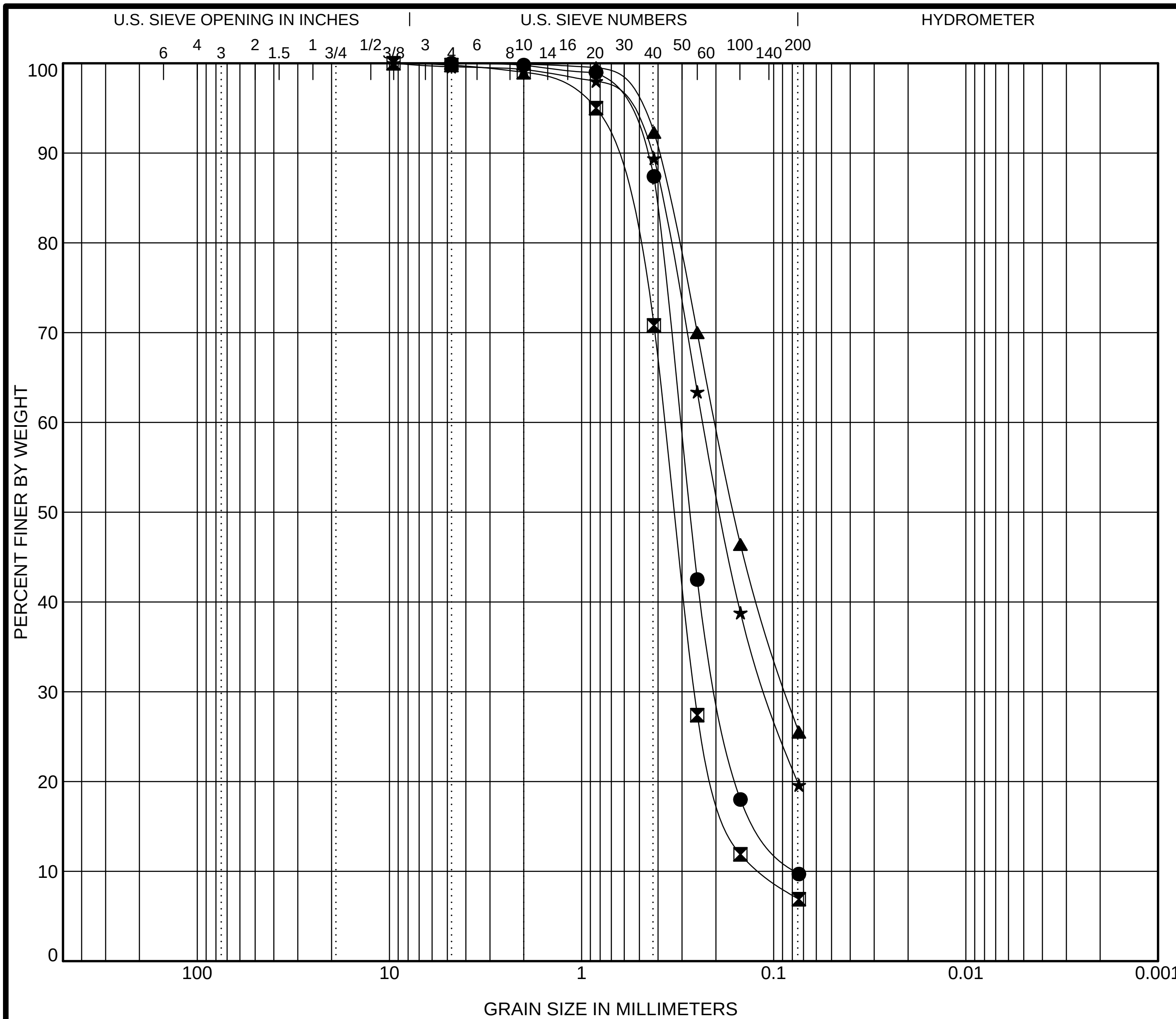
PanGEO INCORPORATED
Phone: 206.262.0370

GRAIN SIZE DISTRIBUTION

Project: 1st & 3rd Street Retrofit
Job Number: 13-239
Location: 1st and 3rd Streets, Marysville, WA

Figure B-3

GRAIN SIZE 13-239 3RD ST LOGS.GPJ PANGEO.GDT 1/30/14



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification			Classification	LL	PL	PI	Cc	Cu
●	**B-7**	**@ 2.5 ft.**	**Light gray, fine to medium SAND, some silt**				**1.59**	**4.03**
⊠	**B-7**	**@ 5.0 ft.**	**Light gray, fine to medium SAND, trace to some silt**				**1.58**	**3.23**
▲	**B-8**	**@ 2.5 ft.**	**Red brown, silty fine SAND**					
★	**B-8**	**@ 5.0 ft.**	**Light brown-gray, silty fine SAND**					

Specimen Identification			D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-7**	**2.5**	**4.76**	**0.306**	**0.192**	**0.076**	**0.0**	**90.1**	**9.9**	
⊠	**B-7**	**5.0**	**9.52**	**0.369**	**0.258**	**0.114**	**0.2**	**92.8**	**7.0**	
▲	**B-8**	**2.5**	**4.76**	**0.201**	**0.086**		**0.0**	**74.1**	**25.9**	
★	**B-8**	**5.0**	**9.52**	**0.233**	**0.108**		**0.4**	**79.6**	**20.0**	

PanGEO
INCORPORATED
Phone: 206.262.0370

GRAIN SIZE DISTRIBUTION

Project: 1st & 3rd Street Retrofit
Job Number: 13-239
Location: 1st and 3rd Streets, Marysville, WA

Figure B-4

GRAIN SIZE 13-239 3RD ST LOGS.GPJ PANGEO.GDT 1/30/14

APPENDIX D

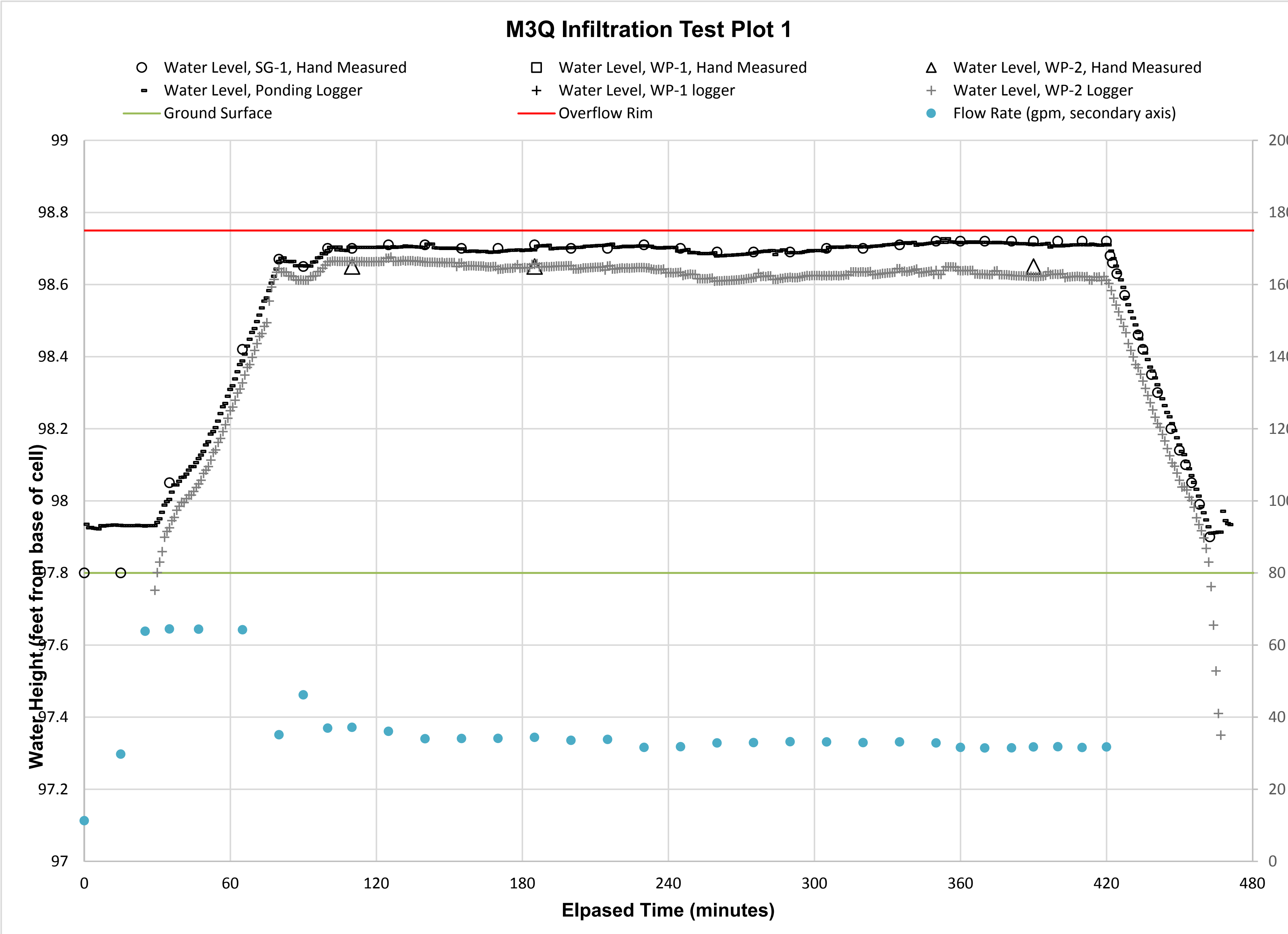
Soil Probe, Level Survey, and Field Infiltration Testing Data

Project Name:	BHPS	Water Source:	Hydrant
Project Number:	150387H007	Meter:	AESI FM5
Date:	10/30/2018	Base Area (sq.ft.):	200
Weather:	overcast, 60's	Ponded Area(sq.ft.):	200.0
Test No.:	M3Q	Test Depth (feet):	NA
Performed By:	ADY	Receptor Soils:	Recessional Outwash

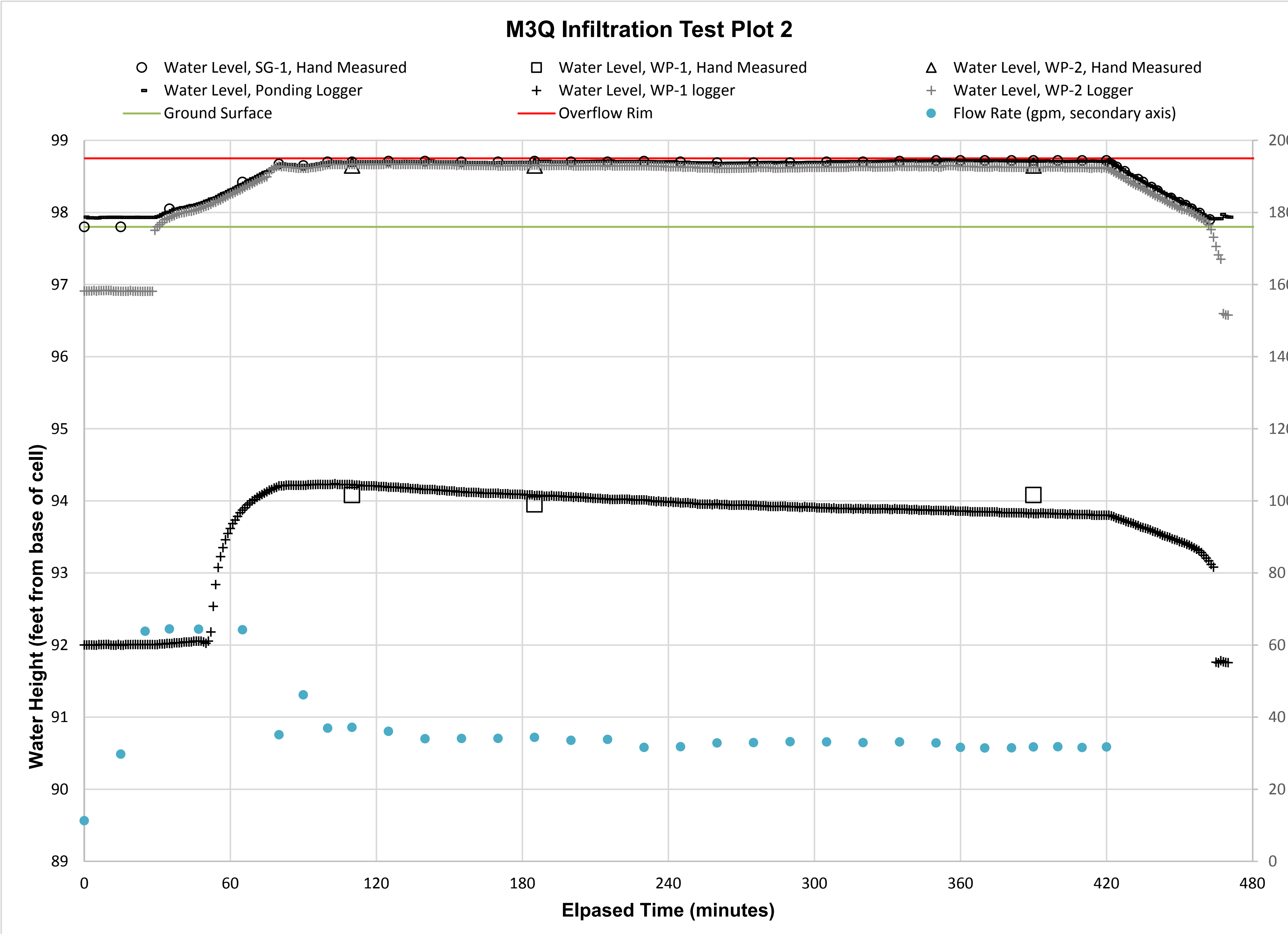
Time (24-hr)	Flow Rate (gpm)	Stage (feet)	Totalizer (gallons)	Comments
9:10	11.28	0	0	Flow on
9:25	29.72	0	187	Water pooling on East, South sides
9:35	63.83		464	
9:45	64.44	0.25	1062	
9:57	64.39	33	1840	Base fully wetted
10:15	64.22	0.62	3001	
10:30	35.11	0.87	3961	
10:40	46.17	0.85	4341	
10:50	36.94	0.9	4769	
11:00	37.17	0.9	5159	
11:15	36.06	0.91	5694	
11:30	34	0.91	6267	
11:45	34.06	0.9	6737	
12:00	34.11	0.9	7246	
12:15	34.39	0.91	7784	
12:30	33.56	0.9	8283	
12:45	33.83	0.9	8778	
13:00	31.61	0.91	9283	
13:15	31.78	0.9	9750	
13:30	32.83	0.89	10243	
13:45	32.94	0.89	10738	
14:00	33.17	0.89	11216	
14:15	33.11	0.9	11712	
14:30	32.94	0.9	12240	
14:45	33.11	0.91	12704	
15:00	32.83	0.92	13214	
15:10	31.61	0.92	13513	
15:20	31.44	0.92	13851	
15:31	31.46	0.92	14200	
15:40	31.72	0.92	14454	
15:50	31.78	0.92	14781	
16:00	31.56	0.92	15098	
16:10	31.72	0.92	15420	Flow off
16:11		0.88		
16:12		0.86		
16:14		0.83		
16:17		0.77		
16:23		0.66		
16:25		0.62		
16:28		0.55		
16:31		0.5		
16:36		0.4		
16:40		0.34		
16:42		0.3		
16:45		0.25		

16:48		0.19		
16:52		0.1		

	Average Infiltration Rate (in/hr) during last hour of inflow:	15.3
	Average Infiltration Rate (in/hr) during falling head:	13.7



M3Q Infiltration Test Plot 1
Water Level, SG-1, Hand Measured
Water Level, WP-1, Hand Measured
Water Level, WP-2, Hand Measured
Water Level, Ponding Logger
Water Level, WP-1 logger
Water Level, WP-2 Logger
Ground Surface
Overflow Rim
Flow Rate (gpm, secondary axis)
Water Height (feet from base of cell)
99
98.8
98.6
98.4
98.2
98
97.8
97.6
97.4
97.2
97
200
180
160
140
120
100
80
60
40
20
0
0
60
120
180
240
300
360
420
480
Elpased Time (minutes)



M3Q Infiltration Test Plot 2
Water Level, SG-1, Hand Measured
Water Level, WP-1, Hand Measured
Water Level, WP-2, Hand Measured
Water Level, Ponding Logger
Water Level, WP-1 logger
Water Level, WP-2 Logger
Ground Surface
Overflow Rim
Flow Rate (gpm, secondary axis)
Water Height (feet from base of cell)
Elpased Time (minutes)
99
98
97
96
95
94
93
92
91
90
89
0
60
120
180
240
300
360
420
480
200
180
160
140
120
100
80
60
40
20
0

APPENDIX E

Site Photos

Cell M3Q overview. In above photo, the curbcut weir has not been installed.
Lower photo is after weir install and during infiltration testing.

Above photo: Cell M3Q inlet modified for monitoring and nearby well points and ponding station.
Lower Photo: close up of overflow structure during infiltration testing.

Technical Memorandum

Date:	June 14, 2019	**From:**	Anton Ympa Suzanne Cook, L.G.
To:	Clear Creek Solutions, Inc.	**Project Manager:**	Jennifer H. Saltonstall, L.G., L.Hg.
	15800 Village Green Drive #3 Mill Creek, Washington 98012	**Principal in Charge:**	Jennifer H. Saltonstall, L.G., L.Hg.
cc:	Eric Christensen	**Project Name:**	Bioretention Hydrologic Performance Study
Attn:	Doug Beyerlein, P.E.	**Project No:**	150387H007
Subject:	Deliverable Task 4.5, Site MPP, Geotechnical/Soils Assessment Design Data and Current Conditions, Monroe Park Place Middle School, Monroe, Washington		

1.0 INTRODUCTION

This technical memorandum documents existing shallow soil and groundwater conditions in Bioretention Cell #6 of the Monroe Park Place Middle School Project, located in the city of Monroe, Washington (Figure MPP F1). This memorandum was prepared in accordance with Task 4 of the contract scope of work. Associated Earth Sciences, Inc. (AESI) collected shallow soil and groundwater conditions data related to bioretention cell function, and documented the current condition of the facility relative to the as-built drawings and available background geotechnical information. The information will be used in the WWHM2012 modeling that will be conducted as part of Task 5 (Data Analysis). In Task 5, the team will compare the previously-documented hydrologic design information with our field-collected information and will note where there are significant differences. The purpose of this technical memorandum is to document the collection of current and accurate geotechnical, geologic, and hydrogeologic site information for this later work.

The following summary of shallow soil and groundwater conditions integrates the observations made during the geotechnical assessment which included site visits on October 10, 2018, infiltration testing on November 8, 2018, provisional results of hydrologic monitoring, and background geotechnical information.

This technical memorandum has been prepared for the exclusive use of Clear Creek Solutions and the City of Olympia and their agents for specific application to this project. Within the limitations of scope, schedule, and budget, our services have been performed in accordance with generally accepted hydrogeologic and geotechnical engineering practices in effect in this area at the time our document was prepared. No other warranty, express or implied, is made.

2.0 PURPOSE AND SCOPE

The purpose of our work was to perform a shallow soil and groundwater conditions assessment and provide baseline documentation data to assess effectiveness of bioretention hydrologic performance.

Specifically, our scope included the following activities:

- Review of project documents.
- Site reconnaissance.
- Visual condition assessment of erosion and deposition features near inlet and outlet.
- Review project plans relative to constructed facility, in particular, the number and location of inlets, energy dissipation devices, outlets, and other flow-related details.
- Survey elevations of inlet, outlet, well point rim, and other observation points relative to a project datum.
- Excavate shallow hand augers through the bioretention soil.
- Classify sediment according to the Unified Soil Classification System (USCS) and *American Society for Testing and Materials* (ASTM) D2488, "Standard Recommended Practice for Description of Soils."
- Collect samples for laboratory testing of: (1) particle size distribution in accordance with ASTM D422-63, "Standard Test Method for Particle-Size Analysis of Soils"; (2) organic matter content per ASTM D2974.
- Preparation of descriptive exploration logs for each exploration.
- Conduct qualitative assessment of soil compaction via T-probe.
- Conduct infiltration testing.
- Review of hydrologic monitoring data.
- Preparation of this summary document.

Existing facility features and the locations of hand-auger boreholes completed for this study are shown on Figure MPP F2, "Facility and Exploration Plan." Project civil plans are attached as Appendix A. Exploration logs and laboratory testing data conducted as part of this study are attached as Appendix B. Background soil, geology, and groundwater information are attached as Appendix C. Soil probe, level survey, and field infiltration testing data are attached as Appendix D. Site photos are attached as Appendix E.

3.0 SITE DESCRIPTION AND DESIGN BACKGROUND

The project site is the Monroe Park Place Middle School Project, located in Monroe, Washington as shown on the attached "Vicinity Map" (Figure MPP F1). The Monroe Park Place Middle School is located on a 21-acre parcel. The site is bordered by West Main Street to the north, mixed-use residential and business and associated parking to the west and east and vacant, wooded area to the south. Site topography slopes gently toward the southeast with a vertical relief of less than

10 feet (60 feet near the northwest corner and 56 feet along the west side with a low of 54 feet). The site is located about 1,000 feet north of the Skykomish River, which flows to the southwest in the vicinity of the site. An abandoned channel of the river is immediately south of the site. No on-site surface water features are present.

Our specific area of study for this project includes bioretention facility cell #6 located on the southeast portion of campus referred to as cell MPP for this study. The attached "Facility and Exploration Plan" (Figure MPP F2) illustrates the cell area and some of the surrounding site features and utilities.

Details of the bioretention facility design and basis for design were presented in the following documents:

- Associated Earth Sciences, Inc., 2015, Subsurface Exploration, Geologic Hazard, and Preliminary Geotechnical Engineering Report, Park Place Middle School, Monroe, Washington: Prepared for Monroe Public Schools, July 31, 2015.
- Associated Earth Sciences, Inc., 2016, In-situ Infiltration Testing and Design Infiltration Rate Recommendations, Park Place Middle School, Monroe, Washington: Prepared for Monroe Public Schools, January 22, 2016.
- Harmsen & Associates, Inc., 2016, Stormwater Site Plan for Park Place Middle School, Monroe, Washington, February 4, 2016 (Drainage report).
- Integrus Architecture, Monroe School District Park Place Middle School, Plan Set, June 6, 2016 (plan set).
- Associated Earth Sciences, Inc., 2017, Park Place Middle School, Project No. 150324E011, Selected Field Reports, June 2017.

3.1 Summary of Facility Design

From our review of these documents, the bioretention facility design for cell MPP consists of an approximately rectangular-shaped bioretention cell with approximately 684 square feet of base area, as shown on Figure MPP F2, "Facility and Exploration Plan." We understand that the site was developed under the 2005 Washington State Department of Ecology (Ecology) *Stormwater Management Manual for Western Washington* (2005 Ecology Manual) as adopted by the City of Monroe for design and construction of stormwater facilities and modeled using WWHM2012 with a design infiltration rate of 2 inches per hour (in/hr) for the bioretention soil; the native subgrade infiltration rate exceeded the bioretention soil rate. As described in the drainage report, land use within the drainage basin is primarily roads and walkways (0.29 acres) and lawn/landscaping (0.19 acres). Per plan sheet C302, "Monroe School District Park Place Middle School" (Integrus Architecture, June 6, 2016), the facility design includes 18 inches of bioretention soil mix overlying approximately 6 inches of "A33" sand (washed fine- to medium-grained sand) overlying native subgrade.

The facility is designed to infiltrate 100 percent of inflow into the subgrade. Stormwater enters the facility through one inlet curbcut on the north end. No overflow structure was installed in cell MPP.

The inlet to cell MPP and the pond rim was designed to be 1.5 feet above the cell base to create 1.5 feet of ponding depth. If water ponds up and fills the cell, the ponded water would flow into the parking lot to the north. The facility was constructed during Summer 2017.

4.0 SITE OBSERVATIONS

During AESI's site visits, we made notes regarding the physical construction of the bioretention facilities including documenting site inlet/outlet layout relative to site plans and qualitative bioretention soil thickness and compaction. These notes were used to indicate key features of the facility on Figure MPP F2, "Facility and Exploration Plan."

- <u>Level Survey</u>: AESI conducted an elevation survey of the cell using a Leitz C40 automatic level and a stadia rod. An arbitrary project datum was established for this survey, with the top of curb at the northeast corner of the track (west of cell MPP defined as project datum elevation 100 feet. All other elevations measured by the survey are relative to this project datum. Key level data is summarized in Table 1. Additional data points are included in Appendix D to this document. This survey was not conducted by a licensed surveyor. Surveyed elevations are expected to be sufficiently accurate for this general assessment of facility construction, but may be inaccurate for purposes requiring greater precision.

- <u>Inflow</u>: One inflow consisting of a curb cut to cell MPP was observed on the north end of the cell.
    - Inflow to the facility via a curb cut, allows sheet flow from the parking lot to discharge onto a quarry spall energy dissipation pad approximately 4 to 5 feet wide and 18 feet long.

- <u>Overflow</u>: No overflow structure for cell MPP was observed. The approximate low of the rim of the cell to the south was measured to be 3.6 feet above the cell base and 1.8 feet above the cell inlet. If ponded water filled the cell, overflow would flow into the parking lot to the north before overtopping the cell rim to the south, west, or east.

- AESI investigated the loose bioretention soil thickness present in cell MPP using a geotechnical soil T-probe. This qualitative data was used in conjunction with the hand-auger observations to understand loose soil thickness and relative potential compactness of the bioretention soils at depth. AESI measured the depth of penetration of the soils probe at locations generally arranged in a 4-foot to 5-foot grid on the facility base. Penetration of the T-probe generally ranged from approximately 1.4 feet to 2.5 feet, and averaged 1.9 feet. Probe penetration data is included in Appendix D to this document.

Table 1
Summary of Cell MPP
Level Survey Data

Location	Elevation (feet, project datum)
Top of curb, northeast corner of track, west of cell	100
MPP-WP-1 TOC	98.82
Ground surface at MPP-WP-1 and temporary staff gauge MPP-SG-1	96.17
Ponding tube TOC (DL)	99.05
Temporary inlet pipe top/end	98.21
Curbcut, inside lip, low	97.99
Cell rim low, south of cell	99.82

WP: well point; TOC: top of Casing; DL: datalogger;

5.0 SITE SETTING

The text sections below describe our research findings in regards to the topographic, geologic, and hydrogeologic setting of the project site both from regional studies and background site-specific geotechnical and groundwater studies. Our sources of information included the following:

- Site-specific documents cited previously under "Project and Site Description."
- Dragovich, J. et al., 2011, *Geologic Map of the Monroe 7.5' Quadrangle, King and Snohomish Counties, Washington*, Washington Department of Natural Resources (DNR), scale 1:24,000.
- Natural Resources Conservation Service (NRCS), Web Soil Survey, United States Department of Agriculture (USDA), http://websoilsurvey.nrcs.usda.gov/, accessed December 2018.
- *Soil Survey of Snohomish County Area, Washington*, United States Department of Agriculture (USDA), Natural Resource Conservation Service (NRCS), in cooperation with Washington Agricultural Experiment Station, 1983.
- Newcomb, R.C., 1952, Ground-water Resources of Snohomish County, Washington: U.S. Geological Survey (USGS).
- Thomas, B.E., Wilkinson, J.M., and Embrey, S.S., 1997, The Ground-water System and Groundwater Quality in Western Snohomish County, Washington: U.S. Geological Survey USGS), U.S. Department of the Interior.

5.1 Regional Topography and Project Grading

The site and vicinity are on the south edge of the city of Monroe, within a broad river valley flat near the confluence of the Skykomish and Snoqualmie rivers. Topographic features in the vicinity of the site were formed by glacial and post-glacial processes. Elevations on the larger project site range from about 54 to 60 feet. The site is located about a 1,000 feet north of the Skykomish River, and is about 15 to 20 feet higher in elevation than the river. An abandoned channel of the river is immediately south of the site. No on-site surface water features are present.

On a closer scale, the area near cell MPP is relatively flat, situated on an alluvial plain at about elevation 59 to 60 feet. Level parking and access road areas are to the north, lawn and an athletic track are to the west and lawn is to the east and south. A curb separates the paved surfaces from the cell and the track.

The project site was previously developed as Park Place Middle School which was demolished, to allow for the construction of the new Park Place Middle School. Minor cutting (about 4 to 5 feet) was needed to achieve design bioretention cell grades based on a review of existing topography compared with built topography.

5.2 Regional Geology and Background Geotechnical Information

According to the geology map (Dragovich et al., 2011), the site vicinity is underlain by Deltaic Outwash of the Vashon Stade of the Fraser Glaciation. The interpretation of the sediments encountered at the subject site during our geotechnical and infiltration studies (AESI, 2015 and 2016) is not in general agreement with the regional geologic map, and is not consistent with our observations and interpretations of subsurface materials encountered in our explorations for this project. Sediments interpreted to be representative of Skykomish River alluvium were encountered directly below the topsoil and/or fill at the locations of all explorations done during our geotechnical and infiltration studies (AESI, 2015 and 2016). The Skykomish River alluvium was deposited by the Skykomish River system. The alluvial sediments generally consisted of two facies: levee deposits which were deposited during river flooding and coarse grained alluvium which was deposited within stream channels.

- <u>Alluvium - Levee Deposits</u>: Sediments interpreted to be levee deposits were encountered in all explorations to depths between 3 to 6 feet. These sediments generally consisted of soft to medium stiff, moist, tannish brown to brown, fine sandy silt with varying amounts of organics. The levee deposits form in a low-energy environment at the edges of channels where the floodwater velocity decreases.

- <u>Alluvium - Coarse-Grained</u>: Sediments interpreted to be coarse-grained alluvium extended below the levee deposits to the bottom of all explorations at a maximum depth of 21.5 feet. The channel alluvium generally consisted of medium dense to dense, moist, fine to coarse sand and gravel with cobbles and trace silt. These sediments were deposited by the Skykomish River System in a high-energy environment.

Infiltration tests were conducted as part of design. Infiltration tests IT-5 and IT-7 were located near cell MPP (bioretention cell #6) with field infiltration rates of 12 and 75 inches per hour, respectively. Subsurface information from the bioretention cell during construction (Appendix C, June 2017 field reports) indicate that the cell was ‘over-excavated’ (deepened) in some areas to remove levee deposits (silt and silty fine sand) and expose the better-draining channel deposits (sandy gravel).

5.3 Regional Soils and Soil Data Used in Site Stormwater Model

AESI reviewed the soil survey (Natural Resources Conservation Service [NRCS], 1983) and soils mapping from the NRCS web portal (NRCS, 2018). The soil survey identifies different soil map units based on parent material, climate, topography (slope), organisms (biota), and time. The soils in the study area formed mostly from young glacial deposits and have not had time to develop the deep weathering profiles present in soils in unglaciated terrains. Instead, they exhibit a direct relationship to the underlying parent material, local climate, topography, and vegetation.

Mapped soils in the project area consist of Sultan Silt Loam, which formed in alluvium on 0- to 2-percent slopes. NRCS describes the permeability as moderately slow (NRCS, 1983).

As described in the drainage report (Harmsen & Associates. Inc., 2016), the pre-developed condition was modeled as Type C soils, consistent with mapped soil and background geotechnical data that shows the upper alluvium levee deposits consist of sandy silt.

5.4 Regional Hydrogeology and Background Groundwater Data

Regional hydrogeology is described in Newcomb (1952) and Thomas et al. (1997). Thomas et al, (1997) identifies an alluvial aquifer within the Skykomish River alluvium and notes the Skykomish alluvium deposits are among the most areally extensive in the area of study.

According to our geotechnical and infiltration studies at the site (AESI, 2015 and 2016), groundwater is present at shallow depths beneath the site within the coarse-grained alluvial deposits. Groundwater seepage was encountered in our explorations from previous studies (AESI, 2015 and 2016) below depths of approximately 14 to 21 feet. Exploration EB-3 is within 100 feet of cell MPP and encountered groundwater seepage below depths of approximately 18 feet.

Groundwater measurements were taken from the three groundwater monitoring wells installed June 30, 2015 (AESI, 2015). Groundwater ranged from approximately 48 to 49 feet below ground surface in December 2015 (AESI, 2016), or within about 6 to 7 feet below the top of bioretention soil layer (planned elevation of 54.9 feet). Hydrographs are included in Appendix C.

The shallow unconfined groundwater encountered in the on-site monitoring wells is part of the regional aquifer contained within the alluvial deposits present in the Skykomish/Snoqualmie River deposits. Groundwater flow direction is typically toward the river, except during river flood stage when groundwater flow direction is affected by river stage.

6.0 BIORETENTION CELL SUBSURFACE EXPLORATION

Limited information on subsurface conditions was obtained for this study from hand-auger samples and soil probe penetration measurements at about 2-foot increments in each hand-augered borehole. Three hand-auger borings were performed in the facility bottom and advanced through the bioretention soil and into underlying sand fill. Two of the borings were also advanced into native material underlying the fill (MPP-HA-1 and MPP-HA-2). Representative samples were collected, visually classified in the field, stored in water-tight containers, and transported to AESI's offices for additional classification, geotechnical testing, and study. At the conclusion of the excavation, the boreholes were immediately backfilled with the excavated material or completed as a well point for water level monitoring (described separately below).

The various types of sediments, as well as the depths where characteristics of the sediments changed, are indicated on the exploration logs presented in Appendix B. A detailed record of the observed bioretention soil, subsurface soil, geology, and groundwater conditions was made. The sediments were described by visual and textural examination using the soil classification in general accordance with ASTM D2488, "Standard Recommended Practice for Description of Soils." The depths indicated on the logs where conditions changed may represent gradational variations between sediment types in the field. The exploration logs in Appendix B are based on the field observations, inspection of the samples, and where applicable, laboratory grain-size analysis. Our explorations were approximately located in the field relative to known site features, and are shown on Figure MPP F2, "Facility and Exploration Plan."

The results presented in this document are based on the explorations completed for this study and review of background data. The number, locations, and depths of the explorations were completed within site and budgetary constraints. Because of the nature of exploratory work below ground, interpolation of subsurface conditions between field explorations is necessary. It should be noted that differing subsurface conditions may sometimes be present due to the random nature of deposition and the alteration of topography by past grading and/or filling.

6.1 Hand-Auger Borings

Hand-auger borings in cell MPP were completed on October 10, 2018. No rainfall was noted at the time of exploration.

Hand-auger boring locations are presented on Figure MPP F2. The hand-auger borings encountered a thin layer of shredded wood overlying bioretention soil to a depth of 1.6 to 1.7 feet, overlying a thin layer of sand fill, and native alluvium sediment (MPP-HA-1 and MPP-HA-2). Hand-auger MPP-HA-3 was terminated in the sand fill layer at 2 feet. Bioretention soil thickness was 1.5 to 1.6 feet in each boring. No seepage or caving was observed.

6.2 Well Points

One well point was installed in MPP-HA-1 (WP-1) a depth of 2.5 feet, and screened primarily within the bioretention soil and imported sand layer. Key well point dimensions are provided in Table 2, below.

Table 2
Summary of Cell MPP
Well Point Dimensions

Well Point	Exploration in which Well Point was Installed	Total Length of Casing (feet)	Interior Diameter	Stickup Height (feet)	Total Depth Inside Casing Below Ground Surface
MPP-WP-1	MPP-HA-1	5.1	1.25 inch nominal	2.6	2.5

7.0 LABORATORY ANALYSIS

Laboratory testing included mechanical grain-size distribution and percent organic matter by weight in accordance with the ASTM D422 and D2974, respectively. Bioretention soil was first tested for organic matter content and then the burned material was tested for grain-size distribution for comparison with the aggregate fraction of the bioretention soil mix guidance in the 2014 Ecology *Stormwater Management Manual for Western Washington* (2014 Ecology Manual). Two samples of material interpreted as representative of the bioretention soil were tested for grain-size distribution. The data are summarized in Table 3.

Table 3
Summary of Cell MPP
Organic Content and Grain Size Data

Exploration Number	Depth (feet)	Soil Type	Organic Content (% by weight)	USCS Soil Description	Fines Content (% passing #200)	Cu	Cc	USDA Soil Texture*
MPP-HA-1	0.1-0.5	Bioretention Soil	10.1	SAND, trace silt, trace gravel (SW)	4.2	6.2	1.0	Sand
MPP-HA-2	0.1-0.5	Bioretention Soil	9.9	SAND, trace silt, trace gravel (SW)	2.9	6.0	1.0	Sand
MPP-HA-3	1.0-1.6	Bioretention Soil	--	SAND, trace silt, trace gravel (SP)	2.9	5.1	1.1	Sand

USCS: Unified Soil Classification System; Cu: coefficient of uniformity; Cc: coefficient of curvature; USDA: U.S. Dept. of Agriculture;
*No hydrometers were performed. USDA soil texture range assumes fines consist entirely of silt to entirely of clay.

7.1 Bioretention Soil Mix

We compared the organic content and burned fraction gradation against the general guidelines for the bioretention soil mix (Table 4).

The organic content of the tested bioretention soils ranged between 9.9 to 10.1 percent by weight, slightly higher than the recommended organic content by weight of 5 to 8 percent in the 2014 Ecology Manual.

The grain-size analysis test results on the burned soil fraction indicate that the bioretention soils tested correlate to a "SAND" with trace silt and trace gravel based on ASTM D2487 USCS. The respective fines content as measured on the No. 200 sieve was 2.9 to 4.2 percent, within the recommended range of 2 to 5 percent. The coefficient of uniformity ranged from 5.1 to 6.2, meeting the recommended value of equal to or greater than 4. The coefficient of curvature ranged from 1.0 to 1.1, within the recommended range of greater than or equal to 1 and less than or equal to 3. The soil mix contained slightly more than the recommended range of coarse sand. The tested bioretention soil was a poorly- to well-graded sand.

Table 4
General Guidelines for Bioretention Soil Mix (2014 Ecology Manual)
Compared to Averaged Cell MPP Site Data

Parameter	Recommended Range	Cell MPP
Organic Content (by weight)	5 to 8 percent	10.0 percent by weight
Cu coefficient of uniformity	4 or greater	5.8
Cc coefficient of curvature	1 to 3	1.1
Sieve Size	**Percent Passing**	
3/8" (9.51 mm)	100	100
#4 (4.76 mm)	95 to 100	97.6
#10 (2.0 mm)	75 to 90	72.5
#40 (0.42 mm)	25 to 40	20.1
#100 (0.15 mm)	4 to 10	5.8
#200 (0.074 mm)	2 to 5	3.3

Note: The general guidelines for mineral aggregate gradation are from Table 7.4.1 of the 2014 Ecology Manual.
mm: millimeters.

7.2 Subgrade

In cell MPP, AESI observed excavation of cell MPP during construction and conducted hand-auger borings within the cell as part of the current study. A thin layer of imported sand, 0.2 to 0.9 feet thick, classified as SAND, trace silt (SP), was observed overlying native material consisting of alluvium, classified as a sandy GRAVEL with trace silt (GP). Grain-size testing from a nearby infiltration test at the time of design (AESI, 2016) is included in Appendix C.

8.0 INFILTRATION TESTING

8.1 General Infiltration Test Method

The infiltration test was conducted in general accordance with the 2014 Ecology Manual. The test was conducted by discharging water into the facility for a "soaking period," to allow the receptor soils to become saturated. After completion of the soaking period, water was discharged into the cell at a rate sufficient to maintain a relatively constant head. This constitutes the "constant-head" phase of infiltration testing. Immediately following the constant-head phase of infiltration testing, flow into the facilities was discontinued, and the water level was monitored as it dropped. This constitutes the “falling-head” portion of the infiltration testing.

The water for testing was obtained from an on-site fire hydrant and conveyed to cell MPP with fire hoses. During infiltration testing, the water was conveyed into the bioretention cell via a digital flow meter with gallons per minute (gpm) and total gallon readouts, and discharged through a flow diffuser. Ponded water levels within the cell were monitored using a temporary staff gauge (MPP-SG-1) marked in 0.01-foot increments installed adjacent MPP-WP-1, and within a piezometer (“ponding tube”) with a digital water level tape, and with digital pressure transducers. Data from the digital pressure transducers was compensated for barometric response using a separate digital barometer. The area of the pool was measured periodically during testing.

The infiltration test in cell MPP is discussed below, and results are presented in Table 5. Infiltration test data is included in Appendix D to this document.

8.2 Infiltration Test in Cell MPP

AESI performed infiltration testing on November 8, 2018. No rainfall was noted during testing, and no flow from the inflow pipes was present.

During this test, flow was initially adjusted between about 50 and 100 gpm to fill the cell bottom and stabilize the wetted area, then maintained at about 30 gpm for the duration of the test. Inflow to the facility for the infiltration test was directed, through a diffuser, onto the cell. The entire cell base was wetted after about 100 minutes and a water level between 1.0 and 1.2 feet was maintained at the staff gauge after about 170 minutes (MPP-SG-1, Figure MPP F2). The wetted pool area had been generally stable through most of the soaking and testing period covering an area of about 800 square feet. Approximately 18,000 gallons of water were used.

Ponded water in the bioretention cell was monitored in well point MPP-WP-1 using a data logger during the infiltration test and responded to inflow. Groundwater was observed within the bioretention soil prior to the start of inflow to the bottom depth of MPP-WP-1 (2.5 feet). The water level in the well point is interpreted to have responded to inflow within several minutes. The first about 70 minutes of water level data was not recovered. The water level in MPP-WP-1 rose approximately 3.5 feet above the base of the well point to 1.0 feet above ground surface during the course of testing. AESI interprets this response to indicate that water from the infiltration test infiltrated rapidly through the bioretention soil and then mounded then mounded on the native alluvial sediments. The shallow subsurface ponded water level mirrored the surface water ponding level.

After about 7 hours, AESI shut off the flow and monitored water level as it fell. AESI observed that the pooled water in the base of the facility and the groundwater level in well point MPP-WP-1 dropped about 0.3 feet after 60 minutes.

Water was still ponded in the base of the facility about 0.9 feet and groundwater still mounded in well point MPP-WP-1 about 0.7 feet above the ground surface 60 minutes after inflow was stopped.

The constant-head test infiltration rate in Table 5 is calculated based on flow rate from the hose for infiltration testing, and the wetted area of bioretention soil through which the water infiltrated, and represents the infiltration rate of the native subgrade.

Table 5
Cell MPP
Infiltration Test Results

Test No.	Surface Area (square feet)	Discharge Time (minutes)	Total Volume Discharged (gallons)	Approximate Constant-Head Level (feet)	Field Infiltration Rates	
					Constant-Head Test (in/hr)	Falling-Head Test (in/hr)
MPP (bioretention soil)	800	420	18,065	1.2	greater than native soil infiltration rate	
MPP (subgrade)	interpreted to be similar to wetted area				3	3

in/hr: inches per hour.

9.0 CONCLUSIONS AND RECOMMENDATIONS

Cell MPP was generally consistent with the design shown on the civil plan sheets. Observations on site design, shallow soil and groundwater conditions are discussed below.

- No overflow was designed or observed. Site design documents indicate that the ponding level was designed as 1.5 feet.

- Bioretention soil:
  - Thickness: The apparent thickness of loose bioretention soil based on soil probe data was generally about 1.9 feet thick, slightly thicker than as indicated on the plans (1.5 feet).
  - Composition: The soil tested in generally the recommended guidelines for sand gradation. The organic content was higher than recommended with an average of 10 percent.

- Subgrade conditions: The subgrade is interpreted to consist of a thin layer of imported sand fill overlying native alluvium sediments as documented during construction and design reports (AESI, 2015, 2016).

- During infiltration testing, water readily soaked through the bioretention soil mix. Water was observed in the shallow well point (screened at the base of the bioretention soil), demonstrating that water accumulated on the underlying subgrade. The native alluvium is interpreted to have a lower permeability than the overlying bioretention soil. The shallow subsurface ponded water level mirrored the surface water ponding level.

- Subgrade infiltration rate: Measured at about 3 in/hr. This is lower than the infiltration testing conducted as part of design (infiltration rates of 12 and 75 inches per hour).

- Bioretention soil field infiltration rate:
    - Greater than the measured field rate of at about 3 in/hr.
    - Water readily soaked through the bioretention soil mix and the field rate is interpreted to represent the native subgrade infiltration rate.

- Groundwater is expected to be present seasonally at shallow depths in the location of the MPP facility below the bottom of well point MPP-WP-1 since it was encountered in several explorations onsite (AESI, 2015 and 2016) and seasonal groundwater monitoring indicates high of about 6 feet below top of bioretention soil surface. Peak groundwater occurred for a few days during peak river stage during the groundwater level monitoring period of record.

- The effects of shallow groundwater mounding will increase during the wetter winter months, and will reduce the effective infiltration rate by reducing the vertical gradient. The ongoing monitoring data will be reviewed for groundwater influence.

10.0 CLOSURE

We appreciate the opportunity to be of continued service to you on this project. Should you have any questions regarding this document or other geotechnical/hydrogeologic aspects of the project, please call us at your earliest convenience.

Anton D. Ypma
Staff Geologist

Suzanne S. Cook, L.G.
Senior Project Geologist

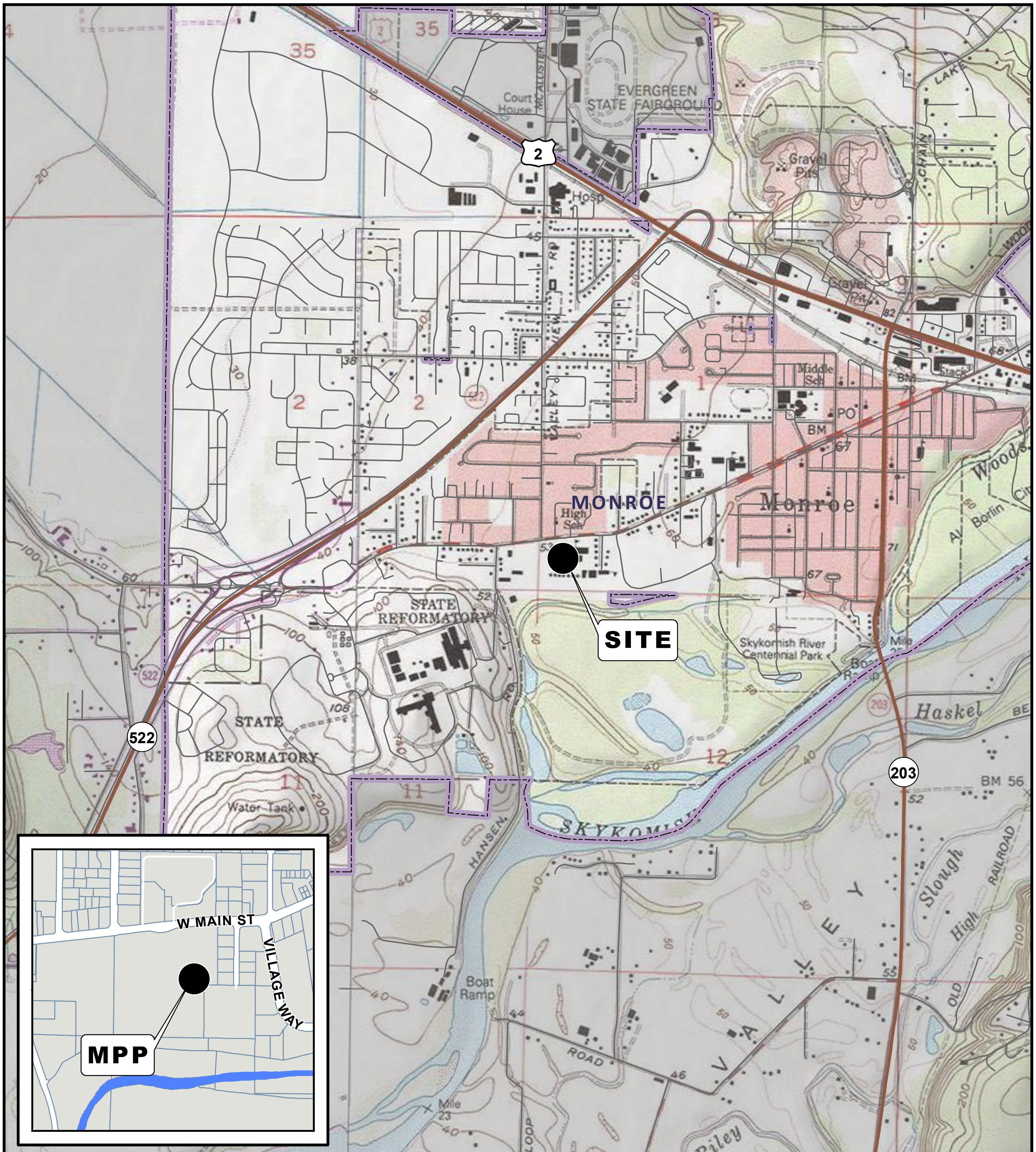
State of Washington
Hydrogeologist
2335
Licensed Geologist
Jennifer H. Saltonstall

6/14/19

Jennifer H. Saltonstall, L.G., L.Hg.
Principal Geologist/Hydrogeologist

Attachments:	Figure MPP F1:	Vicinity Map
	Figure MPP F2:	Facility and Exploration Plan
	Appendix A:	Project Civil Plans
	Appendix B:	Current Study Exploration Logs and Laboratory Testing Data
	Appendix C:	Background Soil, Geology, and Groundwater Data (Regional Maps, Previous Studies Exploration Logs and Laboratory Testing Data)
	Appendix D:	Soil Probe, Level Survey, and Field Infiltration Testing Data
	Appendix E:	Site Photos

JHS/ld
150387H007-3
Projects\20150387\KH\WP



N

0 1000 2000
FEET

DATA SOURCES / REFERENCES:
USGS: 7.5' SERIES TOPOGRAPHIC MAPS, ESRI/I-CUBED/NATIONAL GEOGRAPHIC SOCIETY 2013
SNOHOMISH CO: STREETS, CITY LIMITS, PARCELS, 1/18
LOCATIONS AND DISTANCES SHOWN ARE APPROXIMATE

NOTE: BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION

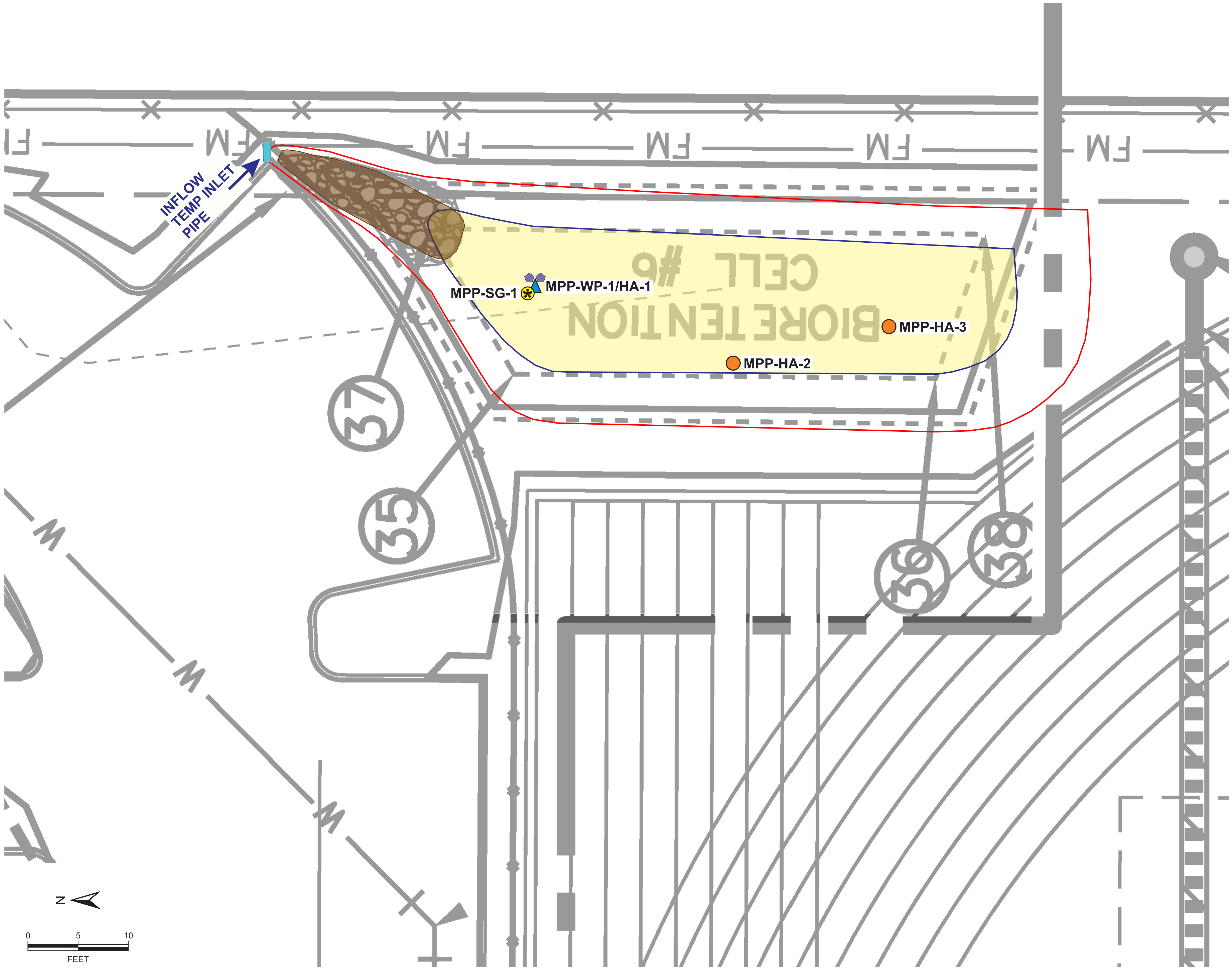
associated earth sciences incorporated

VICINITY MAP

BIORETENTION HYDROLOGIC PERFORMANCE STUDY, MPP SITE
MONROE, WASHINGTON

PROJ NO.	DATE:	FIGURE:
150387H007	3/19	MPP F1

Document Path: G:\GIS_Projects\aY15post0716\150387 Bioretention Hydro Performance Monitoring\mxd\PhaseII\Fig1s\150387H007 F1 VM_MPP.mxd



LEGEND:

- HA — HAND AUGER
- WP — WELL POINT
- TEMPORARY STAFF GAUGE
- BASE OF FACILITY
- TOP OF FACILITY SLOPE
- INFLOW / OVERFLOW DIRECTION
- PVC PONDING TUBE
- CURB CUT
- ENERGY DISSIPATER

CONTOUR INTERVAL = N/A

NOTE: LOCATION AND DISTANCES SHOWN ARE APPROXIMATE.

NOTES:
1. BASE MAP REFERENCE: INTEGRUS ARCHITECTURE, MONROE SCHOOL DISTRICT, PARK PLACE MIDDLE SCHOOL, STORM DRAINAGE PLAN, SHEETS C300 AND C301, 6/6/16

associated earth sciences incorporated

FACILITY AND EXPLORATION PLAN
MPP SITE
BIORETENTION HYDROLOGIC PERFORMANCE
MONROE, WASHINGTON

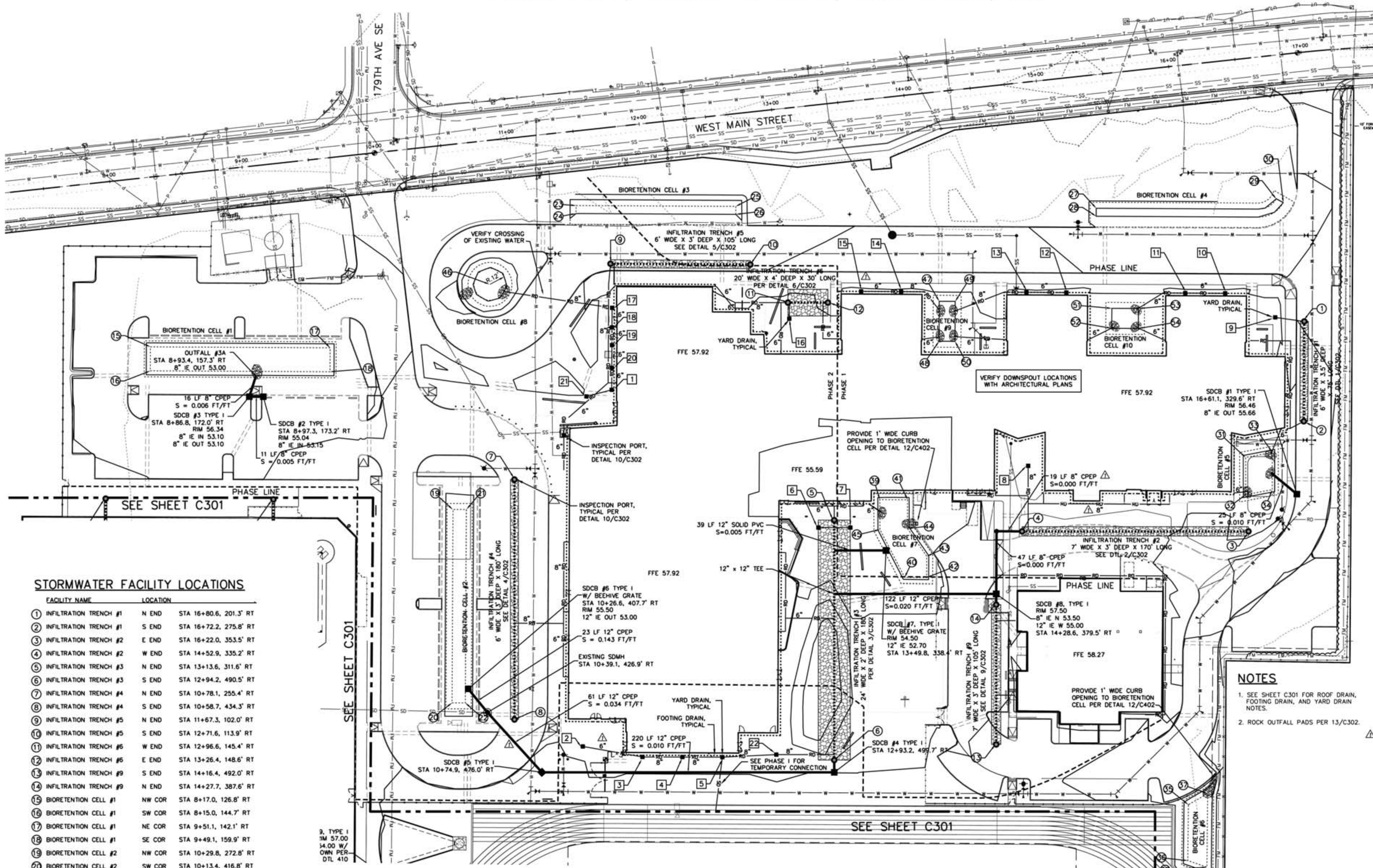
PROJ NO.	DATE:	FIGURE:
150387H007	3/19	MPP F2

150387 BHPS MCCA \ 150387H007 Site-Expl ALL.cdr PAGE x: MPP F2

APPENDIX A

Project Civil Plans

SECTION 1 & 2, TOWNSHIP 27 NORTH, RANGE 6 EAST, W.M.



STORMWATER FACILITY LOCATIONS

	FACILITY NAME	LOCATION	
1	INFILTRATION TRENCH #1	N END	STA 16+80.6, 201.3' RT
2	INFILTRATION TRENCH #1	S END	STA 16+72.2, 275.8' RT
3	INFILTRATION TRENCH #2	E END	STA 16+22.0, 353.5' RT
4	INFILTRATION TRENCH #2	W END	STA 14+52.9, 335.2' RT
5	INFILTRATION TRENCH #3	N END	STA 13+13.6, 311.6' RT
6	INFILTRATION TRENCH #3	S END	STA 12+94.2, 490.5' RT
7	INFILTRATION TRENCH #4	N END	STA 10+78.1, 255.4' RT
8	INFILTRATION TRENCH #4	S END	STA 10+58.7, 434.3' RT
9	INFILTRATION TRENCH #5	N END	STA 11+67.3, 102.0' RT
10	INFILTRATION TRENCH #5	S END	STA 12+71.6, 113.9' RT
11	INFILTRATION TRENCH #6	W END	STA 12+96.6, 145.4' RT
12	INFILTRATION TRENCH #6	E END	STA 13+26.4, 148.6' RT
13	INFILTRATION TRENCH #9	S END	STA 14+16.4, 492.0' RT
14	INFILTRATION TRENCH #9	N END	STA 14+27.7, 387.6' RT
15	BIORETENTION CELL #1	NW COR	STA 8+17.0, 126.8' RT
16	BIORETENTION CELL #1	SW COR	STA 8+15.0, 144.7' RT
17	BIORETENTION CELL #1	NE COR	STA 9+51.1, 142.1' RT
18	BIORETENTION CELL #1	SE COR	STA 9+49.1, 159.9' RT
19	BIORETENTION CELL #2	NW COR	STA 10+29.8, 272.8' RT
20	BIORETENTION CELL #2	SW COR	STA 10+13.4, 416.8' RT
21	BIORETENTION CELL #2	NE COR	STA 10+39.7, 273.8' RT
22	BIORETENTION CELL #2	SE COR	STA 10+23.3, 417.9' RT
23	BIORETENTION CELL #3	NW COR	STA 11+46.3, 55.7' RT
24	BIORETENTION CELL #3	SW COR	STA 11+45.6, 61.7' RT
25	BIORETENTION CELL #3	NE COR	STA 12+65.5, 69.3' RT
26	BIORETENTION CELL #3	SE COR	STA 12+64.9, 75.3' RT
27	BIORETENTION CELL #4	NW COR	STA 15+34.5, 99.9' RT
28	BIORETENTION CELL #4	SW COR	STA 15+33.8, 105.8' RT
29	BIORETENTION CELL #4	NE COR	STA 16+69.6, 107.5' RT
30	BIORETENTION CELL #4	SE COR	STA 16+74.5, 110.8' RT
31	BIORETENTION CELL #5	NW COR	STA 16+25.8, 298.1' RT
32	BIORETENTION CELL #5	SW COR	STA 16+22.8, 325.9' RT
33	BIORETENTION CELL #5	NE COR	STA 16+46.1, 296.4' RT
34	BIORETENTION CELL #5	SE COR	STA 16+43.1, 324.3' RT
35	BIORETENTION CELL #6	NW COR	STA 15+55.0, 552.5' RT
36	BIORETENTION CELL #6	SW COR	STA 15+50.0, 594.2' RT

	FACILITY NAME	LOCATION	
37	BIORETENTION CELL #6	NE COR	STA 15+70.3, 545.8' RT
38	BIORETENTION CELL #6	SE COR	STA 15+63.8, 600.7' RT
39	BIORETENTION CELL #7	NW COR	STA 13+49.3, 300.0' RT
40	BIORETENTION CELL #7	SW COR	STA 13+61.5, 360.0' RT
41	BIORETENTION CELL #7	NE COR	STA 13+70.0, 302.3' RT
42	BIORETENTION CELL #7	SE COR	STA 13+77.9, 362.0' RT
43	BIORETENTION CELL #7	CORNER	STA 13+79.7, 346.1' RT
44	BIORETENTION CELL #7	CORNER	STA 13+67.6, 323.8' RT
45	BIORETENTION CELL #7	CORNER	STA 13+46.9, 322.3' RT
46	BIORETENTION CELL #8	CENTER	STA 10+75.6, 107.6' RT
47	BIORETENTION CELL #9	NW COR	STA 14+09.7, 156.7' RT
48	BIORETENTION CELL #9	SW COR	STA 14+06.3, 186.5' RT

	FACILITY NAME	LOCATION	
49	BIORETENTION CELL #9	NE COR	STA 14+21.6, 158.0' RT
50	BIORETENTION CELL #9	SE COR	STA 14+18.2, 187.8' RT
51	BIORETENTION CELL #10	NW COR	STA 15+38.0, 175.9' RT
52	BIORETENTION CELL #10	SW COR	STA 15+36.3, 190.8' RT
53	BIORETENTION CELL #10	NE COR	STA 15+57.9, 178.1' RT
54	BIORETENTION CELL #10	SE COR	STA 15+56.2, 193.1' RT

STORM DRAINAGE PLAN
SCALE: 1" = 30'

YARD DRAIN LOCATIONS

	FACILITY NAME	LOCATION	RIM	DISCHARGE
1	YARD DRAIN	STA 11+58.0, 196.2' RT	57.40	BIORETENTION CELL #8
2	YARD DRAIN	STA 11+07.5, 460.0' RT	57.20	INFILTRATION TRENCH #3
3	YARD DRAIN	STA 11+51.2, 472.7' RT	57.50	INFILTRATION TRENCH #3
4	YARD DRAIN	STA 11+81.0, 475.9' RT	57.50	INFILTRATION TRENCH #3
5	YARD DRAIN	STA 12+10.9, 479.3' RT	57.50	INFILTRATION TRENCH #3
6	YARD DRAIN	STA 13+01.1, 315.8' RT	55.10	INFILTRATION TRENCH #3
7	YARD DRAIN	STA 13+25.0, 318.5' RT	55.10	INFILTRATION TRENCH #3
8	YARD DRAIN	STA 14+62.8, 286.7' RT	57.50	INFILTRATION TRENCH #2
9	YARD DRAIN	STA 16+59.3, 195.9' RT	57.20	INFILTRATION TRENCH #1
10	YARD DRAIN	STA 16+23.9, 173.8' RT	57.30	BIORETENTION CELL #10
11	YARD DRAIN	STA 15+94.1, 170.4' RT	57.30	BIORETENTION CELL #10

	FACILITY NAME	LOCATION	RIM	DISCHARGE
12	YARD DRAIN	STA 15+05.3, 160.4' RT	57.30	BIORETENTION CELL #9
13	YARD DRAIN	STA 14+75.5, 157.0' RT	57.30	BIORETENTION CELL #9
14	YARD DRAIN	STA 13+82.0, 146.3' RT	57.30	INFILTRATION TRENCH #9
15	YARD DRAIN	STA 13+52.2, 142.9' RT	57.30	INFILTRATION TRENCH #9
16	YARD DRAIN	STA 12+96.5, 156.5' RT	57.20	INFILTRATION TRENCH #6
17	YARD DRAIN	STA 11+64.9, 135.0' RT	57.40	BIORETENTION CELL #8
18	YARD DRAIN	STA 11+63.2, 149.6' RT	57.40	BIORETENTION CELL #8
19	YARD DRAIN	STA 11+61.8, 162.9' RT	57.40	BIORETENTION CELL #8
20	YARD DRAIN	STA 11+59.8, 179.8' RT	57.40	BIORETENTION CELL #8
21	YARD DRAIN	STA 11+38.6, 199.2' RT	57.40	BIORETENTION CELL #8
22	YARD DRAIN	STA 12+51.3, 481.7' RT	57.40	INFILTRATION TRENCH #3

NOTES

1. SEE SHEET C301 FOR ROOF DRAIN, FOOTING DRAIN, AND YARD DRAIN NOTES.
2. ROCK OUTFALL PADS PER 13/C302.

1" = 30'
0 15 30 60

VERTICAL DATUM
NAVD 88
ESTABLISHED BY GPS

BENCHMARK #1:
FOUND MONUMENT 3" BRASSIE WITH "X" ON 4"x4" CONC. MONUMENT INTX OF W. MAIN ST & 179th AVE SE
ELEV: 57.24'

BENCHMARK #2:
FOUND 4x4 CONC. MONUMENT W/BRASS DISK & PUNCH,DOWN 0.7' ON C/L W. MAIN ST.
ELEV: 60.40'

LEGEND

- FOUND MONUMENT IN CASE
- FOUND PLAT MONUMENT
- BASKETBALL HOOP
- GATE POST
- CATCH BASIN
- TURN ARROW
- WATER VALVE
- FINISHED FLOOR ELEVATION
- GAS VALVE
- IRRIGATION CONTROL VALVE
- LUMINAIRE
- POLE & LUMINAIRE
- YARD POLE
- CULVERT END
- TRANSFORMER PAD
- POWER VAULT
- FLAGPOLE
- STORM DRAIN MANHOLE
- SIGN POST
- SEWER MANHOLE
- CEDAR TREE
- DECIDUOUS TREE
- FIR TREE
- FRUIT TREE
- TELEPHONE PEDESTAL
- TELEPHONE GAS CANISTER
- JUNCTION BOX
- MANHOLE (UNKNOWN)
- POWER POLE W/ U.G. FEED
- POWER POLE
- GUY ANCHOR
- FIRE HYDRANT
- BOLLARD
- WATER METER
- WATER VAULT
- GROUND SHOT
- FENCE LINE
- G — GAS LINE
- P — POWER LINE
- UP — UNDERGROUND POWER
- SS — SEWER LINE
- SD — STORM DRAIN LINE
- T — TELEPHONE LINE
- UT — UNDERGROUND TELEPHONE
- W — WATER LINE
- INSPECTION PORT PER DETAIL 10/C302

integrus
ARCHITECTURE

DAVID W. HARMSEN
STATE OF WASHINGTON
33745
REGISTERED PROFESSIONAL ENGINEER
6/6/16

THIS DRAWING HAS BEEN UPDATED TO INCORPORATE CHANGES MADE TO THE BID DOCUMENTS BY ADDENDA. IT IS ISSUED FOR THE CONVENIENCE OF THE CONTRACTOR AND DOES NOT REPLACE THE CONTRACT DOCUMENTS AS ENUMERATED IN THE CONTRACT.

Monroe School District
Park Place Middle School
1408 W Main St, Monroe, WA 98272

Date:	6.6.2016
Job No.:	21004.00
Drawn By:	AWK
Checked by:	DWH

Revisions

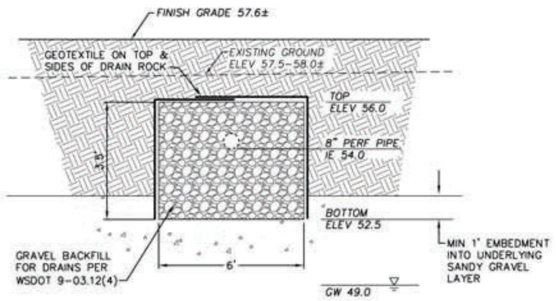
#	Date	Description
1	3-28-16	ADDENDUM #1

STORM DRAINAGE PLAN

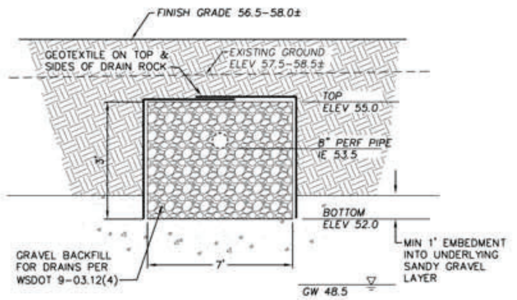
C300

811
Know what's below. Call before you dig.

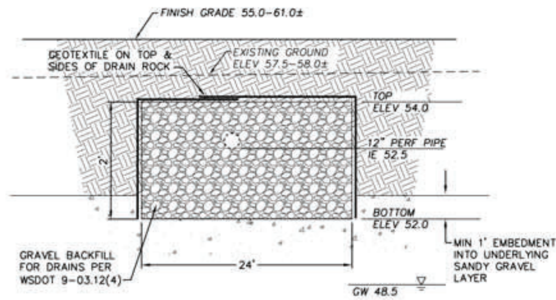
CONFORM SET



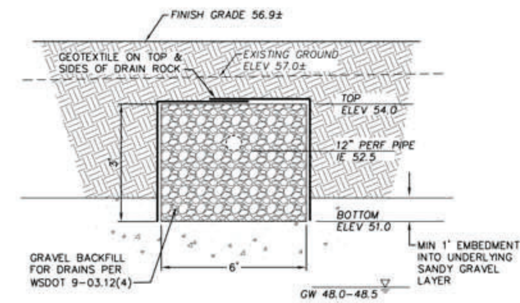
1 INFILTRATION TRENCH #1
SCALE: NONE



2 INFILTRATION TRENCH #2
SCALE: NONE



3 INFILTRATION TRENCH #3
SCALE: NONE

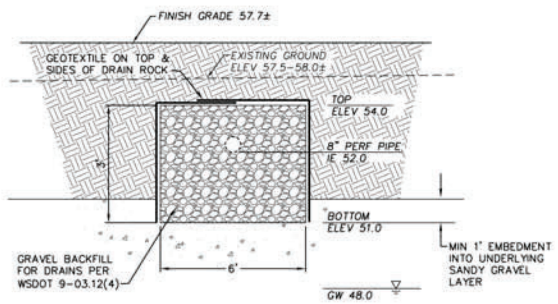


4 INFILTRATION TRENCH #4
SCALE: NONE

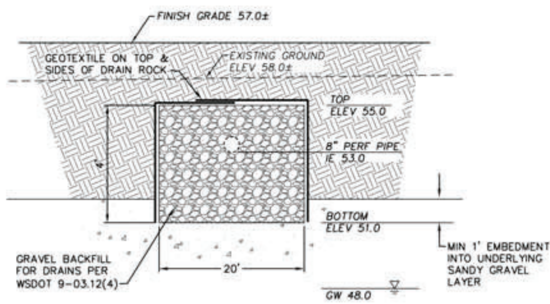
VERTICAL DATUM
NAVD 88
ESTABLISHED BY GPS

INFILTRATION NOTE:

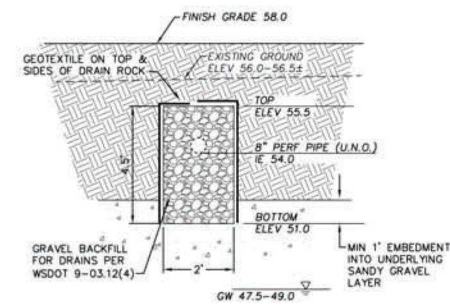
TO ENSURE PROPER FUNCTIONING OF THE BIO-RETENTION AND INFILTRATION TRENCH AREAS IT IS ABSOLUTELY NECESSARY TO AVOID COMPACTION OF THE UNDERLYING SOILS DURING CONSTRUCTION AND SEDIMENT TRANSPORT INTO THE EXCAVATION DURING CONSTRUCTION. NO HEAVY EQUIPMENT SHALL RUN ACROSS THE BASE OF THE POROUS PAVING AREAS TO PREVENT ANY DAMAGE TO THE UNDERLYING SOILS DURING CONSTRUCTION ACTIVITIES. GEOTECHNICAL ENGINEER SHALL INSPECT AND APPROVE THE SUBGRADE SOILS OF INFILTRATION TRENCHES AND THE EMBEDMENT INTO NATIVE SOILS.



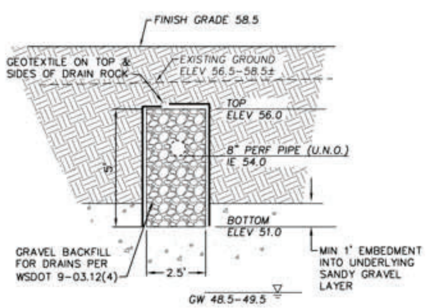
5 INFILTRATION TRENCH #5
SCALE: NONE



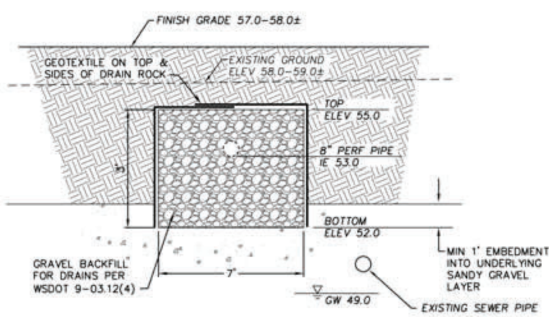
6 INFILTRATION TRENCH #6
SCALE: NONE



7 INFILTRATION TRENCHES 7A&B
SCALE: NONE



8 INFILTRATION TRENCHES 8A&B
SCALE: NONE

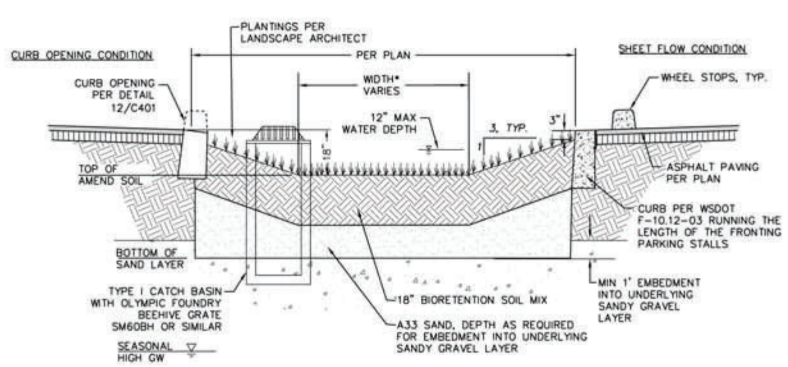


9 INFILTRATION TRENCH #9
SCALE: NONE

BIO-RETENTION CELL CONSTRUCTION NOTES

1. THE BIO-RETENTION CELL SHALL BE OVEREXCAVATED TO ELEVATIONS SHOWN ON GRADING SECTIONS AND FILLED WITH 18" DEPTH OF COMPOST AMENDED SOIL.
2. MINIMUM COMPACTION OF SIDEWALLS AND BASE OF BIO-RETENTION CELL IS ESSENTIAL. KEEP ALL MACHINERY OUTSIDE OF CELL AREA UNDER DIRECTION OF GEOTECHNICAL ENGINEER.
3. SUB-GRADES SHALL BE SCARIFIED, CLEARED OF ALL WEEDS, ROCKS, AND DEBRIS, AND ROUGH GRADED. TOPSOIL SHALL BE ROTOTILLED INTO SUB-GRADE TO A MIN DEPTH OF 8".
4. IF COMPACTION OCCURS IN BOTTOM OF FACILITY DURING EXCAVATION, RIP A MINIMUM OF 12" AND TILL 2 TO 3 INCHES OF AND INTO BASE BEFORE BACKFILLING WITH COMPOST AMENDED SOILS.
5. EXCAVATION FOR THE BIO-RETENTION CELL WILL NOT BE ALLOWED DURING WET WEATHER OR SATURATED SOIL CONDITIONS.
6. SOIL MIXING SHALL OCCUR OUTSIDE/ADJACENT TO THE CELL AREA AND THEN PLACED IN BOTTOM OF CELL.
7. ON-SITE SOIL MIXING SHALL NOT BE PERFORMED IF SOILS ARE SATURATED.
8. FINAL GRADING TO BE ACCOMPLISHED BY HAND.
9. PLANT BOTTOM AND SIDES OF CELL PER LANDSCAPE PLAN.
10. TO PROTECT THE BIORETENTION CELL FROM SEDIMENT LOADING DURING CONSTRUCTION THE INSTALLATION OF THE BIO-RETENTION SOIL AND PLANTINGS SHALL NOT OCCUR UNTIL THE TRIBUTARY AREA DRAINING TO THE CELL HAS BEEN STABILIZED.
DO NOT ROUTE VEHICULAR TRAFFIC THROUGH BIO-RETENTION AREAS AFTER SUBGRADE IS ESTABLISHED.

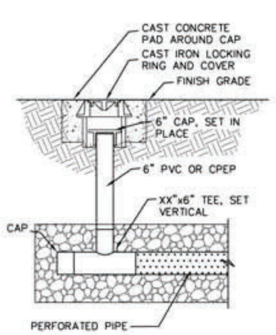
11. GEOTECHNICAL ENGINEER SHALL VERIFY AND APPROVAL ALL EMBEDMENT INTO NATIVE SOILS FOR INFILTRATION AND BIO-RETENTION SYSTEMS.



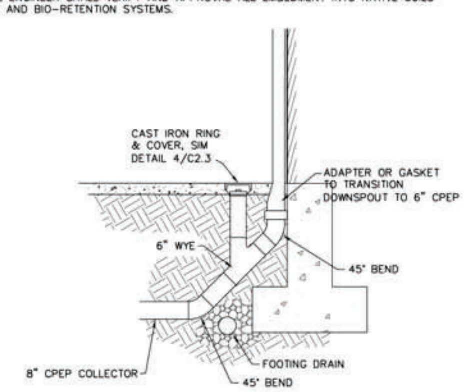
BIORETENTION CELL #	BOTTOM AREA	WIDTH	TOP OF AMEND SOIL	BOTTOM OF SAND LAYER	SEASONAL HIGH GW
1	2,430	18'	53.0	50.0	47.5
2	1,450	10'	55.0	51.0	48.5
3	720	6'	56.0	52.0	48.0
4	840	6'	56.0	53.0	48.5
5*	560	N/A	55.4	54.0	49.0
6	684	N/A	54.9	53.0	49.0
7	1080	N/A	53.5	52.0	48.5
8	450	N/A	53.8	50.0–51.0	47.5
9	360	12'	56.0	53.0	48.5
10	300	15'	56.0	52.0	48.5

* PARKING ALTERNATE C-1:
SEE DETAIL 1/C400 FOR INCREASING SIZE OF BIORETENTION CELL #5

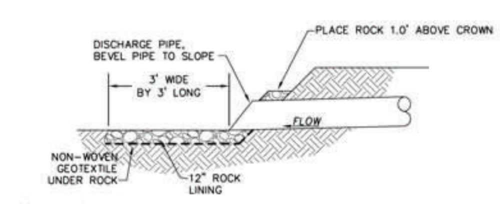
11 TYPICAL BIORETENTION CELL DETAIL
SCALE: NONE



10 INSPECTION PORT DETAIL
SCALE: NONE



12 DOWNSPOUT CONNECTION & CLEANOUT DETAIL
SCALE: NONE



ROCK LINING
QUARRY SPALLS PER WSDOT 9-13.6

13 CULVERT OUTFALL PAD DETAIL
SCALE: NONE

BIO-RETENTION CELL SOIL MIX SPECIFICATIONS

SHOULD HAVE A TESTED LONG TERM DESIGN INFILTRATION RATE OF 2"/HR MINIMUM.

MINERAL AGGREGATE

PERCENT FINES: A RANGE OF 2 TO 4 PERCENT PASSING THE #200 SIEVE IS IDEAL AND FINES SHOULD NOT BE ABOVE 5 PERCENT FOR A PROPER FUNCTIONING SPECIFICATION ACCORDING TO ASTM D422.

AGGREGATE GRADATION

THE AGGREGATE PORTION OF THE BSM SHOULD BE WELL-GRADED. ACCORDING TO ASTM D 2487-98 (CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES (UNIFIED SOIL CLASSIFICATION SYSTEM)), WELL-GRADED SAND SHOULD HAVE THE FOLLOWING GRADATION COEFFICIENTS:

- COEFFICIENT OF UNIFORMITY (CU = D60/D10) EQUAL TO OR GREATER THAN 4, AND
- COEFFICIENT OF CURVE (CC = (D30)2/D60 X D10) GREATER THAN OR EQUAL TO 1 AND LESS THAN OR EQUAL TO 3.

TABLE 7.4.1 PROVIDES A GRADATION GUIDELINE FOR THE AGGREGATE COMPONENT OF A BIORETENTION SOIL MIX SPECIFICATION IN WESTERN WASHINGTON (HINMAN, ROBERTSON, 2007). THE SAND GRADATION BELOW IS OFTEN SUPPLIED AS A WELL- GRADED UTILITY OR SCREENED. WITH COMPOST THIS BLEND PROVIDES ENOUGH FINES FOR ADEQUATE WATER RETENTION, HYDRAULIC CONDUCTIVITY WITHIN RECOMMENDED RANGE (SEE BELOW), POLLUTANT REMOVAL CAPABILITY, AND PLANT GROWTH CHARACTERISTICS FOR MEETING DESIGN GUIDELINES AND OBJECTIVES.

TABLE 7.4.1

GENERAL GUIDELINE FOR MINERAL AGGREGATE GRADATION	
SIEVE SIZE	PERCENT PASSING
3/8"	100
#4	95–100
#10	75–90
#40	25–40
#100	4–10
#200	2–5

WHERE EXISTING SOILS MEET THE ABOVE AGGREGATE GRADATION, THOSE SOILS MAY BE AMENDED RATHER THAN IMPORTING MINERAL AGGREGATE.
COMPOST TO AGGREGATE RATIO, ORGANIC MATTER CONTENT, CATION EXCHANGE CAPACITY

- COMPOST TO AGGREGATE RATIO: 60–65 PERCENT MINERAL AGGREGATE, 35 – 40 PERCENT COMPOST.
- ORGANIC MATTER CONTENT: 5 – 8 PERCENT BY WEIGHT.
- CATION EXCHANGE CAPACITY (CEC) MUST BE ≥ 5 MILLIEQUIVALENTS/100 G DRY SOIL NOTE: SOIL MIXES MEETING THE ABOVE SPECIFICATIONS DO NOT HAVE TO BE TESTED FOR CEC. THEY WILL READILY MEET THE MINIMUM CEC.

COMPOST

TO ENSURE THAT THE BSM WILL SUPPORT HEALTHY PLANT GROWTH AND ROOT DEVELOPMENT, CONTRIBUTE TO BIOFILTRATION OF POLLUTANTS, AND NOT RESTRICT INFILTRATION WHEN USED IN THE PROPORTIONS CITED HEREIN, THE FOLLOWING COMPOST STANDARDS ARE REQUIRED.

- MEETS THE DEFINITION OF "COMPOSTED MATERIALS" IN WAC 173-350-220 (INCLUDING CONTAMINANT LEVELS AND OTHER STANDARDS), AVAILABLE ONLINE AT HTTP://WWW.ECY.WA.GOV/PROGRAMS/SWFA/ORGANICS/SOIL.HTML
- PRODUCED AT A COMPOSTING FACILITY PERMITTED BY THE WA DEPARTMENT OF ECOLOGY. A CURRENT LIST OF PERMITTED FACILITIES IS AVAILABLE AT HTTP://WWW.ECY.WA.GOV/PROGRAMS/SWFA/COMPOST/
- THE COMPOST PRODUCT MUST ORIGINATE A MINIMUM OF 65 PERCENT BY VOLUME FROM RECYCLED PLANT WASTE AS DEFINED IN WAC 173-350-100 AS "TYPE I FEEDSTOCKS." A MAXIMUM OF 35 PERCENT BY VOLUME OF OTHER APPROVED ORGANIC WASTE AS DEFINED IN WAC 173-350-100 AS "TYPE III", INCLUDING POSTCONSUMER FOOD WASTE, BUT NOT INCLUDING BIOSOLIDS,
- MAY BE SUBSTITUTED FOR RECYCLED PLANT WASTE. TYPE II AND IV FEEDSTOCKS SHALL NOT BE USED FOR THE COMPOST GOING INTO BIORETENTION FACILITIES OR RAIN GARDENS.
- STABLE (LOW OXYGEN USE AND CO2 GENERATION) AND MATURE (CAPABLE OF SUPPORTING PLANT GROWTH) BY TESTS SHOWN BELOW. THIS IS CRITICAL TO PLANT SUCCESS IN A BIORETENTION SOIL MIXES.
- MOISTURE CONTENT RANGE: NO VISIBLE FREE WATER OR DUST PRODUCED WHEN HANDLING THE MATERIAL.
- TESTED IN ACCORDANCE WITH THE U.S. COMPOSTING COUNCIL "TESTING METHODS FOR THE EXAMINATION OF COMPOST AND COMPOSTING" (TMECC), AS ESTABLISHED IN THE COMPOSTING COUNCIL'S "SEAL OF TESTING ASSURANCE" (STA) PROGRAM. MOST WASHINGTON COMPOST FACILITIES NOW USE THESE TESTS.
- SCREENED TO THE SIZE GRADATIONS FOR FINE COMPOST UNDER TMECC TEST METHOD 02.02-B (GRADATIONS ARE SHOWN IN THE SPECIFICATION IN AN APPENDIX OF THE LOW IMPACT DEVELOPMENT TECHNICAL GUIDANCE MANUAL FOR PUGET SOUND)
- PH BETWEEN 6.0 AND 8.5 (TMECC 04.11-A). IF THE PH FALLS OUTSIDE OF THE ACCEPTABLE RANGE, IT MAY BE MODIFIED WITH LIME TO INCREASE THE PH OR IRON SULFATE PLUS SULFUR TO LOWER THE PH. THE LIME OR IRON SULFATE MUST BE MIXED UNIFORMLY INTO THE SOIL PRIOR TO USE IN THE BIORETENTION AREA.
- MANUFACTURED INERT CONTENT LESS THAT 1% BY WEIGHT (TMECC 03.08-A)
- MINIMUM ORGANIC MATTER CONTENT OF 40% (TMECC 05.07-A)
- SOLUBLE SALT CONTENT LESS THAN 4.0 MMHOS/CM (TMECC 04.10-A)
- MATURITY GREATER THAN 80% (TMECC 05.05-A "GERMINATION AND VIGOR")
- STABILITY OF 7 OR BELOW (TMECC 05.08-B "CARBON DIOXIDE EVOLUTION RATE")
- CARBON TO NITROGEN RATIO (TMECC 04.01 "TOTAL CARBON" AND 04.02D "TOTAL KJELDAHL NITROGEN") OF LESS THAN 25:1. THE C:N RATIO MAY BE UP TO 35:1 FOR PLANTINGS COMPOSED ENTIRELY OF PUGET SOUND LOWLAND NATIVE SPECIES AND UP TO 40:1 FOR COARSE COMPOST TO BE USED AS A SURFACE MULCH (NOT IN A SOIL MIX).

811 Know what's below. Call before you dig.

CONFORM SET

integrus ARCHITECTURE

DAVID W. HARMSEN STATE OF WASHINGTON 33745 REGISTERED PROFESSIONAL ENGINEER 6/6/16

THIS DRAWING HAS BEEN UPDATED TO INCORPORATE CHANGES MADE TO THE BID DOCUMENTS BY ADDENDA. IT IS ISSUED FOR THE CONVENIENCE OF THE CONTRACTOR AND DOES NOT REPLACE THE CONTRACT DOCUMENTS AS ENUMERATED IN THE CONTRACT.

Monroe School District
Park Place Middle School
1408 W Main St, Monroe, WA 98272

Date:	6.6.2016
Job No.:	21004.00
Drawn By:	AWK
Checked by:	DWH

Revisions

#	Date	Description
1	3-28-16	ADDENDUM #1

STORM DRAINAGE DETAILS

C302

associated earth sciences incorporated

FIELD REPORT

911 Fifth Avenue
Kirkland, Washington 98033
Phone: 425-827-7701
Fax: 425- 827-5424
www.aesgeo.com

Date	Project Name		Project No.
6/12/2017	Park Place Middle School		150324E011
Location		**Municipality**	**Weather**
1408 West Main Street		Monroe	Overcast
Permit No.	**DPD No.**		**Report No.**
			88
Engineer/Architect			
Integrus Architecture			
Client/Owner			
Monroe Public Schools			
General Contractor/Superintendent			
Cornerstone/Eric Scott			
Grading Contractor/Superintendent			
Continental Dirt/Tim			

TO: Monroe Public Schools/Cornerstone
200 East Fremont Street
Monroe, WA 98272

ATTN: John Mannix

AS REQUESTED BY: Client

THE FOLLOWING WAS NOTED:

Associated Earth Sciences, Inc. (AESI) was on site from 10:25 to 14:45 to monitor the construction/widening of Bioretention Cell #6. The cell location and details are shown on sheets C300 (Storm Drainage Plan) and C302 (Storm Drainage Details) of the site plan set, prepared by Integrus Architecture, dated June 6, 2016 (Figures 1 and 2). Bioretention Cell #6 had previously been partially excavated, but the original excavation did not cover the full footprint area as designed. The original excavation was approximately 5' deep in the center and had a flat base about 8' wide in the east-west direction. The purpose of the day's work was to widen the cell to the design length and width, shape the sidewalls, and clear the bottom of the excavation in preparation for installation of C33 sand and bioretention soil as shown on the plan detail. Continental Dirt (Tim) provided survey control for the location and base elevation of the cell. The surveyed ground surface elevation was 56.7' (feet) at the northwest corner of the cell, 57.8' at the southwest corner, and 59.0' at the southeast corner.

Bioretention Cell Construction Summary

Bioretention Cell #6 was widened and shaped using a larger track-mounted excavator (Komatsu PC200 C-135) and a smaller track-mounted excavator (CAT 304E2 CR). The excavated material was stockpiled at the north end of the cell. The cell had a flat base at an elevation of 52.5', with sidewalls sloping up to the ground surface. An area covering the northern ~5' of the cell base was lowered by an additional 0.5' to remove a lens of silty sand (see geologic summary and Photo 2 below), resulting in a base elevation of 52.0' at the north end of the cell. The elevation of the cell base was checked throughout the excavation using a laser survey level and measuring rod. The flat base of the cell was approximately 8.5' wide and 45' long. The overall cell footprint was approximately 24' wide (east-west), 42' long on the west side, and 60' long on the east side. The cell was designed to have 3:1 slopes, but the actual slopes were steeper due to the cell depth, existing base width, and available lateral area. Slopes ranged from approximately 23° to 30 ° on the west side, 16° to 30° on the south side, 21° to 35° on the east side, and 27° to 42° on the north side. The dimensions of the cell were consistent with the plan details shown on sheet C302 (Figure 2).

Geologic Summary

The material exposed by the cell generally consisted of overbank deposits (as described below) overlying native sand and gravel. The flat central part of the cell was dug approximately 1' into the native sand and gravel, as specified on the plan detail (Figure 2). Geologic samples were collected from the base of the cell at the locations indicated on Figure 1 and transported to AESI for further visual classification and testing, as necessary. The contact between the overbank deposits and alluvial deposits was not sharply defined in the sidewalls.

Overbank deposits: Medium dense moist brown SILT (ML), trace gravel, trace root fragments, roots in place observed while excavating the slope on the southeast corner of the cell

Copies To:

Date Mailed: JUL 07 2017

Field Rep: Katherine Beeler, L.G.

Principal / PM: Kurt Merriman, P.E.

This document is considered a DRAFT until signed or initialed by an AESI Principal or Project Manager

To:	Monroe PS/Cornerstone	Project Name:	Park Place Middle School
Date:	6/12/2017	Project No.:	150324E011
Permit No.		DPD No.	

Sample 1: Medium dense moist grayish brown fine to medium sandy GRAVEL (GW), trace coarse sand, trace silt, trace cobble (Alluvial deposits)

Sample 2: Medium dense moist grayish brown fine to medium very sandy GRAVEL (GW), trace coarse sand, trace silt, trace cobble (Alluvial deposits)

Sample 3: Medium dense moist grayish brown fine to medium sandy GRAVEL (GW), trace coarse sand, some silt, trace cobble, iron oxide staining (Alluvial deposits). Small area of medium dense moist gray fine to medium SAND (SW) at the edge of the flat base west of the Sample 3 location.

An area of silty sand was encountered at the north end of the cell base. The cell was excavated an additional ~0.5' to remove the material, described here:
Medium dense moist grayish brown silty fine to medium SAND (SM) to sandy SILT (ML), mottled with iron oxide staining in some areas

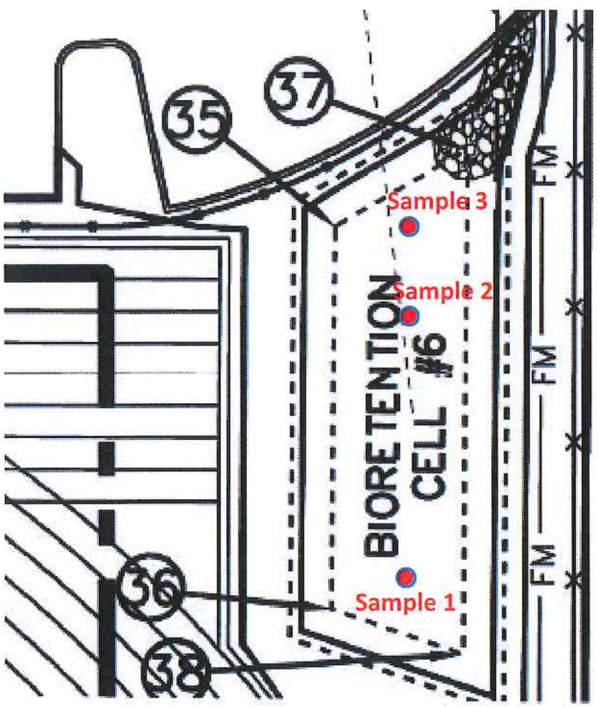
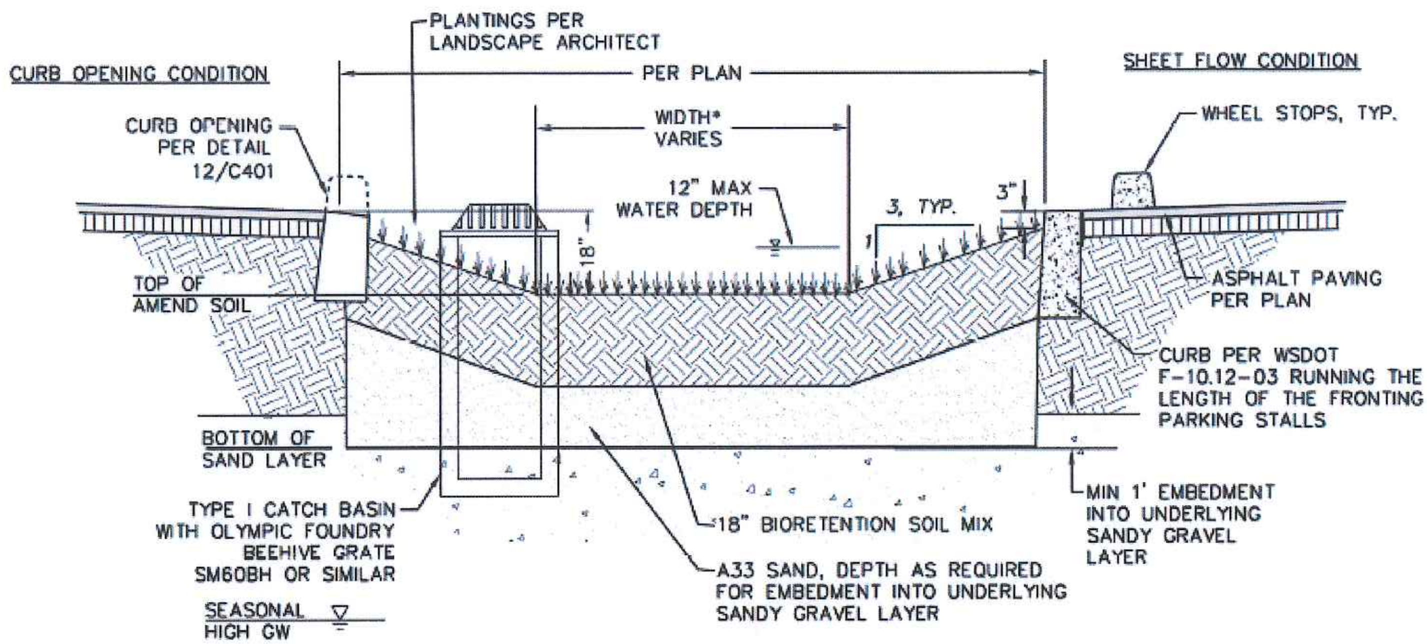


Figure 1: Site plan and sample locations for Bioretention Cell #6, modified from sheet C300, Integrus Architecture (2016).

AESI FIELD REPORT

To:	Monroe PS/Cornerstone	Project Name:	Park Place Middle School
Date:	6/12/2017	Project No.:	150324E011
Permit No.		DPD No.	



BIORETENTION CELL #	BOTTOM AREA	WIDTH	TOP OF AMEND SOIL	BOTTOM OF SAND LAYER	SEASONAL HIGH GW
1	2,430	18'	53.0	50.0	47.5
2	1,450	10'	55.0	51.0	48.5
3	720	6'	56.0	52.0	48.0
4	840	6'	56.0	53.0	48.5
5*	560	N/A	55.4	54.0	49.0
6	684	N/A	54.9	53.0	49.0
7	1080	N/A	53.5	52.0	48.5
8	450	N/A	53.8	50.0–51.0	47.5
9	360	12'	56.0	53.0	48.5
10	300	15'	56.0	52.0	48.5

* PARKING ALTERNATE C-1:
SEE DETAIL 1/C400 FOR INCREASING
SIZE OF BIORETENTION CELL #5

11 *TYPICAL BIORETENTION CELL DETAIL*

SCALE: NONE

Figure 2: Plan detail for bioretention cells, from sheet C302, Integrus Architecture (2016).

Copies To:		Field Rep:	Katherine Beeler, L.G.
Date Mailed:		Principal / PM:	Kurt Merriman, P.E.

This document is considered a DRAFT until signed or initialed by an AESI Principal or Project Manager

AESI FIELD REPORT

To:	Monroe PS/Cornerstone	Project Name:	Park Place Middle School
Date:	6/12/2017	Project No.:	150324E011
Permit No.		DPD No.	

Photo 1 (left)**:** Excavation of Bioretention Cell #6 in progress.

Photo 2 (right)**:** Area excavated an additional ~0.5' at the north end of the cell.

Photo 3 (left)**:** Bioretention Cell #6 viewed from the north.

Photo 4 (right)**:** Bioretention Cell #6 viewed from the south.

Copies To:		Field Rep:	Katherine Beeler, L.G.
Date Mailed:		Principal / PM:	Kurt Merriman, P.E.

This document is considered a DRAFT until signed or initialed by an AESI Principal or Project Manager

associated earth sciences incorporated

FIELD REPORT

911 Fifth Avenue
Kirkland, Washington 98033
Phone: 425-827-7701
Fax: 425- 827-5424
www.aesgeo.com

Date	Project Name		Project No.
6/13/17	Park Place Middle School		150324E011
Location		Municipality	Weather
1408 West Main Street		Monroe	Rain, 50s
Permit No.	DPD No.		Report No.
			89
Engineer/Architect			
Harmsen and Associates/ Integrus Architecture			
Client/Owner			
Monroe School District			
General Contractor/Superintendent			
Cornerstone/Eric Scott			
Grading Contractor/Superintendent			
Continental Dirt/Tim			

TO: **Monroe Public Schools / Cornerstone**
200 East Fremont Street
Monroe, WA 98272

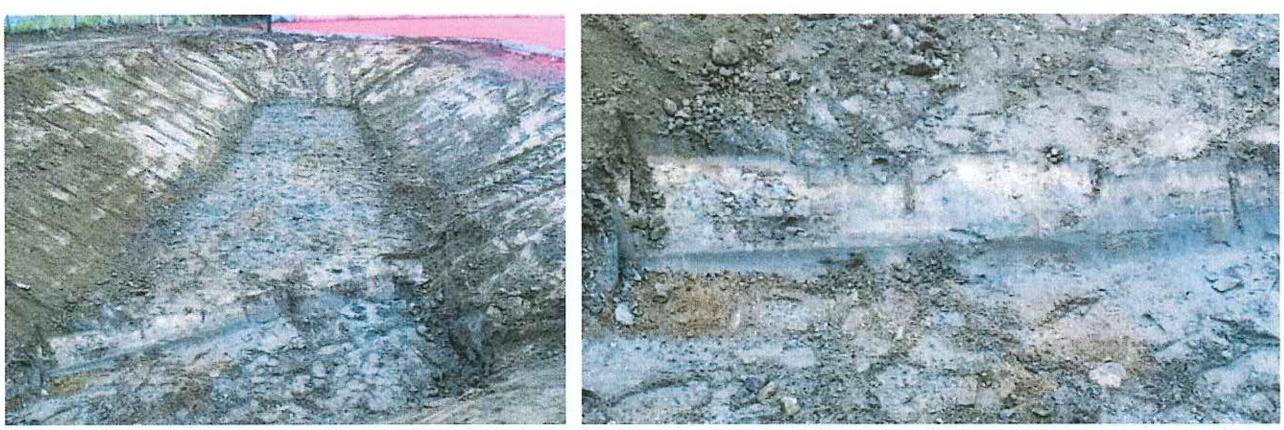
ATTN: **John Mannix**

AS REQUESTED BY: **Client**

THE FOLLOWING WAS NOTED:
AESI was on site at the Park Place Middle School site part time to observed the excavated condition of bioretention cell #6 (BR6), following excavation activities on 6/12/2017 (FR# 88).

We arrived on the site at 06:40 and observed that although it rained overnight, there was no inflow into the pond and the surficial sediments appeared damp but not saturated. We observed that in general sand and gravel were exposed on the bottom of BR6, however, an area near the north end of BR6 was visibly silty – described as a tan/light brown to gray fine sandy silt/silty fine sand.

We discussed this with Tim (Continental Dirt), who said he could work on it immediately. We observed the removal of approximately 6 inches of silty material, which graded into gray, fine to medium sand for a few inches, which was underlain by sandy gravel/gravelly sand, trace to some silt. In total, an area about 6 feet wide (east to west) by 5 feet long (north to south) by 5 to 6 inches deep was removed and placed in the existing stockpile immediately north of BR6. The photos below show the conditions before and after the excavation.



Left: Looking south at bioretention cell #6 subgrade. Right: Close-up of ridge of in-place silty material.

Copies To:
Date Mailed: JUL 07 2017

Field Rep: Stan Thompson, L.G., L.Hg.
Principal / PM: Kurt D. Merriman P.E.

(This document is considered a draft until signed and approved by an AESI Principal or Project Manager)


Left: BR6 viewing west; removal of silty sediments under way. Right: finished product after silty sediment removal.

Additional observations:

We observed the following constructed bioretention cells: BR9, BR10, BR5.

<u>Bioretention Cell #9</u>
BR9 has been receiving roof water since it was installed earlier this year. Although the contractor placed a row of sand bags around BR9 to prevent surface water flow into the facility, there are several breaches of the sand bag line, which have caused blow-outs of the bioretention mix, and silty sand plumes on the surface of the bioretention mix out into the facility. See photos.

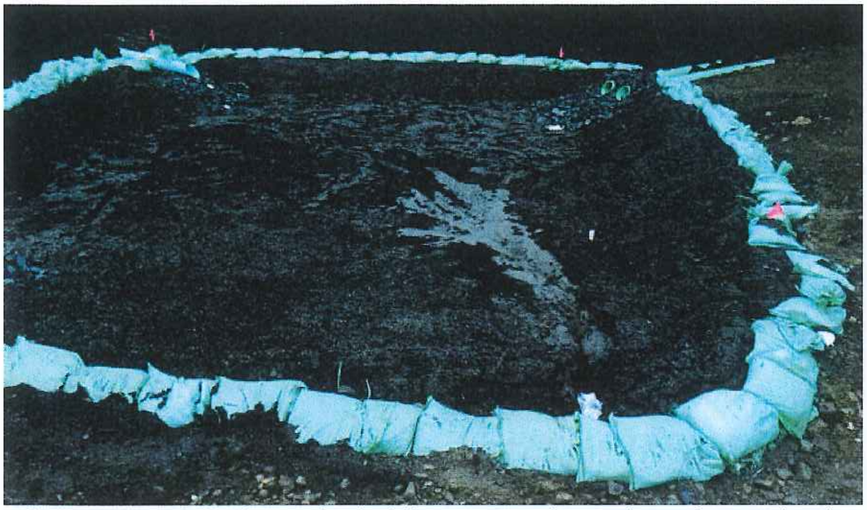

Left: BR9 showing native material on the bioretention mix surface. Right: Close up of a blow out and the resultant plume/delta on the bioretention mix.

Copies To:		Field Rep:	Stan Thompson, L.G., L.Hg.
Date Mailed:		Principal/PM:	Kurt Merriman P.E.

(This document is considered a draft until signed and approved by an AESI Principal or Project Manager)

Bioretention Cell #10

The surface of BR#10 is in approximately the same condition as that of BR9. There are a few breaches of the sand bag line where surface soils have flowed out with surface water onto the surface of the bioretention mix. See photos.



Left: BR10 showing surface soils which have migrated onto the surface. Right: Close-up of breach in the northwest corner of BR10.

Bioretention Cell #5

BR5 has seen fewer storm events than BR9 or BR10. The surface appears in good shape, with only minor detritus (plastic water bottles, etc.) on the surface. See photo.

BR5, viewing north.

Copies To:		Field Rep:	Stan Thompson, L.G., L.Hg.
Date Mailed:		Principal/PM:	Kurt Merriman P.E.

(This document is considered a draft until signed and approved by an AESI Principal or Project Manager)

associated earth sciences incorporated

FIELD REPORT

911 Fifth Avenue
Kirkland, Washington 98033
Phone: 425-827-7701
Fax: 425- 827-5424
www.aesgeo.com

Date	Project Name		Project No.
6/16/17	Park Place Middle School		150324E011
Location		Municipality	Weather
1408 West Main Street		Monroe	Overcast, 50s
Permit No.	DPD No.		Report No.
			93
Engineer/Architect			
Harmsen and Associates/ Integrus Architecture			
Client/Owner			
Monroe School District			
General Contractor/Superintendent			
Cornerstone/Eric Scott			
Grading Contractor/Superintendent			
Continental Dirt/Tim			

TO: **Monroe Public Schools / Cornerstone**
200 East Fremont Street
Monroe, WA 98272

ATTN: **John Mannix**

AS REQUESTED BY: **Client**

THE FOLLOWING WAS NOTED:
AESI was on site at the Park Place Middle School site part time to observed the completed condition of bioretention cell #6 (BR6), following the installation of the C33 sand and bioretention soil, and to observe the other completed bioretention cells (BR5, BR9 and BR10).

Bioretention Cell #6
The top of the berm around BR6 is approximately 4 to 6 inches above surrounding grade. Additionally, it appears that there is no water directed toward BR6 at this time. The irrigation has been installed within BR6. Photos show the current condition.

Copies To:
Date Mailed: JUL 07 2017

Field Rep: Stan Thompson, L.G., L.Hg.
Principal / PM: Kurt D. Merriman P.E.

(This document is considered a draft until signed and approved by an AESI Principal or Project Manager)

associated earth sciences incorporated

FIELD REPORT

911 Fifth Avenue
Kirkland, Washington 98033
Phone: 425-827-7701
Fax: 425- 827-5424
www.aesgeo.com

Date	Project Name			Project No. /Task
6/29/2017	Park Place Middle School			150324011
Location			Municipality	Weather
1408 West Main Street			Monroe	Sun 70's
Permit No.		SDCI Permit No.		Report No. 95
Engineer/Architect: Harmsen and Associates/ Integrus Architecture				
Client/Owner: Monroe Public Schools				
General Contractor/Superintendent: Cornerstone/ Eric Scott				
Grading Contractor/Superintendent: Continental/ Tim				

TO: Monroe Public School
200 East Freemont Street
Monroe, WA 98272

ATTN: John Mannix

AS REQUESTED BY: Client

THE FOLLOWING WAS NOTED:

Storm:

AESI was on site today to examine and photograph the finished bio retention cells and connecting storm systems. Bio retention cells 5, 6, 9, and 10 were examined and photographed. The connecting storm systems to infiltration trenches 1 and 2 were also examined no area drains are connected to 1 and 2. All area drains have been plugged and the catch basin east of cell 5 has also been plugged. The baseball softball field infiltration trench at the north and south ends were also photographed. The photo of the northwest baseball softball field infiltration trench shows exposed drain rock. The earthwork contractor notes: Filter fabric will be placed over the drain rock and anchored to protect the exposed drain rock this afternoon.

Portion of cell # 7 used for temporary storm retention

Plugged area drain to infiltration trench #1

Copies To:

Date Mailed: JUL 07 2017

Field Rep: Jon Stevenson

Principal / PM: Kurt D Merriman P.E.

v. 5.17

This document is considered a DRAFT until signed or initialed by an AESI Principal or Project Manager

AESI FIELD REPORT

To:		Project Name:	Park Place MS
Date:	6/29/2017	Project No.:	150324E011
Permit No.		SDCI Permit	

Plugged area drain to cell # 9

Riling at cell # 9

Erosion at cell # 9

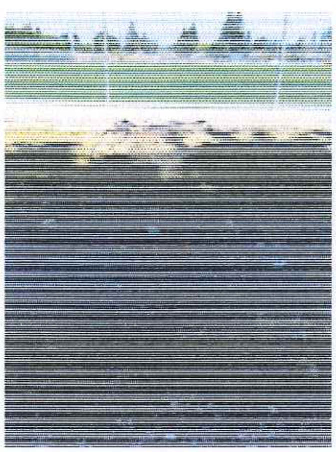
Overall cell # 9

Copies To:		Field Rep:	Jon Stevenson
Date Mailed:		Principal / PM:	Kurt D Merriman P.E.

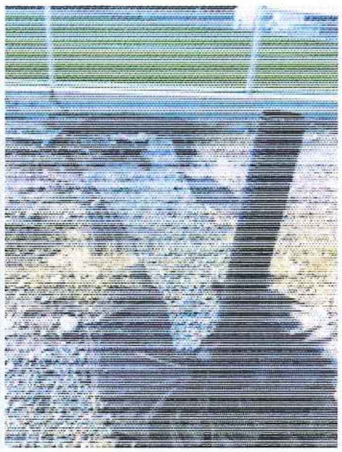
This document is considered a DRAFT until signed or initialed by an AESI Principal or Project Manager

AESI FIELD REPORT

To:		Project Name:	Park Place MS
Date:	6/29/2017	Project No.:	150324E011
Permit No.		SDCI Permit	



SW ballfield infiltration trench



NW ballfield infiltration trench to be covered today

Overall cell # 5

Plugged catch basin to cell # 5

Area drain plugged to cell # 10

Overall cell # 10

Copies To:		Field Rep:	Jon Stevenson
Date Mailed:		Principal / PM:	Kurt D Merriman P.E.

This document is considered a DRAFT until signed or initialed by an AESI Principal or Project Manager

AESI FIELD REPORT

To:		Project Name:	Park Place MS
Date:	6/29/2017	Project No.:	150324E011
Permit No.		SDCI Permit	

Entry point cell 6 not complete

Irrigation trench to be backfilled cell # 6

Copies To:		Field Rep:	Jon Stevenson
Date Mailed:		Principal / PM:	Kurt D Merriman P.E.

This document is considered a DRAFT until signed or initialed by an AESI Principal or Project Manager

APPENDIX B

Current Study Exploration Logs and Laboratory Testing Data

Geologic & Monitoring Well Construction Log

associated earth sciences incorporated

Project Number	Well Number	Sheet
150387H007	MPP-HA-1/WP	1 of 1

Project Name	Bioretention Hydrologic Performance Study	Location	Monroe, WA
Elevation (Top of Well Casing)	98.8 (Project Datum)	Surface Elevation (ft)	96.2 (Project Datum)
Water Level Elevation	Dry	Date Start/Finish	10/10/18,10/10/18
Drilling/Equipment	Hand Auger	Hole Diameter (in)	4 inches
Hammer Weight/Drop	N/A		

Depth (ft)	Water Level	WELL CONSTRUCTION	S T	Blows/ 6"	Graphic Symbol	DESCRIPTION
		Shredded wood 0 to 0.1 feet				**Shredded Wood**
		Threaded steel pipe 1.25-inch I.D. -2.6 to 0.7 feet				**Bioretention Soil Mix** Loose, moist, dark brown, medium SAND, trace gravel, trace silt; organic rich; massive (SP).
		Tape over well point screen 0.7 to 1.4 feet				
		Bioretention soil mix 0.1 to 1.6 feet				
		Stainless steel jacket over stainless steel #60 gauze, welded to perforated steel pipe 1.4 to 2.3 feet Sand fill 1.6 to 2.5 feet				**Sand Fill** Loose, moist, brown, fine to medium SAND, trace silt; massive (SP).
		Coarse grained alluvium 2.5 to 2.6 feet Threaded steel pipe 1.25-inch I.D. and drive point 2.3 to 3 feet				**At 2.5 feet: Coarse Alluvium -** Medium dense, brown, sandy GRAVEL, trace silt (GP). No stratification observed in exploration.
						Boring terminated at 2.6 feet Well completed at 2.6 feet on 10/10/18. Steel drive point placed in borehole and hand driven with slide hammer to depth of 2.6 feet.
		Note: ~4 inches of "dead space" below bottom of perforated openings and total inside depth. Total inside depth = 5.1 feet.				
5						

Sampler Type (ST):

2" OD Split Spoon Sampler (SPT)	No Recovery	M - Moisture	**Logged by:** ADY
3" OD Split Spoon Sampler (D & M)	Ring Sample	Water Level ()	**Approved by:** JHS
Grab Sample	Shelby Tube Sample	Water Level at time of drilling (ATD)	

associated earth sciences incorporated

Exploration Log

Project Number	Exploration Number	Sheet
150387H007	MPP-HA-2	1 of 1

Project Name: Bioretention Hydrologic Performance Study
Location: Monroe, WA
Driller/Equipment: Hand Auger
Hammer Weight/Drop: N/A
Ground Surface Elevation (ft):
Datum: N/A
Date Start/Finish: 10/10/18,10/10/18
Hole Diameter (in): 4 inches

Depth (ft)	S T	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Water Level	Blows/6"	Blows/Foot 10 20 30 40	Other Tests
				Shredded Wood					
		S-1		**Bioretention Soil Mix** Loose, moist, dark brown, medium SAND, trace gravel, trace silt; organic rich; massive (SP).					
				Sand Fill Loose, moist, brown, fine to medium SAND, trace silt; massive (SP).					
				At 1.8 feet: Coarse Alluvium - Medium dense, brown, sandy GRAVEL, trace silt (GP). No stratification observed in exploration.					
				Bottom of exploration boring at 1.9 feet.					
5									

Sampler Type (ST):
- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample
- M - Moisture
- Water Level ()
- Water Level at time of drilling (ATD)

Logged by: ADY
Approved by: JHS

associated earth sciences incorporated

Exploration Log

Project Number	Exploration Number	Sheet
150387H007	MPP-HA-3	1 of 1

Project Name	Bioretention Hydrologic Performance Study	Ground Surface Elevation (ft)	
Location	Monroe, WA	Datum	N/A
Driller/Equipment	Hand Auger	Date Start/Finish	10/10/18,10/10/18
Hammer Weight/Drop	N/A	Hole Diameter (in)	4 inches

Depth (ft)	S T	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Water Level	Blows/6"	Blows/Foot 10 20 30 40	Other Tests
				Shredded Wood					
				Bioretention Soil Mix Loose, moist, dark brown, medium SAND, trace gravel, trace silt; organic rich; massive (SP).					
		S-1							
				Sand Fill Loose, moist, brown, fine to medium SAND, trace silt; massive (SP).					
				Bottom of exploration boring at 2 feet.					
5									

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample
- M - Moisture
- Water Level ()
- Water Level at time of drilling (ATD)

Logged by: ADY
Approved by: JHS

a s s o c i a t e d
e a r t h s c i e n c e s
i n c o r p o r a t e d

Moisture, Ash, and Organic Matter of Peat and Other Organic Soils - ASTM 2974

Date Sampled	Project	Project No.		Soil Description
10/10/2018	Bioretention Hydrologic Performance Monitoring Study	150387 E007		Bioretention soil mix
Tested By	**Location**	**EB/EP No.**	**Depth**	
BN	Onsite- MPP			

Moisture Content

Sample ID	**HA-1/WP (0.1'-0.5')**	**HA-2 (0.1'-0.5')**
Wet Weight + Pan	**872.09**	**1019.77**
Dry Weight + Pan	**756.80**	**898.62**
Weight of Pan	**452.01**	**537.33**
Weight of Moisture	**115.29**	**121.15**
Dry Weight of Soil	**304.79**	**361.29**
% Moisture	**27.4**	**25.1**

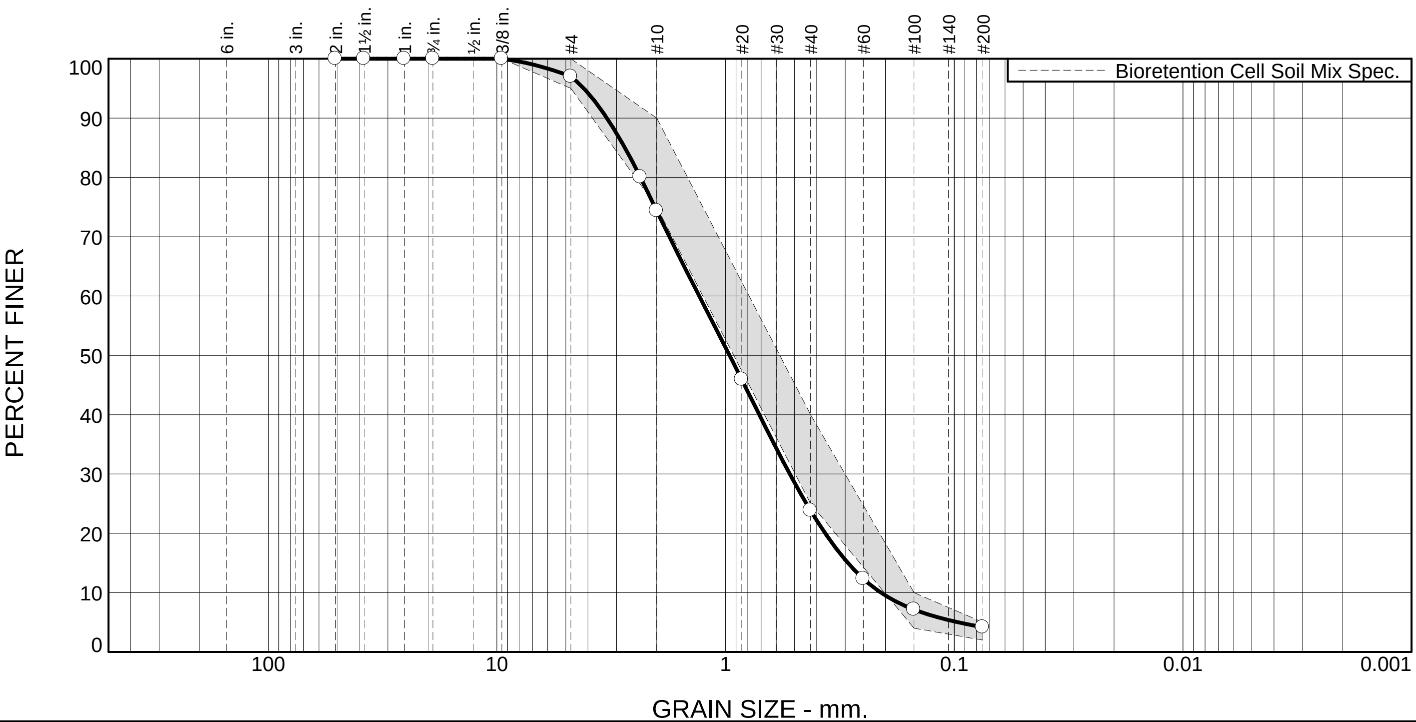
Organic Matter and Ash Content

Dry Soil Befor Burn + Pan	**568.60**	**610.72**
Dry Soil After Burn + Pan	**547.28**	**589.02**
Weight of Pan	**357.89**	**391.91**
Wt. Loss Due to Ignition	**21.32**	**21.70**
Actual Wt. Of Soil After Burr	**189.39**	**197.11**
% Organics	**10.1**	**9.9**

ASSOCIATED EARTH SCIENCES, INC.

911 5th Ave., Suite 100 Kirkland, WA 98033 425-827-7701 FAX 425-827-5424

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	3.0	22.7	50.5	19.6	4.2	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
2	100.0		
1.5	100.0		
1	100.0		
.75	100.0		
.375	100.0	100.0	
#4	97.0	95.0 - 100.0	
#8	80.0		
#10	74.3	75.0 - 90.0	X
#20	45.9		
#40	23.8	25.0 - 40.0	X
#60	12.3		
#100	7.1	4.0 - 10.0	
#200	4.2	2.0 - 5.0	

* Bioretention Cell Soil Mix Spec.

Material Description

SAND, trace silt, trace gravel

Atterberg Limits (ASTM D 4318)

PL= LL= PI=

Classification

USCS (D 2487)= SW AASHTO (M 145)=

Coefficients

D_{90}= 3.3054 D_{85}= 2.7577 D_{60}= 1.3045
D_{50}= 0.9616 D_{30}= 0.5241 D_{15}= 0.2918
D_{10}= 0.2095 C_u= 6.23 C_c= 1.01

Remarks

Collected by: ADY
Bioretention soil mix burned first per ASTM D2974 then sieved.

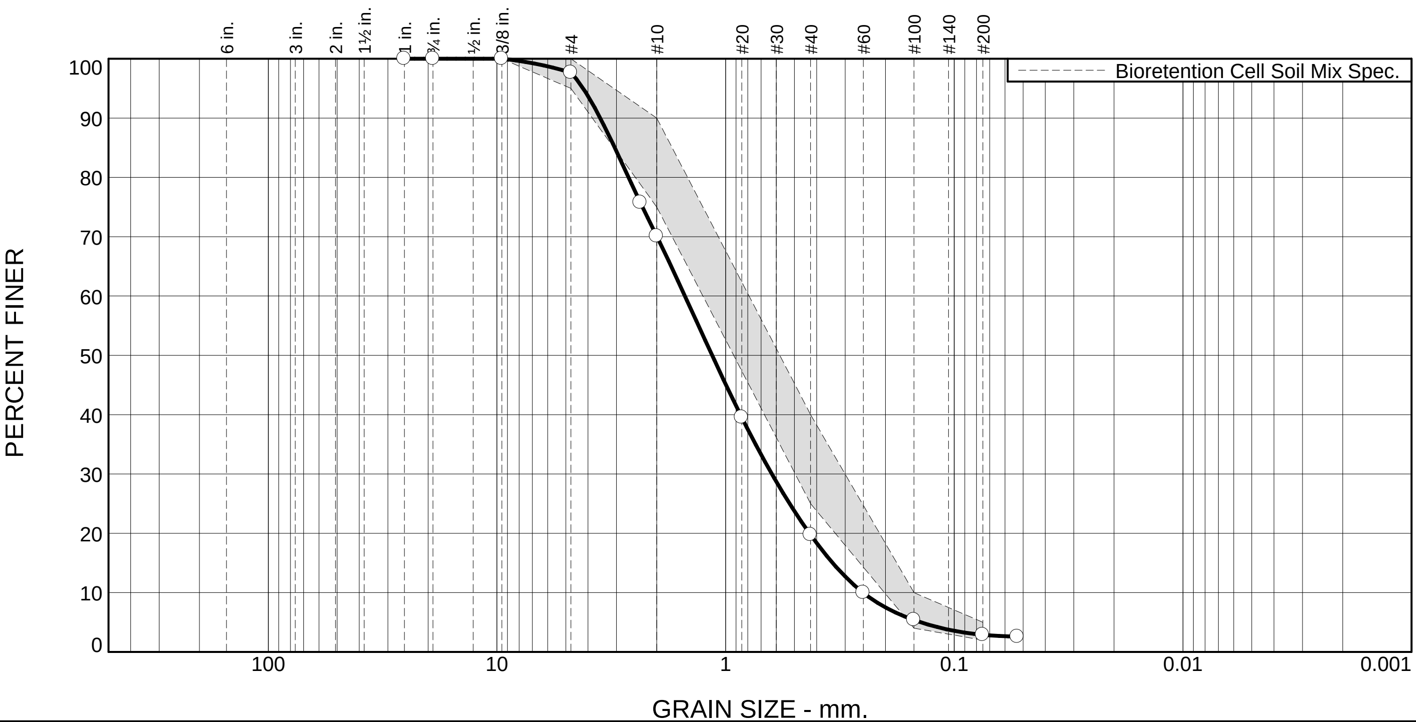
Date Received: **Date Tested:**
Tested By: BN
Checked By: JHS
Title:

Source of Sample: (MPP) Marysville- Park Place Middle School **Depth:** 0.1'-0.5' **Date Sampled:**
Sample Number: HA-1/ WP

a s s o c i a t e d
e a r t h s c i e n c e s
i n c o r p o r a t e d

Client: Clear Creek Solutions
Project: Bioretention Hydrologic Performance Study
Project No: 150387 H004 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	2.3	27.6	50.4	16.8	2.9	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1	100.0		
.75	100.0		
.375	100.0	100.0	
#4	97.7	95.0 - 100.0	
#8	75.8		
#10	70.1	75.0 - 90.0	X
#20	39.5		
#40	19.7	25.0 - 40.0	X
#60	10.0		
#100	5.4	4.0 - 10.0	
#200	2.9	2.0 - 5.0	
#270	2.6		

* Bioretention Cell Soil Mix Spec.

Material Description

SAND, trace silt, trace gravel

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SW **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 3.5333 D_{85}= 3.0525 D_{60}= 1.5063
D_{50}= 1.1453 D_{30}= 0.6277 D_{15}= 0.3402
D_{10}= 0.2506 C_u= 6.01 C_c= 1.04

Remarks

Collected by: ADY

Bioretention soil mix burned first per ASTM D2974 then sieved.

Date Received: 10/12/2018 **Date Tested:** 12/12/2018

Tested By: BN

Checked By: JHS

Title:

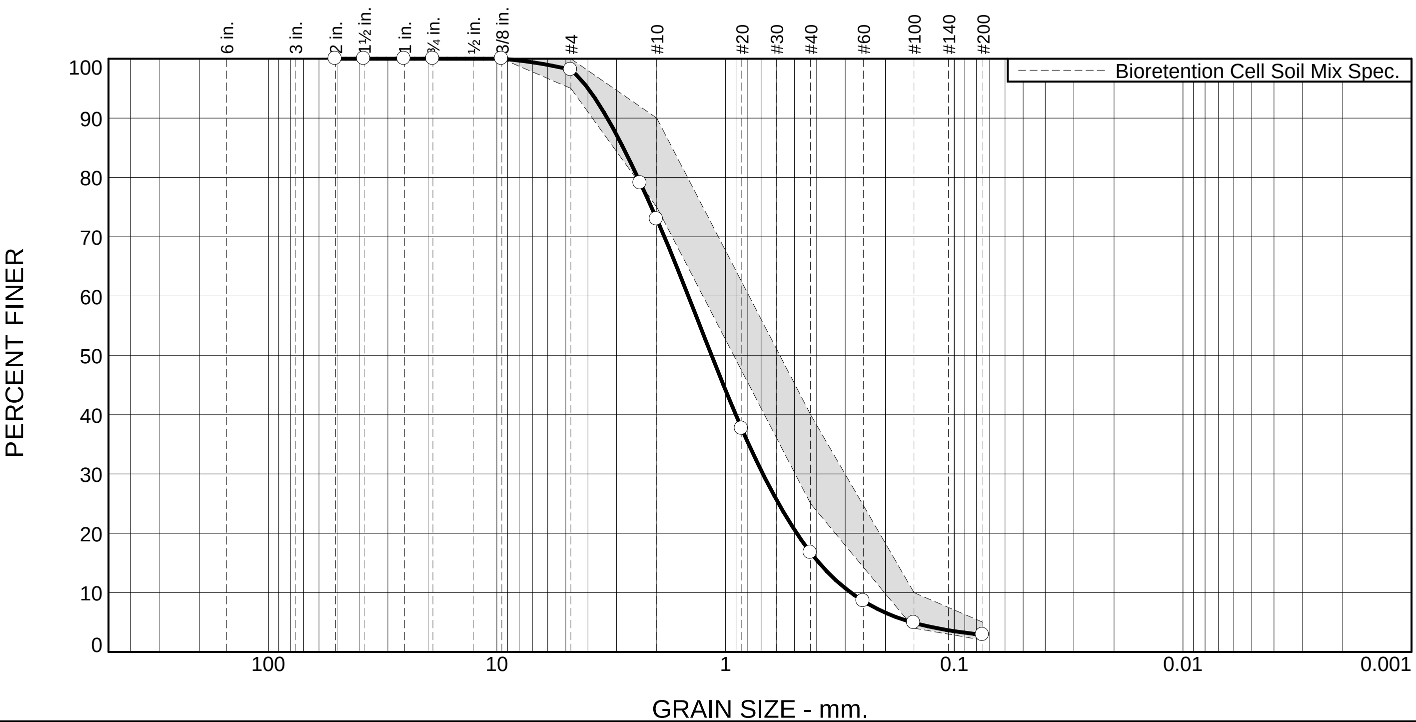
Source of Sample: (MPP) Marysville- Park Place Middle School **Depth:** 0.1'-0.5' **Date Sampled:** 10/10/2018
Sample Number: HA-2

a s s o c i a t e d e a r t h s c i e n c e s i n c o r p o r a t e d

Client: Clear Creek Solutions
Project: Bioretention Hydrologic Performance Study

Project No: 150387 H004 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	1.9	25.1	56.2	13.9	2.9	

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
2	100.0		
1.5	100.0		
1	100.0		
.75	100.0		
.375	100.0	100.0	
#4	98.1	95.0 - 100.0	
#8	79.1		
#10	73.0	75.0 - 90.0	X
#20	37.6		
#40	16.8	25.0 - 40.0	X
#60	8.6		
#100	4.9	4.0 - 10.0	
#200	2.9	2.0 - 5.0	

* Bioretention Cell Soil Mix Spec.

Material Description

SAND, trace silt, trace gravel

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 3.2911 D_{85}= 2.8037 D_{60}= 1.4556
D_{50}= 1.1517 D_{30}= 0.6868 D_{15}= 0.3899
D_{10}= 0.2832 C_u= 5.14 C_c= 1.14

Remarks

Collected by: ADY

Bioretention soil mix burned first per ASTM D2974 then sieved.

Date Received: **Date Tested:**

Tested By: BN

Checked By: JHS

Title:

Source of Sample: (MPP) Marysville- Park Place Middle School **Depth:** 1'-1.6' **Date Sampled:**
Sample Number: HA-3

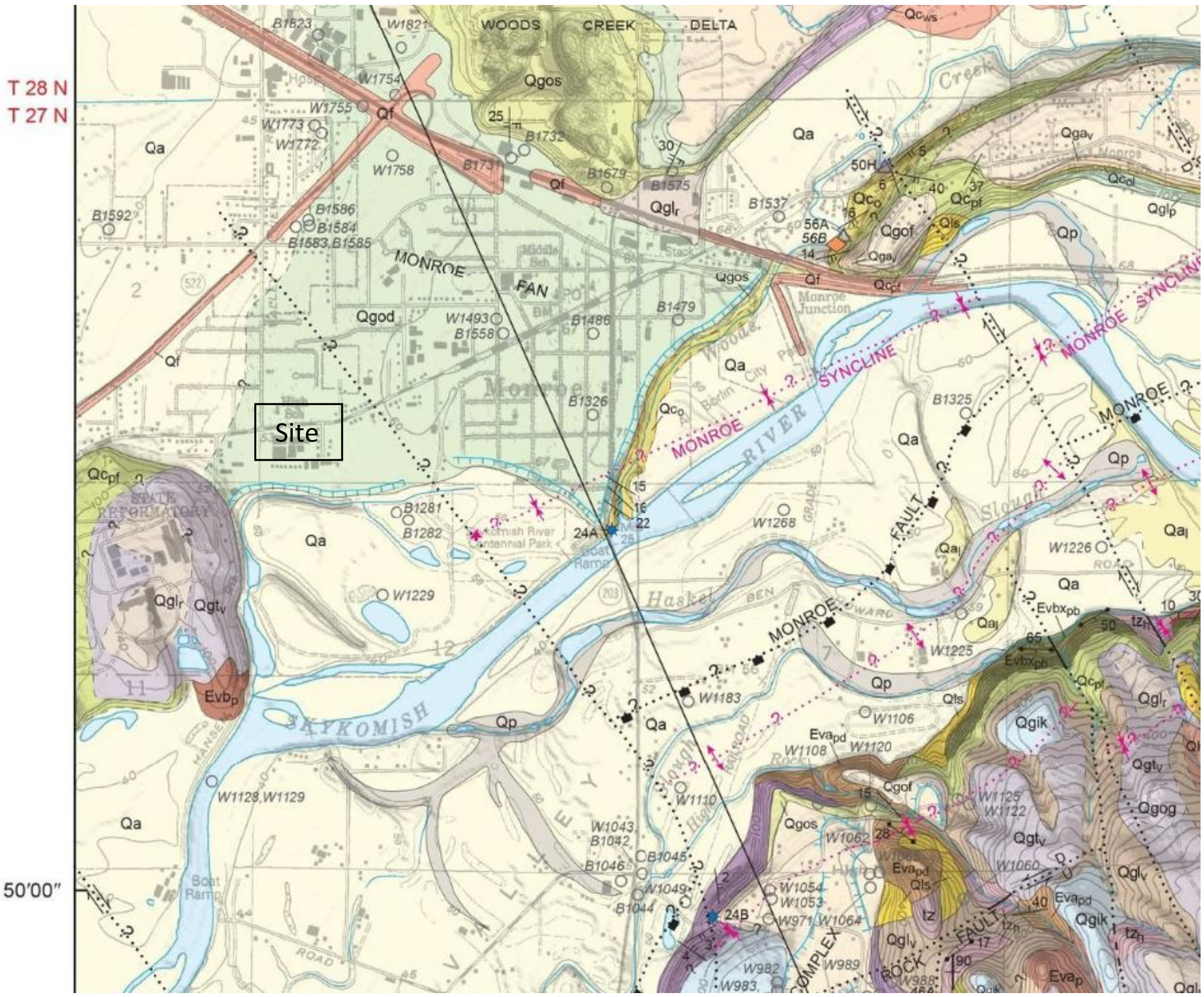
a s s o c i a t e d
e a r t h s c i e n c e s
i n c o r p o r a t e d

Client: Clear Creek Solutions
Project: Bioretention Hydrologic Performance Study

Project No: 150387 H004 **Figure**

APPENDIX C

Background Soil, Geology, and Groundwater Data (Regional Maps, Previous Studies Exploration Logs and Laboratory Testing Data)



Site Unit: Qpod: Deltaic Outwash of the Vashon Stade of the Fraser Glaciation

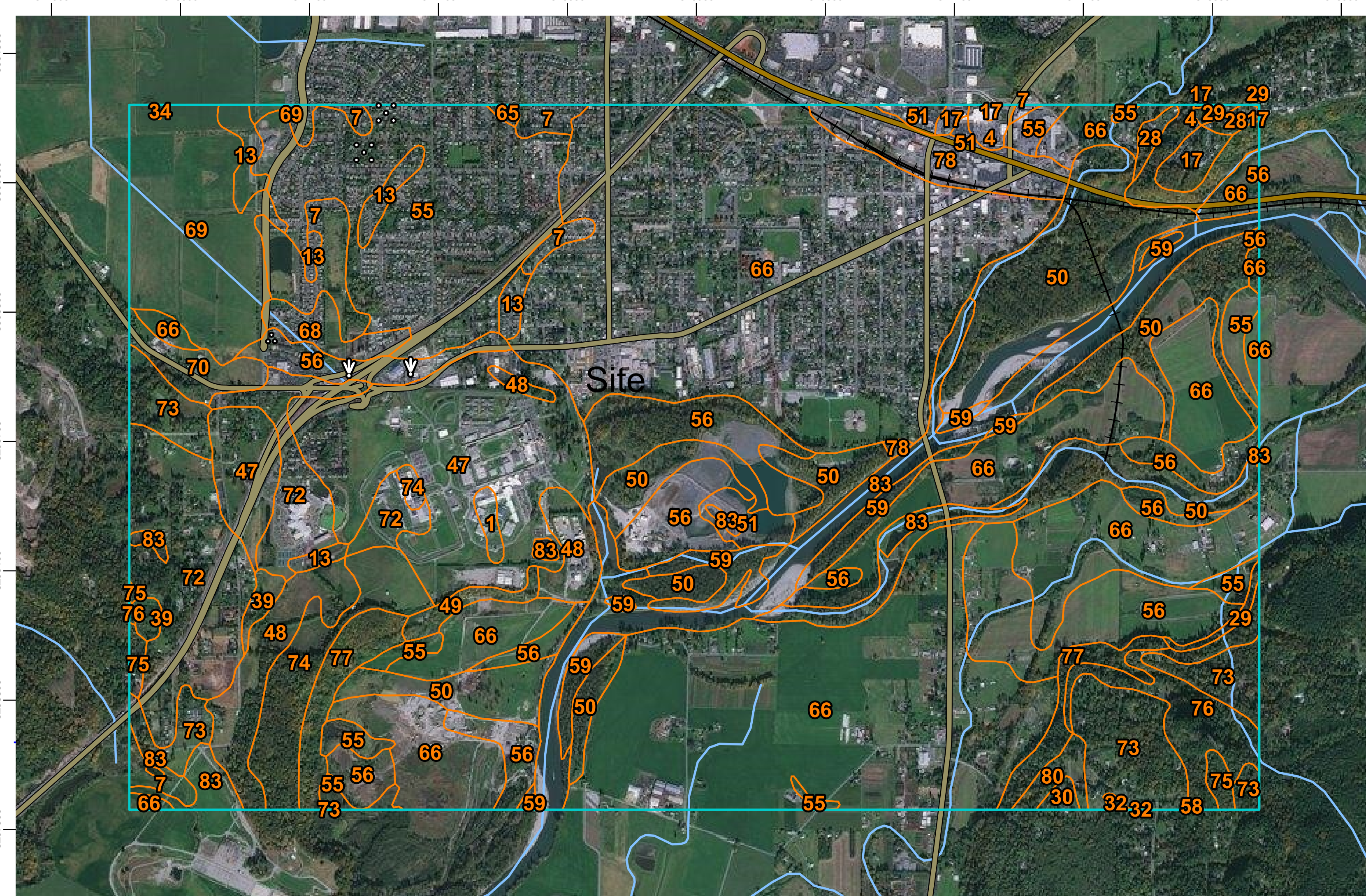
Source:
Geologic map of the Monroe 7.5-minute quadrangle, King and Snohomish Counties, Washington
Author(s): Dragovich, J.D., Anderson, M.L., Mahan, S.A., Koger, C.J., Saltonstall, J.H., MacDonald, J.H., Jr., Wessel, G.R., Stoker, B.A., Bethel, J.P., Labadie, J.E., Cakir, Recep, Bowman, J.D., and DuFrane, S.A.
Publishing Organization: Washington Division of Geology and Earth Resources
Series and Number: Open File Report 2011-1
Publication Date: 2011
Map Scale: 1:24,000

Soil Map—Snohomish County Area, Washington

122° 1' 38" W | 121° 56' 34" W

572900 573500 574100 574700 575300 575900 576500 577100 577700 578300 578900

47° 51' 51" N | 47° 51' 51" N



5301500 5300900 5300300 5299700 5299100 5298500 5297900

47° 49' 38" N | 47° 49' 38" N

572900 573500 574100 574700 575300 575900 576500 577100 577700 578300 578900

122° 1' 38" W | 121° 56' 34" W

Map Scale: 1:28,900 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 400 800 1600 2400

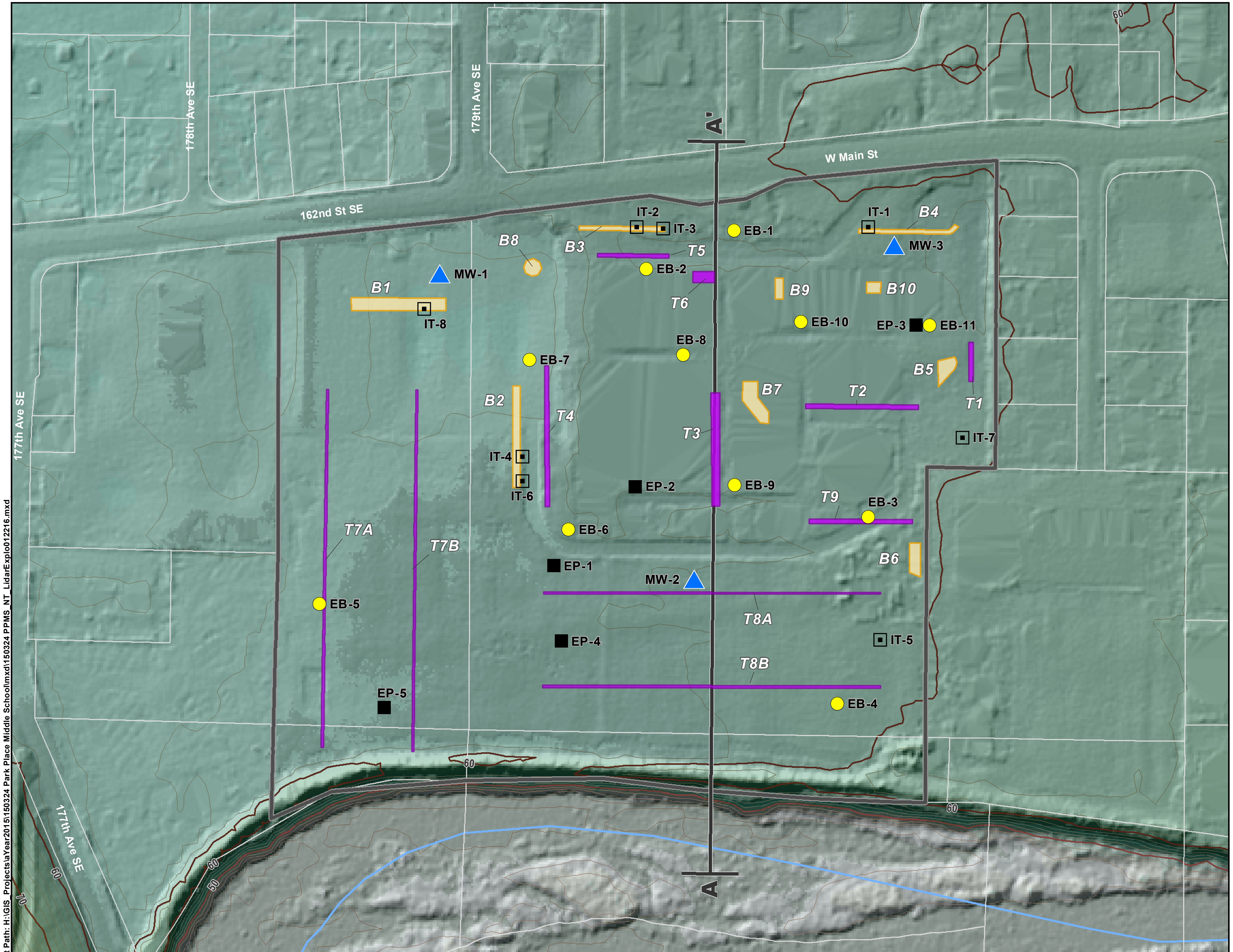
Feet: 0 1000 2000 4000 6000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
1	Alderwood gravelly sandy loam, 0 to 8 percent slopes	6.9	0.2%
4	Alderwood-Everett gravelly sandy loams, 25 to 70 percent slopes	34.3	0.8%
7	Bellingham silty clay loam	70.9	1.7%
13	Custer fine sandy loam	39.2	0.9%
17	Everett very gravelly sandy loam, 0 to 8 percent slopes	19.7	0.5%
28	Kitsap silt loam, 8 to 25 percent slopes	11.0	0.3%
29	Kitsap silt loam, 25 to 50 percent slopes	8.4	0.2%
30	Lynnwood loamy sand, 0 to 3 percent slopes	4.6	0.1%
32	McKenna gravelly silt loam, 0 to 8 percent slopes	1.4	0.0%
34	Mukilteo muck	0.7	0.0%
39	Norma loam	13.1	0.3%
47	Pastik silt loam, 0 to 8 percent slopes	280.2	6.6%
48	Pastik silt loam, 8 to 25 percent slopes	88.7	2.1%
49	Pastik silt loam, 25 to 50 percent slopes	13.8	0.3%
50	Pilchuck loamy sand	391.6	9.2%
51	Pits	24.9	0.6%
55	Puget silty clay loam	318.1	7.5%
56	Puyallup fine sandy loam	331.2	7.8%
58	Ragnar fine sandy loam, 8 to 15 percent slopes	0.3	0.0%
59	Riverwash	62.0	1.5%
65	Sulsavar gravelly loam, 0 to 8 percent slopes	2.3	0.1%
66	Sultan silt loam	1,519.0	35.6%
68	Sumas silt loam	24.2	0.6%
69	Terric Medisaprists, nearly level	158.4	3.7%
70	Tokul silt loam, 2 to 8 percent slopes	27.3	0.6%
72	Tokul gravelly medial loam, 0 to 8 percent slopes	208.4	4.9%

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
73	Tokul gravelly medial loam, 8 to 15 percent slopes	136.6	3.2%
74	Tokul gravelly medial loam, 15 to 30 percent slopes	74.3	1.7%
75	Tokul-Ogarty-Rock outcrop complex, 0 to 25 percent slopes	12.0	0.3%
76	Tokul-Ogarty-Rock outcrop complex, 25 to 65 percent slopes	60.0	1.4%
77	Tokul-Winston gravelly loams, 25 to 65 percent slopes	60.7	1.4%
78	Urban land	60.6	1.4%
80	Winston gravelly loam, 0 to 3 percent slopes	12.8	0.3%
83	Water	190.0	4.5%
Totals for Area of Interest		**4,267.6**	**100.0%**



LEGEND:

- EXPLORATION BORING
- EXPLORATION PIT
- INFILTRATION TEST
- MONITORING WELL
- BIORETENTION CELL
- UNDERGROUND INFIL TRENCH
- CROSS SECTION
- PROJECT SITE
- CONTOUR 10 FT
- CONTOUR 2 FT

DATA SOURCES / REFERENCES:
PSLC: LIDAR 2014, GRID CELL SIZE IS 3'.
WA STATE PLANE NORTH, NAD83(HARN) NAVD88, US SURVEY FEET.

SNOHOMISH CO: PARCELS, STREETS

LOCATIONS AND DISTANCES SHOWN ARE APPROXIMATE

N

0 70 140
FEET

BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION

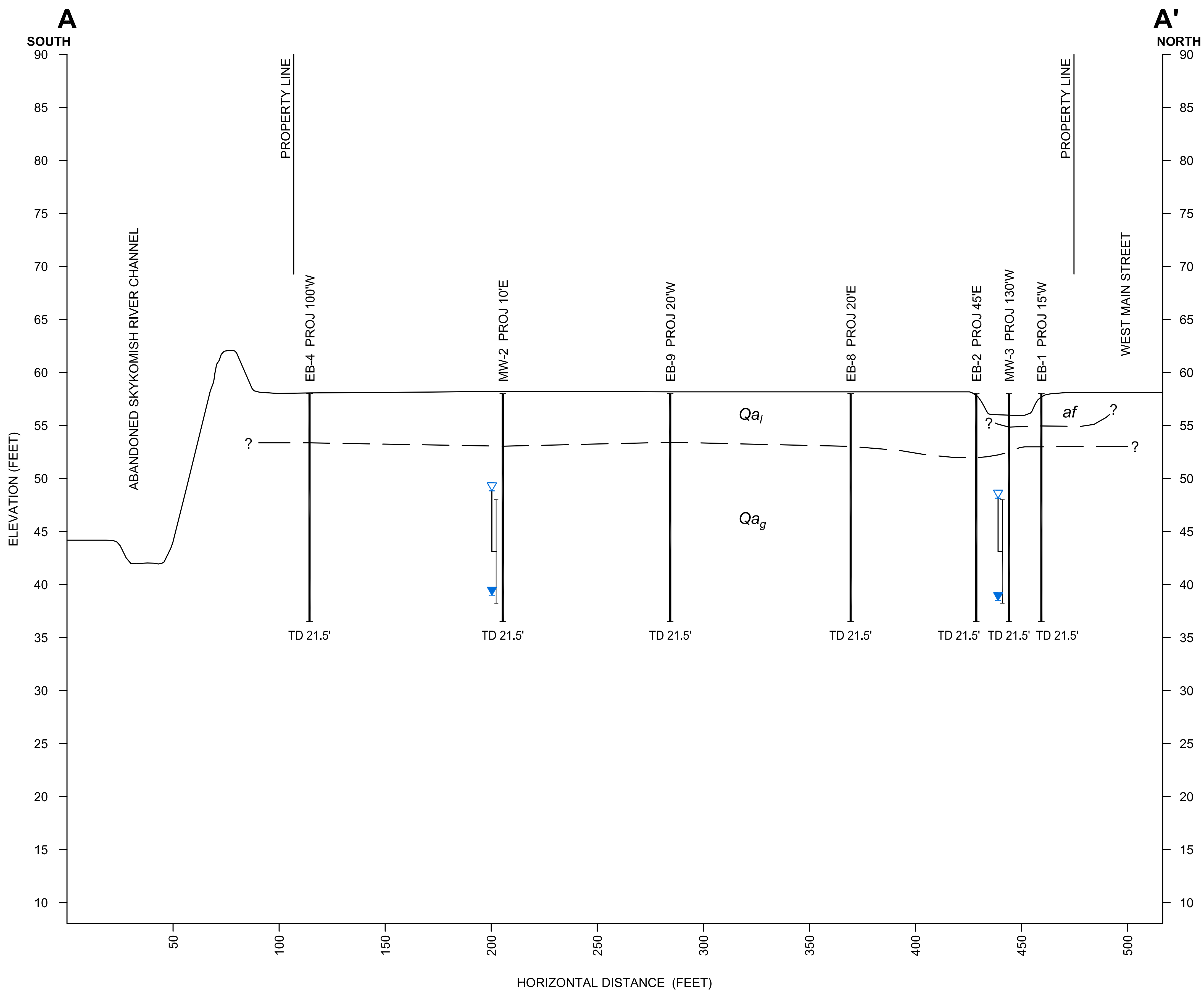
associated earth sciences incorporated

EXPLORATIONS AND LIDAR BASED TOPOGRAPHY

PARK PLACE MIDDLE SCHOOL
MONROE, WASHINGTON

PROJ NO.	DATE:	FIGURE:
KE150324B	1/16	2

Document Path: H:\GIS_Projects\aYear2015\150324 Park Place Middle School\mxd\150324 PPMS_NT_LidarExplo012216.mxd



LEGEND:

af	FILL
Qa_l	ALLUVIUM - LEVEE DEPOSITS
Qa_g	ALLUVIUM - COARSE GRAINED
	EXPLORATION: BORING (EB) MONITORING WELL (MW)
	WATER LEVEL AT TIME OF DRILLING - 7/1/15
	WATER LEVEL - 12/9/15
	SCREENED INTERVAL
TD	TOTAL DEPTH OF BORING
	GEOLOGIC CONTACT

VERTICAL EXAGGERATION = 5X

NOTE: LOCATION AND DISTANCES SHOWN ARE APPROXIMATE

NOTE:

1. THE SUBSURFACE CONDITIONS PRESENTED IN THIS GEOLOGIC CROSS-SECTION ARE BASED ON AN INTERPRETATION OF CONDITIONS ENCOUNTERED IN WIDELY SPACED EXPLORATIONS COMPLETED AT THE SUBJECT SITE AND RELEVANT SITE INFORMATION DEVELOPED AND PROVIDED BY OTHERS. THE SUBSURFACE INTERPRETATIONS PRESENTED IN THIS GEOLOGIC CROSS-SECTION SHOULD NOT BE CONSTRUED AS A WARRANTY OF ACTUAL SUBSURFACE CONDITIONS AT THE SITE. OUR EXPERIENCE HAS SHOWN THAT SOIL AND GROUND WATER CONDITIONS CAN VARY SIGNIFICANTLY OVER SMALL DISTANCES.

2. OFFSITE GROUND SURFACE ELEVATIONS DERIVED FROM LIDAR.

associated earth sciences incorporated

SCHEMATIC HYDROGEOLOGIC CROSS-SECTION A - A'

PARK PLACE MIDDLE SCHOOL
MONROE, WASHINGTON

PROJ NO.	DATE:	FIGURE:
KE150324B	1/16	3

150324 Park Place MS \ 150324 GeoSect 1-16.dwg LAYOUT: F3 Sect A-A

Geologic & Monitoring Well Construction Log

associated earth sciences incorporated

Project Number	Well Number	Sheet
KE150324A	-MW-2	1 of 1

Project Name: Park Place Middle School
Elevation (Top of Well Casing):
Water Level Elevation:
Drilling/Equipment: GDI / Tracked
Hammer Weight/Drop: 140# / 30"

Location: Monroe, WA
Surface Elevation (ft):
Date Start/Finish: 6/30/15,6/30/15
Hole Diameter (in): 8.5 inches

Depth (ft)	Water Level	WELL CONSTRUCTION	S T	Blows/ 6"	DESCRIPTION
0		Flush mount locking monument Concrete seal 0 to 1.5 feet			**Grass / Topsoil - 3 inches** **Alluvium - Levee Deposits**
2.5				3 3 4	Medium stiff, moist, tannish brown, sandy SILT; contains trace organics (ML).
4		Bentonite seal 1.5 to 8 feet			Driller notes gravelly drill action at 5 feet.
5				14 13 24	**Alluvium - Coarse-Grained** Dense, moist to very moist, gray, SAND, some gravel (SP).
9		2-inch I.D. PVC pipe casing: 0 to 10 feet			
10				22 30 22	Dense, moist, brownish gray, gravelly SAND, some silt; contains fractured gravel in sampler tip (SW).
12		2-inch I.D. PVC well screen: 0.020-inch slot width, 10 to 19.46 feet			
15		10/20 silica sand 8 to 21.5 feet		50/2"	No recovery. Blow counts overstated due to gravel.
19	▼	Slip cap			
20		Well Tag #BIJ 526		12 12 13	Medium dense, wet, dark brown, gravelly SAND / sandy GRAVEL; contains dark-stained sediments (SP/GP).
21.5					Boring terminated at 21.5 feet. Well completed at 19.66 feet on 6/30/15.

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample

M - Moisture
Water Level ()
Water Level at time of drilling (ATD)

Logged by: AWR
Approved by: JHS

Exploration Log

associated earth sciences incorporated

Project Number	Exploration Number	Sheet
KE150324A	EB-3	1 of 1

Project Name	Park Place Middle School	Ground Surface Elevation (ft)	
Location	Monroe, WA	Datum	N/A
Driller/Equipment	GDI / Tracked	Date Start/Finish	6/30/15,6/30/15
Hammer Weight/Drop	140# / 30"	Hole Diameter (in)	6 inches

Depth (ft)	Samples	DESCRIPTION	Water Level	Blows/6"	Blows/Foot
		Asphalt - 4 inches			
		Alluvium - Levee Deposits			
	S-1	Medium dense/stiff, moist, brown, silty SAND/sandy SILT (SM-ML).		4 4 12	16
5		**Alluvium - Coarse-Grained**			
	S-2	Dense, dry, tan, gravelly SAND; contains unsorted silty till-like clast in sampler tip (SP). Driller notes gravel at 5.5 feet.		6 18 23	41
10	S-3	Dense, moist, tan, gravelly SAND; contains unsorted silty till-like clasts; blow counts overstated due to gravel (SP).		27 50/4"	50/4"
15	S-4	Dense, moist, dark brown, silty SAND, some gravel; contains unsorted silty till-like clasts; blow count overstated (SP).		50/3"	50/3"
			▼ (ATD)		
20	S-5	Dense, wet, brown, gravelly SAND / sandy GRAVEL; poor recovery (SP/GP).		31 36 20	56
		Bottom of exploration boring at 21.5 feet			

Columns also printed: S T, Graphic Symbol, Well Completion, Other Tests. Blows/Foot scale: 10 20 30 40

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample
- M - Moisture
- Water Level ()
- Water Level at time of drilling (ATD)

Logged by: AWR
Approved by: JHS

LOG OF EXPLORATION PIT NO. IT-5

Depth (ft)	DESCRIPTION
	This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered.
	Topsoil / Grass
1	**Alluvium - Levee Deposits**
2	Medium stiff, moist, brown, fine sandy SILT (ML).
3	
4	
5	**Alluvium - Coarse-Grained**
6	Medium dense to dense, moist, tannish gray, fine to coarse sandy GRAVEL, trace silt; contains cobbles (GW).
7	
8	Operator notes very dense digging action at 8.5 feet.
9	Very dense, very moist, tan, fine to coarse sandy GRAVEL; contains cobbles (GW).
10	
11	
12	As above.
13	Bottom of exploration pit at depth 12 feet Minor caving from 6 to 12 feet. Infiltration test completed at 6 feet. Post-test seepage was observed in sidewalls of pit at depths of 6 to 7 feet.
14	
15	
16	
17	
18	
19	
20	

Park Place Middle School
Monroe, WA

Logged by: AWR

Approved by: CJK

associated earth sciences incorporated

Project No. KE150324B

11/12/15

LOG OF EXPLORATION PIT NO. IT-7

Depth (ft)	This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered. DESCRIPTION
	Asphalt - 5 inches
1	**Crushed Rock Base Course - 8 inches**
	Alluvium - Levee Deposits
2	Medium stiff, moist, tannish brown, fine sandy SILT (ML).
3	**Alluvium - Coarse-Grained**
4	
5	Medium dense to dense, wet, brown, sandy GRAVEL; contains cobbles (GW).
6	
7	
8	
9	
10	
11	Bottom of exploration pit at depth 10 feet Moderate to heavy seepage at 7.5 feet. Slight to heavy caving from 4.5 to 10 feet. Infiltration test completed at 4.5 feet.
12	
13	
14	
15	
16	
17	
18	
19	
20	

Park Place Middle School
Monroe, WA

Logged by: AWR

Approved by: CJK

associated earth sciences incorporated

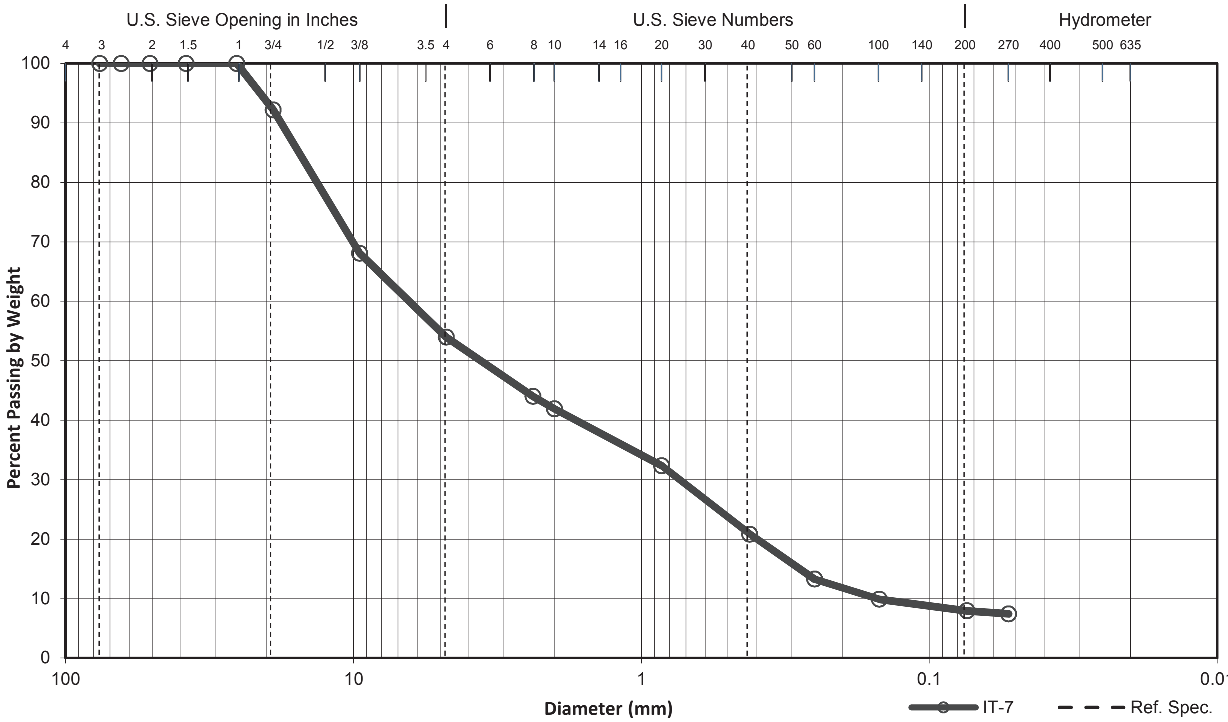
Project No. KE150324B

12/29/15

associated earth sciences incorporated

GRAIN SIZE ANALYSIS - MECHANICAL ASTM D422

Project Name	Project Number	Date Sampled	Date Tested	Tested By
PPMS	**KE150524B**	**12/29/2015**	**1/13/2016**	**MS**
Sample Source	Sample No.	Depth (ft)	Soil Description	
Onsite	**IT-7**	**4-5**	**very sandy GRAVEL, some silt (GP-GM)**	
Total Sample Dry Wt. (g)	Moisture Content (%)	D_{10} (mm)	Reference Specification	
974.5	**8**	**0.151**		



Cobb.	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Sieve No.	Diam. (mm)	Cum. Wt. Ret. (g)	% Ret. by Wt.	% Passing by Wt.	% Specs. Pass. by Wt. Min	Max
3	76.1		0.0	100.0		
2.5	64		0.0	100.0		
2	50.8		0.0	100.0		
1.5	38.1		0.0	100.0		
1	25.4		0.0	100.0		
3/4	19	75.9	7.8	92.2		
3/8	9.51	310.9	31.9	68.1		
#4	4.76	448.7	46.0	54.0		
#8	2.38	545.7	56.0	44.0		
#10	2	566.2	58.1	41.9		
#20	0.85	659.2	67.6	32.4		
#40	0.42	771.4	79.2	20.8		
#60	0.25	845.1	86.7	13.3		
#100	0.149	878.3	90.1	9.9		
#200	0.074	897.1	92.1	7.9		
#270	0.053	902.0	92.6	7.4		

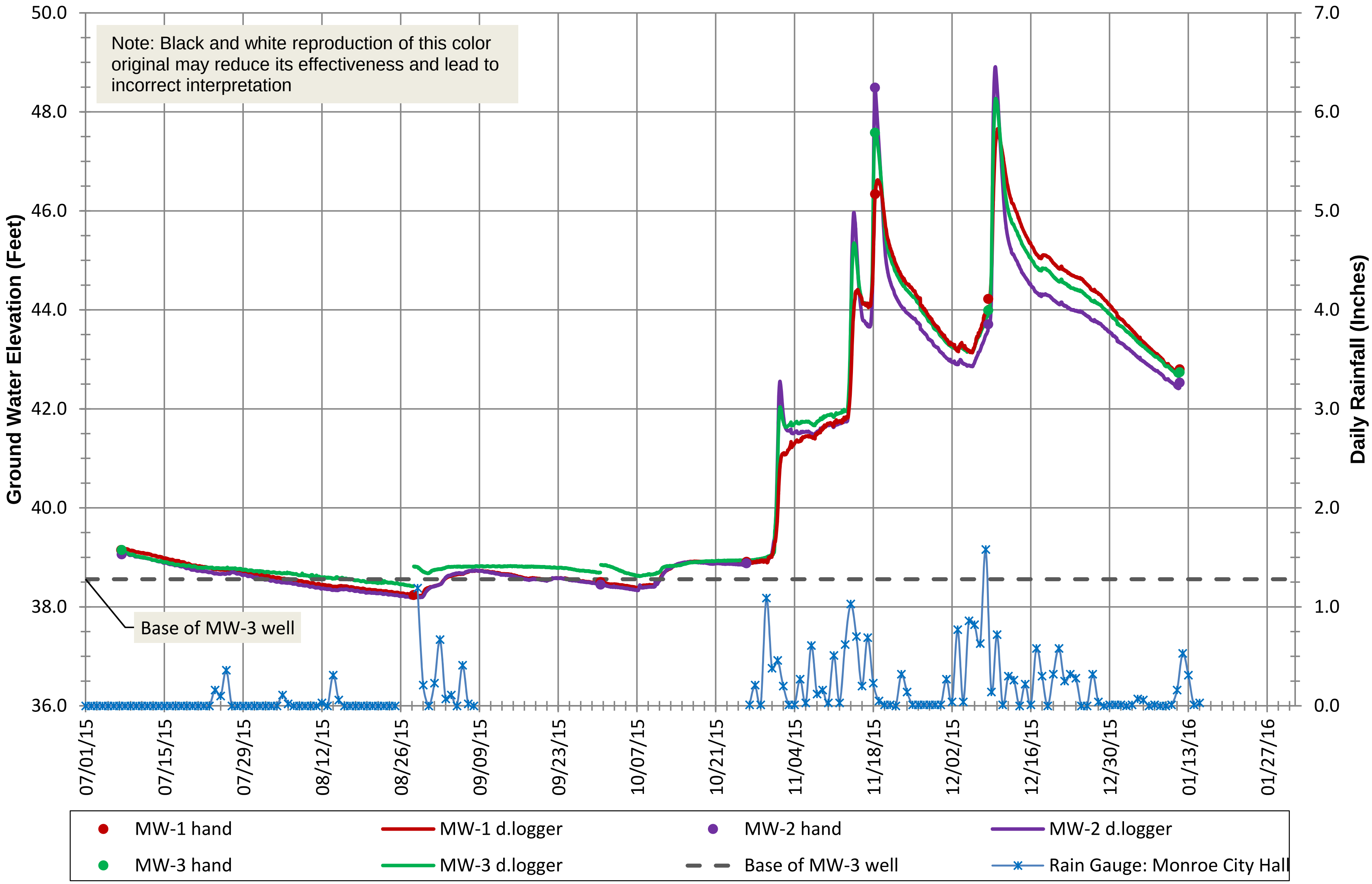
Project Name	Park Place Middles School	**Initial Pit Area (ft^2)**	71-inch-diameter ring
Project Number	KE150324B	**Test Depth (ft)**	6
Date	11.12.12	**Receptor Soils**	sandy GRAVEL
Weather	Pt. Sunny, 60's	**Testing Performed By**	AWR
Test No.	IT-5		
Meter	AESI Low Flow		
Water Source	City of Monroe Hydrant		

Time (24-hr)	Increm. Time (min)	Total (min)	Flow Rate (gpm)	Stage (ft)	Totalizer (gal)	Incremental Infiltration Rate (in/hr)	Notes
9:18:00	0.0	0.0	0	0	0		
9:20:00	2.0	2.0	39.63	0.05	60	120.7	
9:21:00	1.0	3.0	39.63	0.16	97	59.5	
9:22:00	1.0	4.0	39.81	0.30	140	38.5	
9:23:00	1.0	5.0	39.51	0.50	180	-5.7	decrease flow
9:25:00	2.0	7.0	8.01	0.56	203	6.4	
9:28:00	3.0	10.0	7.86	0.58	239	22.7	
9:33:00	5.0	15.0	7.92	0.60	278	24.8	decrease flow
9:37:00	4.0	19.0	5.41	0.60	301	18.9	
9:45:00	8.0	27.0	5.41	0.60	348	18.9	
9:53:00	8.0	35.0	5.41	0.62	394	17.1	decrease flow
10:00:00	7.0	42.0	4.13	0.62	419	14.5	
10:30:00	30.0	72.0	4.21	0.61	545	15.0	
10:45:00	15.0	87.0	3.95	0.61	608	13.8	
11:00:00	15.0	102.0	4.14	0.62	672	14.0	decrease flow
11:15:00	15.0	117.0	3.35	0.61	702	12.2	
11:30:00	15.0	132.0	3.29	0.59	770	12.5	
12:00:00	30.0	162.0	3.21	0.56	866	12.0	increase flow
12:10:00	10.0	172.0	4.04	0.56	899	14.1	
12:27:00	17.0	189.0	3.87	0.60	970	11.9	
12:42:00	15.0	204.0	3.75	0.61	1027	12.6	
13:13:00	31.0	235.0	3.59	0.63	1140	12.1	decrease flow
13:49:00	36.0	271.0	3.36	0.62	1262	12.0	
13:54:00	5.0	276.0	3.38	0.62	1279	11.8	
14:16:00	22.0	298.0	3.52	0.62	1355	12.3	
14:20:00	4.0	302.0	3.5	0.62	1369	12.2	
14:25:00	5.0	307.0	3.5	0.62	1387	12.2	
14:30:00	5.0	312.0	3.48	0.62	1404	12.2	
14:35:00	5.0	317.0	3.52	0.62	1421	12.3	
14:40:00	5.0	322.0	3.48	0.62	1439	12.2	
14:45:00	5.0	327.0	3.36	0.62	1456	11.8	
14:50:00	5.0	332.0	3.38	0.62	1473	11.8	
14:55:00	5.0	337.0	3.36	0.63	1490	10.3	
15:00:00	5.0	342.0	3.35	0.63	1506	11.7	
15:05:00	5.0	347.0	3.36	0.63	1523	11.8	
15:10:00	5.0	352.0	3.43	0.63	1540	12.0	
15:15:00	5.0	357.0	3.48	0.63	1556	12.2	
15:20:00	5.0	362.0	3.48	0.63	1575	12.2	water off at 15:20
15:22:00	2.0	364.0		0.62		3.6	falling head
15:24:00	2.0	366.0		0.59		7.2	
15:26:00	2.0	368.0		0.56		8.4	
15:27:00	1.0	369.0		0.54		9.3	
15:29:00	2.0	371.0		0.52		8.8	
15:30:00	1.0	372.0		0.50		9.4	
15:33:00	3.0	375.0		0.46		9.4	
15:38:00	5.0	380.0		0.39		9.6	
15:43:00	5.0	385.0		0.32		9.7	
15:48:00	5.0	390.0		0.27		9.3	
15:54:00	6.0	396.0		0.19		9.3	end test, remove ring, over ex
Average Infiltration Rate During Last Hour of Constant Head Test:						11.9	
Average infiltration Rate During Falling Head Test:						9.3	

Project Name	Park Place Middles School	**Initial Pit Area (ft^2)**	2.17 x 7
Project Number	KE150324B	**Test Depth (ft)**	4.5
Date	12.29.15	**Receptor Soils**	sandy GRAVEL
Weather	Overcast, 30s	**Testing Performed By**	AWR
Test No.	IT-7		
Meter	AESI 3-30gpm		
Water Source	City of Monroe Hydrant		

Time (24-hr)	Increm. Time (min)	Total (min)	Flow Rate (gpm)*	Stage (ft)	Totalizer (gal)*	Incremental Infiltration Rate (in/hr)	Notes
8:08:00	0.0	0.0	7	0	0		flow on
8:10:00	2.0	2.0	31.4	0.17	44	138.0	
8:11:00	1.0	3.0	31.3	0.33	78	81.0	
8:13:00	2.0	5.0	31.5	0.50	111	139.5	decreased flow
8:14:00	1.0	6.0	6.4	0.56	129	-4.2	
8:18:00	4.0	10.0	8.1	0.42	160	77.8	increased flow
8:23:00	5.0	15.0	10.1	0.48	223	54.9	
8:28:00	5.0	20.0	10.5	0.48	269	66.6	increased flow
8:45:00	17.0	37.0	11.2	0.50	453	70.0	
9:00:00	15.0	52.0	11.1	0.50	626	70.5	
9:15:00	15.0	67.0	11.1	0.50	781	70.5	
9:30:00	15.0	82.0	10.9	0.50	957	69.2	increased flow
9:45:00	15.0	97.0	11.02	0.44	1094	72.8	increased flow
10:00:00	15.0	112.0	13.29	0.58	1318	77.2	decreased flow
10:15:00	15.0	127.0	11.18	0.50	1490	74.8	increased flow
10:30:00	15.0	142.0	11.79	0.50	1668	74.7	
10:45:00	15.0	157.0	11.23	0.46	1831	73.2	increased flow
11:00:00	15.0	172.0	12.15	0.50	2012	75.0	
11:15:00	15.0	187.0	12.25	0.52	2190	76.6	
11:30:00	15.0	202.0	12.25	0.52	2373	77.7	
11:45:00	15.0	217.0	12.25	0.52	2554	77.6	
12:00:00	15.0	232.0	12.20	0.52	2739	77.3	
12:15:00	15.0	247.0	12.15	0.52	2925	77.0	
12:30:00	15.0	262.0	12.20	0.52	3109	77.3	
12:45:00	15.0	277.0	12.20	0.52	3283	77.3	
13:00:00	15.0	292.0	12.82	0.54	3462	80.2	
13:15:00	15.0	307.0	12.72	0.60	3654	77.8	decreased flow
13:30:00	15.0	322.0	11.89	0.54	3841	78.1	
13:45:00	15.0	337.0	11.84	0.54	4008	75.1	
14:00:00	15.0	352.0	11.84	0.54	4184	75.0	
14:15:00	15.0	367.0	11.84	0.52	4364	75.9	
14:30:00	15.0	382.0	11.84	0.50	4543	76.0	
14:45:00	15.0	397.0	11.94	0.50	4723	75.7	
15:00:00	15.0	412.0	11.89	0.48	4904	76.3	
15:15:00	15.0	427.0	11.43	0.46	5083	73.4	Flow off, falling head start
15:16:00	1.0	428.0	0.00	0.38	5083	60.0	
15:17:00	1.0	429.0	0.00	0.29	5083	60.0	
15:18:00	1.0	430.0	0	0.21	5083	60.0	
15:19:00	1.0	431.0	0	0.13	5083	60.0	
15:20:00	1.0	432.0	0	0.08	5083	50.0	
15:21:00	1.0	433.0	0	0.04	5083	45.0	End falling head test
Average Infiltration Rate During Last Hour of Constant Head Test:						75.0	
Average infiltration Rate During Falling Head Test:						54.0	

Ground Water Elevation and Daily Rainfall vs Time
Park Place Middle School



APPENDIX D

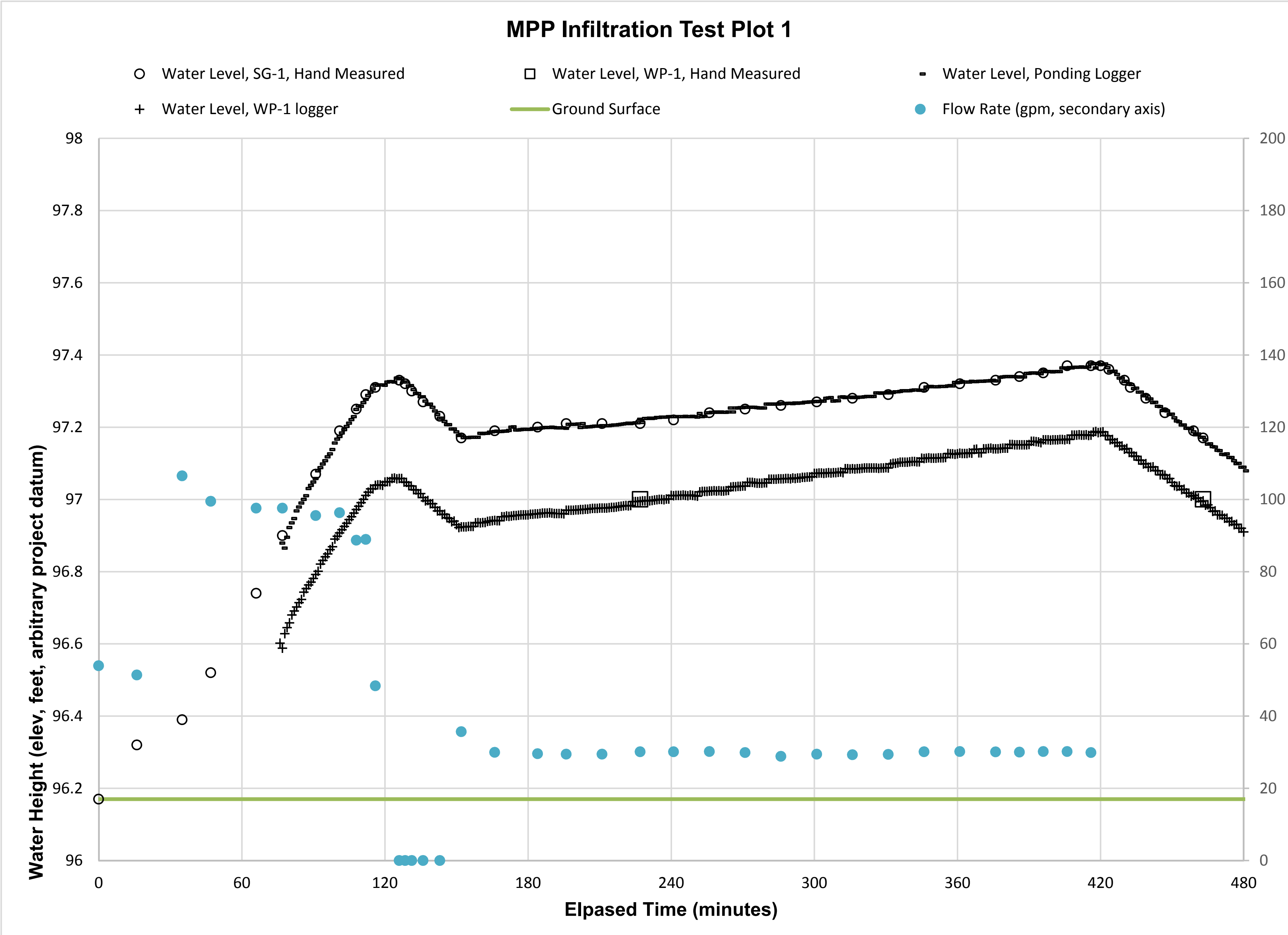
Soil Probe, Level Survey, and Field Infiltration Testing Data

Project Name:	BHPS	Water Source:	Hydrant
Project Number:	150387H007	Meter:	AESI FM5,7
Date:	11/8/2018	Base Area (sq.ft.):	NA
Weather:	Overcast, 60's	Ponded Area(sq.ft.):	800.0
Test No.:	MPP	Test Depth (feet):	NA
Performed By:	ADY, SC	Receptor Soils:	Recessional Outwash

Time (24-hr)	Flow Rate (gpm)	Stage (feet)	Totalizer (gallons)	Comments
8:44	53.94	0	0	Flow on
9:00	51.36	0.15	798.16	
9:19	106.5	0.22	1750	
9:31	99.46	0.35	2921	
9:50	97.58	0.57	4806	
10:01	97.58	0.73	5927	logger in WP-1 wet: moved to alternate loca
10:15	95.5	0.9	7240	
10:25	96.3	1.02	8230	Flow reduced to 92 gpm
10:32	88.7	1.08	8797	Flow reduced to 88 gpm
10:36	88.9	1.12	9221	Flow reduced to 80 gpm
10:40	48.37	1.14	9530	flow reduced to 50 gpm
10:50	0	1.16	9981	Flow off, remove FM7
10:52	0	1.15	9981	
10:55	0	1.13	9981	
11:00	0	1.1	9981	
11:07	0	1.06	9981	
11:16	35.67	1	9981	Flow resumed, FM5
11:30	29.94	1.02	10484	
11:48	29.56	1.03	11024	
12:00	29.44	1.04	11364	
12:15	29.44	1.04	11798	
12:31	30.11	1.04	12296	
12:45	30.11	1.05	12706	
13:00	30.17	1.07	13159	
13:15	29.89	1.08	13626	
13:30	28.83	1.09	14067	
13:45	29.44	1.1	14511	
14:00	29.28	1.11	14938	
14:15	29.39	1.12	15396	
14:30	30.11	1.14	15846	
14:45	30.17	1.15	16284	
15:00	30.06	1.16	16729	
15:10	30	1.17	17039	
15:20	30.17	1.18	17331	
15:30	30.17	1.2	17642	
15:40	29.89	1.2	17930	
15:44	0	1.2	18065	Flow off
15:47		1.19		
15:54		1.16		
15:56		1.14		
16:03		1.11		
16:11		1.07		
16:23		1.02		
16:27		1		
16:40		0.93		

16:45		0.91		
16:48				
16:50		0.89		

	Average Infiltration Rate (in/hr) during last hour of inflow:	3.0
	Average Infiltration Rate (in/hr) during falling head:	3.4



MPP Infiltration Test Plot 1
Water Level, SG-1, Hand Measured
Water Level, WP-1, Hand Measured
Water Level, Ponding Logger
Water Level, WP-1 logger
Ground Surface
Flow Rate (gpm, secondary axis)
Water Height (elev, feet, arbitrary project datum)
98
97.8
97.6
97.4
97.2
97
96.8
96.6
96.4
96.2
96
200
180
160
140
120
100
80
60
40
20
0
0
60
120
180
240
300
360
420
480
Elpased Time (minutes)

APPENDIX E

Site Photos

Cell MPP overview during infiltration testing.

Above photo: Cell MPP inlet modified for monitoring.
Lower Photo: close up of curb cut inlet prior to weir installation.

Technical Memorandum

Date:	June 14, 2019	**From:**	Anton Ypma Suzanne Cook, L.G.
To:	Clear Creek Solutions, Inc.	**Project Manager:**	Jennifer H. Saltonstall, L.G., L.Hg.
	15800 Village Green Drive #3 Mill Creek, Washington 98012	**Principal in Charge:**	Jennifer H. Saltonstall, L.G., L.Hg.
cc:	Eric Christensen	**Project Name:**	Bioretention Hydrologic Performance Study
Attn:	Doug Beyerlein, P.E.	**Project No:**	150387H007
Subject:	Deliverable Task 4.5, Site RSH, Geotechnical/Soils Assessment Design Data and Current Conditions, Renton Sunset Community at Harrington Avenue NE, Renton, Washington		

1.0 INTRODUCTION

This technical memorandum documents existing shallow soil and groundwater conditions in Bioretention Swale E2 of the Sunset Community Low Impact Development Retrofit Green Connection: Harrington Avenue NE Phase II Between NE 8th Place and NE 7th Street Project, located in the City of Renton, Washington (Figure RSH F1). This memorandum was prepared in accordance with Task 4 of the contract scope of work. Associated Earth Sciences, Inc. (AESI) collected shallow soil and groundwater conditions data related to bioretention cell function, and documented the current condition of the facility relative to the as-built drawings and available background geotechnical information. The information will be used in the WWHM2012 modeling that will be conducted as part of Task 5 (Data Analysis). In Task 5, the team will compare the previously-documented hydrologic design information with our field-collected information and will note where there are significant differences. The purpose of this technical memorandum is to document the collection of current and accurate geotechnical, geologic, and hydrogeologic site information for this later work.

The following summary of shallow soil and groundwater conditions integrates the observations made during the geotechnical assessment which included site visits on October 10, 2018, infiltration testing on November 5, 2018, provisional results of hydrologic monitoring, and background geotechnical information.

This technical memorandum has been prepared for the exclusive use of Clear Creek Solutions and the City of Olympia and their agents for specific application to this project. Within the limitations of scope, schedule, and budget, our services have been performed in accordance with generally accepted hydrogeologic and geotechnical engineering practices in effect in this area at the time our document was prepared. No other warranty, express or implied, is made.

2.0 PURPOSE AND SCOPE

The purpose of our work was to perform a shallow soil and groundwater conditions assessment and provide baseline documentation data to assess effectiveness of bioretention hydrologic performance.

Specifically, our scope included the following activities:

- Review of project documents.
- Site reconnaissance.
- Visual condition assessment of erosion and deposition features near inlet and outlet.
- Review project plans relative to constructed facility, in particular, the number and location of inlets, energy dissipation devices, outlets, and other flow-related details.
- Survey elevations of inlet, outlet, well point rim, and other observation points relative to a project datum.
- Excavate shallow hand augers through the bioretention soil.
- Classify sediment according to the Unified Soil Classification System (USCS) and *American Society for Testing and Materials* (ASTM) D2488, "Standard Recommended Practice for Description of Soils."
- Collect samples for laboratory testing of: (1) particle-size distribution in accordance with ASTM D422-63, "Standard Test Method for Particle-Size Analysis of Soils"; (2) organic matter content per ASTM D2974.
- Preparation of descriptive exploration logs for each exploration.
- Conduct qualitative assessment of soil compaction via T-probe.
- Conduct infiltration testing.
- Review of hydrologic monitoring data.
- Preparation of this summary document.

Existing facility features and the locations of hand-auger boreholes completed for this study are shown on Figure RSH F2, "Facility and Exploration Plan." Project civil plans are attached as Appendix A. Exploration logs and laboratory testing data conducted as part of this study are attached as Appendix B. Background soil, geology, and groundwater information are attached as Appendix C. Soil probe, level survey, and field infiltration testing data are attached as Appendix D. Site photos are attached as Appendix E.

3.0 SITE DESCRIPTION AND DESIGN BACKGROUND

The project site is the Sunset Community Project, located in Renton, Washington as shown on the attached "Vicinity Map" (Figure RSH F1). The Phase II Sunset Community project is located along Harrington Avenue NE, generally between 8th Place and NE 7th Street. The site is generally located in the right-of-way of Harrington Avenue, which runs north to south, and is bordered by Highlands Elementary School on the west, and mixed single-family and multifamily residential homes on the

East. Site topography generally slopes gradually downhill to the southwest. No surface water features are present onsite. Stormwater onsite discharges to Johns Creek and Lake Washington (CH2MHILL, August 2012).

Our specific area of study for this project includes bioretention swale E2 located on the east side of Harrington Avenue, immediately north of the intersection with NE 8th Street, referred to as cell RSH for this study. The attached "Facility and Exploration Plan" (Figure RSH F2) illustrates the cell area and some of the surrounding site features and utilities.

Details of the bioretention facility design and basis for design were presented in the following documents:

- "Geotechnical Data and Recommendations Report, Renton Sunset Stormwater Retrofit/LID Project," CH2MHILL, August 2012.
- "Technical Information Report, Green Connections – Harrington Avenue Phase II, NE 8th Place to NE 7th Street – Stormwater Retrofit Project," CH2MHILL, April 2017.
- Sunset Community LID Retrofit Green Connection: Harrington Avenue NE Phase II Between NE 8th Pl and NE 7th St, 100% Submittal," CH2MHILL, May 5, 2017.

3.1 Summary of Facility Design

From our review of these documents, the bioretention facility design for cell RSH consists of an approximately rectangular-shaped bioretention cell with approximately 64 square feet of base area, as shown on Figure RSH F2, "Facility and Exploration Plan." We understand that the site was developed under the 2009 King County Surface Water Design Manual (KCSWDM) along with the 2010 city of Renton Amendments to King County Surface Water Design Manual for design and construction of stormwater facilities and modeled using WWHM4 with a design infiltration rate of 1.2 inches per hour (in/hr) in the native subgrade. Land use within the drainage basin is primarily roadway. Per detail sheet C-5 (CH2MHILL, 2017), the facility design includes a 2-inch woodchip mulch layer overlying 18 inches of bioretention soil mix overlying a rock-filled trench which is present along one side of the facility base, and native subgrade on the remainder of the facility base. The rock-filled trench is not separated from the overlying bioretention soil mix. The rock-filled trench contains an 8-inch-diameter perforated underdrain pipe bedded in approximately 20 inches of "mineral aggregate type 26," which overlies native soil. The underdrain pipe connects to a "drain basin," which then connects to a storm drain catch basin via an 8-inch pipe with a 1-inch orifice. The 8-inch pipe which allows discharge from the drain basin to the storm drain catch basin is at a higher elevation than the underdrain pipe. The storm drain catch basin discharges to the City stormwater system.

The facility is designed to infiltrate 29 percent of inflow into the subgrade. Stormwater enters the facility through two curbcuts. If water ponds up on the bioretention soil, the ponded water would discharge into a Type I Catch Basin with a beehive grate located near the southern end of the cell, and then into the stormwater system. A 6-inch ponding depth is specified, with a 9-inch overflow depth per detail sheet C-5 (CH2MHILL, 2017). Based on review of historic aerial imagery, the facility was constructed and began receiving runoff after June 2017 and before May 2018.

4.0 SITE OBSERVATIONS

During AESI's site visits, we made notes regarding the physical construction of the bioretention facility including documenting site inlet/outlet layout relative to site plans and qualitative bioretention soil thickness and compaction. These notes were used to indicate key features of the facility in Figure RSH F2, "Facility and Exploration Plan."

- Level Survey: AESI conducted an elevation survey of the cell using a Leitz C40 automatic level and a stadia rod. An arbitrary project datum was established for this survey, with the center of the "sewer cleanout" lid in the cell (identified on the "RSH Level Survey Data" map in Appendix D) defined as project datum elevation 100 feet. All other elevations measured by the survey are relative to this project datum. Key level data is summarized in Table 1. Additional data points are included in Appendix D to this document. This survey was not conducted by a licensed surveyor. Surveyed elevations are expected to be sufficiently accurate for this general assessment of facility construction, but may be inaccurate for purposes requiring greater precision.

- Inflow: Two curbcuts are present, with one allowing inflow from the northern end and the other allowing inflow from the side near the southern end, near the overflow beehive grate.
  - The primary inlet (Inlet 1) to the facility is a 1.3-foot-wide curb cut into the northern end of the cell, opposite the overflow. A 3.5-foot by 4-foot gravel/cobble energy dissipater pad was present. We observed sediment deposition across an area of approximately 1 foot by 3 feet of the energy dissipater pad at the time of our October 10, 2018 site visit. The deposited sediment consisted of fine sand and organics at the inlet. At the base of the pad, organic deposits had accumulated to a depth of ½ inch to 2 inches, and extended approximately 3 feet beyond the end of the energy dissipater pad.

  - A second inlet pipe (Inlet 2) to the facility is a 1-foot-wide curbcut. An energy dissipater pad 1.5 to 2.5 feet wide by 5 feet long was present, consisting of rounded gravel and cobbles. Approximately 1 square foot was covered with 1½ inches of sand, with leaves present along the remaining length.

- Overflow: The overflow consists of a Type I Catch Basin with a beehive grate. The rim of this grate was a maximum of 0.3 feet above the facility base, and the southwest corner was inset by less than 0.1 foot into the mulch. AESI observed wood chips accumulated against the sides of the grate on all four sides, interpreted as indicative of the grate receiving flow. AESI notes that the grate is immediately adjacent to the flow dissipater pad from Inlet 2, such that water could flow in the inlet and directly into the overflow grate. The overflow catch basin has two pipes connected to it, one of which is 12-inches in diameter and discharges water from the catch basin to the City storm system. The other pipe is 8-inch polyvinyl chloride (PVC) with a threaded end cap, with an approximately 1-inch orifice, through which water flows into the catch basin from the drain basin.

- Drain Basin: The drain basin consists of an 18-inch pipe, oriented vertically, covered with a circular grated metal lid. The grated metal lid is set approximately 0.6 feet higher than the rim of the beehive overflow grate, such that ponded water should enter the overflow before ponding high enough to directly enter the drain basin through the grated lid. Water enters the drain basin from the 8-inch underdrain pipe, and exits through an 8-inch pipe with 1-inch orifice to the overflow storm drain basin. The underdrain is set approximately 14 inches below the level of the pipe which allows discharge to the overflow. AESI observed one piece of plastic trash floating in the drain basin sump.

- AESI investigated the loose bioretention soil thickness present in cell RSH using a geotechnical soil T-probe. This qualitative data was used in conjunction with the hand-auger observations to understand loose soil thickness and relative potential compactness of the bioretention soils at depth. AESI measured the depth of penetration of the soils probe at locations generally arranged in a 3-foot grid on the facility base. Penetration of the T-probe generally ranged from approximately 1.5 to 1.9 feet and averaged 1.7 feet. Some areas of compacted soil occurred during the primary inlet. Probe penetration data is included in Appendix D to this document.

Table 1
Summary of Cell RSH
Level Survey Data

Location	Elevation (feet, project datum)
Center of "Sewer Cleanout" lid	100.00
Inlet#1 (N) Green pipe top/end@weir	99.53
Inlet#1 (N) curbcut inside lip, LOW (E)	99.14
Inlet#2 (S) Green pipe top/end@weir	98.96
Inlet#2 (S) curbcut LOW (S)	98.88
WP-1 TOC	101.04
Ponding Tube TOC (Baro)	99.49
Ponding Tube TOC (DL)	99.07
Overflow inner rim @ notch (S)	98.48
Overflow outer rim NW corner, LOW	98.56
UD CO Inner rim @notch (W)	98.72

WP: well point; TOC: top of casing; DL: datalogger; UD CO: underdrain cleanout

5.0 SITE SETTING

The text sections below describe our research findings in regards to the topographic, geologic, and hydrogeologic setting of the project site both from regional studies and background site-specific geotechnical and groundwater studies. Our sources of information included the following:

- Site-specific documents cited previously under "Project and Site Description."
- Mullineaux, D.R., *Geologic Map of the Renton Quadrangle, King County, Washington*, 1965, U.S. Geological Survey (USGS), Geologic Quadrangle Map GQ-405, scale 1:24,000.
- Natural Resource Conservation Service (NRCS), Web Soil Survey, United States Department of Agriculture (USDA), http://websoilsurvey.nrcs.usda.gov/, accessed December 2018.
- *Soil Survey of King County Area, Washington*, United States Department of Agriculture (USDA), Natural Resource Conservation Service (NRCS), in cooperation with Washington Agricultural Experiment Station, 1973.
- Liesch, Bruce A., Price, Charles E., and Walters, Kenneth L., *Geology and Ground-water Resources of Northwestern King County, Washington*, Washington State Division of Water Resources, Water Supply Bulletin No. 20, 1963.

5.1 Regional Topography and Project Grading

The project site is situated on an upland area on the southeast of Lake Washington, a little over 300 feet above the elevation to the lake and about a 1¼ mile northeast of Cedar River, which flows into Lake Washington.

On a closer scale, the area near cell RSH slopes gently down to the south, with elevations in the vicinity of the cell around 308 to 310 feet. Harrington Avenue, sloping down to the south, runs along the west side of the cell. Curbside parking is present to the north of the cell. The multifamily residence east of the cell includes a parking lot which is several feet higher in elevation than the cell. A portion of this parking lot appears to slope gently toward a northern driveway, which slopes down to meet Harrington Avenue north of the cell.

The project site was previously developed as sidewalk area and curbside parking along Harrington Avenue. Minor cutting (about 4 feet) was needed to achieve design bioretention cell grades based on a review of existing topography compared with built topography.

5.2 Regional Geology and Background Geotechnical Information

According to the *Geologic Map of the Renton Quadrangle* (U.S. Geological Survey [USGS] Geologic Quadrangle Map GQ-405), the site vicinity is underlain by recessional stratified drift, specifically identified as outwash at the project site. This is consistent with our observations and interpretations of subsurface materials encountered in our explorations for this project.

- <u>Vashon Recessional Stratified Drift, Outwash (Qpa)</u>: Outwash along Cedar River valley: sandy pebble-and-cobble gravel in easternmost terraces, grades to interbedded sand and pebble gravel at Renton, and to sand at northern edge of quadrangle.

Background geotechnical information includes B-12-12, a boring drilled approximately 400 feet from the location of cell RSH. No log was included with the documents received, but the report describes the exploration as encountering ”Soil Unit 1 – Surface Soils” to a depth of 20 feet (CH2MHILL, August 2012). The report indicated that B-12-12 encountered overconsolidated glacial till at 20 feet.

5.3 Regional Soils and Soil Data Used in Site Stormwater Model

AESI reviewed the *Soil Survey of King County Area, Washington* (NRCS, 1973) and soils mapping from the NRCS web portal (NRCS, 2018). The soil survey identifies different soil map units based on parent material, climate, topography (slope), organisms (biota), and time. The soils in the study area formed mostly from young glacial deposits and have not had time to develop the deep weathering profiles present in soils in unglaciated terrains. Instead, they exhibit a direct relationship to the underlying parent material, local climate, topography, and vegetation.

Mapped soils in the project area consist of the Ragnar-Indianola Association soils (NRCS, 2018). These soils are formed from the weathering of glacial drift and outwash. NRCS describes the permeability of both Ragnar and Indianola soils as moderately rapid to rapid in the substratum, with slowly permeable silty layers.

As described in the Technical Information Report (CH2MHILL, April 2017), the pre-developed condition was modeled as Type A soils where not impervious, consistent with mapped soil and background geotechnical data.

5.4 Regional Hydrogeology and Background Groundwater Data

Regional hydrogeology is described in Geology and Ground-water Resources of Northwestern King County (Liesch et al., 1963). Liesch et al. (1963) indicates that recessional outwash can be an aquifer where saturated. This unit commons overlies Vashon lodgement till, which is described by Liesch et al. (1963) as typically a confining bed.

On a closer scale, as described in the Technical Information Report (CH2MHILL, April 2017), the storm drain system at the site ultimately discharges to Johns Creek, which flows into Lake Washington. Limited background groundwater level data was collected in geotechnical explorations pits and boreholes; closest to the RSH site, a 6-inch zone of perched groundwater was observed at 12.5 feet, and groundwater was encountered at 15 feet. Several other explorations are described as encountering perched groundwater at depths ranging from 8 to 15.5 feet (CH2MHILL, August 2017). These explorations were generally located north and uphill of the RSH site.

6.0 BIORETENTION CELL SUBSURFACE EXPLORATION

Limited information on subsurface conditions was obtained for this study from hand-auger samples and soil probe penetration measurements at about 2-foot increments in each hand-augered borehole. Three hand-auger borings were performed in the facility bottom and advanced through the bioretention soil and underlying subgrade, where encountered. Representative samples were collected, visually classified in the field, stored in water-tight containers, and transported to AESI's offices for additional classification, geotechnical testing, and study. At the conclusion of the excavation, the boreholes were immediately backfilled with the excavated material or completed as a well point for water level monitoring (described separately below).

The various types of sediments, as well as the depths where characteristics of the sediments changed, are indicated on the exploration logs presented in Appendix B. A detailed record of the observed bioretention soil, subsurface soil, geology, and groundwater conditions was made. The sediments were described by visual and textural examination using the soil classification in general accordance with ASTM D2488, "Standard Recommended Practice for Description of Soils." The depths indicated on the logs where conditions changed may represent gradational variations between sediment types in the field. The exploration logs in Appendix B are based on the field observations, inspection of the samples, and where applicable, laboratory grain-size analysis. Our explorations were approximately located in the field relative to known site features, and are shown on Figure RSH F2, "Facility and Exploration Plan." Global Positioning System (GPS) coordinates for the explorations were taken using a hand-held GPS, and are summarized in Appendix B.

The results presented in this document are based on the explorations completed for this study and review of background data. The number, locations, and depths of the explorations were completed within site and budgetary constraints. Because of the nature of exploratory work below ground, interpolation of subsurface conditions between field explorations is necessary. It should be noted that differing subsurface conditions may sometimes be present due to the random nature of deposition and the alteration of topography by past grading and/or filling.

6.1 Hand-Auger Borings

Hand-auger borings in cell RSH were completed on October 10, 2018. No rainfall was noted at the time of exploration, however evidence of recent rainfall was observed.

Hand-auger boring number 1 (RSH-HA-1), and hand-auger boring number 2 (RSH-HA-2), which were completed in the base of the cell in the southern portion and near the center, respectively, encountered approximately 1.2 to 1.3 feet of bioretention soil, overlying material interpreted as Vashon recessional outwash to the total depth of up to 3.9 feet. A thin layer (0.3 feet thick) of fill was encountered above the Vashon recessional outwash in RSH-HA-1. Seepage was encountered at 3.7 feet in RSH-HA-1, and from 3.5 to 3.9 feet in RSH-HA-2. RSH-HA-3 encountered bioretention soil mix directly overlying cobbles, interpreted as the buried end of the energy dissipater pad.

6.2 Well Points

A well point was installed in RSH-HA-2 (WP-1). WP-1 was installed to a depth of 4.1 feet to measure groundwater in the shallow aquifer below the bioretention soil. Key well point dimensions are provided in Table 2, below.

Table 2
Summary of Cell RSH
Well Point Dimensions

Well Point	Exploration in which Well Point was Installed	Total Length of Casing (feet)	Interior Diameter	Stickup Height (feet)	Total Depth Inside Casing Below Ground Surface
RSH-WP	RSH-HA-2/WP	6.7	1.25 inch nominal	2.6	4.1

7.0 LABORATORY ANALYSIS

Laboratory testing included mechanical grain-size distribution and percent organic matter by weight in accordance with the ASTM D422 and D2974, respectively. Bioretention soil was first tested for organic matter content and then the burned material was tested for grain-size distribution for comparison with the aggregate fraction of the bioretention soil mix guidance in the 2014 Ecology Manual. Two samples of material interpreted as representative of the subgrade were tested for grain-size distribution. The data is summarized in Table 3.

Table 3
Summary of Cell RSH
Organic Content and Grain Size Data

Exploration Number	Depth (feet)	Soil Type	Organic Content (% by weight)	USCS Soil Description	Fines Content (% passing #200)	Cu	Cc	USDA Soil Texture*
RSH-HA-1	0.2-0.5	Bioretention Soil	4.4	SAND, some silt, trace gravel (SP-SM)	5.2	5.9	0.9	Sand
RSH-HA-1	2-2.5	Recessional outwash		Very sandy SILT, trace gravel (ML)	53.8			Sandy clay to silt loam
RSH-HA-2	0.2-0.5	Bioretention Soil	6.4	SAND, trace silt, trace gravel (SP)	5.7	6.3	0.9	Sand
RSH-HA-2	1.3.-2	Recessional outwash		Very silty SAND, trace gravel (SM)	41.4			Sandy clay to sandy loam

USCS: Unified Soil Classification System; Cu: coefficient of uniformity; Cc: coefficient of curvature; USDA: U.S. Dept. of Agriculture;
*No hydrometers were performed. USDA soil texture range assumes fines consist entirely of silt to entirely of clay.

7.1 Bioretention Soil Mix

We compared the organic content and burned fraction gradation against the general guidelines for the bioretention soil mix (Table 4).

The organic content of the tested bioretention soils ranged between 4.4 and 6.4 percent by weight.

One tested sample meets, and the other does not meet, the recommended organic content by weight of 5 to 8 percent in the 2014 Ecology Manual.

The grain-size analysis test results on the burned soil fraction indicate that the bioretention soils tested correlate to a “SAND” with trace to some silt and trace gravel based on ASTM D2487 Unified Soil Classification System (USCS). The respective fines content as measured on the No. 200 sieve was 5.2 to 5.7 percent, higher than the recommended range of 2 to 5 percent. The coefficient of uniformity ranged from 5.9 to 6.3, meeting the recommended value of equal to or greater than 4. The coefficient of curvature was 0.9, lower than the recommended range of greater than or equal to 1 and less than or equal to 3. The soil mix was generally finer-grained with more than the recommended range of silt and fine sand. The tested bioretention soil was a poorly-graded sand.

Table 4
General Guidelines for Bioretention Soil Mix (2014 Ecology Manual)
Compared to Averaged Cell RSH Site Data

Parameter	Recommended Range	Cell RSH
Organic Content (by weight)	5 to 8 percent	5.4 percent by weight
Cu coefficient of uniformity	4 or greater	6.1
Cc coefficient of curvature	1 to 3	0.9
Sieve Size	**Percent Passing**	
3/8” (9.51 mm)	100	100
#4 (4.76 mm)	95 to 100	96.7
#10 (2.0 mm)	75 to 90	79.5
#40 (0.42 mm)	25 to 40	45.9
#100 (0.15 mm)	4 to 10	14
#200 (0.074 mm)	2 to 5	5.5

Note: The general guidelines for mineral aggregate gradation are from Table 7.4.1 of the 2014 Ecology Manual.
mm: millimeters.

7.2 Subgrade

In RSH-HA-1 and RSH-HA-2, samples of native recessional outwash were sieved, one from a layer that perched groundwater and one from the deeper sandier portion of the augered borehole. The tested material for the perching layer correlates to a sandy SILT, trace gravel with 53.8 percent by weight of the material passing the No. 200 sieve, and the deeper sandier layer correlates to a very silty SAND, trace gravel with 41.4 percent by weight of the material passing the No. 200 sieve.

The grain-size distribution data were also transformed to describe the United States Department of Agriculture (USDA) soil texture. The grain-size distributions were normalized to the No. 10 sieve—i.e., the coarse sand and gravel fraction of the sample is discounted and the remainder is taken as 100 percent of the sample. The fines were assessed relative to the No. 270 sieve. The respective USDA fines content as measured on the No. 270 sieve after adjusting to remove the weight retained on the #10 sieve was 46.8 to 53.3 percent for the native recessional outwash material.

8.0 INFILTRATION TESTING

8.1 General Infiltration Test Method

The infiltration test was conducted in general accordance with the 2014 Ecology Manual. The test was conducted by discharging water into the facility for a "soaking period," to allow the receptor soils to become saturated. After completion of the soaking period, water was discharged into the cell at a rate sufficient to maintain a relatively constant head. This constitutes the "constant-head" phase of infiltration testing. Immediately following the constant-head phase of infiltration testing, flow into the facility was discontinued, and the water level was monitored as it dropped. This constitutes the "falling-head" portion of the infiltration testing.

The water for testing was obtained from an on-site fire hydrant and conveyed to cell RSHwith fire hoses. During infiltration testing, the water was conveyed into the bioretention cell via a digital flow meter with gallons per minute (gpm) and total gallon readouts, and discharged through a flow diffuser. Water levels were monitored using an existing staff gauge (SG-1) marked in 0.01-foot increments installed adjacent to the well point, a second temporary metal staff gauge (SG-2) marked in 0.01-foot increments installed near overflow grate, within the well point with a digital water level tape, the drain basin (structure connecting the underdrain outflow to the overflow structure) and with digital pressure transducers. Data from the digital pressure transducers was compensated for barometric response using a separate digital barometer. The area of the pool was measured periodically during testing.

The infiltration test in cell RSH is discussed below, and results are presented in Table 5. Infiltration test data is included in Appendix D to this document.

8.2 Infiltration Test in Cell RSH

AESI performed infiltration testing on November 5, 2018. No rainfall was noted during testing, and no flow from the inlets was present.

During this test, flow was initially maintained at between 3 and 10 gpm, until water built up to near the overflow beehive grate. Flow was then stopped briefly, and resumed at approximately 1.5 gpm, where it was maintained for the duration of the test. Inflow to the facility for the infiltration test was directed, through a diffuser, onto the energy dissipater from the northern curbcut. After approximately 7 hours, the water level in the wetted area was less than 0.1 feet as measured on SG-1. The wetted pool area had been generally stable for about 4 hours, and had filled in the base of the facility covering an area of about 80 square feet. Approximately 490 gallons of water were used.

Water in the well point and in the drain basin was monitored with a data logger during the infiltration test and responded to inflow. Perched groundwater was present at about 2.7 feet beneath the bioretention cell prior to the start of inflow, and represents the static shallow perched groundwater level. The drain basin water level represents initially stagnant water in the sump, and then water within the underdrain pipe. The water level in the well point and drain basin responded to inflow after about 30 and 50 minutes, respectively, and rose approximately 1.7 feet below ground surface during the course of testing. The water level height is interpreted to be limited by the elevation at which water discharged from the drain basin into the storm drain overflow system.

After about 7 hours, AESI shut off the flow and monitored the water level as it fell. AESI observed that the pooled water in the base of the facility infiltrated over the course of approximately 30 minutes.

The constant-head test infiltration rate in Table 5 is calculated based on flow rate from the hose for infiltration testing, and the wetted area of bioretention soil through which the water infiltrated, and represents the infiltration rate of the bioretention soil.

Table 5
Cell RSH
Infiltration Test Results

Test No.	Surface Area (square feet)	Discharge Time (minutes)	Total Volume Discharged (gallons)	Approximate Constant-Head Level (feet)	Field Infiltration Rates	
					Constant-Head Test (in/hr)	Falling-Head Test (in/hr)
RSH (bioretention soil)	80	415	489	0.08	1.8	2.2
RSH (subgrade)	Shallow groundwater mounding response in well point and drain basin				Unknown, underdrained system with shallow groundwater	

in/hr: inches per hour.

9.0 CONCLUSIONS AND RECOMMENDATIONS

Portions of Cell RSH were inconsistent with the design shown on the civil plan sheets. Observations on site design, shallow soil and groundwater conditions are discussed below.

- The overflow is inconsistent with the plans. Site design documents indicate that the ponding level was designed as 6 inches (0.5 feet). The rim of the overflow grate is at most 0.3 feet above the cell base, and a portion of it is set below the surrounding mulch. AESI also observed that it is placed immediately adjacent to the energy dissipater from Inlet 2, such that flow could enter the overflow directly.

- Base area is inconsistent with the plans. AESI observed that, with the facility near overflow, approximately 80 square feet of base area was wetted. The Technical Information Report (CH2MHILL, April 2017) indicates a base area of 64.5 square feet.

- Bioretention soil:
    - Thickness: The apparent thickness of loose bioretention soil based on soil probe data was generally about 1.5 to 1.9 feet, averaging 1.7 feet, slightly thicker than the 1.5 feet indicated per plan.
    - Composition: The soil tested in generally the recommended guidelines for organic content, although the soil mix was finer-grained, containing slightly more than the recommended range of fine sand and silt.

- Subgrade conditions: The subgrade is interpreted to consist of fine-grained Vashon recessional outwash sand and silt. Perched groundwater was present.

- Bioretention soil field infiltration rate:
    - Measured at about 2 in/hr.
    - The infiltration rate is lower than typical for bioretention soil; some compaction of the bioretention soil was noted during the soil probing.

- Native subgrade infiltration rate: Interpreted to be less than 2 in/hr; the infiltrated water appeared to be mounding on top of perched groundwater.

- Shallow groundwater is present in the location of the RSH facility as measured in the well point and documented in the hand-auger explorations. AESI interprets that the infiltration test water mounded on the bioretention soil and slows soaked vertically downward and caused a moderate rise in the perched water level. During testing, the lag time in response to start of inflow was approximately 30 minutes.

- The effects of shallow groundwater mounding will increase during the wetter winter months; however, the water level height is interpreted to be limited by the elevation at which water discharged from the drain basin into the storm drain overflow system. The ongoing monitoring data will be reviewed for groundwater influence.

- AESI notes that the drain basin, with a grated metal lid, and which discharges into the storm drain via a pipe with a 1-inch orifice, had a piece of plastic trash floating in it at the time of out site visit. It is possible that a large piece of plastic trash or other debris could block the 1-inch orifice, preventing the underdrain from functioning.

- In our opinion, the facility will experience more frequent bypass overflows due to the low-set overflow, the somewhat compacted bioretention soil and low infiltration rate, and the proximity of the secondary inflow to the overflow.

10.0 CLOSURE

We appreciate the opportunity to be of continued service to you on this project. Should you have any questions regarding this document or other geotechnical/hydrogeologic aspects of the project, please call us at your earliest convenience.

Anton D. Ypma
Staff Geologist

State of Washington
Hydrogeologist
2335
Licensed Geologist
Jennifer H. Saltonstall

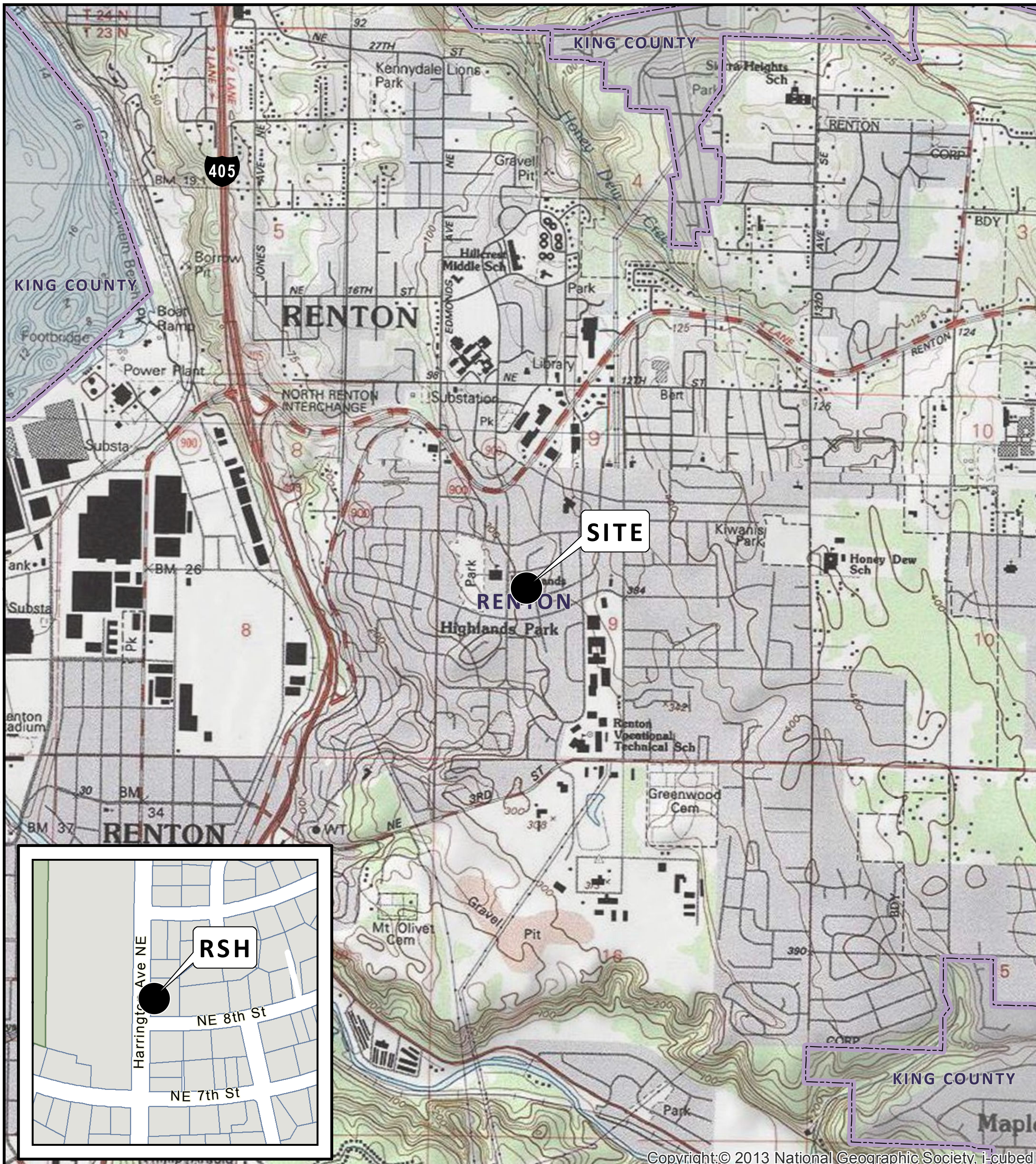
6/14/19

Suzanne S. Cook, L.G.
Senior Project Geologist/Hydrogeologist

Jennifer H. Saltonstall, L.G., L.Hg.
Principal Geologist/Hydrogeologist

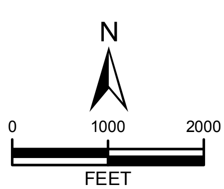
Attachments:	Figure RSH F1:	Vicinity Map
	Figure RSH F2:	Facility and Exploration Plan
	Appendix A:	Project Civil Plans
	Appendix B:	Current Study Exploration Logs and Laboratory Testing Data
	Appendix C:	Background Soil, Geology, and Groundwater Data (Regional Maps, Previous Studies Exploration Logs and Laboratory Testing Data)
	Appendix D:	Soil Probe, Level Survey, and Field Infiltration Testing Data
	Appendix E:	Site Photos

JHS/ld
150387H007-8
Projects\20150387\KH\WP



DATA SOURCES / REFERENCES:
USGS: 7.5' SERIES TOPOGRAPHIC MAPS, ESRI/I-CUBED/NGS 2013
KING CO: STREETS, CITY LIMITS 1/18, PARCELS 8/18

LOCATIONS AND DISTANCES SHOWN ARE APPROXIMATE



NOTE: BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION

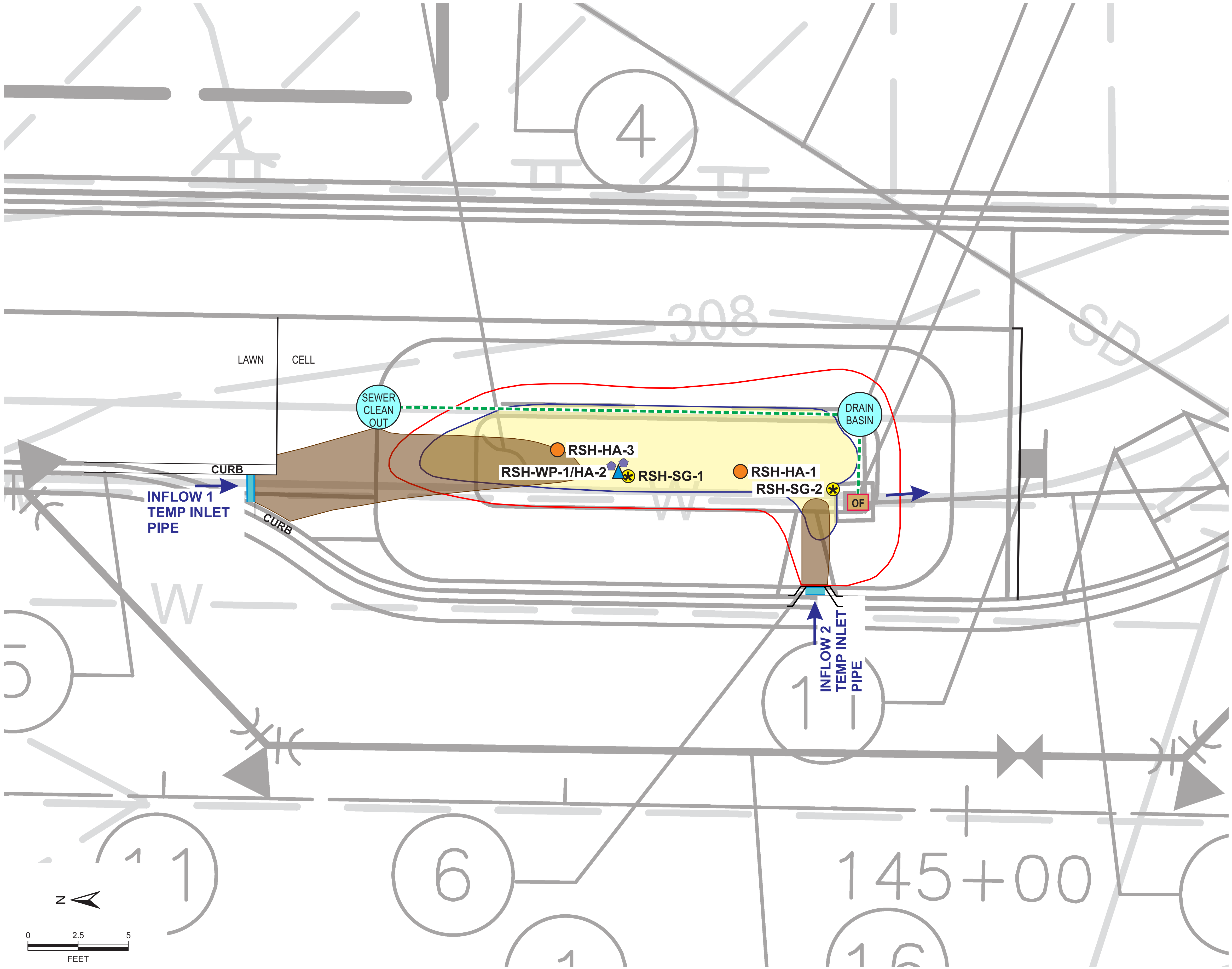
associated earth sciences incorporated

VICINITY MAP

BIORETENTION HYDROLOGIC PERFORMANCE STUDY, RSH SITE
RENTON, WASHINGTON

PROJ NO.	DATE:	FIGURE:
150387H007	3/19	RSH F1

Document Path: G:\GIS_Projects\aY15post0716\150387 Bioretention Hydro Performance Monitoring\mxd\PhaseII\Fig1s\150387H007 F1 VM_RSH.mxd



LEGEND:

HA	HAND AUGER
WP	WELL POINT
	TEMPORARY STAFF GAUGE
	BASE OF FACILITY
	TOP OF FACILITY SLOPE
	INFLOW / OVERFLOW DIRECTION
OF	OVERFLOW GRATE - 24" X 18"
	PVC PONDING TUBE
	UNDERDRAIN
	CURB CUT
	ENERGY DISSIPATER

CONTOUR INTERVAL = N/A

NOTE: LOCATION AND DISTANCES SHOWN ARE APPROXIMATE.

NOTES:
1. BASE MAP REFERENCE: CH2MHILL, HARRINGTON AVENUE NE PHASE II SUNSET COMMUNITY GREEN CONNECTOR, DRW C-2, SHEET 6 OF 24, 5/5/17

associated earth sciences incorporated

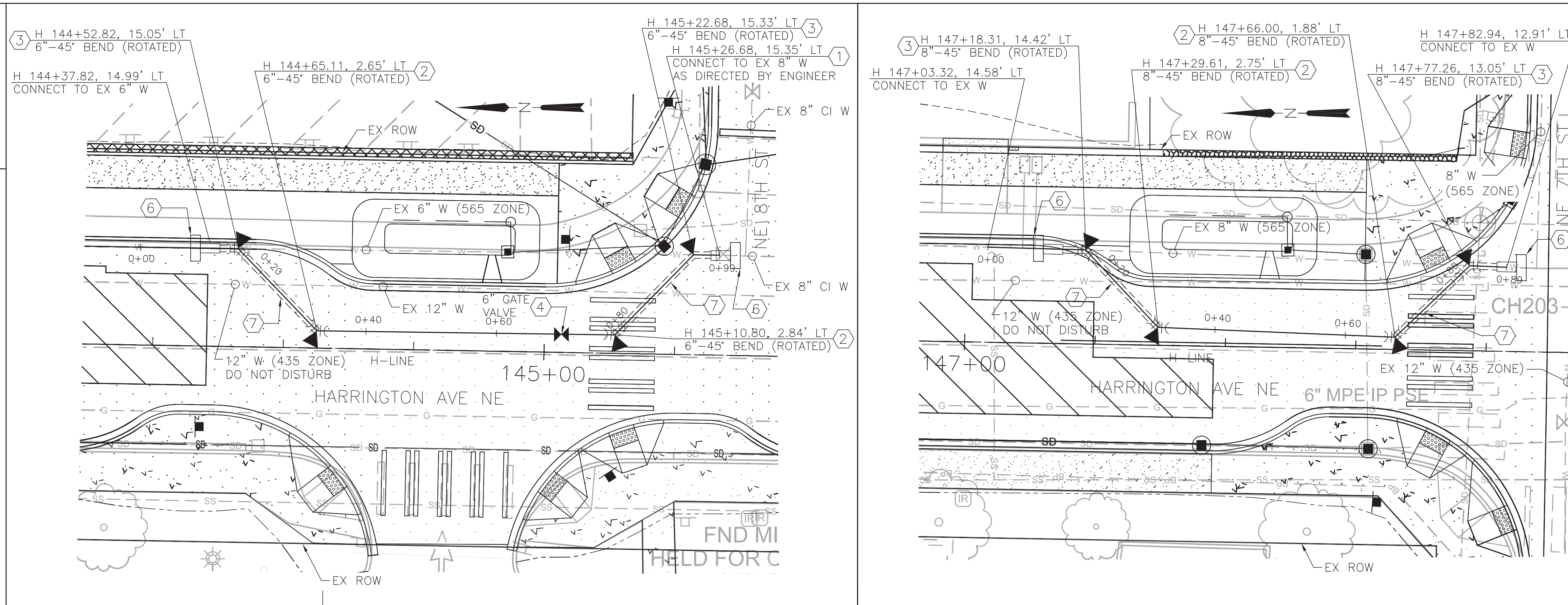
FACILITY AND EXPLORATION PLAN
RSH SITE
BIORETENTION HYDROLOGIC PERFORMANCE
RENTON, WASHINGTON

PROJ NO.	DATE:	FIGURE:
150387H007	3/19	RSH F2

150387 BHPS MCCA \ 150387H007 Site-Expl ALL.cdr PAGE x: RSH F2

APPENDIX A

Project Civil Plans



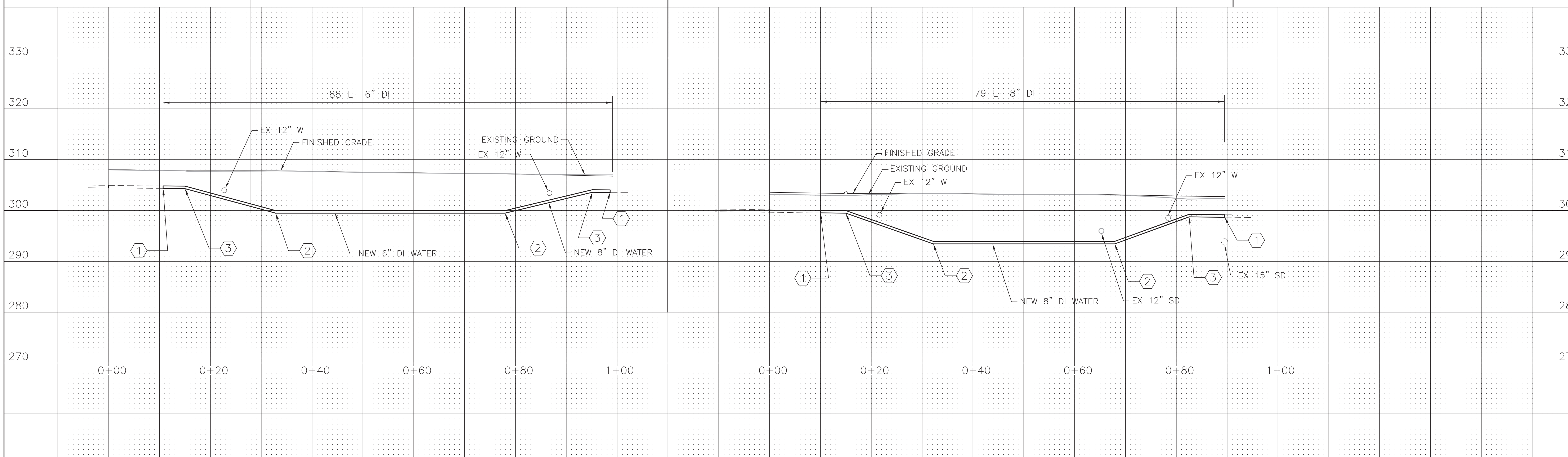
CONSTRUCTION NOTES

1. CONNECT TO EXISTING MAIN WITH DI SLEEVES (MJ X MJ) WITH MEGALUGS
2. INSTALL:
   1 – 45 DEGREE MJ BEND WITH MEGALUGS
   1 – THRUST BLOCK
   PER CITY OF RENTON STANDARD PLAN 330.2
3. INSTALL:
   1 – 45 DEGREE MJ BEND WITH MEGALUGS
   1 – THRUST BLOCK
   PER CITY OF RENTON STANDARD PLAN 330.3, THRUST BLOCK SHALL BE SIZED TO ACCOMMODATE HORIZONTAL AND VERTICAL FORCES. PROVIDE SHACKLE RODS AND TURN BUCKLES IN ACCORDANCE WITH STANDARD PLAN 330.3
4. INSTALL GATE VALVE PER CITY OF RENTON STANDARD PLAN 330.1
5. RECONNECT SERVICE LINE, REPLACE GATE VALVE
6. INSTALL CONCRETE DEAD-MAN BLOCK ON EXISTING WATER MAIN. SEE CITY OF RENTON STANDARD PLAN 330.4.
7. INSTALL 2-3/4" SHACKLE RODS PER CITY ST RENTON STANDARD PLAN 330.5 AND 330.4.

NOTES

1. SEE DRAWINGS C-1 AND C-2 FOR WATER LINE TO BE ABANDONED

10 5 0 10 20
SCALE IN FEET



C:\pw_workdir\ch2mhill_wbg\jw041313\d0260222\W1-WATER PLAN-II.dwg

Apr/14/2017 8:52am

CH2MHILL

RECOMMENDED FOR APPROVAL

BY ____________

BY ____________

NO.	REVISION	BY	DATE	APPR

SURVEYED: G. BROOKS
DESIGNED: A. ROSHAK
DRAWN: K. LORENTSON
CHECKED: R. CHUNG
APPROVED: D. ATCHISON

SCALE: AS NOTED

ONE INCH
AT FULL SCALE IF NOT ONE INCH SCALE ACCORDINGLY

VERTICAL: NAVD 1988
HORIZONTAL: NAD 1983/1991
DATUM

CITY OF RENTON
Planning/Building/Public Works Dept.

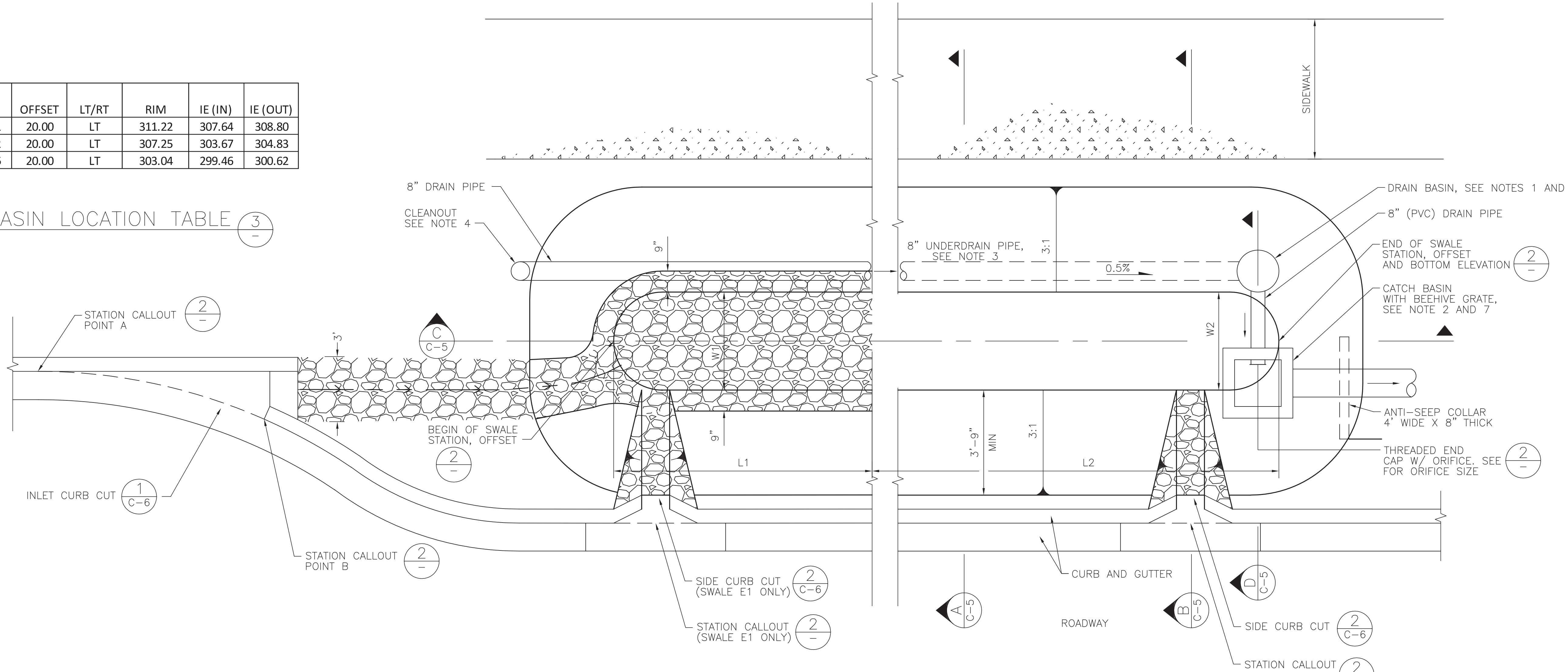
HARRINGTON AVENUE NE PHASE II
SUNSET COMMUNITY - GREEN CONNECTION
WATER PLAN

DATE: 05/05/2017
FIELDBOOK:
PAGE:
DRAWING NO: W-2
SHEET: 23 OF 24

100% SUBMITTAL - NOT FOR CONSTRUCTION

DRAIN BASIN ID	STATION	OFFSET	LT/RT	RIM	IE (IN)	IE (OUT)
2-1	142+50.21	20.00	LT	311.22	307.64	308.80
2-3	144+94.52	20.00	LT	307.25	303.67	304.83
2-5	147+49.26	20.00	LT	303.04	299.46	300.62

DRAIN BASIN LOCATION TABLE 3/–



PLAN

BIORETENTION SWALE DETAIL 1/C-2

SCALE: NTS

	BEGIN OF SWALE			END OF SWALE											
SWALE ID	STATION	OFFSET	LT/RT	STA TO PM	OFFSET	LT/RT	L1	L2	W2	W1	SWALE BOTTOM SLOPE	SWALE BOTTOM ELEVATION	INLET CURB CUT POINT A	INLET CURB CUT POINT B	SIDE CURB CUT
E1	142+16.96	17.00	LT	142+50.96	17.00	LT	8.5	25.5	4.5	2.8	0.50%	310.47	--	--	142+18.46 142+47.46
E2	144+75.27	17.00	LT	144+95.27	17.00	LT	5.0	15.0	4.5	3.6	0.50%	306.50	144+55.6	144+63.68	144+91.77
E3	147+30.01	17.00	LT	147+50.01	17.00	LT	5.0	15.0	4.5	3.2	0.50%	302.29	147+10.3	147+18.40	147+46.51

BIORETENTION SWALE TABLE 2/–

NOTES:

1. FOR L1 AND L2, SEE SECTION C/C-5
2. SWALE BOTTOM ELEVATION AT DOWNSTREAM END

NOTES:

1. DRAIN BASIN SHALL BE 18-INCH NYLOPLAST-ADS DRAIN BASIN WITH 12" SUMP AND 18" DIA. LOCKING COVER PEDESTRIAN H-10 OR APPROVED EQUAL.
2. BEEHIVE GRATE SHALL BE OLYMPIC FOUNDRY FRAME AND GRATE SM60BH OR APPROVED EQUAL.
3. UNDERDRAIN SHALL BE SLOTTED, PVC PIPE SCHEDULE 40. SLOT DIMENSIONS ARE 0.064" WIDE X 1.00" LONG SPACED ALONG PIPE AT 0.3" ON CENTER. FOUR SLOTS PER RADIUS AT 40°, 120°, 240° AND 320°.
4. CLEANOUT SHALL BE PER WSDOT STANDARD PLAN B-85.40-00, 8-INCH SEWER CLEANOUT.
5. FOR W1 AND W2, SEE BIORETENTION SWALE TABLE ON THIS SHEET.
6. ANTI-SEEP COLLAR SHALL BE FORMED WITH CDF.
7. SEE D/C-5 FOR DETAILS.

C:\pw_workdir\ch2mhill_wbg\jw041313\d0260222\C3-DETAILS-II.dwg   Apr/14/2017   8:20am

CH2MHILL

RECOMMENDED FOR APPROVAL

BY ____________

BY ____________

NO.	REVISION	BY	DATE	APPR

SURVEYED: N/A
DESIGNED: J. STICK
DRAWN: K. LORENTSON
CHECKED: R. CHUNG
APPROVED: D. ATCHISON

SCALE: AS NOTED

ONE INCH AT FULL SCALE IF NOT ONE INCH SCALE ACCORDINGLY

VERTICAL: NAVD 1988
HORIZONTAL: NAD 1983/1991

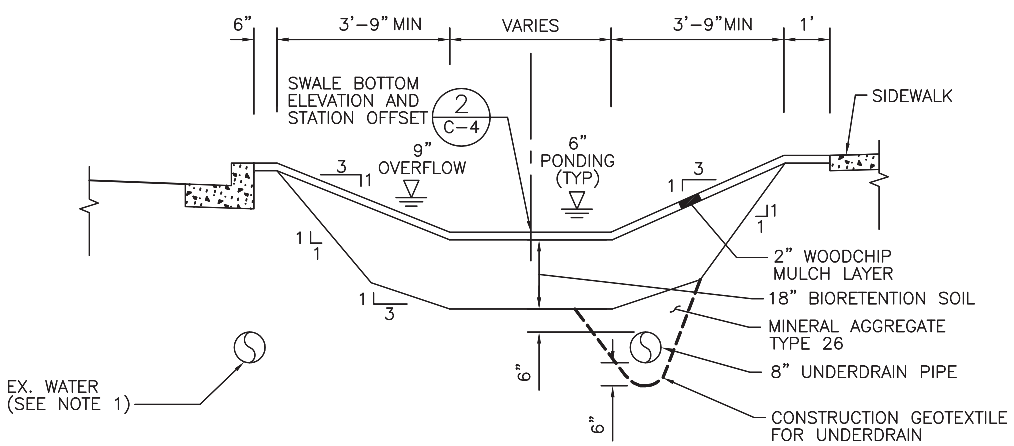
DATUM

CITY OF RENTON
Planning/Building/Public Works Dept.

HARRINGTON AVENUE NE PHASE II
SUNSET COMMUNITY - GREEN CONNECTION
DETAILS

DATE: 05/05/2017
FIELDBOOK:
PAGE:
DRAWING NO: C-4
SHEET: 8 OF: 24

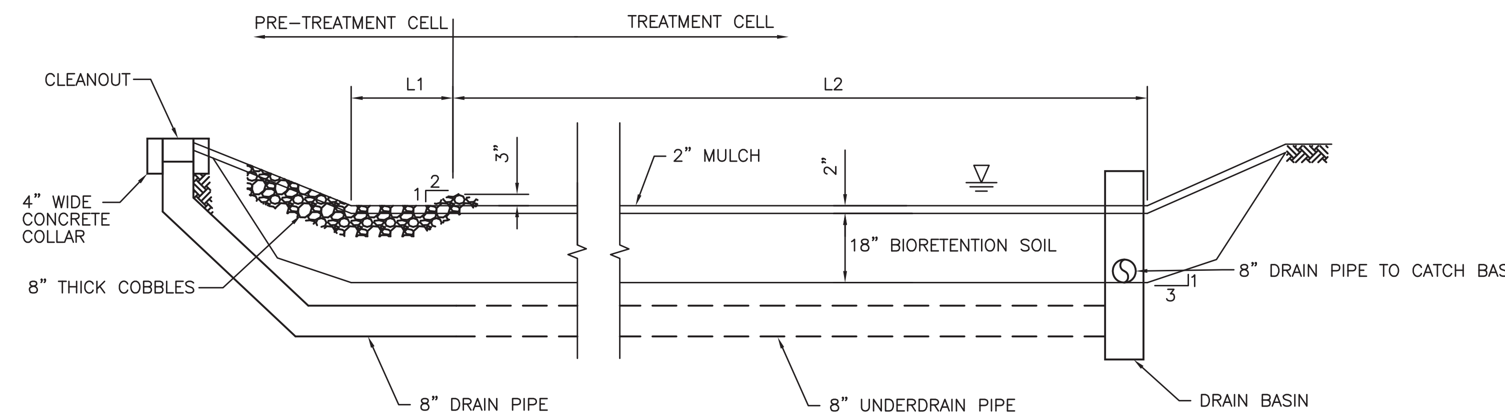
100% SUBMITTAL - NOT FOR CONSTRUCTION



NOTES:

1. CONTRACTOR TO LOCATE AND PROTECT EXISTING WATER LINE.

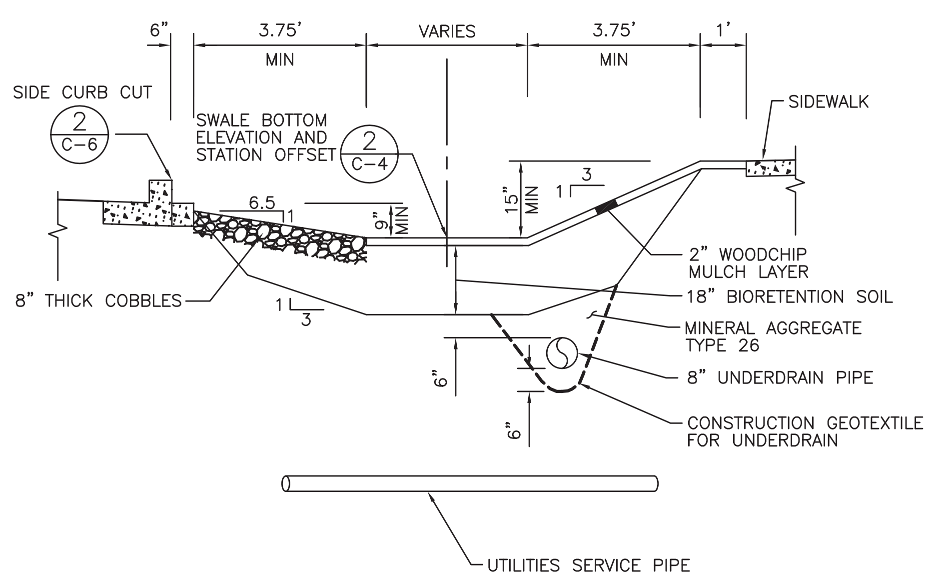
BIORETENTION SWALE
TYPICAL SECTION (A / C-2)
SCALE: NTS



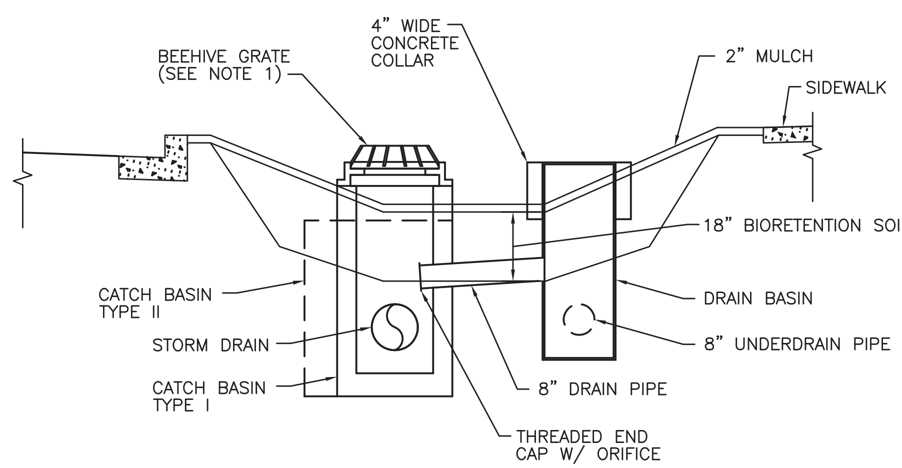
NOTES:

1. FOR L1 AND L2, SEE TABLE (2 / C-4)

BIORETENTION SWALE
TYPICAL LONGITUDINAL SECTION (C / C-2)
SCALE: NTS



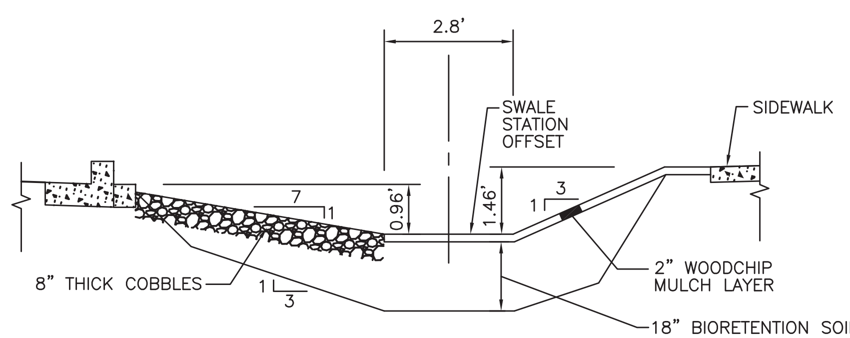
BIORETENTION SWALE TYPICAL
SECTION AT SIDE CURB CUT (B / C-2)
SCALE: NTS



NOTES:

1. STATION CALLOUTS FOR CATCH BASINS AND DRAIN BASIN IN BIORETENTION SWALES ARE TO CENTER OF GRATE.
2. SEE DRAINAGE PROFILES ON SHEET C-3 AND TABLES ON SHEET C-4 FOR DRAINAGE PIPES AND STRUCTURES ELEVATIONS.
3. INSTALL CONCRETE COLLAR TO SECURE THE FRAME AND GRATE OVER THE DRAIN BASIN.

BIORETENTION SWALE TYPICAL
SECTION AT CATCH BASIN (D / C-2)
SCALE: NTS



BIORETENTION SWALE E1
SECTION AT SIDE CURB CUT (E / C-2)
SCALE: NTS

100% SUBMITTAL - NOT FOR CONSTRUCTION

Apr/11/2017 10:25am C:\pw_workdir\ch2mhill_wbg\jw041313\d0260222\C3-DETAILS-II.dwg

CH2MHILL

RECOMMENDED FOR APPROVAL
BY ____________
BY ____________

NO.	REVISION	BY	DATE	APPR

SURVEYED: N/A
DESIGNED: J. STICK
DRAWN: K. LORENTSON
CHECKED: R. CHUNG
APPROVED: D. ATCHISON

SCALE: AS NOTED
ONE INCH AT FULL SCALE IF NOT ONE INCH SCALE ACCORDINGLY

VERTICAL: NAVD 1988
HORIZONTAL: NAD 1983/1991
DATUM

CITY OF RENTON
Planning/Building/Public Works Dept.

HARRINGTON AVENUE NE PHASE II
SUNSET COMMUNITY - GREEN CONNECTION
DETAILS

DATE: 05/05/2017
FIELDBOOK:
PAGE:
DRAWING NO: C-5
SHEET: 9 OF: 24

APPENDIX B

Current Study Exploration Logs and Laboratory Testing Data

Exploration Log

associated earth sciences incorporated

Project Number	Exploration Number	Sheet
150387H007	RSH-HA-1	1 of 1

Project Name	Bioretention Hydrologic Performance Study	Ground Surface Elevation (ft)	
Location	Renton, WA	Datum	N/A
Driller/Equipment	Hand Auger	Date Start/Finish	10/10/18,10/10/18
Hammer Weight/Drop	N/A	Hole Diameter (in)	4 inches

Depth (ft) | S T | Samples | Graphic Symbol | DESCRIPTION | Well Completion | Water Level | Blows/6" | Blows/Foot 10 20 30 40 | Other Tests

Fine Mulch and Wood Chips

Bioretention Soil Mix

S-1

Loose, moist, dark brown, fine SAND, trace to some silt, trace gravel; organic rich; massive (SP/SP-SM).

Fill

S-2

Medium dense,moist, grayish brown, silty, gravelly, fine SAND; massive (SM).

Vashon Recessional Outwash

Loose to medium dense, moist, light brown, silty, fine SAND to very sandy, SILT, trace gravel; stratified (SM-ML).

S-3

Becomes very moist, slightly oxidized tan to grayish brown, fine sandy, SILT (ML).

Grades to moist, brown, fine SAND, trace to some silt, trace gravel (SP-SM/SP). Difficulty augering 3.2 to 3.7 feet, gravel on side locking auger. Water in base of hole at 3.7 ft.

Bottom of exploration boring at 3.7 feet.
Apparent seepage at 3/7 feet. No caving.

5

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample
- M - Moisture
- Water Level ()
- Water Level at time of drilling (ATD)

Logged by: ADY
Approved by: JHS

Geologic & Monitoring Well Construction Log

associated earth sciences incorporated

Project Number	Well Number	Sheet
150387H007	RSH-HA-2/WP	1 of 1

Project Name	Bioretention Hydrologic Performance Study	Location	Renton, WA
Elevation (Top of Well Casing)	101 (Project Datum)	Surface Elevation (ft)	98.4 (Project Datum)
Water Level Elevation	Dry	Date Start/Finish	10/10/18,10/10/18
Drilling/Equipment	Hand Auger	Hole Diameter (in)	4 inches
Hammer Weight/Drop	N/A		

Depth (ft)	Water Level	WELL CONSTRUCTION	S T	Blows/ 6"	Graphic Symbol	DESCRIPTION
		Coarse mulch 0 to 0.1 feet				**Fine Mulch and Wood Chips**
		Threaded steel pipe 1.25-inch I.D. with threaded, vented PVC cap -2.6 to 1.8 feet Bioretention soil mix 0.1 to 1.2 feet				**Bioretention Soil Mix** Loose, moist, dark brown, fine SAND, trace to some silt, trace gravel; organic rich; massive (SP/SP-SM).
		Bentonite chips 1.2 to 1.7 feet Silica sand 1.7 to 3.9 feet Stainless steel jacket over stainless steel #60 gauze, welded to perforated steel pipe 1.8 to 3.9 feet				**Vashon Recessional Outwash** Loose to medium dense, moist, brown, very silty, fine SAND, trace gravel (SM); contains sandy, silt interbeds (ML) stratified. Layer of very moist, tan to grayish brown, sandy, SILT to SILT (ML) from 2.9 to 3.2 feet. Layer of very moist to wet, brown, silty fine to medium SAND, trace gravel (SM) from 3.2 to 3.9 feet.
		Threaded steel pipe 1.25-inch I.D. and drive point3.8 to 4.4 feet				Boring terminated at 3.9 feet Well completed at 4.4 feet on 10/10/18. Slow seepage 3.5 to 3.9 feet. No caving. Steel drive point placed in borehole and hand driven with slide hammer to depth of 4.4 feet.
5		Note: ~4 inches of "dead space" below bottom of perforated openings and total inside depth. Total inside depth = 6.7 feet.				

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample

M - Moisture

Water Level ()

Water Level at time of drilling (ATD)

Logged by: ADY

Approved by: JHS

Exploration Log

associated earth sciences incorporated

Project Number	Exploration Number	Sheet
150387H007	RSH-HA-3	1 of 1

Project Name: Bioretention Hydrologic Performance Study
Location: Renton, WA
Driller/Equipment: Hand Auger
Hammer Weight/Drop: N/A

Ground Surface Elevation (ft):
Datum: N/A
Date Start/Finish: 10/10/18,10/10/18
Hole Diameter (in): 4 inches

Depth (ft)	S T	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Water Level	Blows/6"	Blows/Foot 10 20 30 40	Other Tests
				Fine Mulch and Organic Deposition					
		S-1		**Bioretention Soil Mix** Loose, dark brown, moist, fine SAND, trace to some silt, trace gravel; organic rich; massive (SP/SP-SM). Cobbles at 0.5 feet, end of dispersion pad. Interpreted that end of dispersion pad is partially buried in bioretention soil mix					
				Bottom of exploration boring at 0.5 feet. No seepage. No caving.					
5									

Sampler Type (ST):
- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample
- M - Moisture
- Water Level ()
- Water Level at time of drilling (ATD)

Logged by: ADY
Approved by: JHS

associated earth sciences incorporated

Moisture, Ash, and Organic Matter of Peat and Other Organic Soils - ASTM 2974

Date Sampled	Project	Project No.		Soil Description
10/10/2018	Bioretention Hydrologic Performance Monitoring Study	150387 E007		Bioretention soil mix
Tested By	**Location**	**EB/EP No.**	**Depth**	
BN	Onsite- RSH			

Moisture Content

Sample ID	HA-1/WP (0.2'-0.5')	HA-2 (0.2'-0.5')
Wet Weight + Pan	1088.31	971.05
Dry Weight + Pan	996.60	889.95
Weight of Pan	517.26	534.55
Weight of Moisture	91.71	81.10
Dry Weight of Soil	479.34	355.40
% Moisture	16.1	18.6

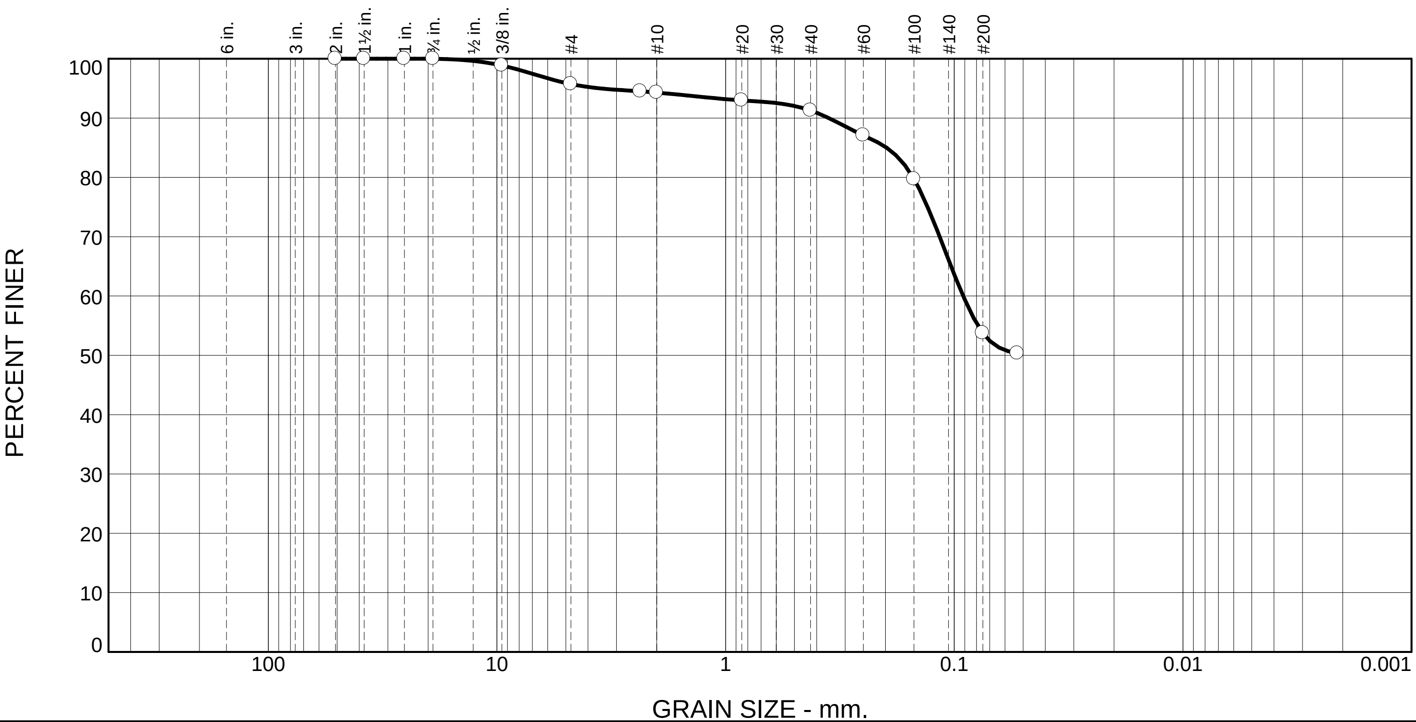
Organic Matter and Ash Content

Dry Soil Befor Burn + Pan	613.14	577.91
Dry Soil After Burn + Pan	603.36	563.89
Weight of Pan	391.92	357.91
Wt. Loss Due to Ignition	9.78	14.02
Actual Wt. Of Soil After Burr	211.44	205.98
% Organics	4.4	6.4

ASSOCIATED EARTH SCIENCES, INC.

911 5th Ave., Suite 100 Kirkland, WA 98033 425-827-7701 FAX 425-827-5424

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	4.3	1.4	3.0	37.5	53.8	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
2	100.0		
1.5	100.0		
1	100.0		
0.75	100.0		
.375	98.9		
#4	95.7		
#8	94.5		
#10	94.3		
#20	93.0		
#40	91.3		
#60	87.1		
#100	79.7		
#200	53.8		
#270	50.3		

* (no specification provided)

Material Description

very sandy SILT, trace gravel

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= ML **AASHTO (M 145)=** A-4(0)

Coefficients

D_{90}= 0.3539 D_{85}= 0.1977 D_{60}= 0.0914
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Collected by: ADY

Date Received: 10/16/2018 **Date Tested:** 10/18/2018

Tested By: MS

Checked By: JHS

Title:

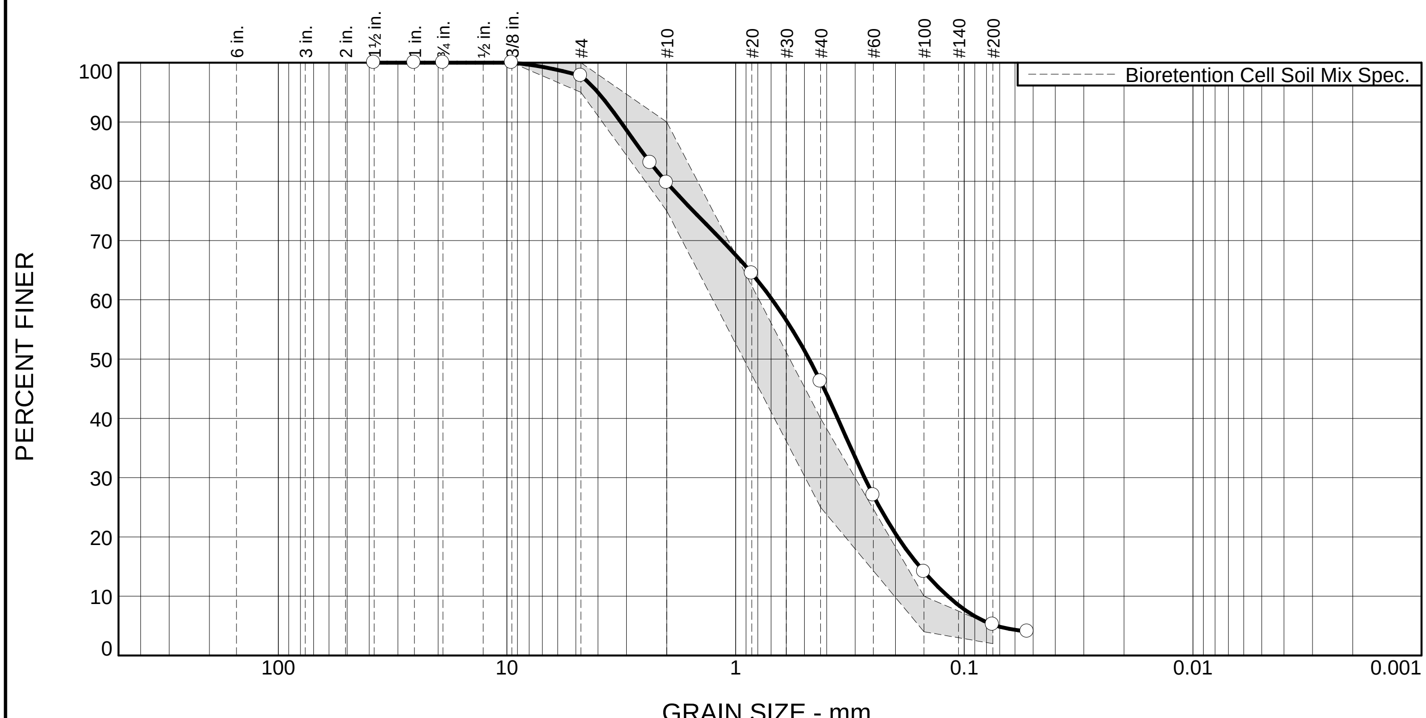
Source of Sample: (RSH) Renton- Sunset Harrington Green Street **Depth:** 2'-2.5' **Date Sampled:** 10/10/2018
Sample Number: HA-1

associated earth sciences incorporated

Client: Clear Creek Solutions
Project: Bioretention Hydrologic Performance Study

Project No: 150387 H004 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	2.2	18.0	33.6	41.0	5.2	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5	100.0		
1	100.0		
.75	100.0		
.375	100.0	100.0	
#4	97.8	95.0 - 100.0	
#8	83.1		
#10	79.8	75.0 - 90.0	
#20	64.5		
#40	46.2	25.0 - 40.0	X
#60	27.0		
#100	14.1	4.0 - 10.0	X
#200	5.2	2.0 - 5.0	X
#270	4.1		

* Bioretention Cell Soil Mix Spec.

Material Description

SAND, some silt, trace gravel

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP-SM **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 3.1786 D_{85}= 2.5689 D_{60}= 0.6912
D_{50}= 0.4769 D_{30}= 0.2730 D_{15}= 0.1567
D_{10}= 0.1180 C_u= 5.86 C_c= 0.91

Remarks

Collected by: ADY

Bioretention soil mix burned first per ASTM D2974 then sieved.

Date Received: 10/16/2018 **Date Tested:** 11/08/2018

Tested By: BN

Checked By: JHS

Title:

Source of Sample: (RSH) Renton- Sunset Harrington Green Street **Depth:** 0.2'-0.5' **Date Sampled:** 10/10/2018

Sample Number: HA-1/WP

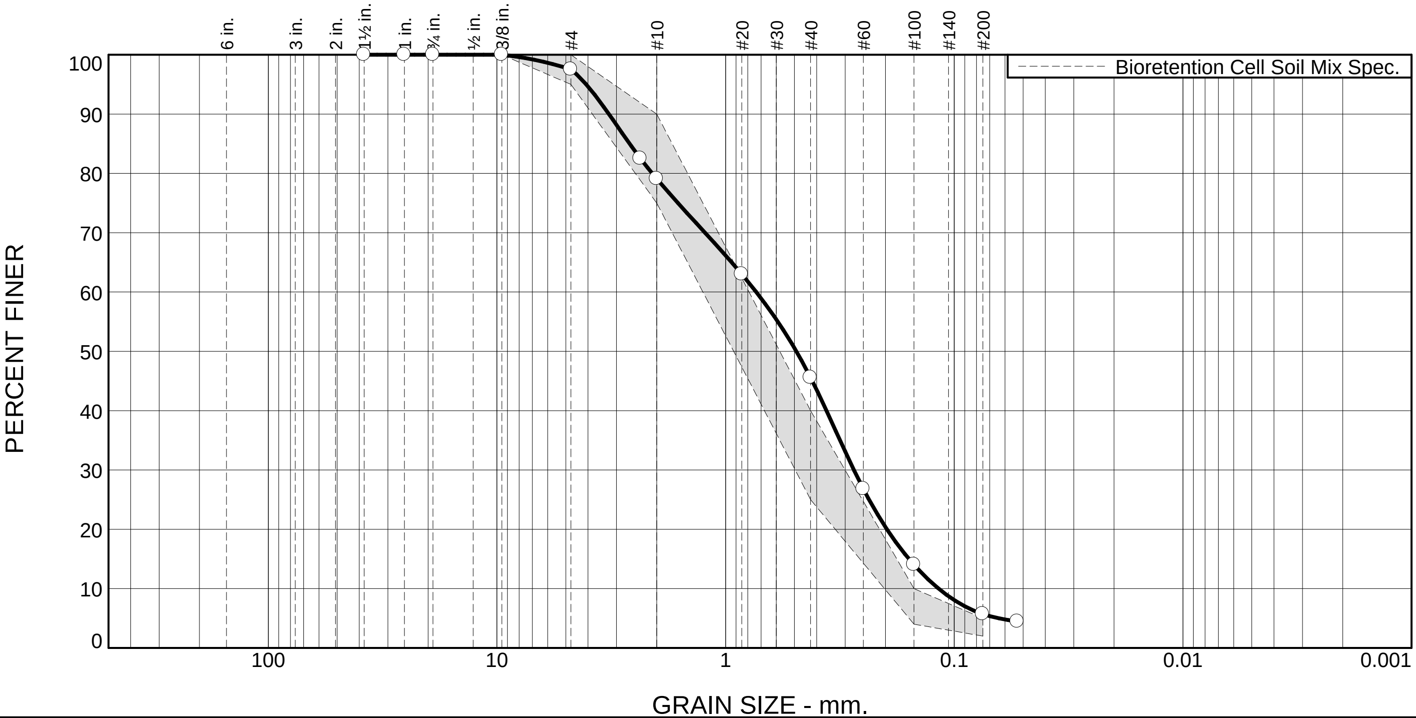
associated earth sciences incorporated

Client: Clear Creek Solutions

Project: Bioretention Hydrologic Performance Study

Project No: 150387 H004 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	2.5	18.4	33.5	39.9	5.7	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5	100.0		
1	100.0		
.75	100.0		
.375	100.0	100.0	
#4	97.5	95.0 - 100.0	
#8	82.5		
#10	79.1	75.0 - 90.0	
#20	63.0		
#40	45.6	25.0 - 40.0	X
#60	26.8		
#100	14.0	4.0 - 10.0	X
#200	5.7	2.0 - 5.0	X
#270	4.5		

* Bioretention Cell Soil Mix Spec.

Material Description

SAND, some silt, trace gravel

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP-SM **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 3.2387 D_{85}= 2.6301 D_{60}= 0.7349
D_{50}= 0.4906 D_{30}= 0.2748 D_{15}= 0.1578
D_{10}= 0.1171 C_u= 6.27 C_c= 0.88

Remarks

Collected by: ADY

Bioretention soil mix burned first per ASTM D2974 then sieved.

Date Received: 10/12/2018 **Date Tested:** 12/12/2018

Tested By: BN

Checked By: JHS

Title:

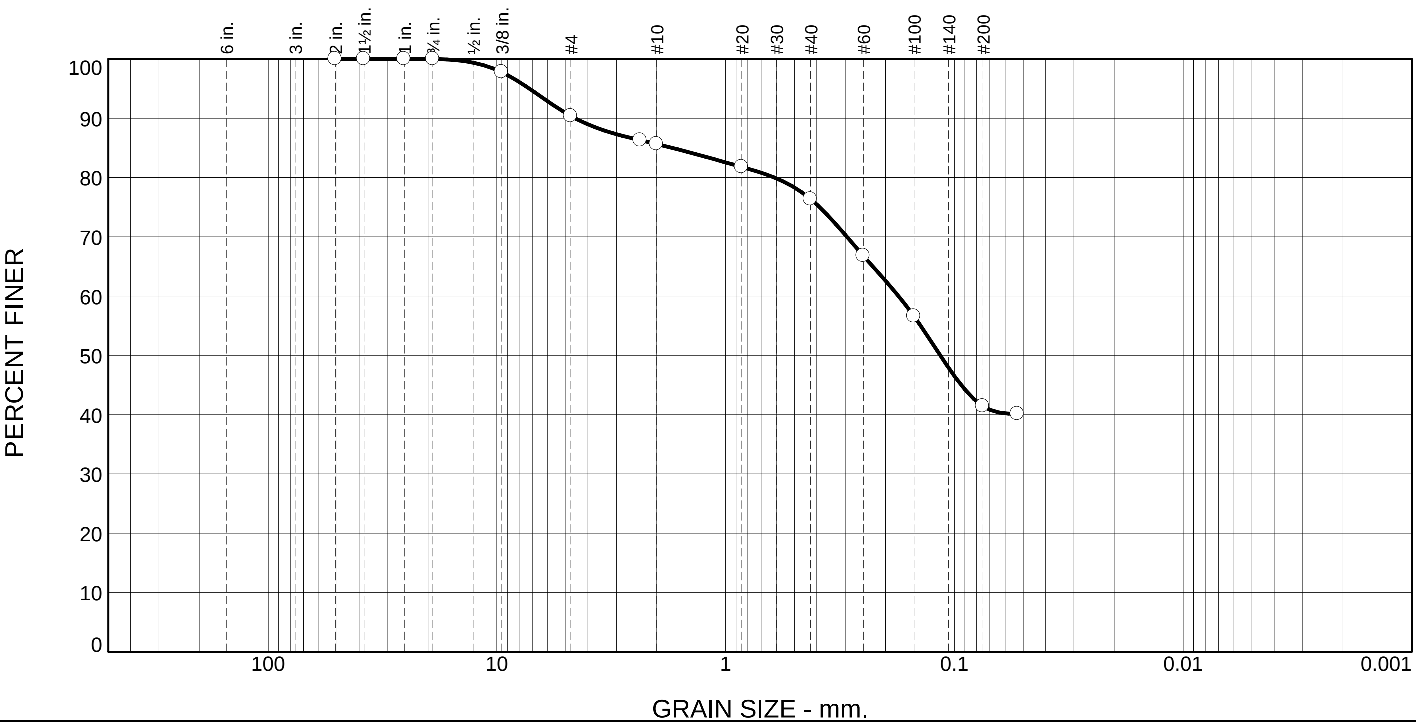
Source of Sample: (RSH) Renton- Sunset Harrington Green Street **Depth:** 0.2'-0.5' **Date Sampled:** 10/10/2018
Sample Number: HA-2/WP

a s s o c i a t e d
e a r t h s c i e n c e s
i n c o r p o r a t e d

Client: Clear Creek Solutions
Project: Bioretention Hydrologic Performance Study

Project No: 150387 H004 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	9.6	4.8	9.2	35.0	41.4	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
2	100.0		
1.5	100.0		
1	100.0		
.75	100.0		
.375	97.8		
#4	90.4		
#8	86.3		
#10	85.6		
#20	81.8		
#40	76.4		
#60	66.8		
#100	56.6		
#200	41.4		
#270	40.1		

* (no specification provided)

Material Description

very silty SAND, some gravel

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-4(0)

Coefficients

D_{90}= 4.5609 D_{85}= 1.7135 D_{60}= 0.1754
D_{50}= 0.1153 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Collected by: ADY

Date Received: 10/16/2018 **Date Tested:** 10/18/2018

Tested By: MS

Checked By: JHS

Title:

Source of Sample: (RSH) Renton- Sunset Harrington Green Street **Depth:** 1.3'-2' **Date Sampled:** 10/10/2018
Sample Number: HA-2/WP

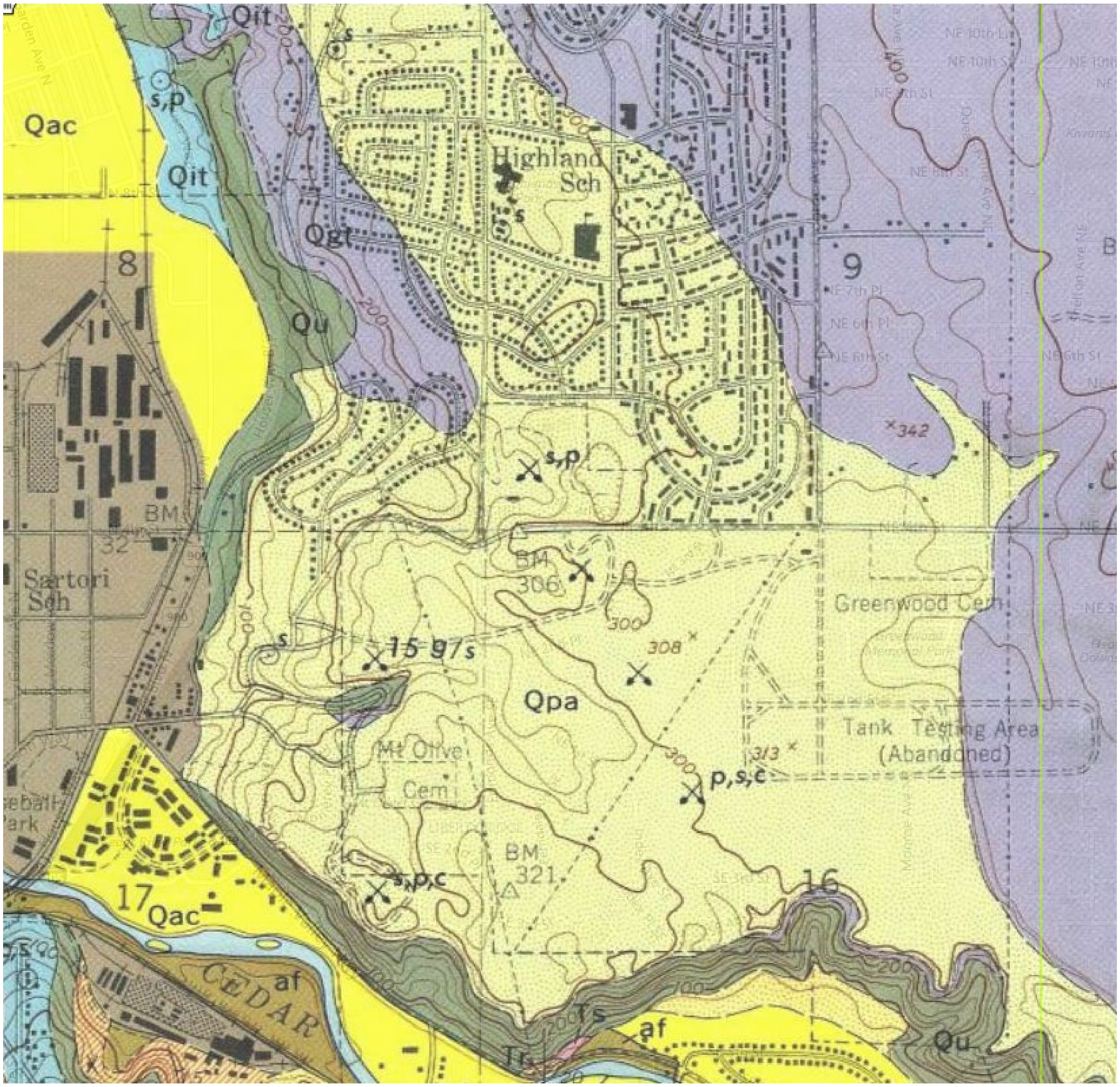
associated earth sciences incorporated

Client: Clear Creek Solutions
Project: Bioretention Hydrologic Performance Study

Project No: 150387 H004 **Figure**

APPENDIX C

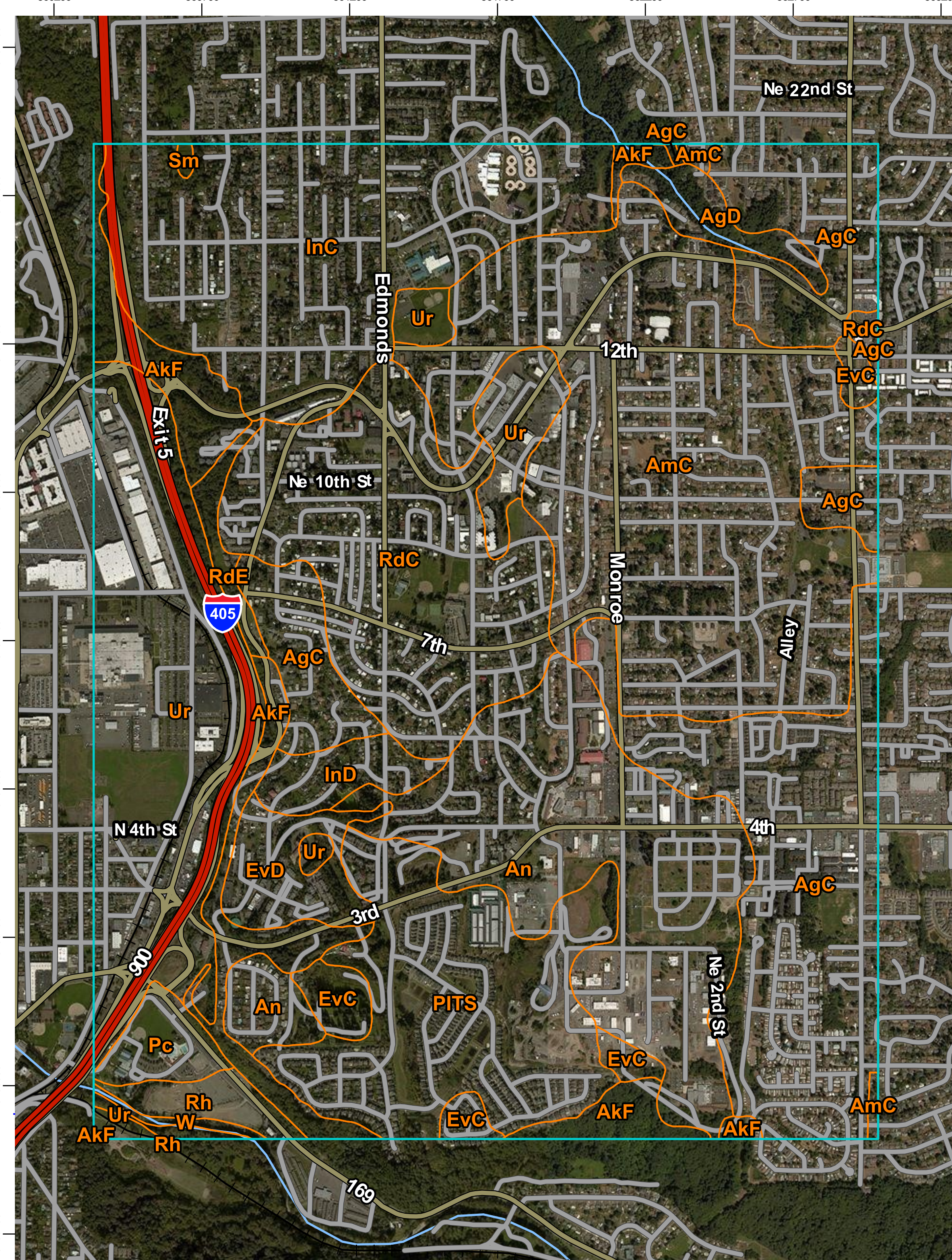
Background Soil, Geology, and Groundwater Data (Regional Maps, Previous Studies Exploration Logs and Laboratory Testing Data)



Excerpt from:

Mullineaux, D.R., *Geologic Map of the Renton Quadrangle, King County, Washington*, 1965, U.S. Geological Survey (USGS), Geologic Quadrangle Map GQ-405, scale 1:24,000.

122° 12' 7" W
122° 9' 35" W
47° 30' 47" N
47° 28' 30" N



Map Scale: 1:20,600 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0, 300, 600, 1200, 1800

Feet: 0, 1000, 2000, 4000, 6000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: King County Area, Washington
Survey Area Data: Version 14, Sep 10, 2018

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 31, 2013—Jul 15, 2014

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
AgC	Alderwood gravelly sandy loam, 8 to 15 percent slopes	340.3	15.4%
AgD	Alderwood gravelly sandy loam, 15 to 30 percent slopes	21.5	1.0%
AkF	Alderwood and Kitsap soils, very steep	100.9	4.6%
AmC	Arents, Alderwood material, 6 to 15 percent slopes	416.2	18.8%
An	Arents, Everett material	244.4	11.1%
EvC	Everett very gravelly sandy loam, 8 to 15 percent slopes	29.7	1.3%
EvD	Everett very gravelly sandy loam, 15 to 30 percent slopes	38.5	1.7%
InC	Indianola loamy sand, 5 to 15 percent slopes	257.9	11.7%
InD	Indianola loamy sand, 15 to 30 percent slopes	25.5	1.2%
Pc	Pilchuck loamy fine sand	22.6	1.0%
PITS	Pits	182.5	8.3%
RdC	Ragnar-Indianola association, sloping	215.6	9.8%
RdE	Ragnar-Indianola association, moderately steep	12.9	0.6%
Rh	Riverwash	23.2	1.1%
Sm	Shalcar muck	1.4	0.1%
Ur	Urban land	271.6	12.3%
W	Water	4.0	0.2%
Totals for Area of Interest		**2,208.6**	**100.0%**

Figure 4
Shallow Till Locations
Renton Sunset Stormwater Retrofit / LID Project
DRAFT Geotechnical Data and Recommendations Report

APPENDIX D

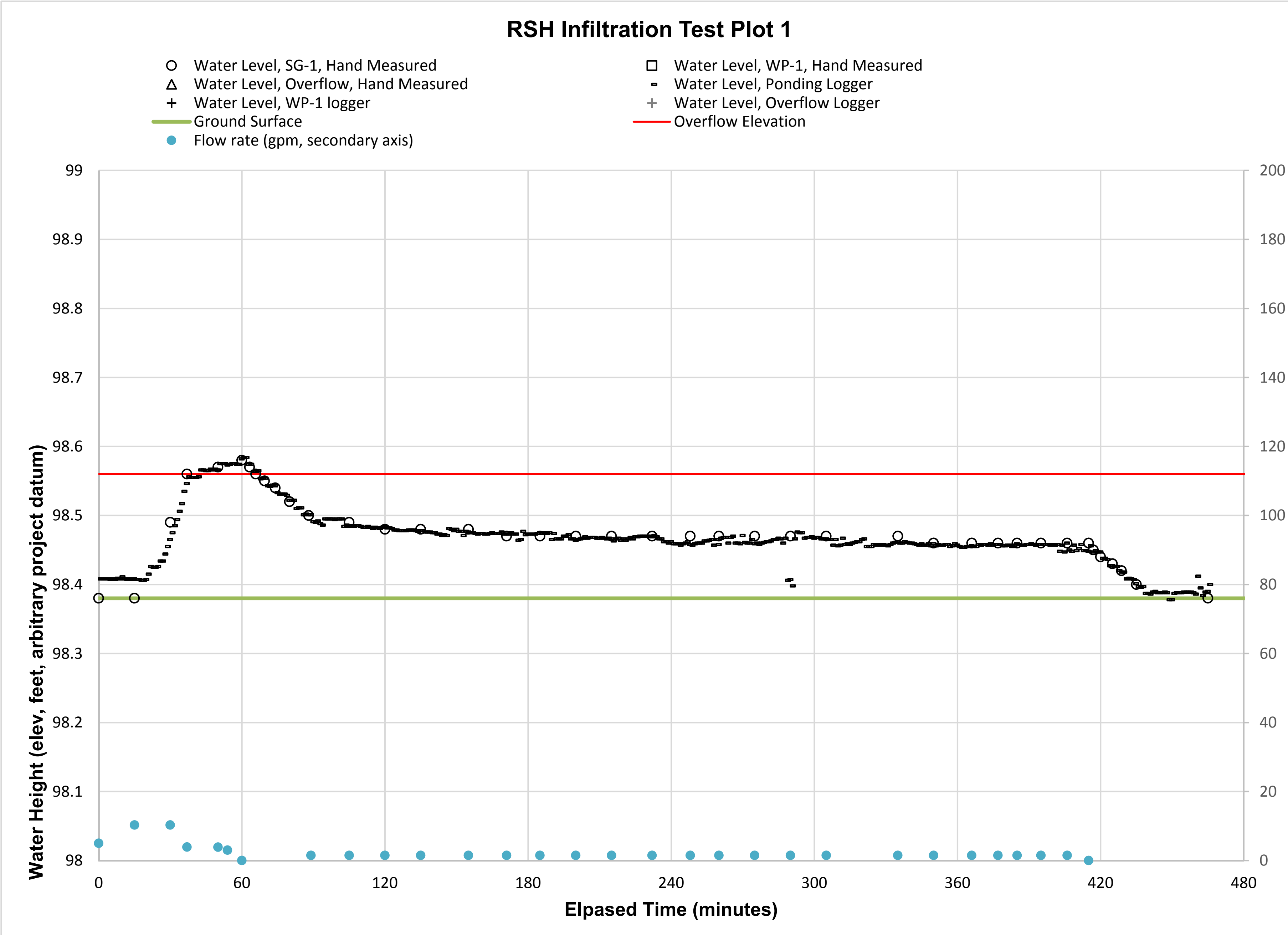
Soil Probe, Level Survey, and Field Infiltration Testing Data

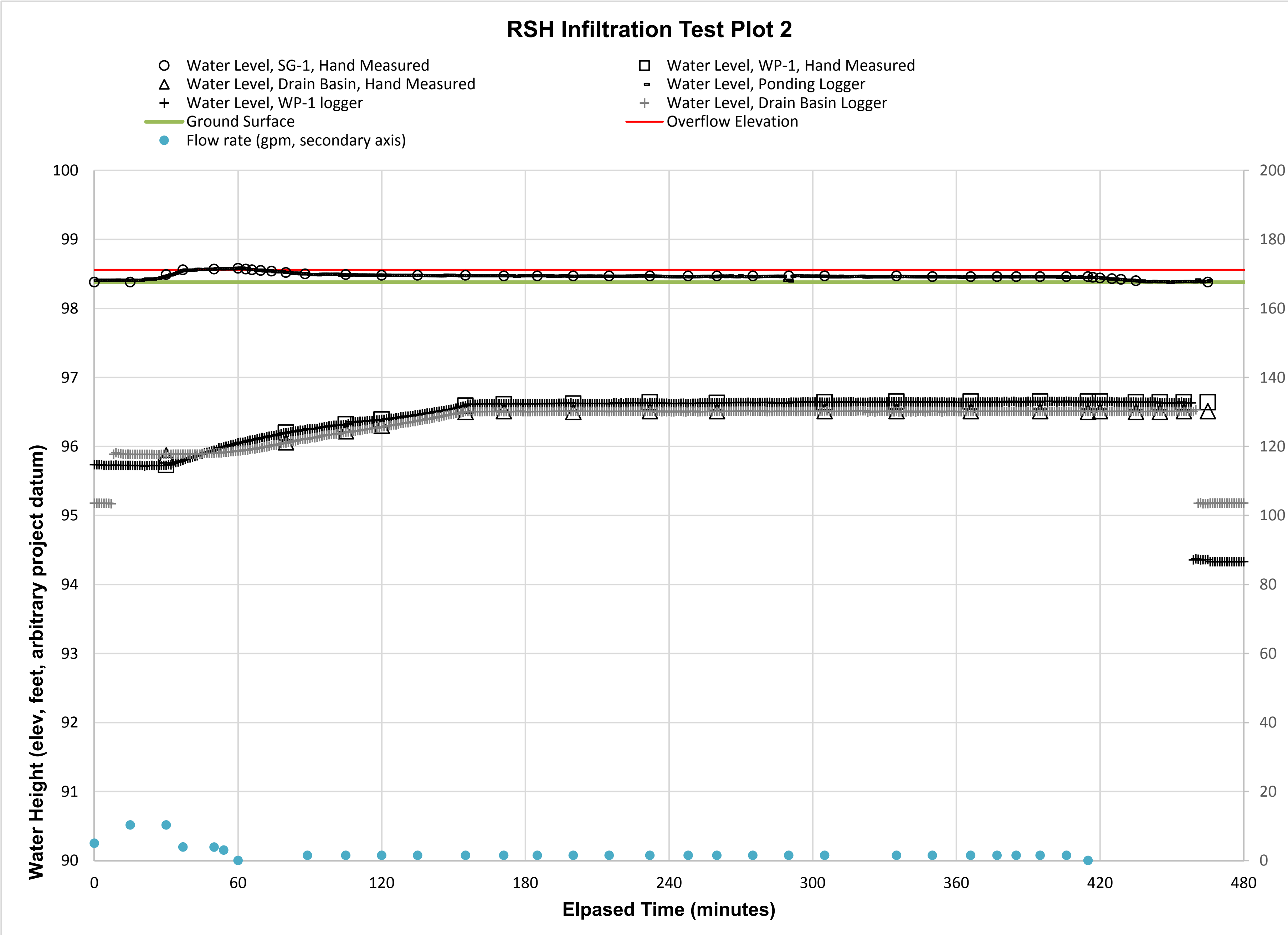
Project Name:	BHPS	**Water Source:**	Hydrant
Project Number:	150387H007	**Meter:**	AESI FM9
Date:	11/5/2018	**Base Area (sq.ft.):**	NA
Weather:	Partly cloudy, 60's	**Ponded Area(sq.ft.):**	80.0
Test No.:	RSH	**Test Depth (feet):**	NA
Performed By:	ADY, SC	**Receptor Soils:**	Recessional Outwash

Time (24-hr)	Flow Rate (gpm)	Stage (feet)	Totalizer (gallons)	Comments
8:18				
8:23				
8:25	5.01	0	0	Flow on
8:40	10.3	0	77.84	
8:55	10.28	0.11	231	Ponding below inlet
9:02	3.91	0.18		
9:15	3.89	0.19	352.23	
9:19	3.02		369.89	
9:25	0	0.2		Flow off.
9:28		0.19		
9:30		0.18		
9:34		0.17		
9:39		0.16		
9:45		0.14		Dripping aroud overflow rim, into overflow.
9:53		0.12		
9:54	1.5		0	Flow on FM8
10:10	1.51	0.11	24.4	
10:25	1.5	0.1	47.52	
10:40	1.49	0.1	70.22	
11:00	1.49	0.1	99.38	dribbling into overflow around edge of metal
11:16	1.5	0.09	123.8	rifice from underdrain, continues through re
11:30	1.5	0.09	145.81	
11:45	1.5	0.09	166.96	
12:00	1.5	0.09	189.64	
12:17	1.49	0.09	214.88	
12:33	1.5	0.09	240	
12:45	1.49	0.09	258	
13:00	1.49	0.09	279	
13:15	1.5	0.09	302	
13:30	1.5	0.09	324	Light rain begins
14:00	1.49	0.09	369	infall becomes moderate. No inflow observe
14:15	1.49	0.08	392	Rain stops. No inflow observed.
14:31	1.49	0.08	416	
14:42	1.5	0.08	433	
14:50	1.49	0.08	446	
15:00	1.49	0.08	459	
15:11	1.49	0.08	475	
15:20	0	0.08	489	Flow off
15:22		0.07		
15:25		0.06		
15:30		0.05		
15:33		0.04		
15:40		0.02		Underdrain still flowing.
15:50		dry		
16:00				

16:10				

Average Infiltration Rate (in/hr) during last hour of inflow:	1.8
Average Infiltration Rate (in/hr) during falling head:	2.2


RSH Infiltration Test Plot 1
Water Level, SG-1, Hand Measured
Water Level, Overflow, Hand Measured
Water Level, WP-1 logger
Ground Surface
Flow rate (gpm, secondary axis)
Water Level, WP-1, Hand Measured
Water Level, Ponding Logger
Water Level, Overflow Logger
Overflow Elevation
Water Height (elev, feet, arbitrary project datum)
Elpased Time (minutes)
99
98.9
98.8
98.7
98.6
98.5
98.4
98.3
98.2
98.1
98
0
60
120
180
240
300
360
420
480
200
180
160
140
120
100
80
60
40
20
0


RSH Infiltration Test Plot 2
Water Level, SG-1, Hand Measured
Water Level, Drain Basin, Hand Measured
Water Level, WP-1 logger
Ground Surface
Flow rate (gpm, secondary axis)
Water Level, WP-1, Hand Measured
Water Level, Ponding Logger
Water Level, Drain Basin Logger
Overflow Elevation
Water Height (elev, feet, arbitrary project datum)
Elpased Time (minutes)
100
99
98
97
96
95
94
93
92
91
90
200
180
160
140
120
100
80
60
40
20
0
0
60
120
180
240
300
360
420
480

APPENDIX E

Site Photos

Cell RSH, primary curb cut inlet. Above photo is prior to install of weir.
Lower photo is after weir install and during infiltration testing. Well point visible.

Above photo: RSH secondary curbcut. Overflow beehive visible in vegetation. Orange cone next to drain basin structure. Lower Photo: view of secondary curbcut, overflow and drain basin.

Technical Memorandum

Date:	June 14, 2019	**From:**	Anton Ympa Suzanne Cook, L.G.
To:	Clear Creek Solutions, Inc.	**Project Manager:**	Jennifer H. Saltonstall, L.G., L.Hg.
	15800 Village Green Drive #3 Mill Creek, Washington 98012	**Principal in Charge:**	Jennifer H. Saltonstall, L.G., L.Hg.
cc:	Eric Christensen	**Project Name:**	Bioretention Hydrologic Performance Study
Attn:	Doug Beyerlein, P.E.	**Project No:**	150387H007
Subject:	Deliverable Task 4.5, Site SSW, Geotechnical/Soils Assessment Design Data and Current Conditions, Salem Woods Elementary School, Snohomish County, Washington		

1.0 INTRODUCTION

This technical memorandum documents existing shallow soil and groundwater conditions in Bioretention Cell #2 of the Salem Woods Elementary School Project, located in the Monroe area of unincorporated Snohomish County, Washington (Figure SSW F1). This memorandum was prepared in accordance with Task 4 of the contract scope of work. Associated Earth Sciences, Inc. (AESI) collected shallow soil and groundwater conditions data related to bioretention cell function, and documented the current condition of the facility relative to the as-built drawings and available background geotechnical information. The information will be used in the WWHM2012 modeling that will be conducted as part of Task 5 (Data Analysis). In Task 5, the team will compare the previously documented hydrologic design information with our field-collected information and will note where there are significant differences. The purpose of this technical memorandum is to document the collection of current and accurate geotechnical, geologic, and hydrogeologic site information for this later work.

The following summary of shallow soil and groundwater conditions integrates the observations made during the geotechnical assessment which included site visits on October 9, 2018, infiltration testing on November 1, 2018, provisional results of hydrologic monitoring, and background geotechnical information.

This technical memorandum has been prepared for the exclusive use of Clear Creek Solutions and the City of Olympia and their agents for specific application to this project. Within the limitations of scope, schedule, and budget, our services have been performed in accordance with generally accepted hydrogeologic and geotechnical engineering practices in effect in this area at the time our document was prepared. No other warranty, express or implied, is made.

2.0 PURPOSE AND SCOPE

The purpose of our work was to perform a shallow soil and groundwater conditions assessment and provide baseline documentation data to assess effectiveness of bioretention hydrologic performance.

Specifically, our scope included the following activities:

- Review of project documents.
- Site reconnaissance.
- Visual condition assessment of erosion and deposition features near inlet and outlet.
- Review project plans relative to constructed facility, in particular, the number and location of inlets, energy dissipation devices, outlets, and other flow-related details.
- Survey elevations of inlet, outlet, well point rim, and other observation points relative to a project datum.
- Excavate shallow hand augers through the bioretention soil.
- Classify sediment according to the Unified Soil Classification System (USCS) and *American Society for Testing and Materials* (ASTM) D2488, “Standard Recommended Practice for Description of Soils.”
- Collect samples for laboratory testing of: (1) particle size distribution in accordance with ASTM D422-63, “Standard Test Method for Particle-Size Analysis of Soils”; (2) organic matter content per ASTM D2974.
- Preparation of descriptive exploration logs for each exploration.
- Conduct qualitative assessment of soil compaction via T-probe.
- Conduct infiltration testing.
- Review of hydrologic monitoring data.
- Preparation of this summary document.

Existing facility features and the locations of hand-auger boreholes completed for this study are shown on Figure SSW F2, “Facility and Exploration Plan.” Project civil plans are attached as Appendix A. Exploration logs and laboratory testing data conducted as part of this study are attached as Appendix B. Background soil, geology, and groundwater information are attached as Appendix C. Soil probe, level survey, and field infiltration testing data are attached as Appendix D. Site photos are attached as Appendix E.

3.0 SITE DESCRIPTION AND DESIGN BACKGROUND

The project site is the Salem Woods Elementary School Project, located in the Monroe area of unincorporated Snohomish County, Washington as shown on the attached “Vicinity Map” (Figure SSW F1). The Salem Woods Elementary School is located on an approximate 14-acre parcel. The site is located in a rural residential area north of the city of Monroe, bordered by Wagner Road on the east and residential parcels to the north, south, and west. The southwest portion of the site is undeveloped and vegetated with young to mature trees and is occupied by Richardson Creek which enters the site at the western property line and exists to the south. As described in the Drainage Report (Harmsen & Associates, Inc. [Harmsen], 2017), the topography of the site slopes at an average of 2.0 percent from elevation 325 at the northeast corner of the existing parking lot to 310 along the south property line, Richardson Creek and associated wetland is located in a lower area on the southwestern corner of the site, and there is an associated 100-year flood plain along Richardson creek that extends partly onto the school site. According to the Critical Aquifer Recharge Areas Report (AESI, 2016), the site is located in a moderate aquifer sensitivity area with a depth of aquifer between 40 and 100 feet.

Our specific area of study for this project includes bioretention facility cell #2 located on the west-central portion of campus referred to as cell SSW for this study. The attached "Facility and Exploration Plan" (Figure SSW F2) illustrates the cell area and some of the surrounding site features and utilities.

Details of the bioretention facility design and basis for design were presented in the following documents:

- Associated Earth Sciences, Inc., 2016, Subsurface Exploration, Geologic Hazards, and Geotechnical Engineering Report, Salem Woods Elementary School, 12802 Wagner Road, Snohomish County, Washington: Prepared for Monroe Public Schools, July 6, 2016.
- Associated Earth Sciences, Inc., 2016, Critical Aquifer Recharge Areas Report, Salem Woods Elementary School, Snohomish County, Washington: Prepared for Monroe Public Schools, September 28, 2016.
- Associated Earth Sciences, Inc., 2017, In-Situ Infiltration Testing and Design Infiltration Rate Recommendations, Salem Woods Elementary School: Prepared for Monroe Public Schools, May 1, 2017.
- Harmsen & Associates, Inc., 2017, Full Drainage Report for Salem Woods Elementary School, Snohomish County, Washington, January 19, 2017.
- DLR Group, 2017, Salem Woods Elementary School, Construction Documents, May 16, 2017 (plan set).
- Associated Earth Sciences, Inc., 2018, Salem Woods Elementary School, Project No. 160200E004, Selected Field Reports, August 2018.
-

3.1 Summary of Facility Design

From our review of these documents, the bioretention facility design for cell SSW consists of an approximately kidney-shaped bioretention cell with approximately 1,170 square feet of base area (DLR Group, 2017), as shown on Figure SSW F2, "Facility and Exploration Plan." We understand that the site was developed under the 2016 *Snohomish County Drainage Manual* for design and construction of stormwater facilities and modeled using WWHM2012 with a design infiltration rate of 1.5 inches per hour (in/hr) for the bioretention soil; in the native subgrade infiltration rate exceeded the bioretention soil rate. As described in the drainage report, land use within the drainage basin consists primarily of pavement and walks (0.46 acres), and landscaping (0.22 acres) with minor roof area (0.03 acres). Per plan sheet C3.20, "Full Drainage Notes & Details" (DLR Group, 2017), the facility design includes 18 inches of bioretention soil mix overlying existing subgrade (native soil).

The facility is designed to infiltrate 100 percent of inflow into the subgrade. Stormwater is designed to enter the facility through two inlets. One inlet is designed as asphalt pavement graded to allow sheet flow to enter the cell on the west side via a small swale at the pavement edge. The second inlet (apparent not installed) is designed as a 6-inch outfall draining a yard drain via a 6-inch polyvinyl chloride (PVC) pipe on the east end. If water ponds up on the bioretention soil, the ponded water would discharge into a Type I Catch Basin (SDCB #4) with a beehive grate located near the west edge of the cell, and then into the perforated pipe laterals in the rock-filled trench situated beneath the bioretention soil. The rim of the Type I Catch Basin was designed to be 12 inches higher than the cell base to create 12 inches of ponding depth. The facility was constructed during July through October 2018 and began receiving runoff in November 2018.

4.0 SITE OBSERVATIONS

During AESI's site visits, we made notes regarding the physical construction of the bioretention facilities including documenting site inlet/outlet layout relative to site plans and qualitative bioretention soil thickness and compaction. These notes were used to indicate key features of the facility in Figure SSW F2, "Facility and Exploration Plan."

- Level Survey: AESI conducted an elevation survey of the cell using a Leitz C40 automatic level and a stadia rod. An arbitrary project datum was established for this survey, with the south corner of the fire hydrant concrete pad north of the cell defined as project datum elevation 100 feet. All other elevations measured by the survey are relative to this project datum. Key level data is summarized in Table 1. Additional data points are included in Appendix D to this document. This survey was not conducted by a licensed surveyor. Surveyed elevations are expected to be sufficiently accurate for this general assessment of facility construction, but may be inaccurate for purposes requiring greater precision.

- Inflow: Although two inflows are indicated on the plan, only one inflow to cell SSW was observed.
  - Primary inflow: The primary inflow to the facility consists of asphalt pavement graded to allow sheet flow to enter the cell on the west side via a small swale at the pavement edge. Inflow discharges onto a quarry spalls energy dissipation pad approximately 6 feet wide and 9 feet long. A significant amount of water was discharging at the time of our November 1, 2018 site visit, and formed a pool of water (about 21 feet by 12 feet) near the inlet and west portion of the cell.

  - Secondary inflow (apparently not installed): A second inflow outfall on the east end of the facility was not observed. A large quarry spall pad was observed on the east end, but the outfall (#9A) and yard drain pipe was not installed. A yard drain (YD#9) is present near the location indicated on plans east of the cell, however the yard drain pipe is directed east away from the cell.

- Overflow: The overflow consists of a Type I Catch Basin (SDCB #4) with a beehive grate. The rim of this grate was approximately 1.4 feet above the base of the facility which is higher than designed at 12 inches of ponding depth (DLR Group, 2017).

- AESI investigated the loose bioretention soil thickness present in cell SSW using a geotechnical soil T-probe. This qualitative data was used in conjunction with the hand-auger observations to understand loose soil thickness and relative potential compactness of the bioretention soils at depth. AESI measured the depth of penetration of the soils probe at locations generally arranged in a 4-foot to 5-foot grid on the facility base. Penetration of the T-probe generally ranged from approximately 0.3 feet to 2.1 feet, and averaged 1.5 feet. Probe data and hand-auger SSW-HA-3 indicate that some compaction of soils has occurred near the north-central portion of the cell. Probe penetration data is included in Appendix D to this document.

Table 1
Summary of Cell SSW
Level Survey Data

Location	Elevation (feet, project datum)
Hydrant concrete pad - south corner	100.00
SSW-WP-1 TOC	97.87
Ground surface at SSW-WP-1 (north) and temporary staff gauge SSW-SG-1	96.21
Ponding Tube TOC (DL)	98.16
Inflow, center inside lip asphalt	97.53
Temporary inlet pipe top/end	97.54
Overflow rim corner (southeast)	97.56
Concrete pad #1, south corner	98.66
Concrete pad #2, south corner	97.87

WP: well point; TOC: top of Casing; DL: datalogger;

5.0 SITE SETTING

The text sections below describe our research findings in regards to the topographic, geologic, and hydrogeologic setting of the project site both from regional studies and background site-specific geotechnical and groundwater studies. Our sources of information included the following:

- Site-specific documents cited previously under “Project and Site Description.”

- Dragovich, J., et al., 2015, *Geologic Map of the Lake Roesiger 7.5-minute Quadrangle, Snohomish County, Washington*, Washington State Department of Natural Resources (DNR), scale 1:24,000
- Natural Resources Conservation Service (NRCS), Web Soil Survey, United States Department of Agriculture (USDA), http://websoilsurvey.nrcs.usda.gov/, accessed December 2018.
- *Soil Survey of Snohomish County Area, Washington*, United States Department of Agriculture (USDA), Natural Resource Conservation Service (NRCS), in cooperation with Washington Agricultural Experiment Station, 1983.
- Thomas, B.E., Wilkinson, J.M., and Embrey, S.S., 1997, *The Ground-water System and Groundwater Quality in Western Snohomish County, Washington*: U.S. Geological Survey (USGS), U.S. Department of the Interior.

5.1 Regional Topography and Project Grading

The site and vicinity are generally north of the city of Monroe and west of Wagner Lake. Topographic features in the vicinity of the site were formed by glacial and post-glacial processes. Elongate, northwest-southeast-trending hills and swales parallel the flow direction of an ice sheet that occupied the Puget Lowland about 15,000 years ago, which have been incised by glacial and post-glacial river channels. Elevations on the larger project site range from about 310 to 325 feet.

On a closer scale, the area near cell SSW is relatively level, situated on an outwash terrace at about elevation 310 to 320 feet, and gently sloping southwestward toward Richardson Creek, approximately 200 feet away. The cell is about 10 feet higher in elevation than Richardson Creek. Cell SSW is surrounded generally by access road and parking to the north and west, a large building to the south and lawn to the east.

The project site was previously developed as Salem Woods Elementary School which was demolished to allow for the construction of the new Salem Woods Elementary School. Cell SSW area was previously a relatively level field with elevations of about 316 to 317 feet. Minor cutting (about 5 to 6 feet) was needed to achieve design bioretention cell grades based on a review of existing topography compared with built topography.

5.2 Regional Geology and Background Geotechnical Information

According to the geology map, (Dragovich et al., 2015), the site vicinity is underlain by fluvial outwash deposited during the Vashon Stade of the Fraser Glaciation. The geologic unit was deposited in valleys that remained after the Vashon glacier retreated at the end of the Vashon Stade of the Fraser Glaciation. The interpretation of the sediments encountered at the subject site during our geotechnical and infiltration studies (AESI, 2016 and 2017) is generally consistent with the regional geologic map.

- <u>Fluvial Outwash Qgof/Vashon Recessional Outwash (Qvr)</u>: Sediments encountered below the existing topsoil and/or fill generally consisted of gray sandy gravel with cobbles and trace amounts of silt. Fluvial outwash deposits were deposited by the retreating continental glacier during the Vashon Stade of the Fraser Glaciation approximately 12,500 to 15,000 years ago. Therefore, these sediments were not glacially consolidated.

Background geotechnical information includes explorations EP-1 to EP-3, EP-11, IT-2, and EB-2 within 100 feet of cell SSW dated June and September 2016 reached depths of about 4 to 19 feet below current grades, and describe material interpreted to be Vashon recessional - fluvial outwash deposits near the surface or underlying existing fill soils. In the explorations, the outwash consisted of sandy gravel to gravelly sand with trace to some silt. The fluvial outwash deposits contain cobbles and occasional boulders and were encountered to depths up to 17 feet below the surface. Interbeds of laminated silts and fine sands were also encountered at a variety of depths between 3 and 12 feet below the surface, within the fluvial deposits in the exploratory pits and the infiltration test pits (AESI, 2016 and 2017). This interpretation is consistent with the geologic mapping in the area.

Infiltration testing was conducted as part of design. Infiltration test IT-2 was located near cell SSW (bioretention cell #2) with a field infiltration rate of about 40 inches per hour. Subsurface information from the footprint of the bioretention cell during construction (Appendix C, August 2018 field report) indicates that the base of the cell was situated in outwash (sandy gravel).

5.3 Regional Soils and Soil Data Used in Site Stormwater Model

AESI reviewed the soil survey (Natural Resources Conservation Service [NRCS], 1983) and soils mapping from the NRCS web portal (NRCS, 2018). The soil survey identifies different soil map units based on parent material, climate, topography (slope), organisms (biota), and time. The soils in the study area formed mostly from young glacial deposits and have not had time to develop the deep weathering profiles present in soils in unglaciated terrains. Instead, they exhibit a direct relationship to the underlying parent material, local climate, topography, and vegetation.

Mapped soils in the project area consist of Tokul gravelly loam, 0 to 8 percent slopes. This unit is described as being associated with till plains and hillslopes, and its parent material is listed as volcanic ash mixed with loess over glacial till. A small portion of the site along the north-central property line is classified as Tokul-Winston gravelly loams, 25 to 65 percent slopes. This unit is described as being associated with escarpments and till plains, with parent material being described as volcanic ash over basal till. We recommend that the site soils be considered “outwash” where the outwash soils were more than 5 feet in thickness, consistent with our subsurface explorations. NRCS describes the permeability as moderate above the glacial till and very slow within glacial till (NRCS, 1983).

As described in the Drainage Report (Harmsen, 2017), the pre-developed condition was modeled as Type C soils, not consistent with the background geotechnical data that indicates surface soils in the vicinity of bioretention cell #2 consisting of sand and gravel. Other areas of the site had glacial till at the ground surface.

5.4 Regional Hydrogeology and Background Groundwater Data

Regional hydrogeology is described in Thomas et al. (1997). Thomas et al. (1997) indicate that recessional outwash can be an aquifer where saturated, and that perched groundwater conditions can occur locally within these units. This unit typically overlies Vashon lodgement till, which is described by Thomas et al. (1997) as typically a confining bed.

According to our geotechnical studies at the site (AESI, 2016 and 2017), a thin groundwater-bearing interval is present at shallow depths beneath the site within the coarse-grained fluvial outwash deposits at the contact with the underlying glacial till. Groundwater seepage was encountered in exploration pits EP-1 and EP-2 near cell SSW and was typically encountered just above the top of the Vashon lodgement till. This groundwater likely represents an unconfined shallow aquifer within the fluvial outwash deposits measuring a few to less than 10 feet thick in our explorations. Limited background groundwater level data was collected at two monitoring wells and two well points; groundwater ranged from approximately 8 to 11 feet below ground surface in March 2017 (AESI, 2017), or within about 4 to 6 feet below the top of bioretention soil layer (planned elevation of 312 feet). Hydrographs are included in Appendix C.

Based on groundwater levels recorded during our studies, the aquifer flow direction is generally to the southwest, downslope toward Richardson Creek. The aquifer is recharged by precipitation and responds relatively quickly to rainfall events (AESI, 2017).

6.0 BIORETENTION CELL SUBSURFACE EXPLORATION

Limited information on subsurface conditions was obtained for this study from hand-auger samples and soil probe penetration measurements at about 2-foot increments in each hand-augered borehole. Three hand-auger borings were performed in the facility bottom and advanced through the bioretention soil. Two of the borings were also advanced into native material underlying the bioretention soil (SSW-HA-2 and SSW-HA-3). Representative samples were collected, visually classified in the field, stored in water-tight containers, and transported to AESI's offices for additional classification, geotechnical testing, and study. At the conclusion of the excavation, the boreholes were immediately backfilled with the excavated material or completed as a well point for water level monitoring (described separately below).

The various types of sediments, as well as the depths where characteristics of the sediments changed, are indicated on the exploration logs presented in Appendix B. A detailed record of the observed bioretention soil, subsurface soil, geology, and groundwater conditions was made. The sediments were described by visual and textural examination using the soil classification in general accordance with ASTM D2488, "Standard Recommended Practice for Description of Soils." The depths indicated on the logs where conditions changed may represent gradational variations between sediment types in the field. The exploration logs in Appendix B are based on the field observations, inspection of the samples, and where applicable, laboratory grain-size analysis. Our explorations were approximately located in the field relative to known site features, and are shown on Figure SSW F2, "Facility and Exploration Plan."

The results presented in this document are based on the explorations completed for this study and review of background data. The number, locations, and depths of the explorations were completed within site and budgetary constraints. Because of the nature of exploratory work below ground, interpolation of subsurface conditions between field explorations is necessary. It should be noted that differing subsurface conditions may sometimes be present due to the random nature of deposition and the alteration of topography by past grading and/or filling.

6.1 Hand-Auger Borings

Hand-auger borings in cell SSW were completed on October 9, 2018. No rainfall was noted at the time of exploration.

Hand-auger boring locations are presented on Figure SSW-F2. The hand-auger borings encountered a thin layer of wood chips overlying bioretention soil to a depth of 2.1 to 2.2 feet overlying native Vashon recessional outwash (SSW-HA-2 and SSW-HA-3). Hand-auger SSW-HA-1 was terminated on gravel at the base of the bioretention soil at 2.2 feet. Bioretention soil thickness was 1.9 to 2.0 feet in each boring. No seepage or caving was observed.

6.2 Well Points

One well point was installed in SSW-HA-2 (WP-1) a depth of 3.0 feet, and screened within the bioretention soil and into the native sandy gravel beneath the soil. Key well point dimensions are provided in Table 2, below.

Table 2
Summary of Cell SSW
Well Point Dimensions

Well Point	Exploration in which Well Point was installed	Total Length of Casing (feet)	Interior Diameter	Stickup Height (feet)	Total Depth Inside Casing Below Ground Surface
SSW-WP-1	SSW-HA-2	4.7	1.25 inch nominal	1.7	3.0

7.0 LABORATORY ANALYSIS

Laboratory testing included mechanical grain-size distribution and percent organic matter by weight in accordance with the ASTM D422 and D2974, respectively. Bioretention soil was first tested for organic matter content and then the burned material was tested for grain-size distribution for comparison with the aggregate fraction of the bioretention soil mix guidance in the 2014 Washington State Department of Ecology (Ecology) *Stormwater Management Manual for Western Washington* (2014 Ecology Manual). Two samples of material interpreted as representative of the bioretention soil were tested for grain-size distribution. The data are summarized in Table 3.

Table 3
Summary of Cell SSW
Organic Content and Grain-Size Data

Exploration Number	Depth (feet)	Soil Type	Organic Content (% by weight)	USCS Soil Description	Fines Content (% passing #200)	Cu	Cc	USDA Soil Texture*
SSW-HA-2	0.2-0.5	Bioretention Soil	16.8	SAND, some silt, trace gravel (SP-SM)	5.7	9.2	0.8	Sand
SSW-HA-3	0.2-0.5	Bioretention Soil	14.2	SAND, some silt, trace gravel (SW-SM)	5.0	10.0	1.1	Sand

USCS: Unified Soil Classification System; Cu: coefficient of uniformity; Cc: coefficient of curvature; USDA: U.S. Dept. of Agriculture; *No hydrometers were performed. USDA soil texture range assumes fines consist entirely of silt to entirely of clay.

7.1 Bioretention Soil Mix

We compared the organic content and burned fraction gradation against the general guidelines for the bioretention soil mix (Table 4).

The organic content of the tested bioretention soils ranged between 16.8 to 14.2 percent by weight. This is significantly higher than the recommended organic content by weight of 5 to 8 percent in the 2014 Ecology Manual.

The grain-size analysis test results on the burned soil fraction indicate that the bioretention soils tested correlate to a “SAND” with some silt and trace gravel based on ASTM D2487 USCS. The respective fines content as measured on the No. 200 sieve was 5.0 to 5.7 percent, higher than the recommended range of 2 to 5 percent. The coefficient of uniformity ranged from 9.2 to 10.0, meeting the recommended value of equal to or greater than 4. The coefficient of curvature ranged from 0.8 to 1.1, one sample below the recommended range of greater than or equal to 1 and less than or equal to 3. The soil mix was also out of the recommended ranges for other sand gradations, containing more than the recommended range of coarse sand. The tested bioretention soil was a poorly to well-graded sand.

7.2 Subgrade

In cell SSW, a sample of native recessional outwash was sieved. The tested material correlates to a very gravelly SAND, trace silt with 1 percent by weight of the material passing the No. 200 sieve.

The grain-size distribution data were also transformed to describe the USDA soil texture. The grain-size distributions were normalized to the No. 10 sieve—i.e., the coarse sand and gravel fraction of the sample is discounted and the remainder is taken as 100 percent of the sample. The fines were assessed relative to the No. 270 sieve. The respective USDA fines content as measured on the No. 270 sieve after adjusting to remove the weight retained on the #10 sieve was 2.5 percent for the native recessional outwash material.

Grain-size testing from a nearby infiltration test at the time of design (AESI, 2017) is included in Appendix C.

Table 4
General Guidelines for Bioretention Soil Mix (2014 Ecology Manual)
Compared to Averaged Cell SSW Site Data

Parameter	Recommended Range	Cell SSW
Organic Content (by weight)	5 to 8 percent	15.5 percent by weight
Cu coefficient of uniformity	4 or greater	9.6
Cc coefficient of curvature	1 to 3	1.0
Sieve Size	**Percent Passing**	
3/8" (9.51 mm)	100	100
#4 (4.76 mm)	95 to 100	96.6
#10 (2.0 mm)	75 to 90	69.9
#40 (0.42 mm)	25 to 40	29.6
#100 (0.15 mm)	4 to 10	10.2
#200 (0.074 mm)	2 to 5	5.4

Note: The general guidelines for mineral aggregate gradation are from Table 7.4.1 of the 2014 Ecology Manual.
mm: millimeters.

8.0 INFILTRATION TESTING

8.1 General Infiltration Test Method

The infiltration test was conducted in general accordance with the 2014 Ecology Manual. The test was conducted by discharging water into the facility for a "soaking period," to allow the receptor soils to become saturated. After completion of the soaking period, water was discharged into the cell at a rate sufficient to maintain a relatively constant head. This constitutes the "constant-head" phase of infiltration testing. Immediately following the constant-head phase of infiltration testing, flow into the facilities was discontinued, and the water level was monitored as it dropped. This constitutes the "falling-head" portion of the infiltration testing.

The water for testing was obtained from an on-site fire hydrant and conveyed to cell SSW with fire hoses. During infiltration testing, the water was conveyed into the bioretention cell via a digital flow meter with gallons per minute (gpm) and total gallon readouts, and discharged through a flow diffuser. Ponded water levels within the cell were monitored using a temporary staff gauge (SSW-SG-1) marked in 0.01-foot increments installed adjacent well point SSW-WP-1 and within a piezometer ("ponding tube") with a digital water level tape, and with digital pressure transducers. Data from the digital pressure transducers was compensated for barometric response using a separate digital barometer. The area of the pool was measured periodically during testing.

The infiltration test in cell SSW is discussed below, and results are presented in Table 5. Infiltration test data is included in Appendix D to this document.

8.2 Infiltration Test in Cell SSW

AESI performed infiltration testing on November 1, 2018. Steady rain was noted during the soaking portion of the testing but no rainfall was occurring during the constant-head portion of the test. Significant flow (between 5 and 40 gpm) from the inflow was present from the beginning of the testing through an elapsed time of about 290 minutes. Less than 1 gpm inflow was observed after 290 minutes to the end of the testing.

Table 5
Cell SSW
Infiltration Test Results

Test No.	Surface Area (square feet)	Discharge Time (minutes)	Total Volume Discharged (gallons)	Approximate Constant Head Level (feet)	Field Infiltration Rates	
					Constant Head Test (in/hr)	Falling Head Test (in/hr)
SSW (bioretention soil)	940	423	55,522	0.53	greater than native soil infiltration rate	
SSW (subgrade)	interpreted to be similar to wetted area				16	10

in/hr: inches per hour.

During this test, flow was initially adjusted between about 50 and 180 gpm to fill the cell bottom and stabilize the wetted area, then maintained at about 160 gpm for the duration of test. Inflow to the facility for the infiltration test was directed, through a diffuser, onto the cell. The entire cell base was wetted after about 30 minutes and a water level of about 0.5 feet was maintained at the staff gauge after approximately 160 minutes (SSW-SG-1, Figure SSW F2). The wetted pool area had been generally stable through most of the soaking and testing period covering an area of about 940 square feet. Approximately 55,500 gallons of water were used.

Perched water in the bioretention cell was monitored in well point SSW-WP-1 using a data logger during the infiltration test and responded to inflow. Groundwater was not observed within the bioretention soil prior to the start of inflow to the bottom depth of SSW-WP-1 (3 feet). The water level in SSW-WP-1 responded to inflow after about 140 minutes, and rose approximately 1.2 feet above the base of the well point to 0.7 feet below ground surface during the course of testing. AESI interprets this lag in response to indicate the time for water from infiltration testing to infiltrate through the bioretention soil and spread out along the contact with the native recessional outwash sediments. The shallow subsurface ponded water level mirrored the surface water ponding level.

After about 7 hours, AESI shut off the flow and monitored water level as it fell. AESI observed that the pooled water in the base of the facility infiltrated over the course of approximately 40 minutes.

The constant-head test infiltration rate in Table 5 is calculated based on flow rate from the hose for infiltration testing, and the wetted area of bioretention soil through which the water infiltrated, and represents the infiltration rate of the native subgrade.

9.0 CONCLUSIONS AND RECOMMENDATIONS

Cell SSW was generally consistent with the design shown on the civil plan sheets. Observations on site design, shallow soil and groundwater conditions are discussed below.

- Drainage area: is generally consistent with the plans. Site design documents indicate that the drainage area consists of 0.49 acres of pavement and roof tops and 0.22 acres of lawn. However, we observed that second inflow (outfall #9A) from a yard drain (YD #9) to the east was not directed to cell SSW, but toward the east. Therefore, a portion of the lawn that drains to YD #9 is not draining to cell SSW.

- The overflow is higher than design. Site plans (DLR Group, 2017) indicate that the ponding level was designed as 12 inches and the overflow rim was measured at 1.4 feet.

- Bioretention soil:
  - Thickness: The apparent thickness of loose bioretention soil based on soil probe data was on average about 1.5 feet as indicated on the plan. However an area of compacted soil was identified near the north-central portion of the cell bottom and hand-auger SSW-HA-3.
  - Composition: The soil tested out of the recommended ranges for sand gradations, containing more than the recommended range of coarse sand and slightly too much fine sand and silt.The organic content was significantly higher than the recommended range with an average of 15 percent.

- Subgrade conditions: The subgrade is interpreted to consist of Vashon recessional outwash, as documented during construction (AESI, 2018) and design reports (AESI, 2016 and 2017).

- During infiltration testing, water readily soaked through the bioretention soil mix. Water was observed in the shallow well point (screened at the base of the bioretention soil and into the upper portion of the recessional outwash), demonstrating that water accumulated on the underlying subgrade. The native recessional outwash is interpreted to have a lower permeability than the overlying bioretention soil. The shallow subsurface ponded water level mirrored the surface water ponding level.

- Bioretention soil field infiltration rate:

    - Greater than the measured field rate of 16 in/hr.
    - Water readily soaked through the bioretention soil mix and the field rate is interpreted to represent the native subgrade infiltration rate.
- Shallow groundwater is expected to be present in the location of the SSW facility below the bottom of well point SSW-WP-1 since it was encountered in several explorations onsite (AESI, 2016 and 2017).
- The effects of shallow groundwater mounding will increase during the wetter winter months, and will reduce the effective infiltration rate by reducing the vertical gradient. The ongoing monitoring data will be reviewed for groundwater influence.

10.0 CLOSURE

We appreciate the opportunity to be of continued service to you on this project. Should you have any questions regarding this document or other geotechnical/hydrogeologic aspects of the project, please call us at your earliest convenience.

State of Washington
Hydrogeologist
2335
Licensed Geologist
Jennifer H. Saltonstall

6/14/19

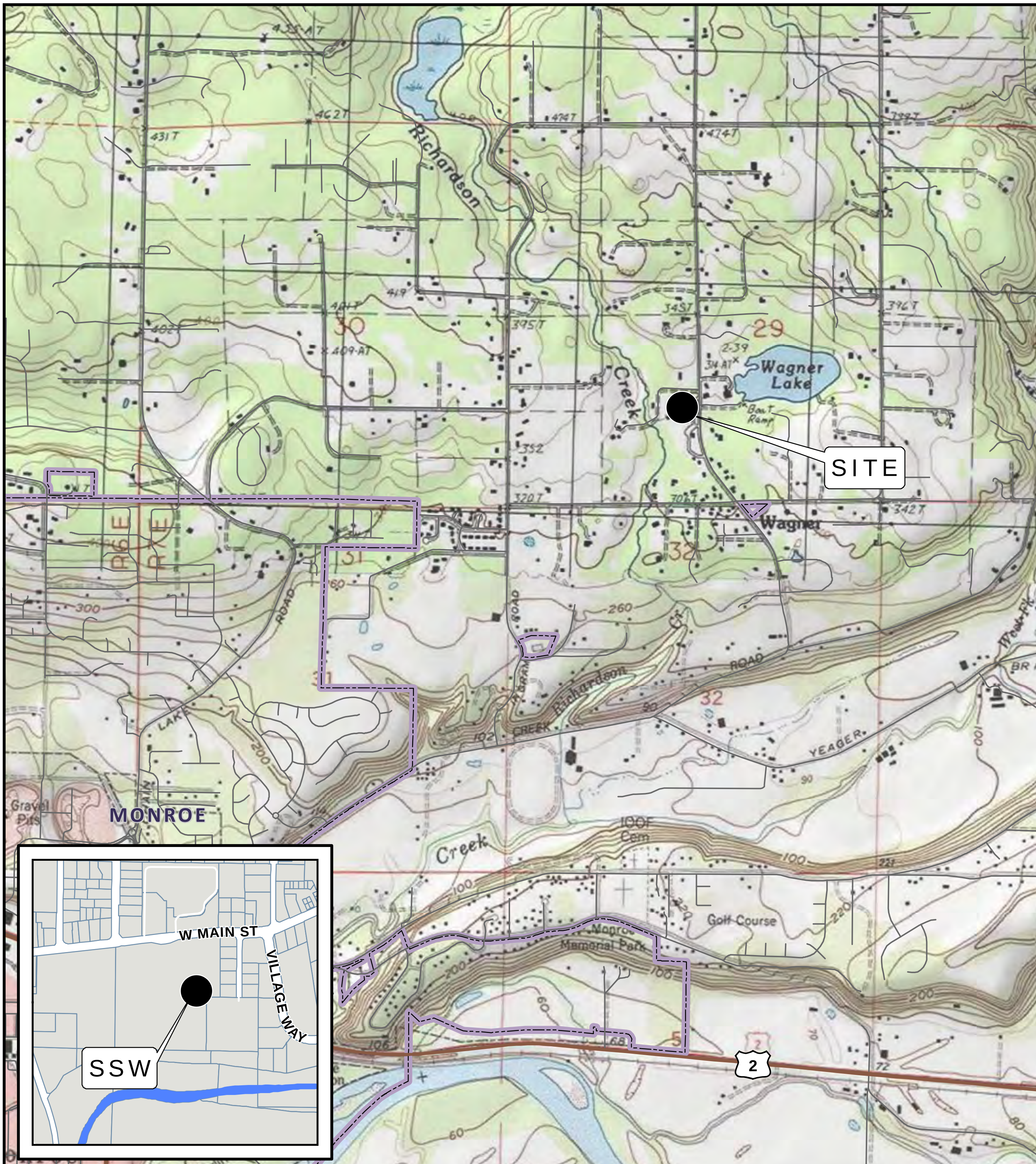
Anton D. Ypma
Staff Geologist

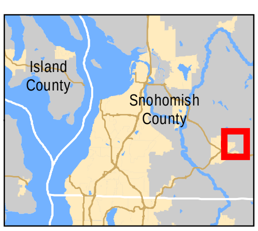
Suzanne S. Cook, L.G.
Senior Project Geologist

Jennifer H. Saltonstall, L.G., L.Hg.
Principal Geologist/Hydrogeologist

Attachments:	Figure SSW F1:	Vicinity Map
	Figure SSW F2:	Facility and Exploration Plan
	Appendix A:	Project Civil Plans
	Appendix B:	Current Study Exploration Logs and Laboratory Testing Data
	Appendix C:	Background Soil, Geology, and Groundwater Data (Regional Maps, Previous Studies Exploration Logs and Laboratory Testing Data)
	Appendix D:	Soil Probe, Level Survey, and Field Infiltration Testing Data
	Appendix E:	Site Photos

JHS/ld
150387H007-2
Projects\20150387\KH\WP





DATA SOURCES / REFERENCES:
USGS: 7.5' SERIES TOPOGRAPHIC MAPS, ESRI/I-CUBED/NATIONAL GEOGRAPHIC SOCIETY 2013
SNOHOMISH CO: STREETS, CITY LIMITS, PARCELS, 1/18
LOCATIONS AND DISTANCES SHOWN ARE APPROXIMATE

N

0 1000 2000
FEET

NOTE: BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION

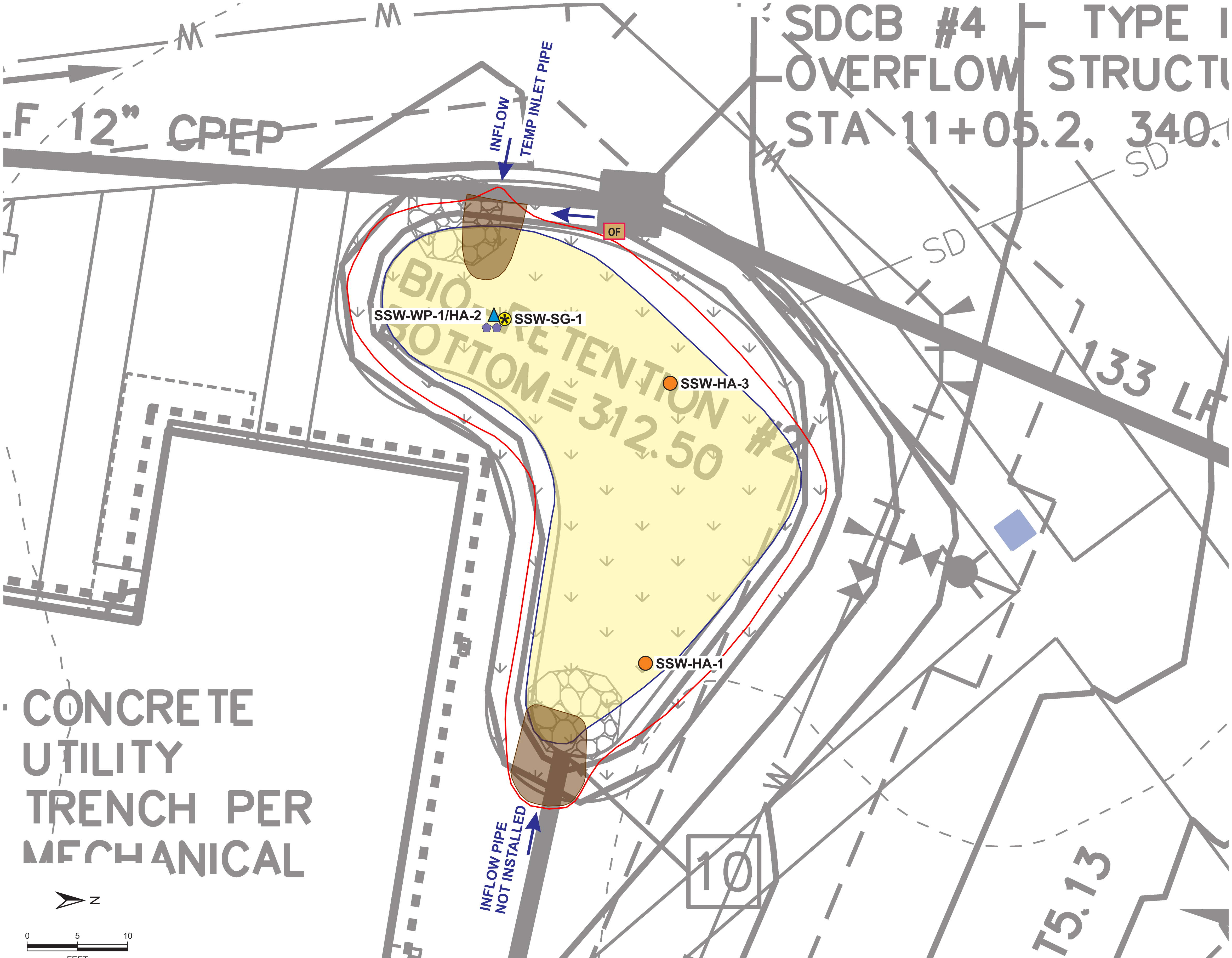
associated earth sciences incorporated

VICINITY MAP

BIORETENTION HYDROLOGIC PERFORMANCE STUDY, SSW SITE
SNOHOMISH COUNTY, WASHINGTON

PROJ NO.	DATE:	FIGURE:
150387H007	3/19	SSW F1

Document Path: G:\GIS_Projects\aV15post0716\150387 Bioretention Hydro Performance Monitoring\mxd\PhaseII\Fig1s\150387H007 F1 VM_SSW.mxd



LEGEND:

HA	HAND AUGER
WP	WELL POINT
	TEMPORARY STAFF GAUGE
	BASE OF FACILITY
	TOP OF FACILITY SLOPE
	INFLOW / OVERFLOW DIRECTION
OF	OVERFLOW GRATE - 24" X 18"
	PVC PONDING TUBE
	ENERGY DISSIPATER

CONTOUR INTERVAL = N/A

NOTE: LOCATION AND DISTANCES SHOWN ARE APPROXIMATE.

NOTES:
1. BASE MAP REFERENCE: DLR GROUP, SALEM WOODS ELEMENTARY SCHOOL CONSTRUCTIONS DOCUMENTS, FULL DRAINAGE PLAN, SHEET C3.00, CONFORMED SET, 5/16/17

associated earth sciences incorporated

FACILITY AND EXPLORATION PLAN
SSW SITE
BIORETENTION HYDROLOGIC PERFORMANCE
SNOHOMISH COUNTY, WASHINGTON

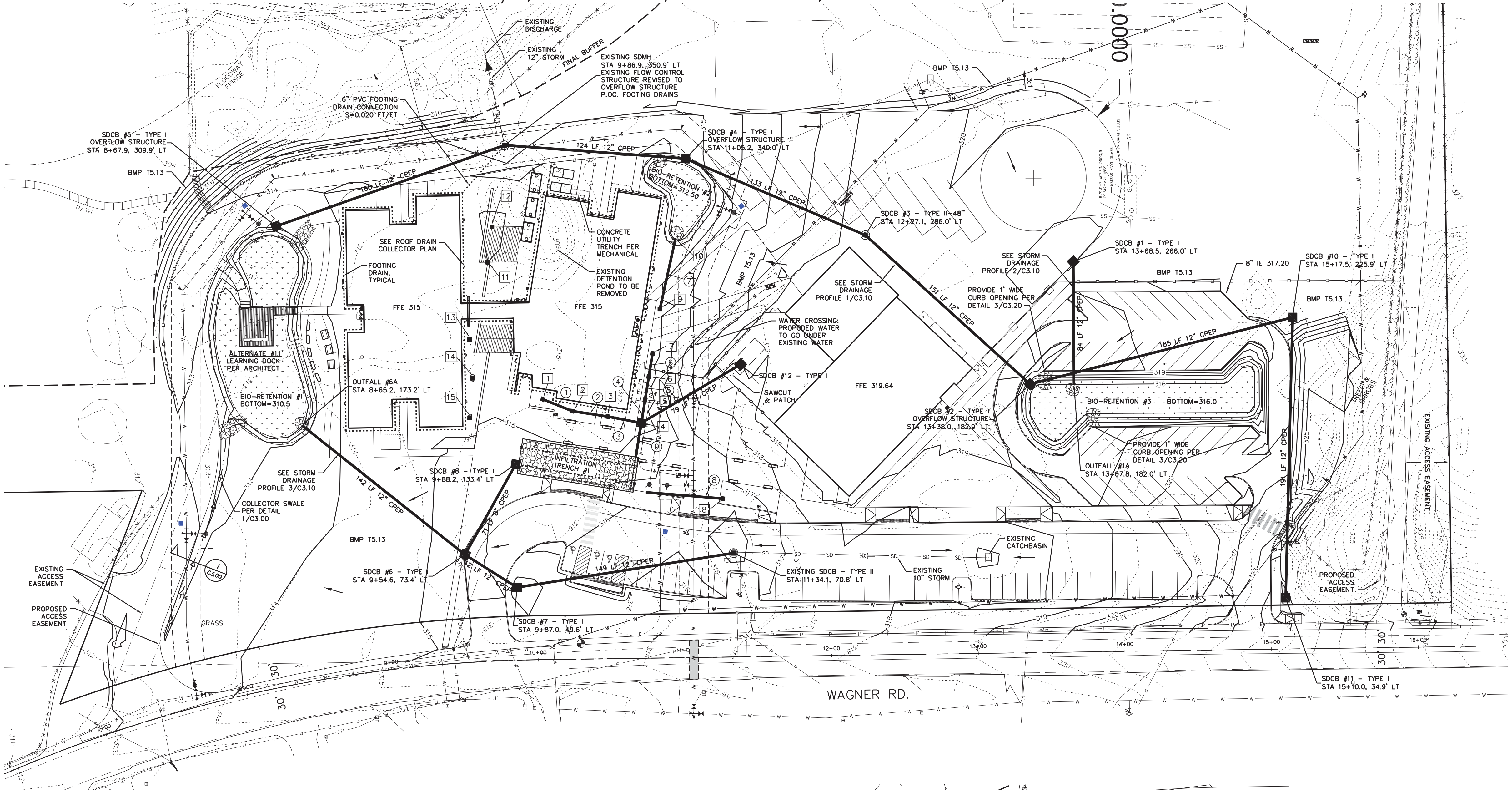
PROJ NO.	DATE:	FIGURE:
150387H007	3/19	SSW F2

150387 BHPS MCCA \ 150387H007 Site-Expl ALL.cdr PAGE x: SSW F2

APPENDIX A

Project Civil Plans

SW1/4, SECTION 29, TOWNSHIP 28, RANGE 07 EAST, W.M.



1" = 30'

0 15 30 60

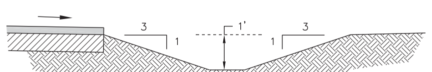
VERTICAL DATUM
NAVD 88 GEOID 12A
ESTABLISHED BY GPS

EQUATION: NAVD 88 – 3.7' = NGVD 29

BENCHMARKS:

TBM #1: PK NAIL SET NORTH SIDE OF DRIVEWAY TO #12620 WAGNER RD.
(PT #8)
ELEV=329.93'

TBM #2: MAGNETIC NAIL SET IN ASPHALT 1.5' E OF WEST EDGE OF ASPHALT OF WAGNER ROAD
53' S OF SOUTH ENTRANCE TO SCHOOL
13' N OF WATER GATE VALVE.
(PT #901)
ELEV=315.63'



1 COLLECTOR SWALE DETAIL

SCALE: NONE

YARD DRAIN NOTES

1. YARD DRAINS TO BE CUZ CONCRETE DRIVEWAY CB'S (17"x17") WITH 12"x12" MINIMUM GRATES OR APPROVED EQUAL UNLESS OTHERWISE NOTED
2. DISCHARGE YARD DRAINS TO STORM FACILITY PER YARD DRAIN TABLE.
3. CONNECT YARD DRAINS TO ROOF DRAIN COLLECTOR OR DIRECTLY TO INFILTRATION FACILITY OR BIORETENTION CELL AS APPROPRIATE.

ROOF & YARD DRAIN PIPE NOTES

CONTRACTOR TO DESIGN AND INSTALL ROOF DRAIN COLLECTOR SYSTEM AND CONNECT TO INFILTRATION TRENCH #1.

1. VERIFY DOWNSPOUT LOCATIONS WITH ARCHITECTURAL PLANS.
2. PIPE RUNS SHALL HAVE MINIMUM POSITIVE SLOPE OF 1% AND 6" MIN DIAMETER SMOOTH WALL PIPE PER PLAN.
3. INSTALL CLEANOUTS AT TEES, BENDS 45° OR GREATER AND AT INTERVALS NO GREATER THAN 150 LF.
4. PROVIDE NECESSARY FITTINGS TO CONNECT ROOF STUB TO DOWNSPOUT.

FOOTING DRAIN NOTES

1. CONNECT BUILDING PERIMETER FOOTING DRAINS TO STORM COLLECTION SYSTEM. PROVIDE TO THE ENGINEER A CONNECTION PLAN FOR APPROVAL PRIOR TO CONSTRUCTION OF THE FOOTING DRAIN SYSTEM.
2. PROVIDE 6" PVC PIPE WITH MINIMUM PIPE SLOPE OF 0.5% FROM BOTTOM OF FOOTING DRAIN ELEVATION AT BUILDING TO LOCAL STORM FACILITY.

YARD DRAIN

1 YD #1
STA 10+05.7, 177.4' LT
RIM 314.20
6" IE OUT 312.20

2 YD #2
STA 10+25.7, 169.0' LT
RIM 314.20
6" IE IN 312.00
6" IE OUT 312.00

3 YD #3
STA 10+49.7, 165.0' LT
RIM 314.20
6" IE IN 311.80
6" IE OUT 311.80

4 YD #4 – SDCB TYPE I
STA 10+72.6, 160.3' LT
RIM 314.40
6" IE IN 311.60
8" IE IN 311.52
6" IE OUT 311.60
8" IE OUT 311.52

5 YD #5
STA 10+75.4, 176.0' LT
RIM 314.40
6" IE IN 311.80
6" IE OUT 311.80

6 YD #6
STA 10+78.2, 191.8' LT
RIM 314.40
6" IE IN 312.00
6" IE OUT 312.00

7 YD #7
STA 10+80.9, 207.6' LT
RIM 314.40
6" IE IN 312.20

8 YD #8
STA 11+27.3, 108.0' LT
RIM 316.00
6" IE OUT 314.00

9 YD #9
STA 10+86.3, 237.6' LT
RIM 314.40
6" IE OUT 313.00

10 OUTFALL #9A
STA 10+97.7, 285.5' LT
6" IE IN 312.50

11 YD #10
STA 9+76.3, 271.6' LT
RIM 314.00
CONNECT TO
ROOF DRAIN COLLECTOR

12 YD #11
STA 9+79.2, 295.5' LT
RIM 313.55
CONNECT TO
ROOF DRAIN COLLECTOR

13 YD #12
STA 9+64.4, 219.5' LT
RIM 313.90
CONNECT TO
ROOF DRAIN COLLECTOR

14 YD #13
STA 9+64.9, 193.2' LT
RIM 313.90
CONNECT TO
ROOF DRAIN COLLECTOR

15 YD #14
STA 9+62.2, 166.3' LT
RIM 313.90
CONNECT TO
ROOF DRAIN COLLECTOR

YARD DRAIN PIPES

1 22 LF 6" PVC
S = 0.009 FT/FT

2 24 LF 6" PVC
S = 0.008 FT/FT

3 23 LF 6" PVC
S = 0.009 FT/FT

4 16 LF 6" PVC
S = 0.012 FT/FT

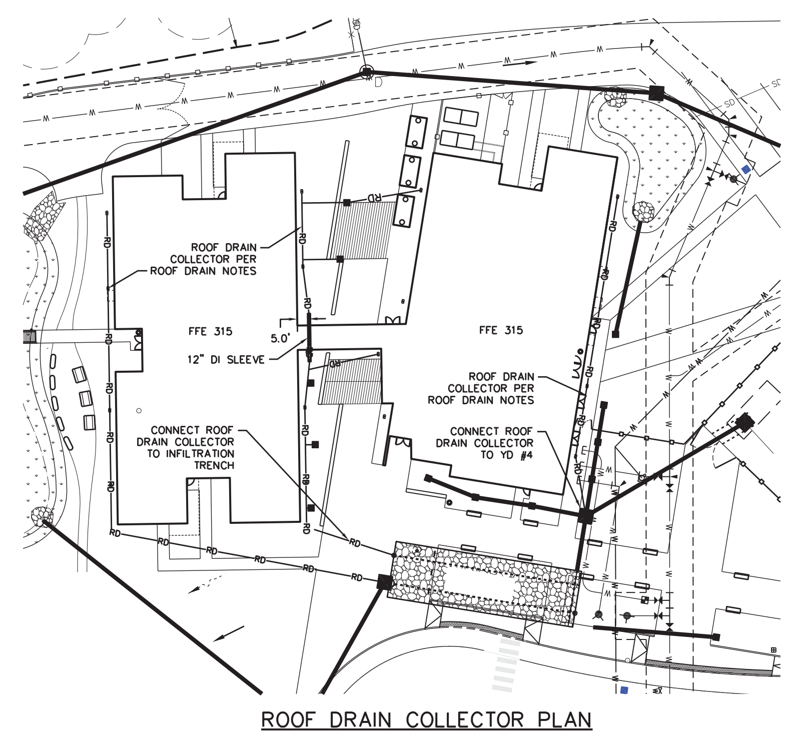
5 16 LF 6" PVC
S = 0.013 FT/FT

6 16 LF 6" PVC
S = 0.013 FT/FT

7 49 LF 6" PVC
S = 0.010 FT/FT

8 53 LF 6" PVC
S = 5.977 FT/FT

9 23 LF 8" CPEP
S = 0.022 FT/FT



ROOF DRAIN COLLECTOR PLAN

SCALE: 1" = 30'

FULL DRAINAGE NOTES

1. THE EXISTING DRAINAGE PATTERN IN THE WORK AREA CONSISTS OF COLLECTION OF STORM WATER IN CATCHBASINS AND DOWNSPOUT LEADERS WITH DISCHARGE TO A DETENTION POND. THE DETENTION SYSTEM DISCHARGES TO THE RICHARDSON CREEK. THE EXISTING SITE FIELDS SHEETFLOW SOUTHWEST INTO THE RICHARDSON CREEK AREA. THE OLD WAGNER COMMUNITY CLUB SITE HAS NO SPECIFIC STORM CONTROLS AND RUNOFF SHEETFLOWS FROM IMPERVIOUS SURFACES AND EITHER INFILTRATES OR FLOWS TOWARDS THE FRONTAGE AND TOWARDS RICHARDSON CREEK DEPENDING ON LOCATION. IN THE DEVELOPED CONDITION, RUNOFF FROM THE NEW STRUCTURES AND PAVED AREAS WILL BE INFILTRATED WITH AN EMERGENCY OVERFLOW SYSTEM THAT UTILIZES THE EXISTING POND DISCHARGE SYSTEM.
2. THERE ARE NO NATURAL STEEP SLOPE AREAS ON THE LOTS. THERE ARE MAN MADE SLOPES AROUND THE EXISTING SCHOOL THAT REACH 50%.
3. THE LOT IS WITHIN A MODERATE AQUIFER SENSITIVITY AREA AND IS NOT WITHIN A WELLHEAD PROTECTION AREA.
4. THERE IS AN EXISTING DETENTION SYSTEM ON FOR THE SCHOOL THAT WILL BE REMOVED. THERE ARE NO EXISTING TREATMENT SYSTEMS. THERE ARE NO EXISTING STORM WATER POLLUTION CONTROL, DETENTION, OR OTHER BMP'S OFF SITE WITHIN 15'.
5. ASSOCIATED EARTH SCIENCE, INC PREPARED A GEOTECHNICAL INVESTIGATION. THE UNDERLYING SOIL IS TOPSOIL OVER SANDS AND GRAVELS (OUTWASH) OVER LODGEMENT TILL. IN SOME AREAS THERE IS SEVERAL FEET OF NATIVE FILL.
6. THE EXISTING GROUND COVER CONSISTS OF TREES, LAWN, ROOFS, PAVEMENT, AND GRAVEL.
7. RICHARDSON CREEK AND ITS ASSOCIATED WETLANDS RUN NORTHWEST TO SOUTH THROUGH THE SOUTHWEST CORNER OF THE PROPERTY.
8. THE DESIGNATED DRAINAGE BASIN FOR THE SITE CONSISTS OF SUBBASINS TRIBUTARY TO BIO-RETENTION CELLS AND INFILTRATION TRENCHES. SEE CALCULATIONS IN THE FULL DRAINAGE REPORT PREPARED FOR THE SITE.
9. SEE LEGAL DESCRIPTION FOR SECTION TIE.
10. FLOOD BOUNDARY PER FIRM PANEL 53061C1100E, NOV 8 1999

PFN: 16–117632 CUP/
17–101024 LDA

SNOHOMISH COUNTY
PLANNING AND DEVELOPMENT SERVICES
APPROVED FOR CONSTRUCTION

BY__________ DATE:________

R/W PERMIT NO.__________

Know what's below. Call before you dig.

CONFORMED SET

12802 WAGNER ROAD
MONROE, WA 98272

FULL DRAINAGE PLAN

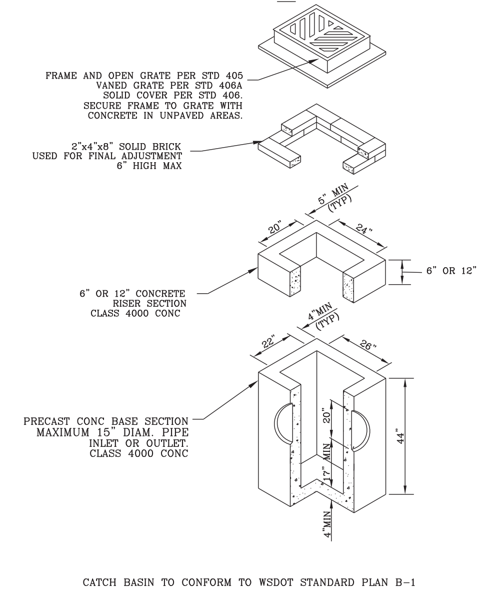
SALEM WOODS ELEMENTARY SCHOOL

CONSTRUCTION DOCUMENTS

C3.00

DLR Group

Architecture Engineering Planning Interiors



CATCH BASIN TO CONFORM TO WSDOT STANDARD PLAN B-1

NOTES:

MAXIMUM DEPTH FROM FINISH GRADE TO PIPE INVERT SHALL BE 5 FEET.
DEPTHS OVER 5 FEET SEE DETAIL #404

MONROE INCORPORATED IN 1902	TYPE 1 CATCH BASIN	NUMBER 402
	CITY OF MONROE DEPARTMENT OF PUBLIC WORKS	DATE 3-1-00

INFILTRATION NOTE:

TO ENSURE PROPER FUNCTIONING OF THE BIO-RETENTION AND INFILTRATION TRENCH AREAS IT IS ABSOLUTELY NECESSARY TO AVOID COMPACTION OF THE UNDERLYING SOILS DURING CONSTRUCTION AND SEDIMENT TRANSPORT INTO THE EXCAVATION DURING CONSTRUCTION. NO HEAVY EQUIPMENT SHALL RUN ACROSS THE BASE OF THE POROUS PAVING AREAS TO PREVENT ANY DAMAGE TO THE UNDERLYING SOILS DURING CONSTRUCTION ACTIVITIES. GEOTECHNICAL ENGINEER SHALL INSPECT AND APPROVE THE SUBGRADE SOILS OF INFILTRATION TRENCHES AND THE EMBEDMENT INTO NATIVE SOILS. SEE GEOTECHNICAL REPORT FOR ADDITIONAL INFORMATION.

BIO-RETENTION CELL CONSTRUCTION NOTES

1. THE BIO-RETENTION CELL SHALL BE OVEREXCAVATED TO ELEVATIONS SHOWN ON GRADING SECTIONS AND FILLED WITH 18" DEPTH OF COMPOST AMENDED SOIL.
2. MINIMUM COMPACTION OF SIDEWALLS AND BASE OF BIO-RETENTION CELL IS ESSENTIAL. KEEP ALL MACHINERY OUTSIDE OF CELL AREA UNDER DIRECTION OF GEOTECHNICAL ENGINEER.
3. SUB-GRADES SHALL BE SCARIFIED, CLEARED OF ALL WEEDS, ROCKS, AND DEBRIS, AND ROUGH GRADED. TOPSOIL SHALL BE ROTOTILLED INTO SUB-GRADE TO A MIN DEPTH OF 8".
4. IF COMPACTION OCCURS IN BOTTOM OF FACILITY DURING EXCAVATION, RIP A MINIMUM OF 12" AND TILL 2 TO 3 INCHES OF AND INTO BASE BEFORE BACKFILLING WITH COMPOST AMENDED SOILS.
5. EXCAVATION FOR THE BIO-RETENTION CELL WILL NOT BE ALLOWED DURING WET WEATHER OR SATURATED SOIL CONDITIONS.
6. SOIL MIXING SHALL OCCUR OUTSIDE/ADJACENT TO THE CELL AREA AND THEN PLACED IN BOTTOM OF CELL.
7. ON-SITE SOIL MIXING SHALL NOT BE PERFORMED IF SOILS ARE SATURATED.
8. FINAL GRADING TO BE ACCOMPLISHED BY HAND.
9. PLANT BOTTOM AND SIDES OF CELL PER LANDSCAPE PLAN.
10. TO PROTECT THE BIORETENTION CELL FROM SEDIMENT LOADING DURING CONSTRUCTION THE INSTALLATION OF THE BIO-RETENTION SOIL AND PLANTINGS SHALL NOT OCCUR UNTIL THE TRIBUTARY AREA DRAINING TO THE CELL HAS BEEN STABILIZED.
DO NOT ROUTE VEHICULAR TRAFFIC THROUGH BIO-RETENTION AREAS AFTER SUBGRADE IS ESTABLISHED.
11. GEOTECHNICAL ENGINEER SHALL VERIFY AND APPROVAL ALL EMBEDMENT INTO NATIVE SOILS FOR INFILTRATION AND BIO-RETENTION SYSTEMS.

STORM DRAINAGE NOTES:

1. ALL STORM DRAIN PIPE MAY BE CONSTRUCTED OF ONE OF THE FOLLOWING MATERIALS UNLESS OTHERWISE SPECIFIED IN THE PLANS. ALL PIPE JOINTS MUST BE GASKETED AND MUST BE OF THE SAME MATERIAL AS THE PIPE. THE PIPE SHALL HAVE MINIMUM COVER AS SHOWN BELOW.
   *COVERAGE REQUIREMENTS FOR 18" OR SMALLER:
   < 1.0' REQUIRES RCP (REINFORCED CONCRETE PIPE WITH GASKETED JOINTS, ASTM C-76 CLASS II) MINIMUM OR DUCTILE IRON PIPE.
   1.0' – 1.5' REQUIRES CP (CONCRETE PIPE WITH RUBBER GASKETED JOINTS, ASTM C-14) MINIMUM OR DUCTILE IRON PIPE.
   > 1.5' REQUIRES 16 GAUGE CMP (CORRUGATED METAL PIPE AASHTO M236 TYPE I & II) OR CPEP PIPE WITH DOUBLE GASKETED SLEEVED JOINTS. IN HIGH WATER TABLE AREAS PVC (PVC ASTM D 3034, SDR 35 WITH GASKETED JOINTS SHALL BE REQUIRED.
2. ALL PLASTIC PIPE SHALL BE MADE LOCATABLE BY LAYING VINYL COATED 10 GA. WIRE 1' ABOVE PIPE.
3. ALL STORM DRAIN WORK MUST BE STAKED BY SURVEY FOR LINE AND GRADE PRIOR TO STARTING CONSTRUCTION.
4. THE BACKFILL SHALL BE PLACED EQUALLY ON BOTH SIDES OF THE PIPE IN LAYERS WITH A LOOSE AVERAGE DEPTH OF 6 INCHES, MAXIMUM DEPTH 8 INCHES, THOROUGHLY TAMPING EACH LAYER. THESE COMPACTED LAYERS MUST EXTEND FOR ONE DIAMETER ON EACH SIDE OF THE PIPE OR TO THE SIDE OF THE TRENCH. TO DETERMINE MATERIAL REQUIREMENTS FOR BACKFILL REFER TO WSDOT STANDARD SPEC. 7.08.3(3) AND STANDARD SPEC. 2.03.3(14)C, METHOD B & C.
5. ALL CATCH BASINS WITH A DEPTH OVER 5 FEET TO THE FLOW LINE SHALL BE A TYPE II CB (48" DIAMETER OR LARGER).
6. STORM WATER RETENTION/DETENTION FACILITIES, STORM PIPE, AND CATCH BASINS SHALL BE FLUSHED AND CLEANED PRIOR TO CITY ACCEPTANCE. CONTAMINATED WATER SHALL NOT BE PUMPED INTO AN EXISTING CITY STORM SYSTEM.
7. ALL PIPE AND APPURTENANCES SHALL BE LAID ON A PROPERLY PREPARED FOUNDATION IN ACCORDANCE WITH WSDOT 7.08.3(1). IF, IN THE OPINION OF THE INSPECTOR THE EXISTING FOUNDATION IS UN-SATISFACTORY, THEN IT SHALL BE EXCAVATED BELOW GRADE AND BACKFILLED IN ACCORDANCE WITH STANDARD SPECIFICATIONS (WSDOT 7-08.3(3). PIPE SHALL NOT BE INSTALLED ON SOD, FROZEN EARTH, OR LARGE BOULDERS OR ROCK.
8. ALL GRATES (INLETS AND CATCH BASINS) SHALL BE DEPRESSED 0.1 FEET BELOW PAVEMENT LEVEL.
9. ALL CATCH BASINS AND CURB INLETS SHALL HAVE LOCKING LIDS.
10. STORM STUB OUTS SHALL BE MARKED WITH A 2" X 4" BOARD AND LABELED "STORM" AND EXTENDED 5 FEET ONTO PROPERTY. LOCATOR WIRE TO EXTEND TO TOP OF MARKER BOARD.
11. TESTING AND TV INSPECTION OF STORM DRAIN LINES ARE AT THE CITY OF MONROE OPTION. TRASH RACKS SHALL BE INSTALLED ON THE UPSTREAM AND DOWNSTREAM END OF PIPES, CULVERTS, AND BIOSWALES.
12. HANDHOLDS IN RISER OR ADJUSTMENT SECTION SHALL HAVE 3' MINIMUM CLEARANCE. STEPS IN CATCH BASIN SHALL HAVE 6" CLEARANCE.
13. FOR CATCH BASINS AND CURB INLETS SHALL BE PER CITY OF MONROE STANDARD PLANS.

BMP T5.13: POST-CONSTRUCTION SOIL QUALITY

THIS BMP SHALL BE USED IN THE LANDSCAPED AREAS ON THE SITE AND ANY OTHER DISTURBED AREAS.

PURPOSE AND DEFINITION

NATURALLY OCCURRING (UNDISTURBED) SOIL AND VEGETATION PROVIDE IMPORTANT STORMWATER FUNCTIONS INCLUDING: WATER INFILTRATION; NUTRIENT, SEDIMENT, AND POLLUTANT ADSORPTION; SEDIMENT AND POLLUTANT BIOFILTRATION; WATER INTERFLOW STORAGE AND TRANSMISSION; AND POLLUTANT DECOMPOSITION. THESE FUNCTIONS ARE LARGELY LOST WHEN DEVELOPMENT STRIPS AWAY NATIVE SOIL AND VEGETATION AND REPLACES IT WITH MINIMA! TOPSOIL AND SOD. NOT ONLY ARE THESE IMPORTANT STORMWATER FUNCTIONS LOST, BUT SUCH LANDSCAPES THEMSELVES BECOME POLLUTION-GENERATING PERVIOUS SURFACES DUE TO INCREASED USE OF PESTICIDES, FERTILIZERS AND OTHER LANDSCAPING AND HOUSEHOLD/INDUSTRIAL CHEMICALS, THE CONCENTRATION OF PET WASTES, AND POLLUTANTS THAT ACCOMPANY ROADSIDE LITTER,

ESTABLISHING SOIL QUALITY AND DEPTH REGAINS GREATER STORMWATER FUNCTIONS IN THE POST DEVELOPMENT LANDSCAPE, PROVIDES INCREASED TREATMENT OF POLLUTANTS AND SEDIMENTS THAT RESULT FROM DEVELOPMENT AND HABITATION, AND MINIMIZES THE NEED FOR SOME LANDSCAPING CHEMICALS, THUS REDUCING POLLUTION THROUGH PREVENTION.

APPLICATIONS AND LIMITATIONS

ESTABLISHING A MINIMUM SOIL QUALITY AND DEPTH IS NOT THE SAME AS PRESERVATION OF NATURALLY OCCURRING SOIL AND VEGETATION. HOWEVER, ESTABLISHING A MINIMUM SOIL QUALITY AND DEPTH WILL PROVIDE IMPROVED ON-SITE MANAGEMENT OF STORMWATER FLOW AND WATER QUALITY.

SOIL ORGANIC MATTER CAN BE ATTAINED THROUGH NUMEROUS MATERIALS SUCH AS COMPOST, COMPOSTED WOODY MATERIAL, BIOSOLIDS, AND FOREST PRODUCT RESIDUALS. IT IS IMPORTANT THAT THE MATERIALS USED TO MEET THE SOIL QUALITY AND DEPTH BMP BE APPROPRIATE AND BENEFICIAL TO THE PLANT COVER TO BE ESTABLISHED. LIKEWISE, IT IS IMPORTANT THAT IMPORTED TOPSOILS IMPROVE SOIL CONDITIONS AND DO NOT HAVE AN EXCESSIVE PERCENT OF CLAY FINES.

DESIGN GUIDELINES

SOIL RETENTION

THE DUFF LAYER AND NATIVE TOPSOIL SHOULD BE RETAINED IN AN UNDISTURBED STATE TO THE MAXIMUM EXTENT PRACTICABLE. IN ANY AREAS REQUIRING GRADING REMOVE AND STOCKPILE THE DUFF LAYER AND TOPSOIL ON SITE IN A DESIGNATED, CONTROLLED AREA, NOT ADJACENT TO PUBLIC RESOURCES AND CRITICAL AREAS, TO BE REAPPLIED TO OTHER PORTIONS OF THE SITE WHERE FEASIBLE.

SOIL QUALITY

ALL AREAS SUBJECT TO CLEARING AND GRADING THAT HAVE NOT BEEN COVERED BY IMPERVIOUS SURFACE, INCORPORATED INTO A DRAINAGE FACILITY OR ENGINEERED AS STRUCTURAL FILL OR SLOPE SHALL, AT PROJECT COMPLETION, DEMONSTRATE THE FOLLOWING:

1. A TOPSOIL LAYER WITH A MINIMUM ORGANIC MATTER CONTENT OF TEN PERCENT DRY WEIGHT IN PLANTING BEDS, AND 5% ORGANIC MATTER CONTENT (BASED ON A LOSS-ON-IGNITION TEST) IN TURF AREAS, AND A PH FROM 6.0 TO 8.0 OR MATCHING THE PH OF THE ORIGINAL UNDISTURBED SOIL. THE TOPSOIL LAYER SHALL HAVE A MINIMUM DEPTH OF EIGHT INCHES EXCEPT WHERE TREE ROOTS LIMIT THE DEPTH OF INCORPORATION OF AMENDMENTS NEEDED TO MEET THE CRITERIA. SUBSOILS BELOW THE TOPSOIL LAYER SHOULD BE SCARIFIED AT LEAST 4 INCHES WITH SOME INCORPORATION OF THE UPPER MATERIAL TO AVOID STRATIFIED LAYERS, WHERE FEASIBLE.

2. PLANTING BEDS MUST BE MULCHED WITH 2 INCHES OF ORGANIC MATERIAL

3. QUALITY OF COMPOST AND OTHER MATERIALS USED TO MEET THE ORGANIC CONTENT REQUIREMENTS:
   A. THE ORGANIC CONTENT FOR "PRE-APPROVED" AMENDMENT RATES CAN BE MET ONLY USING COMPOST THAT MEETS THE DEFINITION OF "COMPOSTED MATERIALS" IN WAC 173-350-220. THIS CODE IS AVAILABLE ONLINE AT:
   HTTP://WWW.ECY.WA.GOVFPROGRAMS/SWFA/FACILITIES/350.HTML.

   COMPOST USED IN BIORETENTION AREAS SHOULD BE STABLE, MATURE AND DERIVED FROM YARD DEBRIS, WOOD WASTE, OR OTHER ORGANIC MATERIALS THAT MEET THE INTENT OF THE ORGANIC SOIL AMENDMENT SPECIFICATION. BIOSOLIDS AND MANURE COMPOSTS CAN BE HIGHER IN BIO-AVAILABLE PHOSPHORUS THAN COMPOST DERIVED FROM YARD OR PLANT WASTE AND THEREFORE ARE NOT ALLOWED IN BIORETENTION AREAS DUE TO THE POSSIBILITY OF EXPORTING BIO-AVAILABLE PHOSPHORUS IN EFFLUENT.

   THE COMPOST MUST ALSO HAVE AN ORGANIC MATTER CONTENT OF 35% TO 65%, AND A CARBON TO NITROGEN RATIO BELOW 25:1.

   THE CARBON TO NITROGEN RATIO MAY BE AS HIGH AS 35:1 FOR PLANTINGS COMPOSED ENTIRELY OF PLANTS NATIVE TO THE PUGET SOUND LOWLANDS REGION.

   B. CALCULATED AMENDMENT RATES MAY BE MET THROUGH USE OF COMPOSTED MATERIALS AS DEFINED ABOVE; OR OTHER ORGANIC MATERIALS AMENDED TO MEET THE CARBON TO NITROGEN RATIO REQUIREMENTS, AND MEETING THE CONTAMINANT STANDARDS OF GRADE A COMPOST.

THE RESULTING SOIL SHOULD BE CONDUCIVE TO THE TYPE OF VEGETATION TO BE ESTABLISHED.

IMPLEMENTATION OPTIONS: THE SOIL QUALITY DESIGN GUIDELINES LISTED ABOVE CAN BE MET BY USING ONE OF THE METHODS LISTED BELOW.
1. LEAVE UNDISTURBED NATIVE VEGETATION AND SOIL, AND PROTECT FROM COMPACTION DURING CONSTRUCTION.

2. AMEND DISTURBED SOIL ACCORDING TO THE FOLLOWING PROCEDURES:

   A. SCARIFY SUBSOIL TO A DEPTH OF ONE FOOT
   B. IN PLANTING BEDS, PLACE THREE INCHES OF COMPOST AND TILL IN TO AN EIGHT-INCH DEPTH.
   C. IN TURF AREAS, PLACE TWO INCHES OF COMPOST AND TILL IN TO AN EIGHT-INCH DEPTH.
   D. APPLY TWO TO FOUR INCHES OF ARBORIST WOOD CHIP, COARSE BARK MULCH, OR COMPOST MULCH TO PLANTING BEDS AFTER FINAL PLANTING.

ALTERNATIVELY, DISTURBED SOIL CAN BE AMENDED ON A SITE-CUSTOMIZED MALULER SO THAT IT MEETS THE SOIL QUALITY CRITERIA SET FORTH ABOVE, AS DETERMINED BY A LICENSED ENGINEER, GEOLOGIST, LANDSCAPE ARCHITECT, OR OTHER PERSON AS APPROVED BY SNOHOMISH COUNTY.

3. STOCKPILE EXISTING TOPSOIL DURING GRADING, AND REPLACE IT PRIOR TO PLANTING. STOCKPILED TOPSOIL MUST BE AMENDED IF NEEDED TO MEET THE ORGANIC MATTER AND DEPTH REQUIREMENTS BY FOLLOWING THE PROCEDURES IN METHOD (2) ABOVE.

4. IMPORT TOPSOIL MIX OF SUFFICIENT ORGANIC CONTENT AND DEPTH TO MEET THE ORGANIC MATTER AND DEPTH REQUIREMENTS.

MORE THAN ONE METHOD MAY BE USED ON DIFFERENT PORTIONS OF THE SAME SITE. SOIL THAT ALREADY MEETS THE DEPTH AND ORGANIC MATTER QUALITY STANDARDS, AND IS NOT COMPACTED, DOES NOT NEED TO BE AMENDED.

MAINTENANCE

1. SOIL QUALITY AND DEPTH SHOULD BE ESTABLISHED TOWARD THE END OF CONSTRUCTION AND ONCE ESTABLISHED, SHOULD BE PROTECTED FROM COMPACTION, SUCH AS FROM LARGE MACHINERY USE, AND FROM EROSION.

2. SOIL SHOULD BE PLANTED AND MULCHED AFTER INSTALLATION.

3. PLANT DEBRIS OR ITS EQUIVALENT SHOULD BE LEFT ON THE SOIL SURFACE TO REPLENISH ORGANIC MATTER.

BIO-RETENTION CELL SOIL MIX SPECIFICATIONS

SHOULD HAVE A TESTED LONG TERM DESIGN INFILTRATION RATE OF 2"/HR MINIMUM.

MINERAL AGGREGATE

PERCENT FINES: A RANGE OF 2 TO 4 PERCENT PASSING THE #200 SIEVE IS IDEAL AND FINES SHOULD NOT BE ABOVE 5 PERCENT FOR A PROPER FUNCTIONING SPECIFICATION ACCORDING TO ASTM D422.

AGGREGATE GRADATION

THE AGGREGATE PORTION OF THE BSM SHOULD BE WELL-GRADED. ACCORDING TO ASTM D 2487-98 (CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES (UNIFIED SOIL CLASSIFICATION SYSTEM)), WELL-GRADED SAND SHOULD HAVE THE FOLLOWING GRADATION COEFFICIENTS:

- COEFFICIENT OF UNIFORMITY (CU = D60/D10) EQUAL TO OR GREATER THAN 4, AND
- COEFFICIENT OF CURVE (CC = (D30)2/D60 X D10) GREATER THAN OR EQUAL TO 1 AND LESS THAN OR EQUAL TO 3.

TABLE 7.4.1 PROVIDES A GRADATION GUIDELINE FOR THE AGGREGATE COMPONENT OF A BIORETENTION SOIL MIX SPECIFICATION IN WESTERN WASHINGTON (HINMAN, ROBERTSON, 2007). THE SAND GRADATION BELOW IS OFTEN SUPPLIED AS A WELL- GRADED UTILITY OR SCREENED. WITH COMPOST THIS BLEND PROVIDES ENOUGH FINES FOR ADEQUATE WATER RETENTION, HYDRAULIC CONDUCTIVITY WITHIN RECOMMENDED RANGE (SEE BELOW), POLLUTANT REMOVAL CAPABILITY, AND PLANT GROWTH CHARACTERISTICS FOR MEETING DESIGN GUIDELINES AND OBJECTIVES.

TABLE 7.4.1

GENERAL GUIDELINE FOR MINERAL AGGREGATE GRADATION	
SIEVE SIZE	PERCENT PASSING
3/8"	100
#4	95–100
#10	75–90
#40	25–40
#100	4–10
#200	2–5

WHERE EXISTING SOILS MEET THE ABOVE AGGREGATE GRADATION, THOSE SOILS MAY BE AMENDED RATHER THAN IMPORTING MINERAL AGGREGATE.

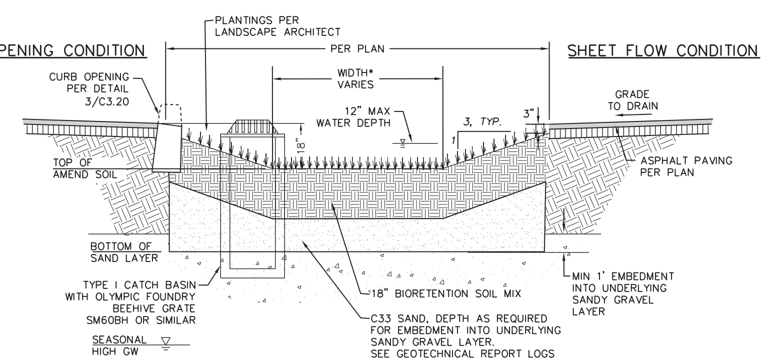
COMPOST TO AGGREGATE RATIO, ORGANIC MATTER CONTENT, CATION EXCHANGE CAPACITY

- COMPOST TO AGGREGATE RATIO: 60–65 PERCENT MINERAL AGGREGATE, 35 – 40 PERCENT COMPOST.
- ORGANIC MATTER CONTENT: 5 – 8 PERCENT BY WEIGHT.
- CATION EXCHANGE CAPACITY (CEC) MUST BE $\geq$ 5 MILLIEQUIVALENTS/100 G DRY SOIL NOTE: SOIL MIXES MEETING THE ABOVE SPECIFICATIONS DO NOT HAVE TO BE TESTED FOR CEC. THEY WILL READILY MEET THE MINIMUM CEC.

COMPOST

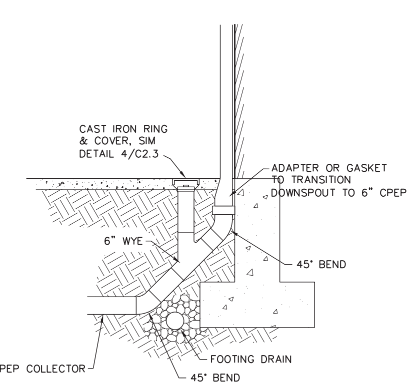
TO ENSURE THAT THE BSM WILL SUPPORT HEALTHY PLANT GROWTH AND ROOT DEVELOPMENT, CONTRIBUTE TO BIOFILTRATION OF POLLUTANTS, AND NOT RESTRICT INFILTRATION WHEN USED IN THE PROPORTIONS CITED HEREIN, THE FOLLOWING COMPOST STANDARDS ARE REQUIRED.

- MEETS THE DEFINITION OF "COMPOSTED MATERIALS" IN WAC 173-350-220 (INCLUDING CONTAMINANT LEVELS AND OTHER STANDARDS), AVAILABLE ONLINE AT HTTP://WWW.ECY.WA.GOV/PROGRAMS/SWFA/ORGANICS/SOIL.HTML
- PRODUCED AT A COMPOSTING FACILITY PERMITTED BY THE WA DEPARTMENT OF ECOLOGY. A CURRENT LIST OF PERMITTED FACILITIES IS AVAILABLE AT HTTP://WWW.ECY.WA.GOV/PROGRAMS/SWFA/COMPOST/
- THE COMPOST PRODUCT MUST ORIGINATE A MINIMUM OF 65 PERCENT BY VOLUME FROM RECYCLED PLANT WASTE AS DEFINED IN WAC 173-350-100 AS "TYPE I FEEDSTOCKS." A MAXIMUM OF 35 PERCENT BY VOLUME OF OTHER APPROVED ORGANIC WASTE AS DEFINED IN WAC 173-350-100 AS "TYPE III", INCLUDING POSTCONSUMER FOOD WASTE, BUT NOT INCLUDING BIOSOLIDS,
- MAY BE SUBSTITUTED FOR RECYCLED PLANT WASTE. TYPE II AND IV FEEDSTOCKS SHALL NOT BE USED FOR THE COMPOST GOING INTO BIORETENTION FACILITIES OR RAIN GARDENS.
- STABLE (LOW OXYGEN USE AND CO2 GENERATION) AND MATURE (CAPABLE OF SUPPORTING PLANT GROWTH) BY TESTS SHOWN BELOW. THIS IS CRITICAL TO PLANT SUCCESS IN A BIORETENTION SOIL MIXES.
- MOISTURE CONTENT RANGE: NO VISIBLE FREE WATER OR DUST PRODUCED WHEN HANDLING THE MATERIAL.
- TESTED IN ACCORDANCE WITH THE U.S. COMPOSTING COUNCIL "TESTING METHODS FOR THE EXAMINATION OF COMPOST AND COMPOSTING" (TMECC), AS ESTABLISHED IN THE COMPOSTING COUNCIL'S "SEAL OF TESTING ASSURANCE" (STA) PROGRAM. MOST WASHINGTON COMPOST FACILITIES NOW USE THESE TESTS.
- SCREENED TO THE SIZE GRADATIONS FOR FINE COMPOST UNDER TMECC TEST METHOD 02.02-B (GRADATIONS ARE SHOWN IN THE SPECIFICATION IN AN APPENDIX OF THE LOW IMPACT DEVELOPMENT TECHNICAL GUIDANCE MANUAL FOR PUGET SOUND)
- PH BETWEEN 6.0 AND 8.5 (TMECC 04.11-A). IF THE PH FALLS OUTSIDE OF THE ACCEPTABLE RANGE, IT MAY BE MODIFIED WITH LIME TO INCREASE THE PH OR IRON SULFATE PLUS SULFUR TO LOWER THE PH. THE LIME OR IRON SULFATE MUST BE MIXED UNIFORMLY INTO THE SOIL PRIOR TO USE IN THE BIORETENTION AREA.
- MANUFACTURED INERT CONTENT LESS THAT 1% BY WEIGHT (TMECC 03.08-A)
- MINIMUM ORGANIC MATTER CONTENT OF 40% (TMECC 05.07-A)
- SOLUBLE SALT CONTENT LESS THAN 4.0 MMHOS/CM (TMECC 04.10-A)
- MATURITY GREATER THAN 80% (TMECC 05.05-A "GERMINATION AND VIGOR")
- STABILITY OF 7 OR BELOW (TMECC 05.08-B "CARBON DIOXIDE EVOLUTION RATE")
- CARBON TO NITROGEN RATIO (TMECC 04.01 "TOTAL CARBON" AND 04.02D "TOTAL KJELDAHL NITROGEN") OF LESS THAN 25:1. THE C:N RATIO MAY BE UP TO 35:1 FOR PLANTINGS COMPOSED ENTIRELY OF PUGET SOUND LOWLAND NATIVE SPECIES AND UP TO 40:1 FOR COARSE COMPOST TO BE USED AS A SURFACE MULCH (NOT IN A SOIL MIX).

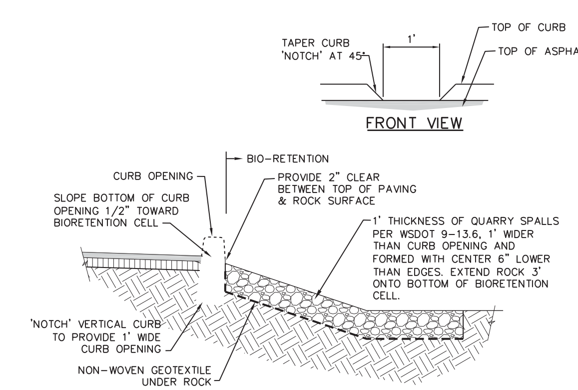


BIORETENTION CELL #	BOTTOM AREA	WIDTH	TOP OF AMEND SOIL	BOTTOM OF SAND LAYER	GROUNDWATER ELEVATION
1	6,700	VARIES	310.5	306.0	303.2
2	1,170	VARIES	312.0	N/A	310.5
3	3,630	VARIES	316.0	N/A	314.5

1 TYPICAL BIORETENTION CELL DETAIL
SCALE: NONE



2 DOWNSPOUT CONNECTION & CLEANOUT DETAIL
SCALE: NONE



3 CURB OPENING DETAIL
SCALE: NONE

PFN: 16-117632 CUP/
17-101024 LDA

811 Know what's below. Call before you dig.

SNOHOMISH COUNTY
PLANNING AND DEVELOPMENT SERVICES
APPROVED FOR CONSTRUCTION

BY_______________ DATE:_________

R/W PERMIT NO.______________

CONFORMED SET

12802 WAGNER ROAD
MONROE, WA 98272

FULL DRAINAGE NOTES & DETAILS
SALEM WOODS ELEMENTARY SCHOOL
CONSTRUCTION DOCUMENTS

C3.20
73-16127-00
05/16/2017
Revisions

DAVID W. HARMSEN STATE OF WASHINGTON 33745 REGISTERED PROFESSIONAL ENGINEER

DLR Group
Architecture Engineering Planning Interiors

C:\Revit\73-16127-00_Salem Woods ES_AR_Central_2015_amieling.rvt
9/28/2016 5:28:09 PM

associated earth sciences incorporated

FIELD REPORT

911 Fifth Avenue
Kirkland, Washington 98033
Phone: 425-827-7701
Fax: 425- 827-5424
www.aesgeo.com

Date	Project Name	Project No.
08/02/2018	Salem Woods Elem. School	KE160200E004

Location	Municipality	Weather
12802 Wagner Road	Snohomish County	Rain, 60s

Permit No.	DPD No.	Report No.
N/A	N/A	57

Engineer/Architect
Harmsen & Associates/ DLR Group

Client/Owner
Monroe School District

General Contractor/Superintendent
Tiger Construction and Excavation Inc.

Grading Contractor/Superintendent
Tiger Construction and Excavation Inc. / Chuck

TO: Monroe Public Schools
200 East Freemont Street
Monroe, WA 98272

ATTN: Heidi Hansen

AS REQUESTED BY: Contractor

THE FOLLOWING WAS NOTED:

AESI (Matthew Porter) on site from 09:15 to 16:00 to observe the excavation and construction of bioretention cell #3 and previously excavated bioretention cell #2. Excavation was performed by Tiger Construction using a Hitachi Zaxis Steel-tracked excavator with an approximately 5-foot flat edge bucket.

BC-2 Excavation

Chuck (Tiger) informed AESI that the cell was excavated the previous day (August 1, 2018). AESI observed the bottom of cell was in native sand and gravel. Pictures are included in this field report.

BC-3 Excavation

AESI recommended that the bottom of Bioretention Pond #3 is situated in the native gravels and should be deepened to extend below the observed silt layer. Our recommendation for pond construction also includes a pit drain down the center of the cell extending down to 3 feet above groundwater. AESI was in contact with Chuck (Tiger) and Harmsen in the morning and received updated detail. During excavation of the northern side of the infiltration region of the cell, the subgrade was observed to be a poorly-graded fine to medium sand with trace silt and some gravel. This contrasts with the material to south which is a poorly-graded sandy gravel with trace silt. The observed native sand and gravel is suitable for bioretention pond subgrade. No till was encountered during excavation of the infiltration region.

Elevation (feet)	Feature
~310	Top of silt layer
~309	Bottom of silt layer
308.0	Bottom of cell
306.5	Bottom of pit drain (5 feet wide)
303.5	Groundwater

Construction

After excavation had finished, Tiger began placing drain rock using a front-end loader and the trackhoe excavator. AESI confirmed with Harmsen that no filter fabric will be used on the sides or the bottom of bioretention cell mix. For the future water measurements a piezometer, a 2" PVC with the bottom 3 feet hand slotted with a saw was placed at 306.5' at approximately 18 feet south of the north edge of the infiltration area.

Copies To:

Date Mailed:

Field Rep: Matthew J. Porter

Principal / PM: Kurt Merriman / Tony Romanick

This document is considered a DRAFT until signed or initialed by an AESI Principal or Project Manager

AESI FIELD REPORT

To:		Project Name:	Salem Woods Elem. School
Date:	8/2/2018	Project No.:	160200E004
Permit No.		DPD No.	

Photos:

Picture 1: Bioretention Cell #3 excavation showing existing subgrade (310.5'), silt layer, underlying gravel, and groundwater.

Copies To:		Field Rep:	Matthew J. Porter
Date Mailed:		Principal / PM:	Kurt Merriman / Tony Romanick

This document is considered a DRAFT until signed or initialed by an AESI Principal or Project Manager

AESI FIELD REPORT

To:		Project Name:	Salem Woods Elem. School
Date:	8/2/2018	Project No.:	160200E004
Permit No.		DPD No.	

Picture 2: [Looking NW] BC-3 installation of 2" PVC for piezometer in pit drain area. Subgrade at northern end of infiltration region is a sand rather than a gravel.

Picture 3: [Looking S] BC-3 Top of drain rock.

Copies To:		Field Rep:	Matthew J. Porter
Date Mailed:		Principal / PM:	Kurt Merriman / Tony Romanick

This document is considered a DRAFT until signed or initialed by an AESI Principal or Project Manager

AESI FIELD REPORT

To:		Project Name:	Salem Woods Elem. School
Date:	8/2/2018	Project No.:	160200E004
Permit No.		DPD No.	

Picture 4: [Looking W] BC-2 bottom of cell

Picture 5: [Looking S/SW] BC-2 bottom of cell.

Copies To:		Field Rep:	Matthew J. Porter
Date Mailed:		Principal / PM:	Kurt Merriman / Tony Romanick

This document is considered a DRAFT until signed or initialed by an AESI Principal or Project Manager

APPENDIX B

Current Study Exploration Logs and Laboratory Testing Data

associated earth sciences incorporated

Exploration Log

Project Number	Exploration Number	Sheet
150387H007	SSW-HA-1	1 of 1

Project Name	Bioretention Hydrologic Performance Study	Ground Surface Elevation (ft)	
Location	Snohomish County, WA	Datum	N/A
Driller/Equipment	Hand Auger	Date Start/Finish	10/9/18,10/9/18
Hammer Weight/Drop	N/A	Hole Diameter (in)	4 inches

Depth (ft)	S T	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Water Level	Blows/6"	Blows/Foot (10 20 30 40)	Other Tests
				Wood Chips					
		S-1		**Bioretention Soil Mix** Loose, moist, dark brown, medium SAND, trace to some silt, trace gravel; organic rich; massive; organic fragments typically range to 1 inch in size (SP/SP-SM).					
				Bottom of exploration boring at 2.2 feet. No seepage. No caving.					
5									

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample
- M - Moisture
- Water Level ()
- Water Level at time of drilling (ATD)

Logged by: ADY
Approved by: JHS

Geologic & Monitoring Well Construction Log

associated earth sciences incorporated

Project Number	Well Number	Sheet
150387H007	SSW-HA-2/WP	1 of 1

Project Name	Bioretention Hydrologic Performance Study	Location	Snohomish County, WA
Elevation (Top of Well Casing)	97.9 (Project Datum)	Surface Elevation (ft)	96.2 (Project Datum)
Water Level Elevation	Dry	Date Start/Finish	10/9/18,10/9/18
Drilling/Equipment	Hand Auger	Hole Diameter (in)	4 inches
Hammer Weight/Drop	N/A		

Depth (ft)	Water Level	WELL CONSTRUCTION	S T	Blows/ 6"	Graphic Symbol	DESCRIPTION
		Wood chips 0 to 0.2 feet				**Wood Chips**
		Threaded steel pipe 1.25-inch I.D. with threaded and vented PVC cap -1.7 to 0.7 feet				**Bioretention Soil Mix** Loose, moist, dark brown, medium SAND, trace to some silt, trace gravel; organic rich; massive; organic fragments typically range to 1 inch in size (SP/SP-SM).
		Bioretention soil mix 0.2 to 2.4 feet				
		Stainless steel jacket over stainless steel #60 gauze, welded to perforated steel pipe 0.7 to 2.6 feet				
						Vashon Recessional Outwash Medium dense, moist, brown, very gravelly, medium SAND, trace silt; no stratification observed (SP).
						Boring terminated at 2.4 feet Well completed at 3.3 feet on 10/9/18. No seepage. No caving. Steel drive point placed in borehole and hand driven with slide hammer to depth of 3.3 feet.
		Driven into existing sediments 2.4 to 3.3 feet Threaded steel pipe 1.25-inch I.D. and drive point 2.6 to 3.3 feet				
		Note: ~4 inches of "dead space" below bottom of perforated openings and total inside depth. Total inside depth = 4.7 feet.				
5						

Sampler Type (ST):

2" OD Split Spoon Sampler (SPT)	No Recovery	M - Moisture	**Logged by:** ADY
3" OD Split Spoon Sampler (D & M)	Ring Sample	Water Level ()	**Approved by:** JHS
Grab Sample	Shelby Tube Sample	Water Level at time of drilling (ATD)	

associated earth sciences incorporated

Exploration Log

Project Number	Exploration Number	Sheet
150387H007	SSW-HA-3	1 of 1

Project Name	Bioretention Hydrologic Performance Study	Ground Surface Elevation (ft)	
Location	Snohomish County, WA	Datum	N/A
Driller/Equipment	Hand Auger	Date Start/Finish	10/9/18,10/9/18
Hammer Weight/Drop	N/A	Hole Diameter (in)	4 inches

Depth (ft)	S T	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Water Level	Blows/6"	Blows/Foot 10 20 30 40	Other Tests
				Wood Chips					
		S-1		**Bioretention Soil Mix** Loose to medium dense, moist, dark brown, medium SAND, trace to some silt, trace gravel; organic rich; massive; organic fragments typically range to 1 inch in size (SP/SP-SM). Difficult to advance hand auger - compaction may have occurred.					
				At 2.2 feet Vashon Recessional Outwash - Medium dense, moist, brown, very gravelly, medium SAND, trace silt; no stratification observed (SP).					
				Bottom of exploration boring at 2.3 feet. No seepage. No caving.					
5									

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample
- M - Moisture
- Water Level ()
- Water Level at time of drilling (ATD)

Logged by: ADY
Approved by: JHS

a s s o c i a t e d
e a r t h s c i e n c e s
i n c o r p o r a t e d

Moisture, Ash, and Organic Matter of Peat and Other Organic Soils - ASTM 2974

Date Sampled	Project	Project No.		Soil Description
10/9/2018	Bioretention Hydrologic Performance Monitoring Study	150387 E007		Bioretention soil mix
Tested By	**Location**	**EB/EP No.**	**Depth**	
BN	Onsite- SSW			

Moisture Content

Sample ID	HA-2 (0.2'-0.5')	HA-3 (0.2'-0.5')
Wet Weight + Pan	902.52	802.93
Dry Weight + Pan	778.69	705.54
Weight of Pan	467.42	426.30
Weight of Moisture	123.83	97.39
Dry Weight of Soil	311.27	279.24
% Moisture	28.5	25.9

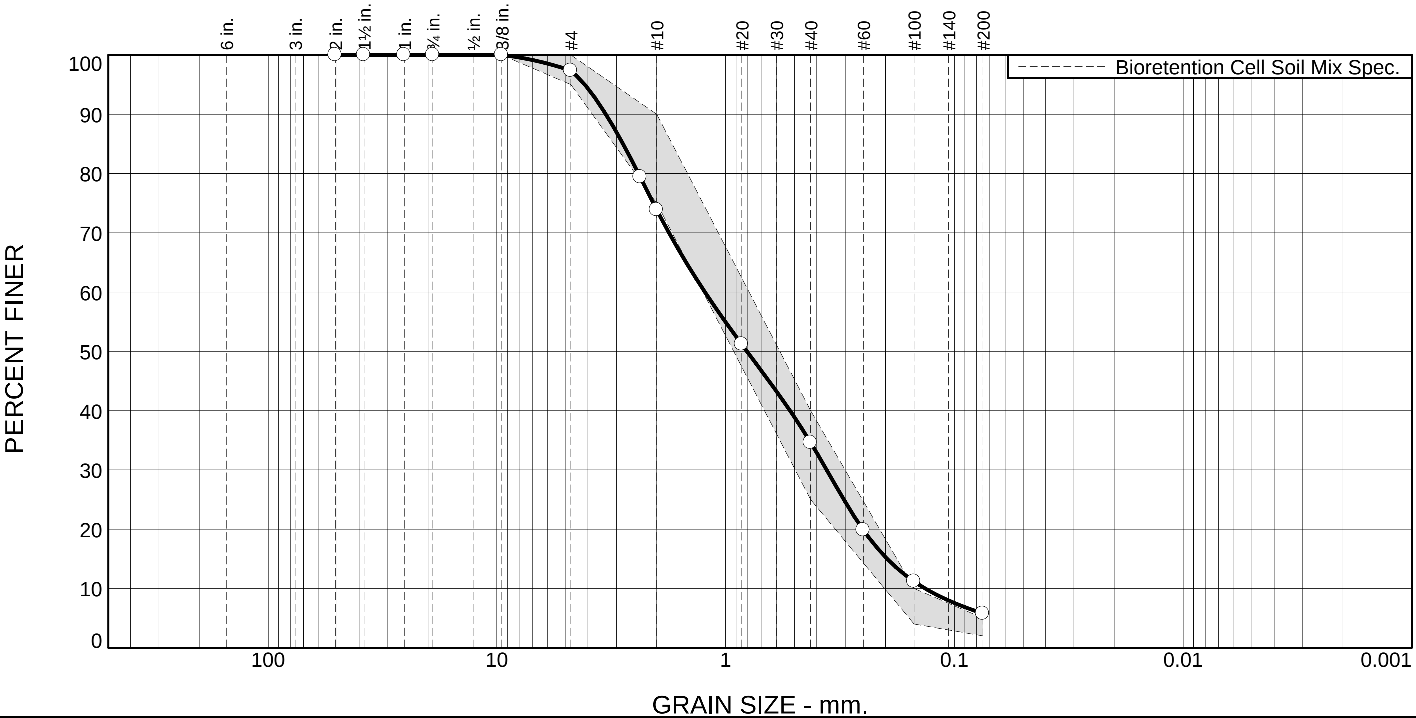
Organic Matter and Ash Content

Dry Soil Befor Burn + Pan	592.05	570.04
Dry Soil After Burn + Pan	558.51	539.98
Weight of Pan	391.92	357.91
Wt. Loss Due to Ignition	33.54	30.06
Actual Wt. Of Soil After Burr	166.59	182.07
% Organics	16.8	14.2

ASSOCIATED EARTH SCIENCES, INC.

911 5th Ave., Suite 100 Kirkland, WA 98033 425-827-7701 FAX 425-827-5424

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	2.6	23.5	39.3	28.9	5.7	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
2	100.0		
1.5	100.0		
1	100.0		
.75	100.0		
.375	100.0	100.0	
#4	97.4	95.0 - 100.0	
#8	79.4		
#10	73.9	75.0 - 90.0	X
#20	51.2		
#40	34.6	25.0 - 40.0	
#60	19.9		
#100	11.2	4.0 - 10.0	X
#200	5.7	2.0 - 5.0	X

* Bioretention Cell Soil Mix Spec.

Material Description

SAND, some silt, trace gravel

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=**

Classification

USCS (D 2487)= SP-SM **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 3.3390 D_{85}= 2.8093 D_{60}= 1.2316
D_{50}= 0.8069 D_{30}= 0.3617 D_{15}= 0.1967
D_{10}= 0.1344 C_u= 9.16 C_c= 0.79

Remarks

Collected by: ADY

Bioretention soil mix burned first per ASTM D2974 then sieved.

Date Received: 10/16/2018 **Date Tested:** 11/13/2018

Tested By: BN

Checked By: JHS

Title:

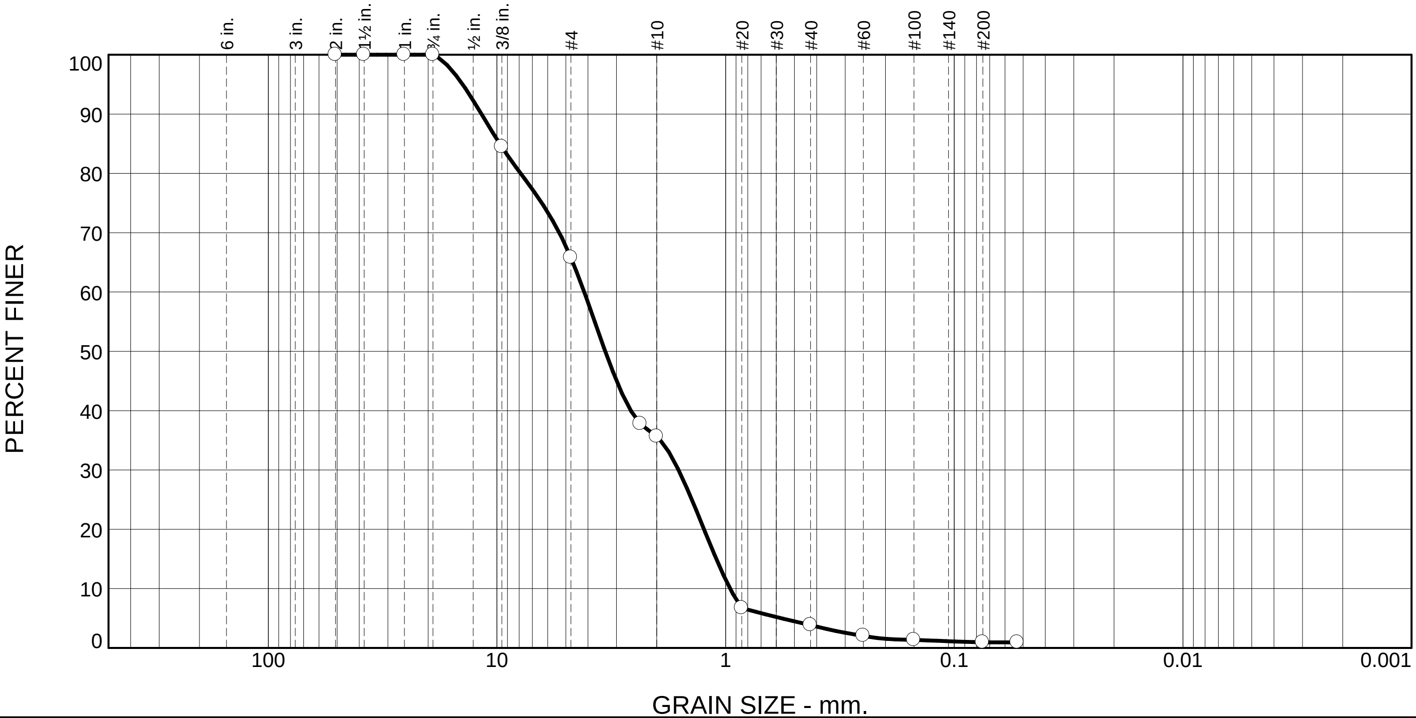
Source of Sample: (SSW) Snohomish County- Salem Woods ES **Depth:** 0.2'-0.5' **Date Sampled:** 10/09/2018
Sample Number: HA-2/WP

a s s o c i a t e d
e a r t h s c i e n c e s
i n c o r p o r a t e d

Client: Clear Creek Solutions
Project: Bioretention Hydrologic Performance Study

Project No: 150387 H004 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	34.2	30.2	31.7	2.9	1.0	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
2	100.0		
1.5	100.0		
1	100.0		
.75	100.0		
.375	84.5		
#4	65.8		
#8	37.8		
#10	35.6		
#20	6.7		
#40	3.9		
#60	2.1		
#100	1.3		
#200	1.0		
#270	0.9		

* (no specification provided)

Material Description

very gravelly SAND, trace silt

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP **AASHTO (M 145)=** A-1-a

Coefficients

D_{90}= 11.6822	D_{85}= 9.7242	D_{60}= 4.1537
D_{50}= 3.3596	D_{30}= 1.6063	D_{15}= 1.0988
D_{10}= 0.9565	C_u= 4.34	C_c= 0.65

Remarks

Collected by: ADY

Date Received: 10/16/2018 **Date Tested:** 10/18/2018

Tested By: MS

Checked By: JHS

Title:

Source of Sample: (SSW) Snohomish County- Salem Woods ES **Depth:** 2.1'-2.4' **Date Sampled:** 10/09/2018

Sample Number: HA-2/WP

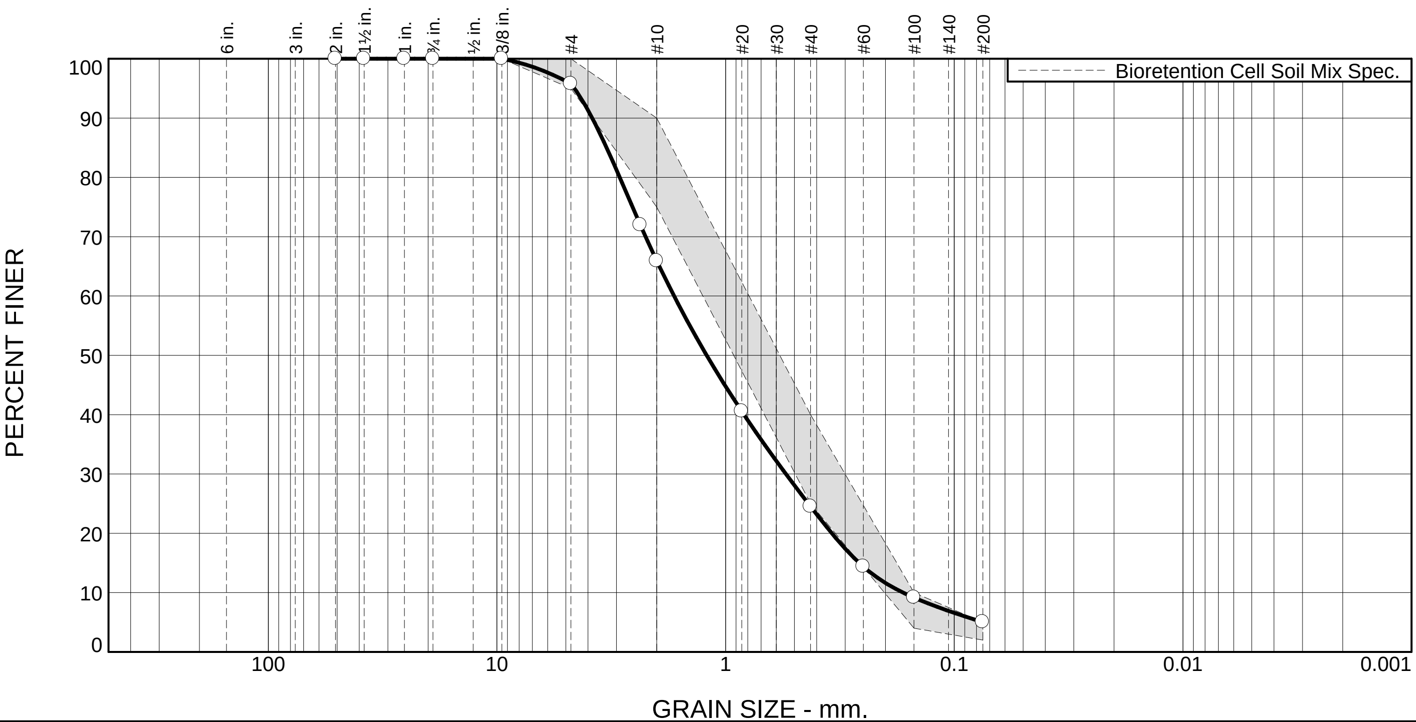
associated earth sciences incorporated

Client: Clear Creek Solutions

Project: Bioretention Hydrologic Performance Study

Project No: 150387 H004 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	4.2	29.9	41.4	19.5	5.0	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
2	100.0		
1.5	100.0		
1	100.0		
.75	100.0		
.375	100.0	100.0	
#4	95.8	95.0 - 100.0	
#8	72.0		
#10	65.9	75.0 - 90.0	X
#20	40.6		
#40	24.5	25.0 - 40.0	X
#60	14.4		
#100	9.2	4.0 - 10.0	
#200	5.0	2.0 - 5.0	

* Bioretention Cell Soil Mix Spec.

Material Description

SAND, some silt, trace gravel

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=**

Classification

USCS (D 2487)= SW-SM **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 3.8293 D_{85}= 3.3133 D_{60}= 1.6799
D_{50}= 1.2097 D_{30}= 0.5450 D_{15}= 0.2603
D_{10}= 0.1674 C_u= 10.04 C_c= 1.06

Remarks

Collected by: ADY

Bioretention soil mix burned first per ASTM D2974 then sieved.

Date Received: 10/16/2018 **Date Tested:** 11/13/2018

Tested By: BN

Checked By: JHS

Title:

Source of Sample: (SSW) Snohomish County- Salem Woods ES **Depth:** 0.2'-0.5' **Date Sampled:** 10/09/2018

Sample Number: HA-3

associated earth sciences incorporated

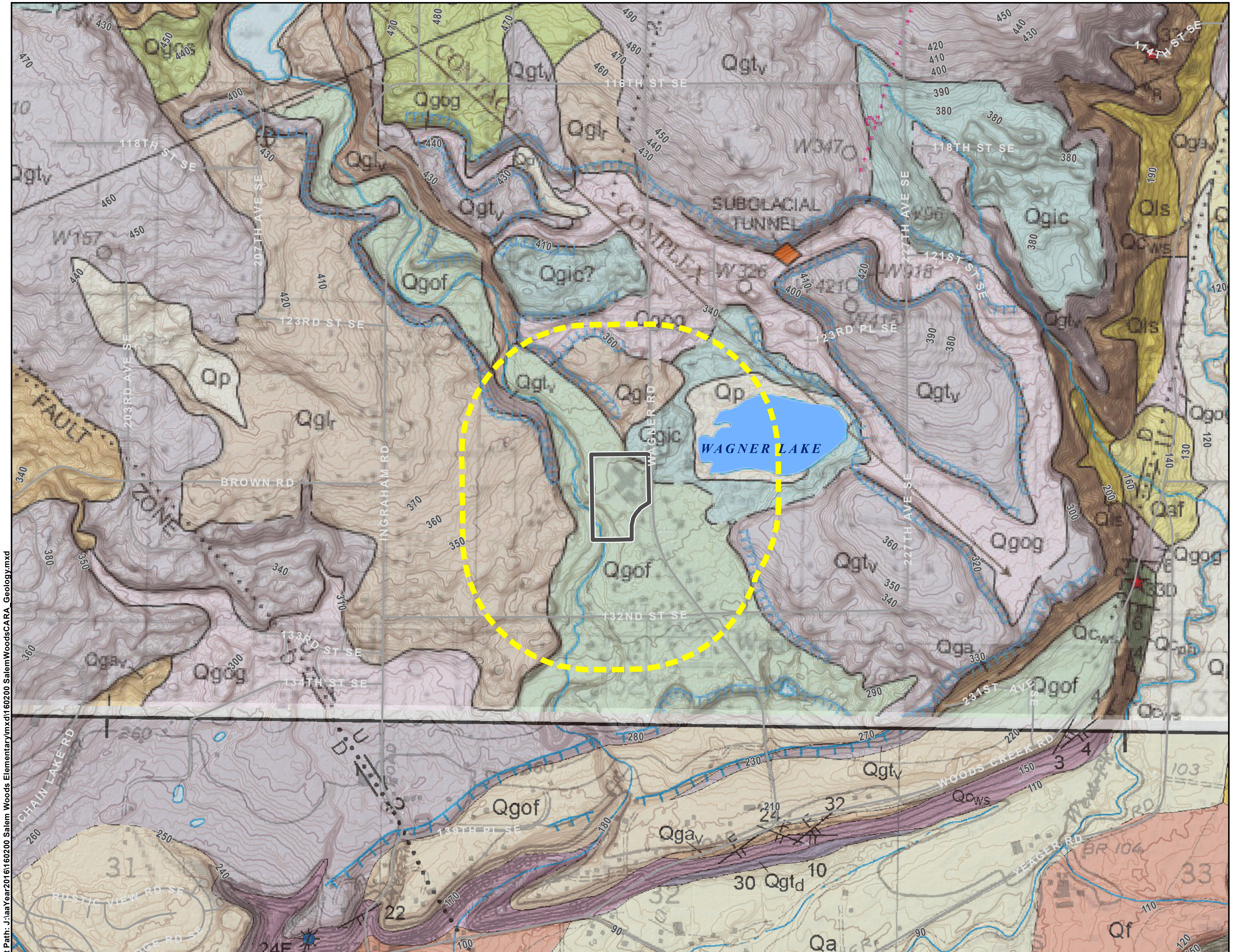
Client: Clear Creek Solutions

Project: Bioretention Hydrologic Performance Study

Project No: 150387 H004 **Figure**

APPENDIX C

Background Soil, Geology, and Groundwater Data (Regional Maps, Previous Studies Exploration Logs and Laboratory Testing Data)



LEGEND:

PROJECT LOCATION

1300 FT BUFFER FROM SITE

CONTOUR 10 FT

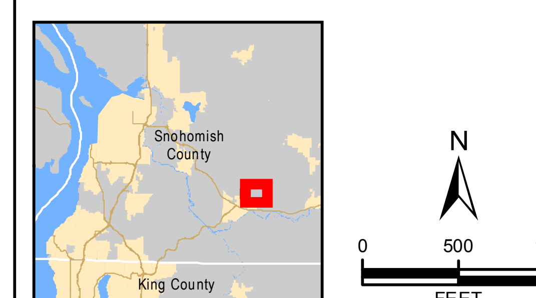
CONTOUR 2 FT

GEOLOGY:
Qf- ARTIFICIAL FILL AND MODIFIED LAND
Qp - PEAT
Qa - ALLUVIUM
Qls - LANDSLIDE
Qaf - ALLUVIAL FAN DEPOSITS
Qglr - RECESSIONAL GLACIOLACUSTRINE
Qgos - OUTWASH SAND
Qgod - DELTAIC OUTWASH AND KAME-DELTA
Qgof - FLUVIAL OUTWASH
Qgic - ICE-CONTACT
Qgog - OUTWASH GRAVEL, UNDIVIDED
Qgtv - LODGEMENT TILL
Qgav - ADVANCE OUTWASH
Qglv - ADVANCE GLACIOLACUSTRINE
Qco - DEPOSITS OF OLYMPIA NONGLACIAL INTERVAL
Qcws - WHIDBEY FORMATION
Qcphl - PRE-HAMM CREEK NON-GLACIAL

DATA SOURCES / REFERENCES:
PSLC: LIDAR 2014, GRID CELL SIZE IS 3'.
WA STATE PLANE NORTH, NAD83(HARN) NAVD88, US SURVEY FEET.
CONTOURS CREATED FROM 6' LIDAR 2005

SNOHOMISH CO:STREETS, WATER, PARCELS, CARA, FLOOD
WADOE: WELL REPORTS
WADNR: MAP SERIES 2015-01, LAKE ROESIGER 7.5-MINUTE QUADRANGLE
OFR2011-1, MONROE 7.5-MINUTE QUADRANGLE

LOCATIONS AND DISTANCES SHOWN ARE APPROXIMATE



BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION

associated earth sciences incorporated

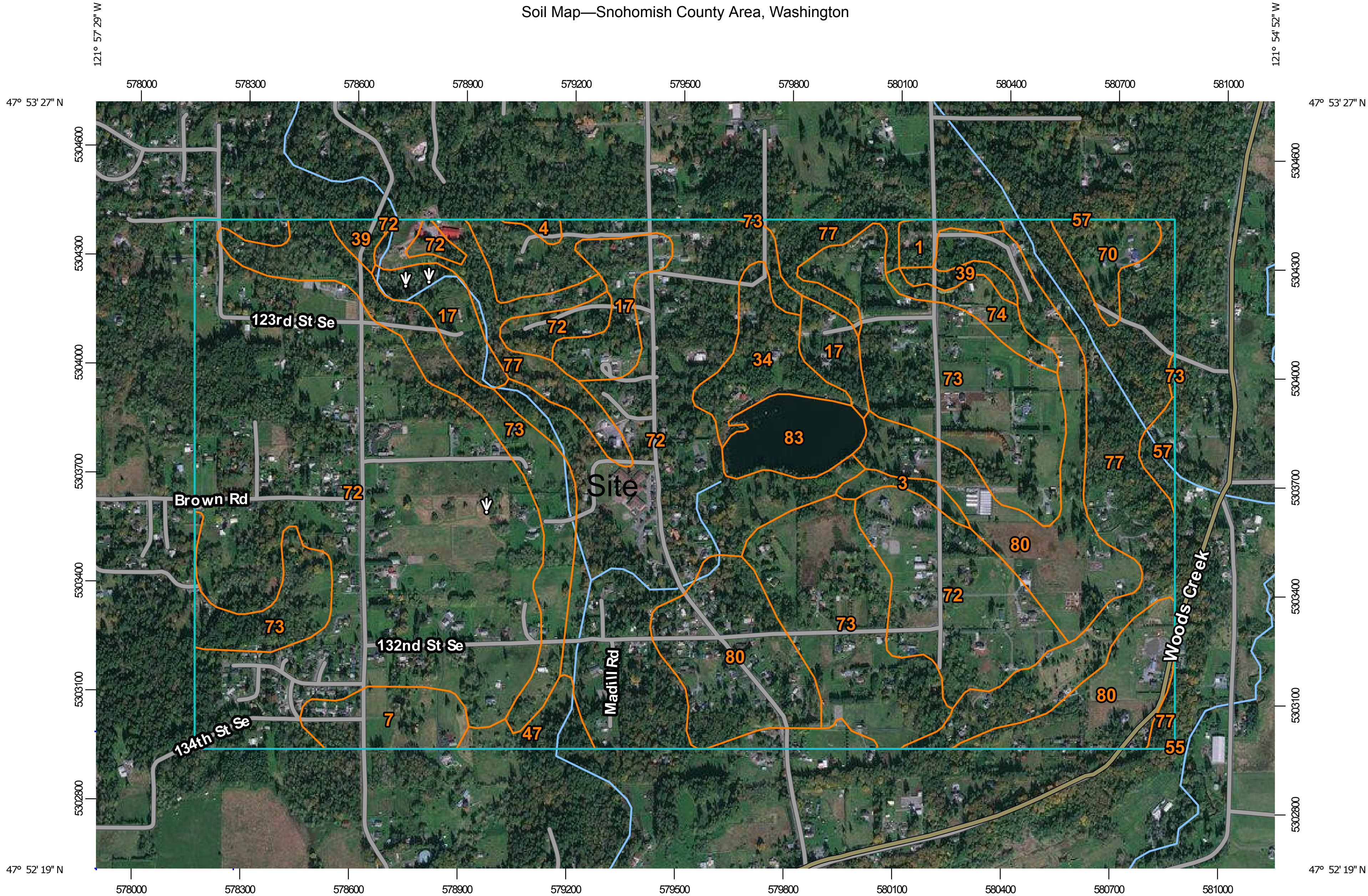
SURFACE GEOLOGY

SALEM WOODS ELEMENTARY SCHOOL
SNOHOMISH COUNTY, WASHINGTON

PROJ NO.	DATE:	FIGURE:
KH160200A	9/16	5

Document Path: J:\aaYear2016\160200 Salem Woods Elementary\mxd\160200 SalemWoodsCARA_Geology.mxd

Soil Map—Snohomish County Area, Washington



Map Scale: 1:14,900 if printed on A landscape (11" x 8.5") sheet.

Meters: 0, 200, 400, 800, 1200

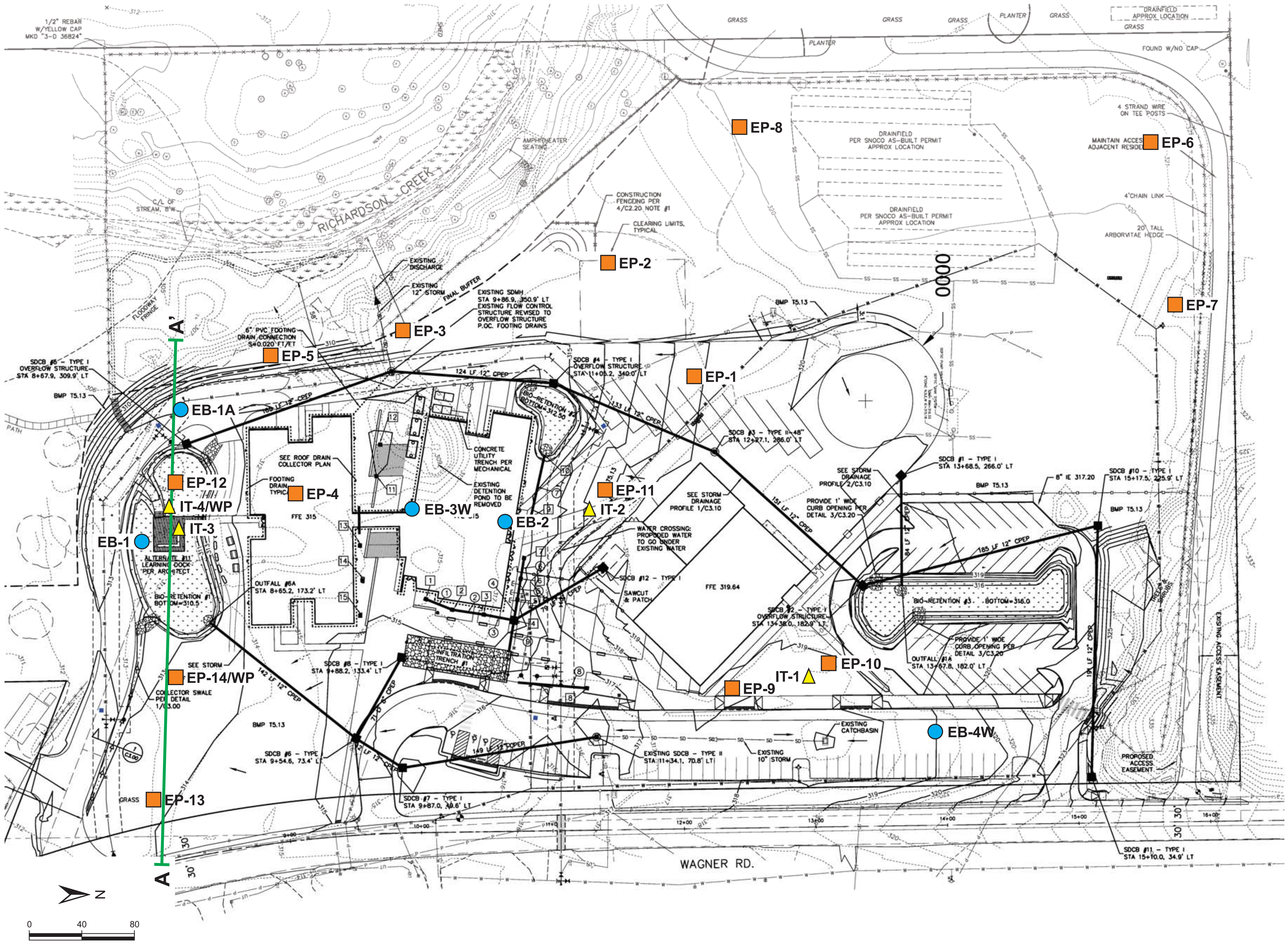
Feet: 0, 500, 1000, 2000, 3000

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
1	Alderwood gravelly sandy loam, 0 to 8 percent slopes	4.8	0.5%
3	Alderwood gravelly sandy loam, 15 to 30 percent slopes	4.3	0.4%
4	Alderwood-Everett gravelly sandy loams, 25 to 70 percent slopes	1.4	0.1%
7	Bellingham silty clay loam	16.8	1.7%
17	Everett very gravelly sandy loam, 0 to 8 percent slopes	36.7	3.8%
34	Mukilteo muck	19.6	2.0%
39	Norma loam	7.1	0.7%
47	Pastik silt loam, 0 to 8 percent slopes	8.4	0.9%
55	Puget silty clay loam	0.0	0.0%
57	Ragnar fine sandy loam, 0 to 8 percent slopes	4.5	0.5%
70	Tokul silt loam, 2 to 8 percent slopes	11.0	1.1%
72	Tokul gravelly medial loam, 0 to 8 percent slopes	440.6	45.0%
73	Tokul gravelly medial loam, 8 to 15 percent slopes	173.1	17.7%
74	Tokul gravelly medial loam, 15 to 30 percent slopes	8.9	0.9%
77	Tokul-Winston gravelly loams, 25 to 65 percent slopes	107.1	10.9%
80	Winston gravelly loam, 0 to 3 percent slopes	117.3	12.0%
83	Water	17.5	1.8%
Totals for Area of Interest		**978.9**	**100.0%**



LEGEND:

EB	EXPLORATION BORING
EP	EXPLORATION PIT
IT	INFILTRATION TEST
W	MONITORING WELL
WP	WELL POINT
	SECTION LINE

CONTOUR INTERVAL = 1'

NOTE: LOCATION AND DISTANCES SHOWN ARE APPROXIMATE.

NOTES:
1. BASE MAP REFERENCE: DLR GROUP, FULL DRAINAGE PLAN, SHEET 3.00, 5/16/17 AND WESTERN MARGIN OF SITE PLAN FROM DEMOLITION AND SWPP PLAN, SHEET C2.10, 5/16/17.

BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION.

associated earth sciences incorporated

SITE AND EXPLORATION PLAN

SALEM WOODS ELEMENTARY SCHOOL
SNOHOMISH COUNTY, WASHINGTON

PROJ NO.	DATE:	FIGURE:
160200H002	8/17	2

160200 Salem Woods Elem \ 160200H002 F2 Site-Expl 8-17. cdr

LOG OF EXPLORATION PIT NO. EP-1

Depth (ft)	This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered. **DESCRIPTION** Elev. ~317
	Fill
1–2	Loose to medium dense, moist, dark brown, fine to medium sandy GRAVEL, trace silt; contains cobbles (GP).
	Fluvial Outwash Deposits
3–4	Loose to medium dense, moist to very moist, gray, fine to coarse sandy GRAVEL, trace silt; contains cobbles; roughly stratified (GP).
6	Operator notes easier digging.
7	Medium dense, wet, tan, silty, fine to medium SAND, some gravel (SM).
8	Bottom of exploration pit at depth 7.5 feet Light seepage at 7 feet. Light caving from 0 to 7.5 feet.

Depth scale: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

KCTP3 160200 NEW#.GPJ March 29, 2017

Salem Woods Elementary School
Snohomish County, WA

Logged by: AWR

Approved by: JHS

associated earth sciences incorporated

Project No. 160200E002

6/30/16

LOG OF EXPLORATION PIT NO. EP-2

This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered.

Depth (ft)	DESCRIPTION Elev. ~317
0–1	**Grass / Topsoil**
1–7	**Fluvial Outwash Deposits**
	Loose to medium dense, moist, tannish brown, fine to medium sandy GRAVEL, trace silt; contains cobbles; oxidized (GP).
	Becomes gray, more coarse sand.
5	Medium dense, very moist, gray, fine to coarse sandy GRAVEL, trace silt; contains cobbles (GP).
6	Becomes wet, less sand.
6.5–7.5	**Vashon Lodgement Till ?**
	Loose to medium dense, wet, tannish gray, fine to medium SAND, trace to some silt (SP-SM).

Bottom of exploration pit at depth 7.5 feet
Moderate to heavy seepage at 6 feet; light seepage at 6.5 feet. Light caving from 0 to 7 feet.

KCTP3 160200 NEW#.GPJ March 29, 2017

Salem Woods Elementary School
Snohomish County, WA

Logged by: AWR
Approved by: JHS

associated earth sciences incorporated

Project No. 160200E002

6/30/16

LOG OF EXPLORATION PIT NO. EP-3

This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered.

Depth (ft)	DESCRIPTION Elev. ~315
	Grass / Topsoil
	Fill
1	
2	Loose, moist, dark brown, fine to medium sandy GRAVEL, trace silt; contains cobbles (GP). Becomes brownish gray.
3	
4	
5	
6	
7	
8	**Fluvial Outwash Deposits**
9	Loose to medium dense, moist, tannish brown, silty, fine SAND, some gravel, trace organics (SM). Medium dense, very moist, gray, fine to coarse sandy GRAVEL, trace silt; contains cobbles, occasional boulders (GP).
10	**Vashon Lodgement Till**
11	Dense, moist, tan, silty, fine SAND, some gravel; unsorted (SM).
12	
13	Dense, moist to very moist, silty, fine to medium SAND, some gravel; contains till-like clasts (SM).
14	
15	Bottom of exploration pit at depth 14 feet No seepage. No caving.
16	
17	
18	
19	
20	

Salem Woods Elementary School
Snohomish County, WA

Logged by: AWR

Approved by: JHS

associated earth sciences incorporated

Project No. 160200E002

6/30/16

LOG OF EXPLORATION PIT NO. EP-11

This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered.

Depth (ft)	DESCRIPTION
	Sand Surfacing - 6 inches
	Fluvial Outwash Deposits
1	Medium dense, moist, tan, fine to medium SAND, some silt, some gravel; oxidized (SP-SM).
2	Becomes less oxidized.
3	
4	Medium dense, moist, gray, fine to coarse sandy GRAVEL, trace silt; contains cobbles; oxidized (GP).
5	
6	
7	Medium dense, moist, gray, fine to coarse sandy GRAVEL; contains cobbles (GP). Boulder encountered.
8	
9	
10	As above.
11	
12	Medium dense, very moist, gray, fine SAND, some silt; laminated (SP-SM).
13	Bottom of exploration pit at depth 12.5 feet No seepage. Light caving from 11 to 12.5 feet.
14	
15	
16	
17	
18	
19	
20	

Salem Woods Elementary School
Snohomish County, WA

Logged by: AWR
Approved by: JHS

associated earth sciences incorporated

Project No. 160200E002
9/10/16

LOG OF EXPLORATION PIT NO. IT-2

Depth (ft)	This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered. **DESCRIPTION**
	Sand Surfacing - 6 inches
	Fluvial Outwash Deposits
1	
2	Medium dense, moist, tan, fine to medium SAND, some silt, some gravel; oxidized (SP-SM).
3	
4	Medium dense, moist, gray, fine to coarse sandy GRAVEL, trace silt; contains cobbles (GP).
5	
6	
7	Layer (~12 inches thick) of fine to coarse SAND, some gravel (SP).
8	Medium dense, wet, gray, fine to coarse sandy GRAVEL (GP).
9	Minor post-test seepage at 8.5 feet.
10	
11	
12	Medium dense, wet, gray, silty, fine SAND; laminated (SM).
13	Medium dense, wet, gray, gravelly, fine to coarse SAND, trace silt (SP).
14	
15	
16	Medium dense, wet, gray, gravelly SAND / sandy GRAVEL, some cobbles, trace silt (SP/GP).
	Vashon Lodgement Till
17	Dense, very moist, gray, silty, fine SAND, some gravel; unsorted (SM).
18	Bottom of exploration pit at depth 17 feet Moderate post-test seepage at 12 feet. Light caving. Infiltration test completed at 6.5 feet.
19	
20	

Salem Woods Elementary School
Snohomish County, WA

Logged by: AWR
Approved by: JHS

associated earth sciences incorporated

Project No. 160200E002

9/10/16

associated earth sciences incorporated

Exploration Log

Project Number	Exploration Number	Sheet
KE160200A	EB-2	1 of 1

Project Name: Salem Woods Elementary School
Location: Snohomish County, WA
Driller/Equipment: GDI / D50
Hammer Weight/Drop: 140# / 30"

Ground Surface Elevation (ft): ~314
Datum: N/A
Date Start/Finish: 6/16/16,6/16/16
Hole Diameter (in): 4 inches

Depth (ft)	Samples	DESCRIPTION	Blows/6"	Blows/Foot
0		**Grass / Topsoil**		
		Fluvial Outwash Deposits Gravelly drill action.		
	S-1	Very dense, moist, tannish gray, fine to medium sandy GRAVEL; interbed of oxidized fine sand; broken gravel in sampler (GP).	28 45 50/3"	50/3"
5	S-2	Very dense, moist, gray, fine to coarse sandy GRAVEL (GP).	14 42 18	60
10	S-3	Very dense, moist, gray, fine to coarse sandy GRAVEL; sand may be cemented (GP).	12 23 50/5"	50/5"
15	S-4		50/6"	50/6"
20	S-5	**Vashon Lodgement Till** Very dense, moist, gray, gravelly, silty, fine to coarse SAND; unsorted (SW/SM).	100/5"	100/5"
		Bottom of exploration boring at 20.5 feet No ground water encountered.		

Column headings also include: S T, Graphic Symbol, Well Completion, Water Level, Other Tests; Blows/Foot scale 10 20 30 40.

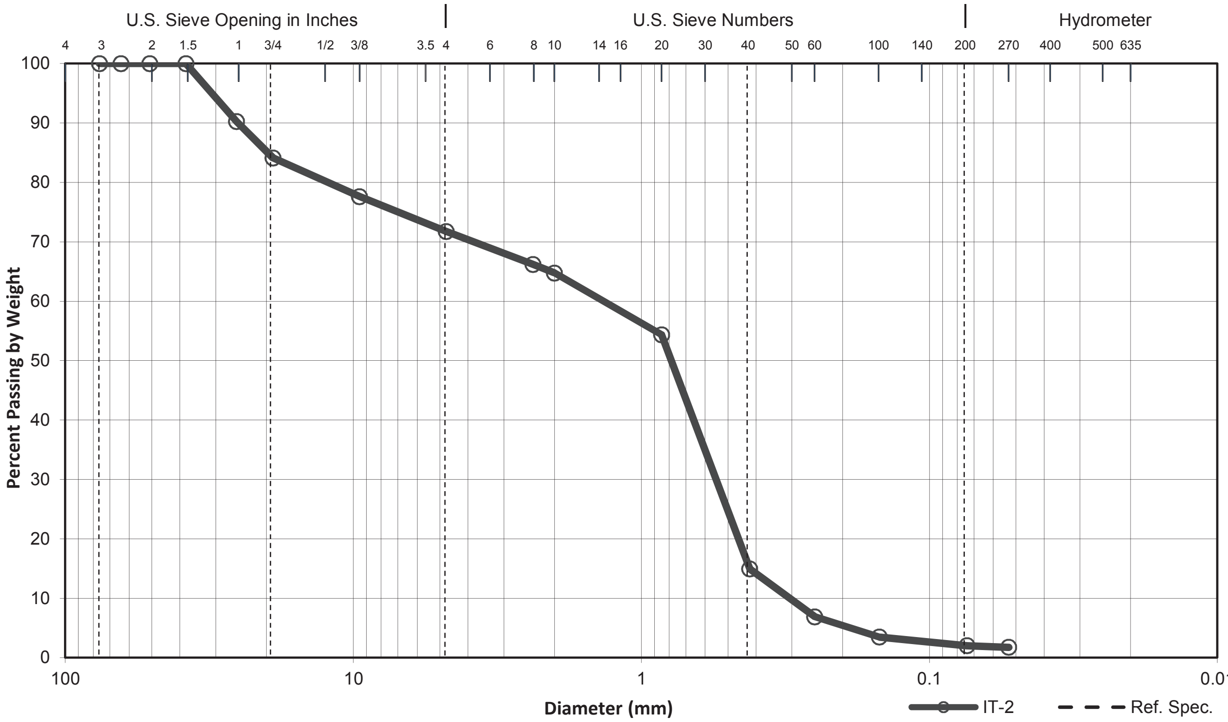
Sampler Type (ST):
- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample
- M - Moisture
- Water Level ()
- Water Level at time of drilling (ATD)

Logged by: AWR
Approved by: JHS

associated earth sciences incorporated

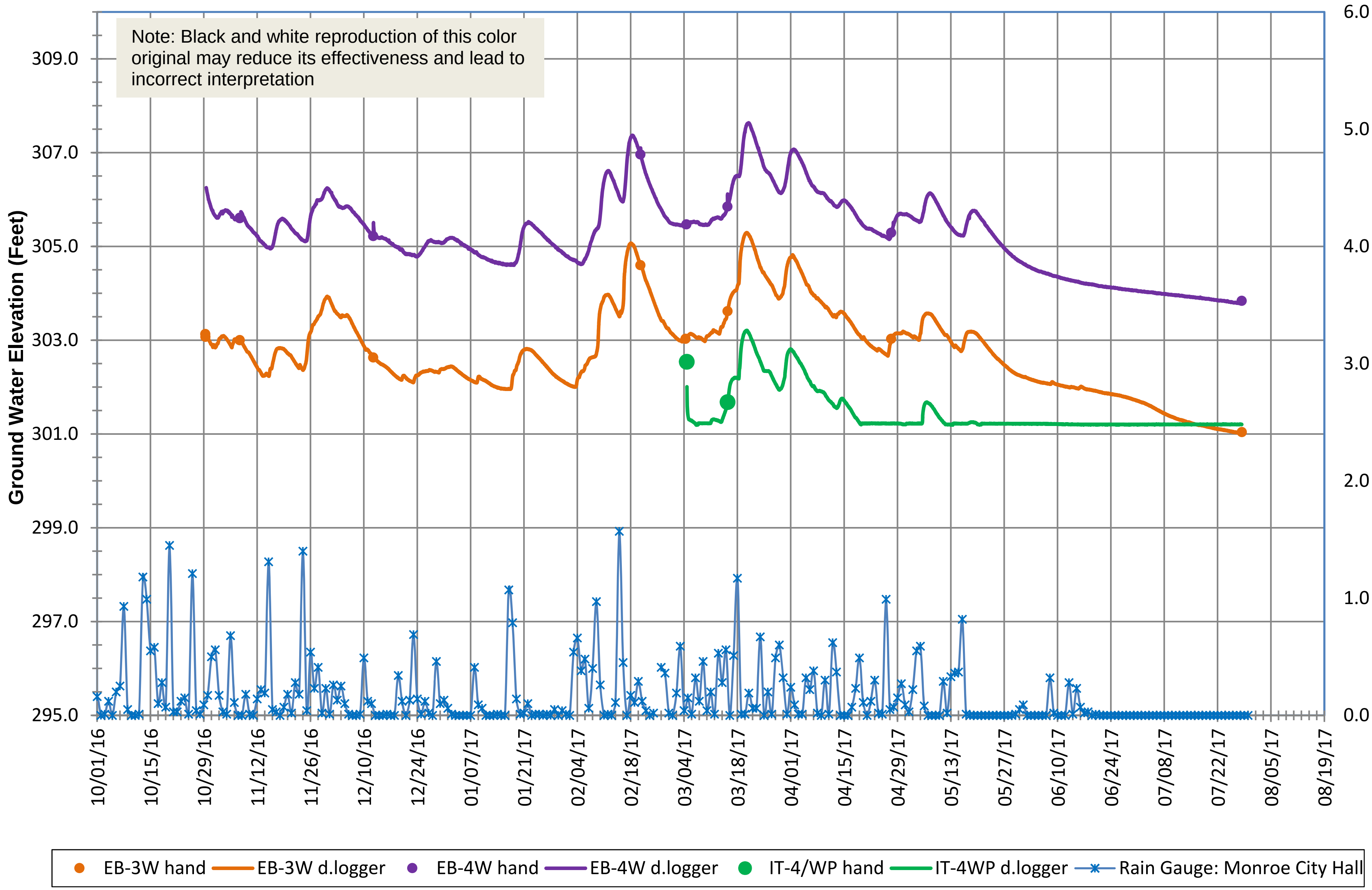
GRAIN SIZE ANALYSIS - MECHANICAL ASTM D422

Project Name	Project Number	Date Sampled	Date Tested	Tested By
Salem Woods Elementary	**KE160200A**	**9/10/2016**	**9/15/2016**	**MS**
Sample Source	Sample No.	Depth (ft)	Soil Description	
Onsite	**IT-2**	**6.5**	**gravelly SAND, trace silt (SP)**	
Total Sample Dry Wt. (g)	Moisture Content (%)	D_{10} (mm)	Reference Specification	
1853.3	**13**	**0.305**		



Cobb.	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Sieve No.	Diam. (mm)	Cum. Wt. Ret. (g)	% Ret. by Wt.	% Passing by Wt.	% Specs. Pass. by Wt. Min	Max
3	76.1		0.0	100.0		
2.5	64		0.0	100.0		
2	50.8		0.0	100.0		
1.5	38.1		0.0	100.0		
1	25.4	180.9	9.8	90.2		
3/4	19	294.2	15.9	84.1		
3/8	9.51	415.0	22.4	77.6		
#4	4.76	523.3	28.2	71.8		
#8	2.38	626.1	33.8	66.2		
#10	2	653.1	35.2	64.8		
#20	0.85	845.5	45.6	54.4		
#40	0.42	1576.1	85.0	15.0		
#60	0.25	1725.4	93.1	6.9		
#100	0.149	1788.5	96.5	3.5		
#200	0.074	1815.5	98.0	2.0		
#270	0.053	1820.6	98.2	1.8		



Ground Water Hydrograph
Salem Woods Elementary School
Snohomish County, Washington

Figure 4
Project Number: 160200H002
Date: August 2017

Associated Earth Sciences, Inc.

APPENDIX D

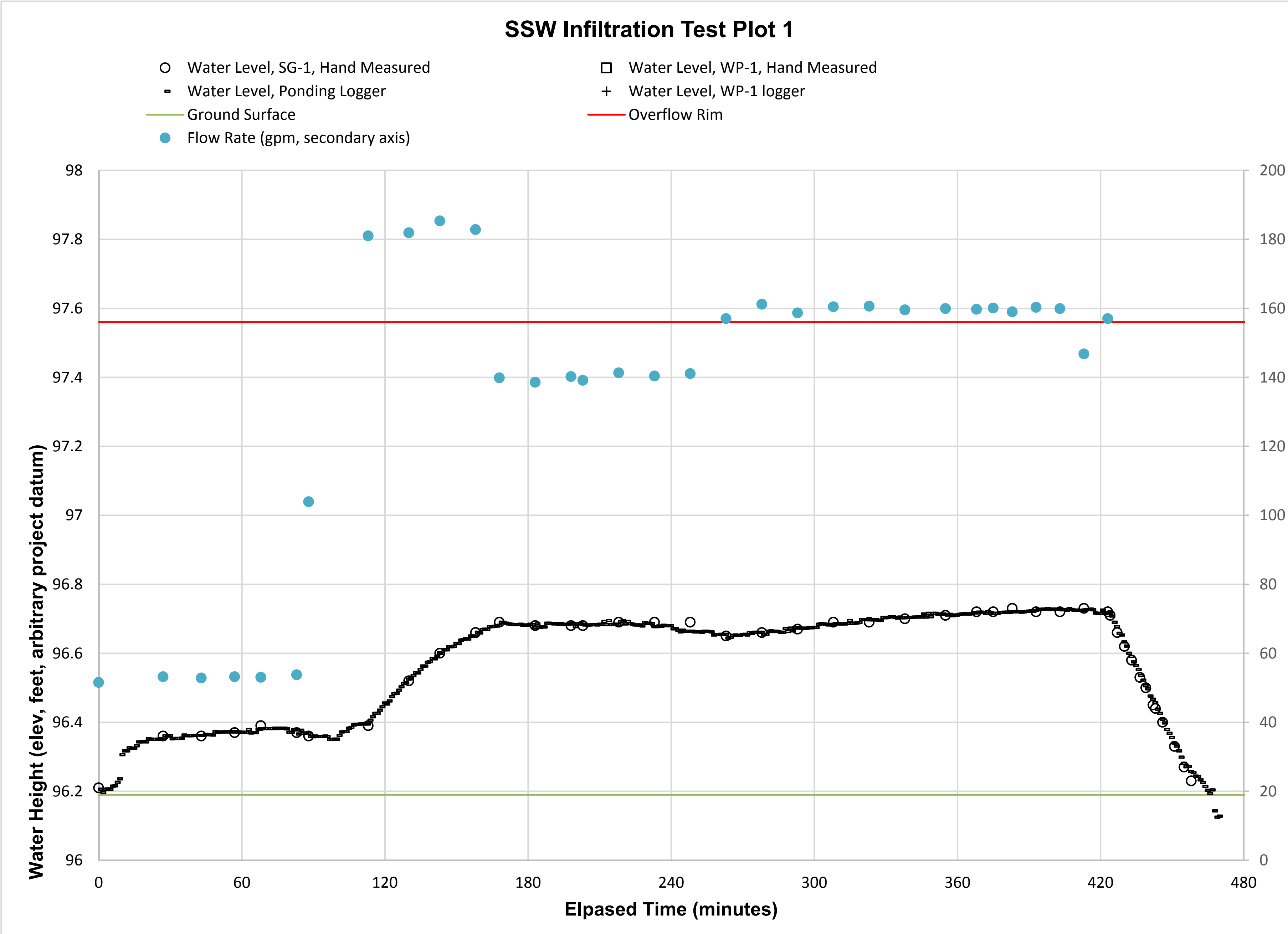
Soil Probe, Level Survey, and Field Infiltration Testing Data

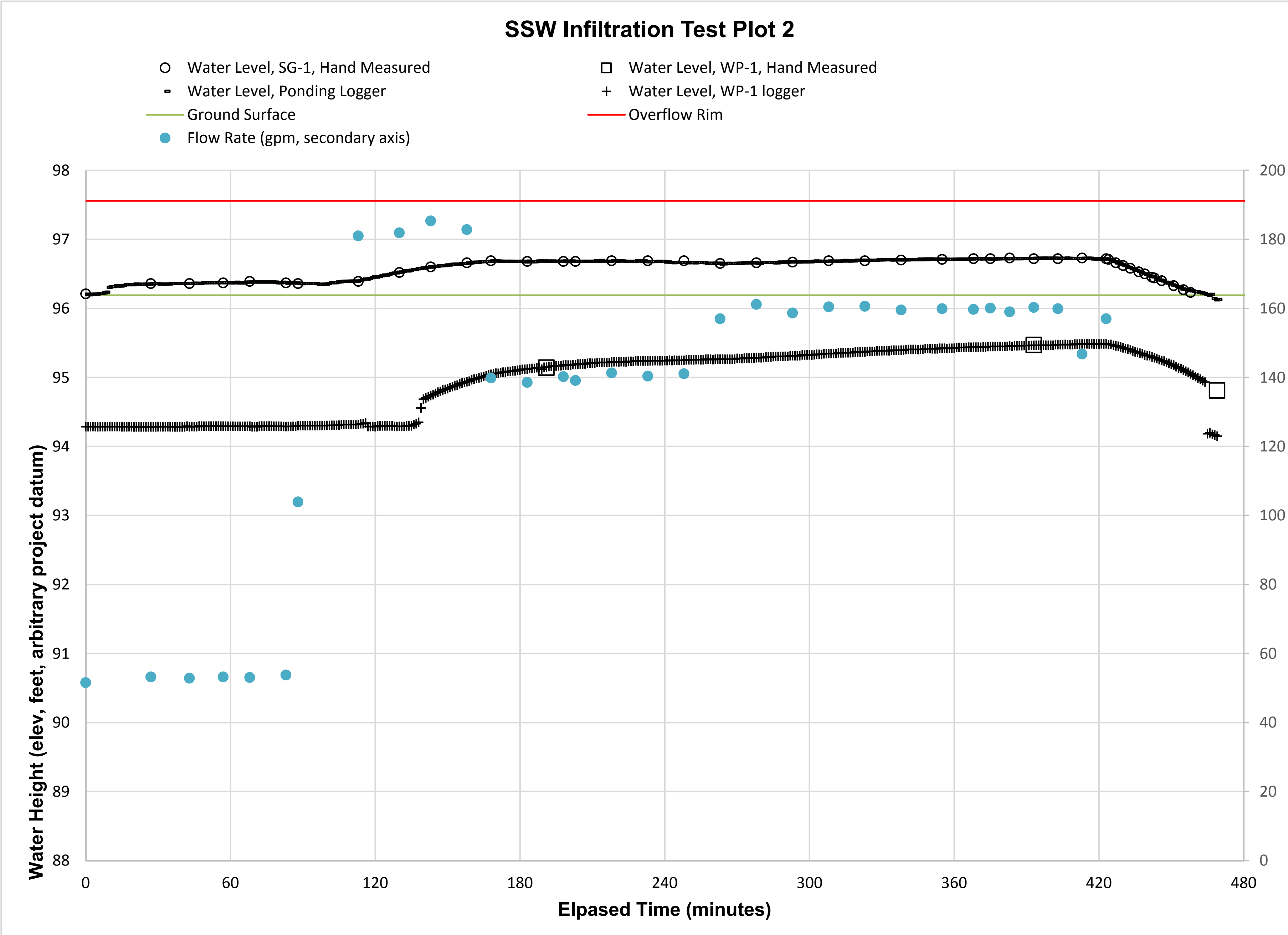
Project Name:	BHPS	**Water Source:**	Hydrant
Project Number:	150387H007	**Meter:**	AESI FM7
Date:	11/1/2018	**Base Area (sq.ft.):**	NA
Weather:	Intermittent rain, 60's	**Ponded Area(sq.ft.):**	940.0
Test No.:	SSW	**Test Depth (feet):**	NA
Performed By:	ADY, SC	**Receptor Soils:**	Recessional Outwash

Time (24-hr)	**Flow Rate (gpm)**	**Stage (feet)**	**Totalizer (gallons)**	**Comments**
8:37	51.53	0.02	0	Raining. Flow on.
9:04	53.2	0.17	1432	
9:20	52.85	0.17	2281	
9:34	53.2	0.18	3045	
9:45	53.03	0.2	3602	
10:00	53.76	0.18	4413	
10:05	103.94	0.17	5182	Flow increased to approx 100 gpm.
10:30	181	0.2	6527	Flow increased to approx 181 gpm.
10:47	181.9	0.33	9856	
11:00	185.34	0.41	12215	
11:15	182.82	0.47	14974	
11:25	139.84	0.5	16756	
11:40	138.54	0.49	18939	
11:48				
11:55	140.2	0.49	209413	Sprinkler testing on nearby landscaping area, runoff from parking lot entering inlet. Rain continues.
12:00	139.1	0.49	21622	
12:15	141.28	0.5	23746	
12:30	140.37	0.5	25814	
12:45	141.05	0.5	27921	
13:00	156.99	0.46	30087	
13:15	161.17	0.47	32480	
13:30	158.64	0.48	34745	Rain stops.
13:45	160.45	0.5	37158	
14:00	160.62	0.5	39483	
14:15	159.54	0.51	42005	
14:32	159.9	0.52	44759	
14:45	159.71	0.53	46732	
14:52	160.08	0.53	47903	
15:00	158.97	0.54	49220	
15:10	160.26	0.53	50855	No rain.
15:20	159.9	0.53	52414	
15:30	146.78	0.54	54033	Flow rate fluctuation.
15:40	156.99	0.53	55522	Flow off.
15:41		0.52		
15:44		0.47		
15:47		0.43		
15:50		0.39		
15:53		0.34		
15:56		0.31		
15:59		0.26		
16:00		0.25		
16:03		0.21		

16:08		0.14		
16:12		0.08		
16:15		0.04		
16:26		dry		

Average Infiltration Rate (in/hr) during last hour of inflow:	16.4
Average Infiltration Rate (in/hr) during falling head:	10.2


SSW Infiltration Test Plot 1
Water Level, SG-1, Hand Measured
Water Level, Ponding Logger
Ground Surface
Flow Rate (gpm, secondary axis)
Water Level, WP-1, Hand Measured
Water Level, WP-1 logger
Overflow Rim
Water Height (elev, feet, arbitrary project datum)
Elpased Time (minutes)
98
97.8
97.6
97.4
97.2
97
96.8
96.6
96.4
96.2
96
0
60
120
180
240
300
360
420
480
200
180
160
140
120
100
80
60
40
20
0


SSW Infiltration Test Plot 2
Water Level, SG-1, Hand Measured
Water Level, Ponding Logger
Ground Surface
Flow Rate (gpm, secondary axis)
Water Level, WP-1, Hand Measured
Water Level, WP-1 logger
Overflow Rim
98
97
96
95
94
93
92
91
90
89
88
200
180
160
140
120
100
80
60
40
20
0
0
60
120
180
240
300
360
420
480
Water Height (elev, feet, arbitrary project datum)
Elpased Time (minutes)

APPENDIX E

Site Photos

Cell SSW overview during infiltration testing.

Above photo: Cell SSW inlet modified for monitoring. Note straw waddle attempt to limit turbid inflow.
Lower Photo: close up of curb cut inlet prior to weir installation. Well point in foreground.

Technical Memorandum

Date:	June 14, 2019	**From:**	Anton Ympa Sue Cook
To:	Clear Creek Solutions, Inc.	**Project Manager:**	Jennifer H. Saltonstall, L.G., L.Hg.
	15800 Village Green Drive #3 Mill Creek, Washington 98012	**Principal in Charge:**	Jennifer H. Saltonstall, L.G., L.Hg.
cc:	Eric Christensen	**Project Name:**	Bioretention Hydrologic Performance Study
Attn:	Doug Beyerlein, P.E.	**Project No:**	150387H007
Subject:	Deliverable Task 4.5, Site TBM, Geotechnical/Soils Assessment Design Data and Current Conditions, George W. Bush Middle School, Tumwater, Washington		

1.0 INTRODUCTION

This technical memorandum documents existing shallow soil and groundwater conditions in the Basin 2A Bioretention Cell (north parking stalls) of the George W. Bush Middle School Project, located in the City of Tumwater, Washington (Figure TBM F1). This memorandum was prepared in accordance with Task 4 of the contract scope of work. Associated Earth Sciences, Inc. (AESI) collected shallow soil and groundwater conditions data related to bioretention cell function, and documented the current condition of the facility relative to the as-built drawings and available background geotechnical information. The information will be used in the WWHM2012 modeling that will be conducted as part of Task 5 (Data Analysis). In Task 5, the team will compare the previously documented hydrologic design information with our field-collected information and will note where there are significant differences. The purpose of this technical memorandum is to document the collection of current and accurate geotechnical, geologic, and hydrogeologic site information for this later work.

The following summary of shallow soil and groundwater conditions integrates the observations made during the geotechnical assessment which included site visits on October 2, 2018, infiltration testing on October 25, 2018, provisional results of hydrologic monitoring, and background geotechnical information.

This technical memorandum has been prepared for the exclusive use of Clear Creek Solutions and the City of Olympia and their agents for specific application to this project. Within the limitations of scope, schedule, and budget, our services have been performed in accordance with generally accepted hydrogeologic and geotechnical engineering practices in effect in this area at the time our document was prepared. No other warranty, express or implied, is made.

2.0 PURPOSE AND SCOPE

The purpose of our work was to perform a shallow soil and groundwater conditions assessment and provide baseline documentation data to assess effectiveness of bioretention hydrologic performance.

Specifically, our scope included the following activities:

- Review of project documents.
- Site reconnaissance.
- Visual condition assessment of erosion and deposition features near inlet and outlet.
- Review of project plans relative to constructed facility, in particular, the number and location of inlets, energy dissipation devices, outlets, and other flow-related details.
- Survey elevations of inlet, outlet, well point rim, and other observation points relative to a project datum.
- Excavate shallow hand-augers through the bioretention soil.
- Classify sediment according to the Unified Soil Classification System (USCS) and *American Society for Testing and Materials* (ASTM) D2488, "Standard Recommended Practice for Description of Soils."
- Collect samples for laboratory testing of: (1) particle size distribution in accordance with ASTM D422-63, "Standard Test Method for Particle-Size Analysis of Soils"; (2) organic matter content per ASTM D2974.
- Preparation of descriptive exploration logs for each exploration.
- Conduct qualitative assessment of soil compaction via T-probe.
- Conduct infiltration testing.
- Review of hydrologic monitoring data.
- Preparation of this summary document.

Existing facility features and the locations of hand-auger boreholes completed for this study are shown on Figure TBM F2, "Facility and Exploration Plan." Project civil plans are attached as Appendix A. Exploration logs and laboratory testing data conducted as part of this study are attached as Appendix B. Background soil, geology, and groundwater information are attached as Appendix C. Soil probe, level survey, and field infiltration testing data are attached as Appendix D. Site photos are attached as Appendix E.

3.0 SITE DESCRIPTION AND DESIGN BACKGROUND

The project site is the George W. Bush Middle School Project, located in Tumwater, Washington as shown on the attached "Vicinity Map" (Figure TBM F1). The George W. Bush Middle School is located on a 21.4-acre parcel. The site is situated in a rural residential area northeast of the intersection of Kimmie Street SW and 83rd Avenue SW, bound to the north by 80th Avenue SW, and bound to the east by undeveloped land owned by the Port of Olympia. Site topography is generally flat-lying with the total relief of the site of approximately 10 feet. No on-site surface water features are present. As described in the Drainage Report, the site is located in the Salmon Creek Drainage Basin and two City of Tumwater water production wells exist immediately north of the site (BCRA, 2016). The Salmon Creek Drainage Basin has high groundwater conditions and is subject to specific stormwater regulations. Per the Washington State Source Water Assessment Program Mapping Application, the site is located within the 6-month time of travel for several wells in City of Tumwater Water System ID#89700.

Our specific area of study for this project includes the bioretention cell for Basin 2A (north parking stalls) located on the north-central portion of campus referred to as cell TBM for this study. The attached “Facility and Exploration Plan” (Figure TBM F2) illustrates the cell area and some of the surrounding site features and utilities.

Details of the bioretention facility design and basis for design were presented in the following documents:

- Landau Associates, 2016a, “Geotechnical Engineering Report, George Washington Bush Middle School, Modernization and Addition, Tumwater, Washington”: Prepared for Tumwater School District No. 33, March 4, 2016.
- Landau Associates, 2016b, “Draft Technical Memorandum, Groundwater Mounding Analysis, Bush Middle, School, Tumwater, Washington”: Prepared for City of Tumwater, March 4, 2016.
- BCRA, 2016, “Drainage Report, George Washington Bush Middle School Renovations and Additions”: Prepared for Tumwater School District, March 3, 2016.
- BCRA, 2017, “George W. Bush Middle School Renovations and Additions, Tumwater School District, Plan Set”: December 29, 2017.

3.1 Summary of Facility Design

From our review of these documents, the bioretention facility design for cell TBM consists of an L-shaped bioretention cell with approximately 294 square feet of base area, as shown on Figure TBM F2, “Facility and Exploration Plan.” We understand that the site was developed under the City of Tumwater *Drainage Design and Erosion Control Manual*, 2010 and the 2005 Washington State Department of Ecology (Ecology) *Stormwater Management Manual for Western Washington* (2005 Ecology Manual). In addition, due to known shallow groundwater conditions within the Salmon Creek Drainage Basin, the site was also subject to specific stormwater facility requirements from: (1) City of Tumwater Ordinance No. 02005-003, Site Development Standards for New Development in the Salmon Creek Basin and Other High Groundwater Areas, October 4th of 2005, and (2) Thurston County’s Salmon Creek Comprehensive Drainage Basin Plan Phase II: Alternatives Analysis and Recommendations, June, 2004.

The site was modeled using WWHM2012 based on developed condition drainage basins of 0.19 acres, of which is 0.13 acres was impervious and 0.06 was pervious. The modeled design infiltration rate was 0.9 inches per hour (in/hr). The design infiltration rate was derived from the geometric mean of estimate hydraulic conductivity used grain-size-based correlations, and conservative assumptions for depth to groundwater and hydraulic gradient. Land use within the drainage basin is primarily parking and roadway with minor lawn area. Per plan sheet C5.09 "Civil Details," item 1, Bioretention Cell (BCRA, 2016), the facility design includes 3 inches of coarse compost over 18 inches of bioretention soil mix overlying native subgrade.

The facility is designed to infiltrate 100 percent of inflow into the subgrade. Stormwater enters the facility through one inlet curb cut on the south side near the center. Sheet C5.09, "Civil Details," item 1, Bioretention Cell, shows a Type 1 Catch Basin to be installed in cell TBM as an overflow in case water ponds up on the bioretention soil. The overflow rim of the Type I Catch Basin is shown to be 10 inches higher than the cell base to create 10 inches of ponding depth. However, the catch basin was not installed. The low area in the rim of the cell is the actual overflow, and if overflow occurs, it generally would flow across a grassy field toward an infiltration pond located east of the cell. The facility was constructed during Summer 2016 based on a review of aerial photography.

4.0 SITE OBSERVATIONS

During AESI's site visits, we made notes regarding the physical construction of the bioretention facilities including documenting site inlet/outlet layout relative to site plans and qualitative bioretention soil thickness and compaction. These notes were used to indicate key features of the facility in Figure TBM F2, "Facility and Exploration Plan."

- <u>Level Survey</u>: AESI conducted an elevation survey of the cell using a Leitz C40 automatic level and a stadia rod. An arbitrary project datum was established for this survey, with the northwest edge of the lamp post concrete base immediately south of cell defined as project datum elevation 100 feet. All other elevations measured by the survey are relative to this project datum. Key level data is summarized in Table 1. Additional data points are included in Appendix D to this document. This survey was not conducted by a licensed surveyor. Surveyed elevations are expected to be sufficiently accurate for this general assessment of facility construction, but may be inaccurate for purposes requiring greater precision.

- <u>Inflow</u>: One inflow consisting of a curb cut and concrete ramp to cell TBM was observed on the south-central edge of cell.

    - The inflow to the facility consists of a curb cut and concrete ramp, 1.5 feet wide and 2 feet long, that allows sheet flow from the parking area to discharge onto an angular rock energy dissipation pad approximately 4 feet wide and 5 feet long. No erosion was noted. The inlet was clear of debris and vegetation at the time of our site visit.

- <u>Overflow</u>: No overflow structure for cell TBM was observed. The natural overflow is a low area along the east side of the cell rim and was 1.1 feet above the cell base, 0.7 feet below the curb cut low and 0.4 feet below the concrete ramp low. If ponded water filled the cell, overflow would discharge over the cell rim to the east and flow easterly toward the existing infiltration pond.

- AESI investigated the loose bioretention soil thickness present in cell TBM using a geotechnical soil T-probe. This qualitative data was used in conjunction with the hand-auger observations to understand loose soil thickness and relative potential compactness of the bioretention soils at depth. AESI measured the depth of penetration of the soils probe at locations generally arranged in a 3-foot to 4-foot grid on the facility base. Penetration of the T-probe generally ranged from approximately 1.0 feet to 2.5 feet, and averaged 1.7 feet. Probe penetration data is included in Appendix D to this document.

Table 1
Summary of Cell TBM
Level Survey Data

Location	Elevation (feet, project datum)
Lamp post, concrete base, northwest	100
TBM-WP-1 TOC	99.75
TBM-WP-2 TOC	98.14
Ground surface at temporary staff gauge	96.17
Temporary inflow pipe top/end	97.66
Ponding tube TOC (DL)	98.19
Curb cut, inside lip, low	97.97
Concrete inflow ramp, inside lip, low	97.67
Cell rim low, east	97.30
Curb top, east of curb cut	98.58

WP: well point; TOC: top of casing; DL: datalogger

5.0 SITE SETTING

The text sections below describe our research findings in regards to the topographic, geologic, and hydrogeologic setting of the project site both from regional studies and background site-specific geotechnical and groundwater studies. Our sources of information included the following:

- Site-specific documents cited previously under “Project and Site Description.”
- Logan, R.L. et al., 2009, *Geologic Map of the Maytown 7.5-minute Quadrangle, Thurston County, Washington*, Washington Division of Geology and Earth Resources, Geologic Map GM-72, Scale 1:24,000 (geologic map).
- Natural Resources Conservation Service (NRCS), Web Soil Survey, United States Department of Agriculture (USDA), http://websoilsurvey.nrcs.usda.gov/, accessed December 2018.
- *Soil Survey of Thurston County, Washington*, United States Department of Agriculture (USDA), Natural Resource Conservation Service (NRCS), in cooperation with Washington Agricultural Experiment Station, 1990.

- Drost, 1998, *Hydrology and Quality of Ground Water in Northern Thurston County, Washington*.

5.1 Regional Topography and Project Grading

The project site is situated on a relatively flat-lying glacial outwash terrace near the southern extent of the Puget Sound Lowland. Elevations on the larger project site range from about 185 to 200 feet. The site is located about 2.5 miles southeast of Black Lake. Other small lakes and creeks are within 1 to 2 miles of the site but surface water is not present on the project site.

On a closer scale, the area near cell TBM is relatively level, situated on a recessional outwash terrace at about elevation 185 to 190 feet. Level parking stalls and access road areas are on the south side of the cell. Lawn surrounds the cell on the north, west, and east. A curb separates the paved surfaces from the cell. A large infiltration pond is approximately 100 feet to the east and the area east of cell TBM is graded gently toward the infiltration pond.

The project site was previously developed as George W. Bush Middle School and was renovated, including additions. Minor cutting (less than 3 feet) was needed to achieve design bioretention cell grades based on a review of existing topography compared with built topography.

5.2 Regional Geology and Background Geotechnical Information

According to the geology map (Logan, 2009), the site vicinity is underlain by Vashon recessional outwash sand and silt (Qgos). Recessional outwash sediments in the project area are described on the referenced map to consist of sand and silt with variable gravel content deposits from glacial meltwater, which is consistent with our observations and interpretations of subsurface materials encountered in our explorations for this project.

- <u>Vashon Recessional Outwash (Qgos)</u>: This unit is composed of stratified sand and silt with minor gravel interbeds, generally well sorted. Recessional outwash in the project area was deposited by glacial meltwater derived from stagnant ice and drainage from glacial Lake Puyallup farther east during ice retreat. Recessional outwash was deposited during the retreat of glacial ice, and has not been glacially overridden.

Background geotechnical information includes exploration logs B-1 and B-8 approximately 50 feet and 150 feet east of cell TBM, respectively, reached depths of about 20 feet below current grades, and describe material generally consisting of sand and silt with variable gravel grading to gravel with sand (Landau, 2016a). Boring EB-8 was completed as a well. Landau (2016a) interpreted the sediments as recessional outwash, which is consistent with the geologic mapping in the area.

5.3 Regional Soils and Soil Data Used in Site Stormwater Model

AESI reviewed the soil survey (Natural Resources Conservation Service [NRCS], 1990) and soils mapping from the NRCS web portal (NRCS, 2018). The soil survey identifies different soil map units based on parent material, climate, topography (slope), organisms (biota), and time. The soils in the study area formed mostly from young glacial deposits and have not had time to develop the deep weathering profiles present in soils in unglaciated terrains. Instead, they exhibit a direct relationship to the underlying parent material, local climate, topography, and vegetation.

Mapped soils in the project area consist of Cagey loamy sand (NRCS, 2018). Cagey soils are typically situated on terraces and formed from the weathering of sandy glacial drift. NRCS describes the permeability as rapid (6 to 20 in/hr) (NRCS, 1990)].

As described in the drainage report (BCRA, 2016), the pre-developed condition was modeled as Type A/B soils, consistent with mapped soil and background geotechnical data.

5.4 Regional Hydrogeology and Background Groundwater Data

Regional hydrogeology is described in Drost et al. (1998). Drost et al. (1998) indicates that recessional outwash and end moraine deposits can be an aquifer where saturated, and that perched groundwater conditions can occur locally within these units. This unit typically overlies Vashon lodgement till, which is described by Drost et al. (1998) as typically a confining bed.

On a closer scale, as described in the drainage report (BCRA, 2016), the site is within the Salmon Creek Drainage Basin, which has high groundwater conditions and is subject to specific site development standards. A groundwater mounding analysis was performed by Landau (2016b), to model high groundwater conditions. According to Landau (2016b), the development standards include steps the project must take in order to minimize potential flooding due to proposed project stormwater infiltration facilities.

Limited background groundwater level data was collected at six on-site monitoring wells; groundwater ranged from approximately 1 to 7 feet (about 5 feet near cell TBM) below ground surface in February 2016. Historical groundwater fluctuations are on the order of 8 feet, and peak groundwater is predicted to be at ground surface under extreme conditions (Landau, 2016b).

6.0 BIORETENTION CELL SUBSURFACE EXPLORATION

Limited information on subsurface conditions was obtained for this study from hand-auger samples and soil probe penetration measurements at about 2-foot increments in each hand-augered borehole. Three hand-auger borings were performed in the facility bottom and advanced through the bioretention soil and into the underlying fill and native Vashon recessional outwash. Representative samples were collected, visually classified in the field, stored in water-tight containers, and transported to AESI's offices for additional classification, geotechnical testing, and study. At the conclusion of the excavation, the boreholes were immediately backfilled with the excavated material or completed as a well point for water level monitoring (described separately below).

The various types of sediments, as well as the depths where characteristics of the sediments changed, are indicated on the exploration logs presented in Appendix B. A detailed record of the observed bioretention soil, subsurface soil, geology, and groundwater conditions was made. The sediments were described by visual and textural examination using the soil classification in general accordance with ASTM D2488, “Standard Recommended Practice for Description of Soils.” The depths indicated on the logs where conditions changed may represent gradational variations between sediment types in the field. The exploration logs in Appendix B are based on the field observations, inspection of the samples, and where applicable, laboratory grain-size analysis. Our explorations were approximately located in the field relative to known site features, and are shown on Figure TBM F2, "Facility and Exploration Plan."

The results presented in this document are based on the explorations completed for this study and review of background data. The number, locations, and depths of the explorations were completed within site and budgetary constraints. Because of the nature of exploratory work below ground, interpolation of subsurface conditions between field explorations is necessary. It should be noted that differing subsurface conditions may sometimes be present due to the random nature of deposition and the alteration of topography by past grading and/or filling.

6.1 Hand-Auger Borings

Hand-auger borings in cell TBM were completed on October 2, 2018. No rainfall was noted at the time of exploration.

Hand-auger boring locations are presented on Figure TBM F2. The hand-auger borings encountered approximately 1.2 feet to 1.5 feet of bioretention soil, overlying fill (TBM-HA-3) and/or native material interpreted to be Vashon recessional outwash. TBM-HA-3, located on the northwest end of the cell, encountered a thin layer of compost and topsoil at the surface and a thin layer of fill (about 5 inches thick) between the bioretention soil and the native material. The native recessional outwash was observed to the maximum depth explored of 7.7 feet (TBM-HA-1). No seepage or caving was observed. The recessional outwash contained a silty interbed.

6.2 Well Points

Two well points were installed in cell TBM within TBM-HA-1 (WP-1) and TBM-HA-2 (WP-2). Key well point dimensions are provided in Table 2, below. WP-1 was installed to a depth of 7.6 feet to measure groundwater in the shallow aquifer below the bioretention soil. WP-2 was installed to a depth of 1.9 feet, and screened primarily within the bioretention soil.

Table 2
Summary of Cell TBM
Well Point Dimensions

Well Point	Exploration in which Well Point was Installed	Total Length of Casing (feet)	Interior Diameter	Stickup Height (feet)	Total Depth Inside Casing Below Ground Surface
TBM-WP-1	TBM-HA-1	11.2	1.25 inch nominal	3.6	7.6
TBM-WP-2	TBM-HA-2	3.7	1.25 inch nominal	1.8	1.9

7.0 LABORATORY ANALYSIS

Laboratory testing included mechanical grain-size distribution and percent organic matter by weight in accordance with the ASTM D422 and D2974, respectively. Bioretention soil was first tested for organic matter content and then the burned material was tested for grain-size distribution for comparison with the aggregate fraction of the bioretention soil mix guidance in the 2014 Ecology *Stormwater Management Manual for Western Washington* (2014 Ecology Manual). Two samples of material interpreted as representative of bioretention soil were tested for grain-size distribution. The data is summarized in Table 3.

Table 3
Summary of Cell TBM
Organic Content and Grain-Size Data

Exploration Number	Depth (feet)	Soil Type	Organic Content (% by weight)	USCS Soil Description	Fines Content (% passing #200)	Cu	Cc	USDA Soil Texture*
TBM-HA-1	0.1-0.5	Bioretention Soil	8.4	SAND, some gravel, some silt (SP-SM)	5.2	8.1	0.9	Sand
TBM-HA-3	0.2-0.7	Bioretention Soil	4.6	SAND, trace gravel, trace silt (SP)	3.0	5.3	0.8	Sand
TBM-HA-1	3.5-4.0	Recessional Outwash	--	Very silty SAND (SM)	33	--	--	Sandy loam to sandy clay loam
TBM-HA-2	1.5-2.0	Recessional Outwash	--	SAND, some gravel, some silt (SP-SM)	9.0	--	--	Sand to Loamy Sand
TBM-HA-3	1.8-2.4	Recessional Outwash	--	SAND, some gravel, trace silt (SP)	4.6	--	--	Sand

USCS: Unified Soil Classification System; Cu: coefficient of uniformity; Cc: coefficient of curvature; USDA: U.S. Dept. of Agriculture;
*No hydrometers were performed. USDA soil texture range assumes fines consist entirely of silt to entirely of clay.

7.1 Bioretention Soil Mix

We compared the organic content and burned fraction gradation against the general guidelines for the bioretention soil mix (Table 4).

The organic content of the tested bioretention soils ranged between 4.6 and 8.4 percent by weight. These results are slightly above (TBM-HA-1, located near the inlet) and slightly below (TBM-HA-3, located near the north end of cell) the recommended organic content by weight of 5 to 8 percent in the 2014 Ecology Manual.

The grain-size analysis test results on the burned soil fraction indicate that the bioretention soils tested correlate to a “SAND” with trace to some silt and trace to some gravel based on ASTM D2487 USCS. The respective fines content as measured on the No. 200 sieve was 3.0 to 5.2 percent. The coefficient of uniformity ranged from 5.3 to 8.1, meeting the recommended value of equal to or greater than 4. The coefficient of curvature ranged from 0.8 to 0.9, below the recommended range of greater than or equal to 1 and less than or equal to 3. The soil mix was generally coarser-graned with more than the recommended range of gravel and coarse sand. The tested bioretention soil was a poorly-graded sand.

Table 4
General Guidelines for Bioretention Soil Mix (2014 Ecology Manual)
Compared to Averaged Cell TBM Site Data

Parameter	Recommended Range	Cell TBM
Organic Content (by weight)	5 to 8 percent	6.5 percent by weight
Cu coefficient of uniformity	4 or greater	6.7
Cc coefficient of curvature	1 to 3	0.9
Sieve Size	**Percent Passing**	
3/8” (9.51 mm)	100	99.2
#4 (4.76 mm)	95 to 100	94.7
#10 (2.0 mm)	75 to 90	63.5
#40 (0.42 mm)	25 to 40	18.3
#100 (0.15 mm)	4 to 10	5.9
#200 (0.074 mm)	2 to 5	4.1

Note: The general guidelines for mineral aggregate gradation are from Table 7.4.1 of the 2014 Ecology Manual.
mm = millimeters.

7.2 Subgrade

In cell TBM, three samples of native recessional outwash were sieved. The tested materials illustrate the variability in silt content with depth with 5 to 33 percent by weight of the material passing the No. 200 sieve.

The grain-size distribution data were also transformed to describe the U.S. Department of Agriculture (USDA) soil texture. The grain-size distributions were normalized to the No. 10 sieve—

i.e., the coarse sand and gravel fraction of the sample is discounted and the remainder is taken as 100 percent of the sample. The fines were assessed relative to the No. 270 sieve. The respective USDA fines content as measured on the No. 270 sieve after adjusting to remove the weight retained on the #10 sieve was 4 to 29 percent for the native recessional outwash material.

8.0 INFILTRATION TESTING

8.1 General Infiltration Test Method

The infiltration test was conducted in general accordance with the 2014 Ecology Manual. The test was conducted by discharging water into the facility for a "soaking period," to allow the receptor soils to become saturated. After completion of the soaking period, water was discharged into the cell at a rate sufficient to maintain a relatively constant head. This constitutes the "constant-head" phase of infiltration testing. Immediately following the constant-head phase of infiltration testing, flow into the facilities was discontinued, and the water level was monitored as it dropped. This constitutes the "falling-head" portion of the infiltration testing.

The water for testing was obtained from an on-site fire hydrant and conveyed to cell TBM with fire hoses. During infiltration testing, the water was conveyed into the bioretention cell via a digital flow meter with gallons per minute (gpm) and total gallon readouts, and discharged through a flow diffuser. Ponded water levels within the cell were monitored using a temporary staff gauge (TBM-SG-1) marked in 0.01-foot increments installed adjacent to TBM-WP-1, and within a piezometers ("ponding tube") with a digital water level tape, and with digital pressure transducers for the duration of the test. The water level at the base of the bioretention soil and the shallow groundwater table were monitored in well point TBM-WP-2 and TBM-WP-1, respectively, with a digital water level tape, and with digital pressure transducers. Data from the digital pressure transducers were compensated for barometric response using a separate digital barometer. The area of the pool was measured periodically during testing.

The infiltration test in cell TBM is discussed below, and results are presented in Table 5. Infiltration test data is included in Appendix D to this document.

8.2 Infiltration Test in Cell TBM

AESI performed infiltration testing on October 25, 2018. Light rainfall was noted during testing, and approximately 0.3 gpm of flow from the inflow was present at the start of the test.

During this test, flow was initially adjusted between about 45 and 85 gpm to fill the cell bottom and stabilize the wetted area, then maintained at about 42 gpm for the duration of test. Inflow to the facility for the infiltration test was directed, through a diffuser, onto the cell. The entire cell base was wetted after about 65 minutes and a water level of about 1.0 feet was maintained at the staff gauge after about 215 minutes (TBM-SG-1). The wetted pool area had been generally stable for about 3.4 hours, covering an area of about 520 square feet. Approximately 20,000 gallons of water were used.

Ponded water in the bioretention cell was monitored in well point TBM-WP-2 with a data logger during the infiltration test and responded rapidly to inflow. Groundwater was not observed within the bioretention soil prior to the start of inflow. The water level in the well point responded to inflow within a few minutes of the start of the test, and was present in the well point throughout the test, generally corresponding to water level within the cell. AESI interprets this response to indicate that water from the infiltration test infiltrated relatively rapidly through the bioretention soil and then mounded on the native finer-grained recessional outwash.

Groundwater was monitored in well point TBM-WP-1 using a data logger during the infiltration test and responded to inflow. Groundwater was not present beneath the bioretention cell prior to the start of inflow to a bottom depth of TBM-WP-1 (7.6 feet). The water level in TBM-WP-1 responded to inflow above the base of the well point after about 140 minutes, and rose an additional 1.1 feet (from 7.6 feet below ground surface to 6.5 feet below ground surface) during the course of testing. AESI interprets that the infiltration test water mounded on the native finer-grained recessional outwash, slowly soaked vertically downward. During testing, the deeper well point lag was approximately 140 minutes when water appeared in the well point in response to inflow. The water in the deeper well point could represent mounding on shallow groundwater present beneath the facility (and below the bottom of well point TBM-WP-1 prior to inflow), or intermittent perching on silty interbeds.

After about 7 hours, AESI shut off the flow and monitored the water level as it fell. AESI observed that the pooled water in the base of the facility dropped about 0.7 feet and water was still ponded in the base of the facility about 0.3 feet after 70 minutes. Groundwater was still mounded approximately 0.7 feet above the base of TBM-WP-1, 70 minutes after inflow stopped.

The constant-head test infiltration rate in Table 5 is calculated based on flow rate from the hose for infiltration testing, and the wetted area of bioretention soil through which the water infiltrated, and is interpreted to represent the infiltration rate of the native subgrade.

Table 5
Cell TBM
Infiltration Test Results

Test No.	Surface Area (square feet)	Discharge Time (minutes)	Total Volume Discharged (gallons)	Approximate Constant Head Level (feet)	Field Infiltration Rates: Constant Head Test (in/hr)	Field Infiltration Rates: Falling Head Test (in/hr)
TBM (bioretention soil)	520	420	19,933	1.0	greater than native soil infiltration rate	
TBM (subgrade)	Interpreted to be similar to wetted area				8	8

in/hr: inches per hour.

9.0 CONCLUSIONS AND RECOMMENDATIONS

Cell TBM were inconsistent with the design shown on the civil plan sheets. Observations on site design, shallow soil and groundwater conditions are discussed below.

- The overflow is inconsistent with the plans. The plans show for a Type 1 catch basin. No overflow structure was observed The natural overflow is a low area along the east side of the cell rim and was 1.1 feet above the cell base, 0.7 feet below the curb cut low and 0.4 feet below the concrete ramp low. If ponded water filled the cell, overflow would discharge over the cell rim to the east and flow easterly toward the existing infiltration pond. Site design documents indicate that the ponding level was designed as 12 inches.

- Bioretention soil:
    - Thickness: The apparent thickness of loose bioretention soil based on soil probe data averaged about 1.7 feet, generally consistent with the plan.
    - Composition: The soil tested was not within the recommended guidelines for organic content and sand gradation. The soil mix was generally coarser-grained with more than the recommended range of medium- and coarse-grained sand. The average organic content was within the recommended range of 5 to 8 percent; however, the individual samples were either above at 8.4 percent or slightly below at 4.6 percent. The coefficient of curvature was slightly below the recommended range.

- Subgrade conditions: The subgrade is interpreted to consist of Vashon recessional outwash, as documented in the geotechnical explorations for this study and in the design documents. A thin layer (5 inch) of sand fill was observed overlying native material at the northwest end of the cell.

- During infiltration testing, water readily soaked through the bioretention soil mix. Water was observed in the shallow well point (screened at the base of the bioretention soil), demonstrating that water accumulated on the underlying subgrade. The native fine sand is interpreted to have a lower permeability than the overlying bioretention soil. The shallow subsurface ponded water level mirrored the surface water ponding level.

- Subgrade infiltration rate: Measured at about 8 in/hr.

- Bioretention soil field infiltration rate:
    - Greater than the measured field rate of 8 in/hr.
    - Water readily soaked through the bioretention soil mix and the field rate is interpreted to represent the native subgrade soil infiltration rate.

- Shallow groundwater is expected to be present in the location of the TBM facility below the bottom of well point TBM-WP-1 as measured in the on-site monitoring wells and historic water level data (Landau, 2016b). AESI interprets that the infiltration test water mounded on the native finer-grained recessional outwash, and slowly soaked vertically downward.

During testing, the deeper well point lag was approximately 140 minutes when water appeared in the well point in response to inflow. The water in the deeper well point could represent mounding on shallow groundwater present beneath the facility (and below the bottom of well point TBM-WP-1 prior to inflow), or intermittent perching on silty interbeds. AESI interprets that mounded water dissipated both laterally and vertically as shallow groundwater flow. Water was still ponded in the base of the facility about 0.3 feet above the ground surface and groundwater was still mounded approximately 0.7 feet above the base of TBM-WP-1 about 70 minutes after inflow was stopped.

- The effects of shallow groundwater mounding will increase during the wetter winter months, and will reduce the effective infiltration rate by reducing the vertical gradient. The ongoing monitoring data will be reviewed for groundwater influence.

10.0 CLOSURE

We appreciate the opportunity to be of continued service to you on this project. Should you have any questions regarding this document or other geotechnical/hydrogeologic aspects of the project, please call us at your earliest convenience.

State of Washington
Hydrogeologist
2335
Licensed Geologist
Jennifer H. Saltonstall

6/14/19

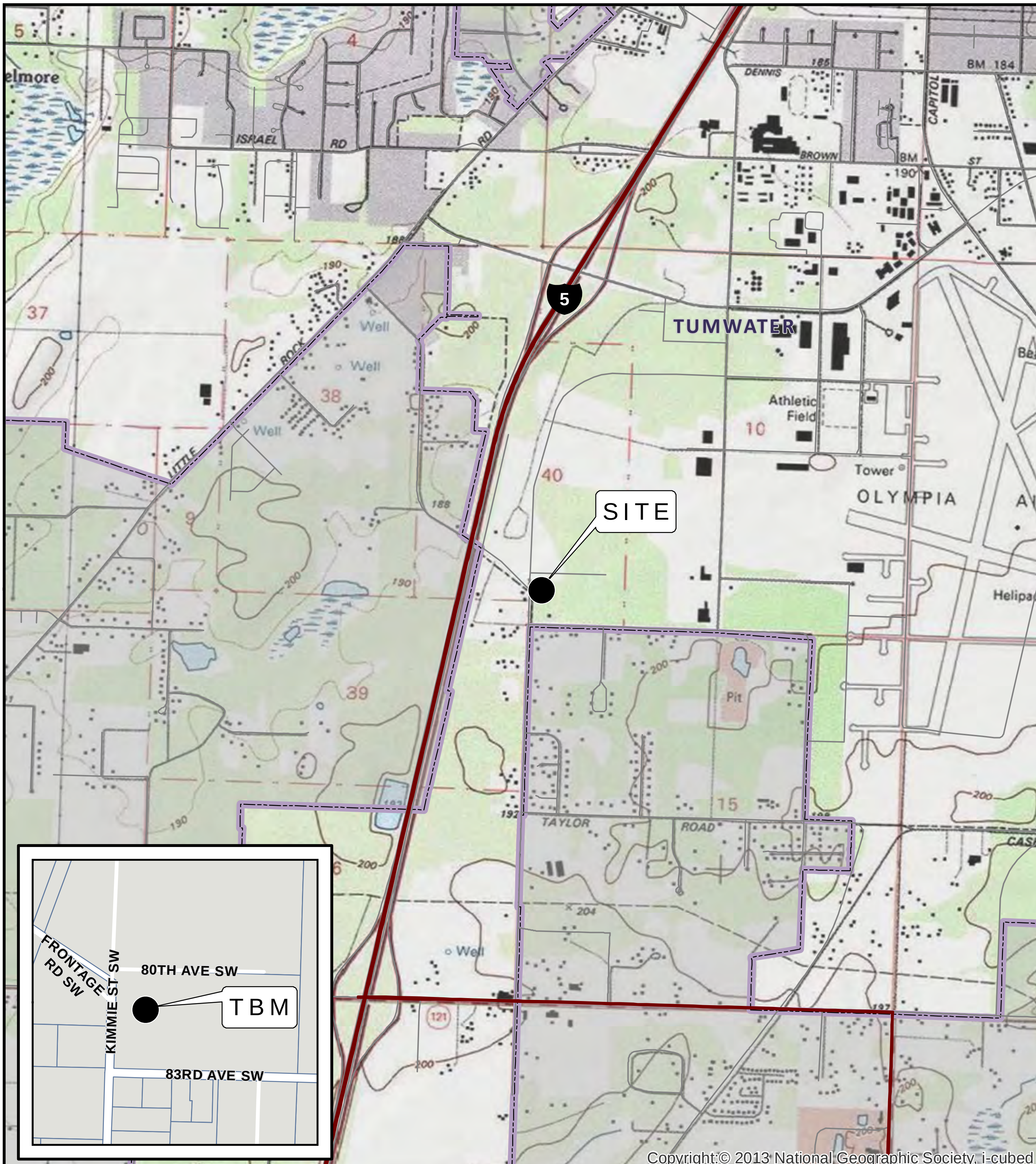
Anton D. Ypma
Staff Geologist

Suzanne S. Cook, L.G.
Senior Project Geologist

Jennifer H. Saltonstall, L.G., L.Hg.
Principal Geologist/Hydrogeologist

Attachments:	Figure TBM F1:	Vicinity Map
	Figure TBM F2:	Facility and Exploration Plan
	Appendix A:	Project Civil Plans
	Appendix B:	Current Study Exploration Logs and Laboratory Testing Data
	Appendix C:	Background Soil, Geology, and Groundwater Data (Regional Maps, Previous Studies Exploration Logs and Laboratory Testing Data)
	Appendix D:	Soil Probe, Level Survey, and Field Infiltration Testing Data
	Appendix E:	Site Photos

JHS/ld / 150387H007-1 / Projects\20150387\KH\WP



N

0 1000 2000
FEET

DATA SOURCES / REFERENCES:
USGS: 7.5' SERIES TOPOGRAPHIC MAPS, ESRI/I-CUBED/NGS 2013
THURSTON CO: STREETS, PARCELS, CITY LIMITS 01/17

LOCATIONS AND DISTANCES SHOWN ARE APPROXIMATE

NOTE: BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION

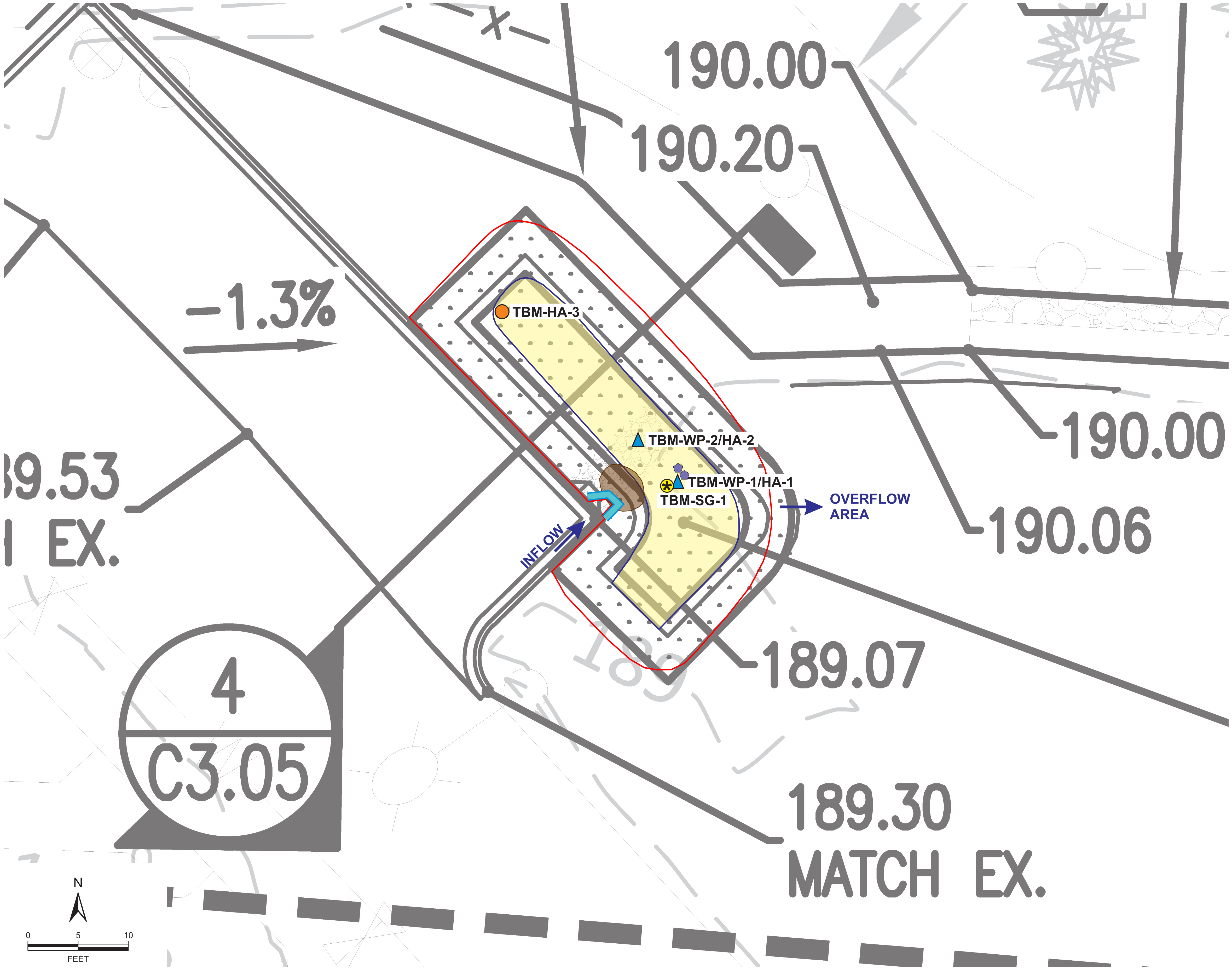
associated earth sciences incorporated

VICINITY MAP

BIORETENTION HYDROLOGIC PERFORMANCE STUDY, TBM SITE
TUMWATER, WASHINGTON

PROJ NO.	DATE:	FIGURE:
150387H007	3/19	TBM F1

Document Path: G:\GIS_Projects\aY15post0716\150387 Bioretention Hydro Performance Monitoring\mxd\PhaseII\Fig1s\150387H007 F1 VM_TBM.mxd



LEGEND:

HA	HAND AUGER
WP	WELL POINT
	TEMPORARY STAFF GAUGE
	BASE OF FACILITY
	TOP OF FACILITY SLOPE
	INFLOW / OVERFLOW DIRECTION
	PVC PONDING TUBE
	CURB CUT
	ENERGY DISSIPATER

CONTOUR INTERVAL = N/A

NOTE: LOCATION AND DISTANCES SHOWN ARE APPROXIMATE.

NOTES:
1. BASE MAP REFERENCE: BCRA, TUMWATER SCHOOL DISTRICT, GEORGE W. BUSH MIDDLE SCHOOL RENOVATION AND ADDITIONS, GRADING PLAN, SHEET C3.01, 12/29/07

BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION.

associated earth sciences incorporated

FACILITY AND EXPLORATION PLAN
TBM SITE
BIORETENTION HYDROLOGIC PERFORMANCE
TUMWATER, WASHINGTON

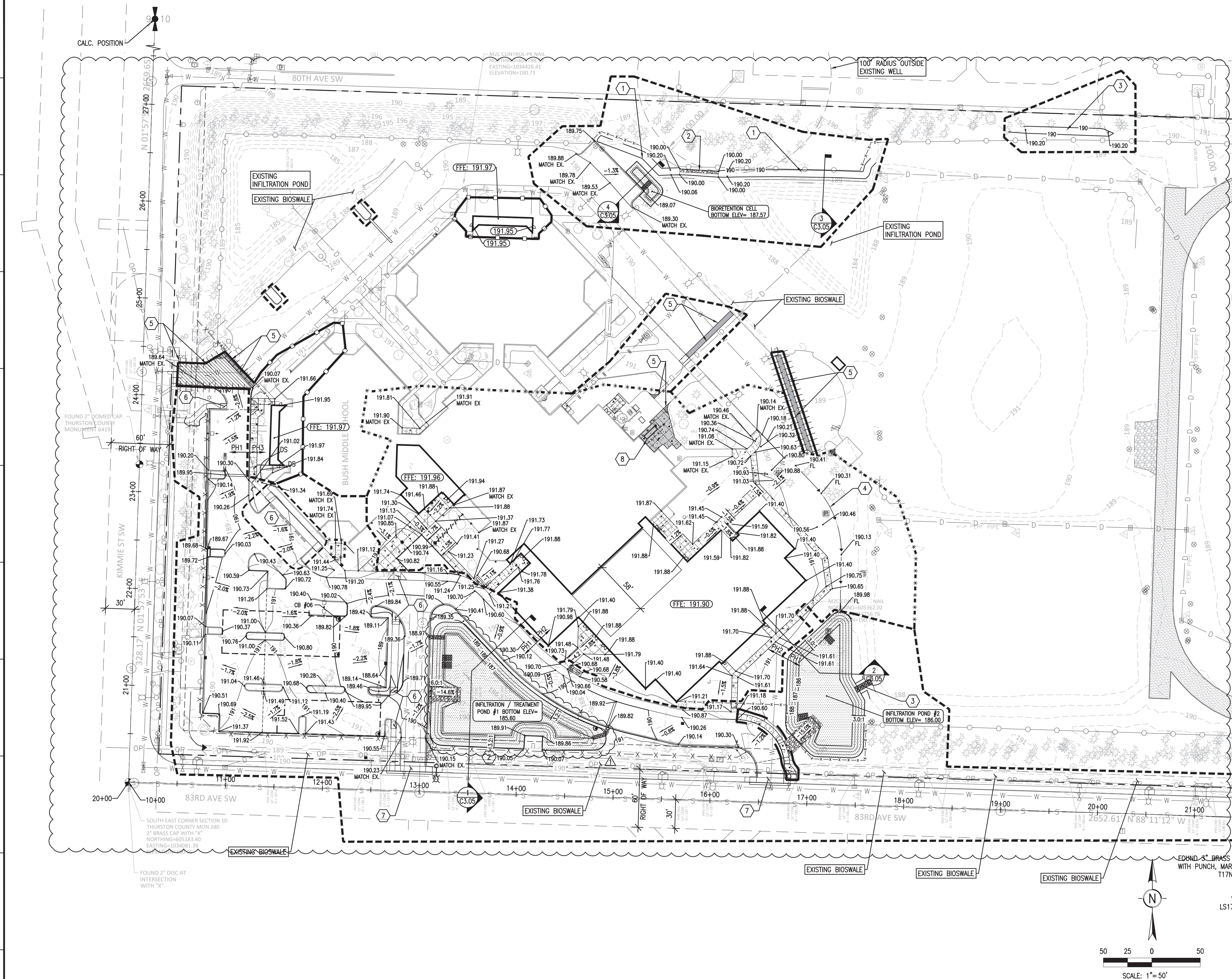
PROJ NO.	DATE:	FIGURE:
150387H007	3/19	TBM F2

150387 BHPS MCCA \ 150387H007 Site-Expl ALL.cdr PAGE x: TBM F2

APPENDIX A

Project Civil Plans

A PORTION OF THE SOUTHWEST QUARTER OF SECTION 10, TOWNSHIP 17 NORTH, RANGE 2 WEST, W.M.



LEGEND

----	PHASE 1 LIMIT OF WORK
----	PHASE 2 LIMIT OF WORK
----	PHASE 3 LIMIT OF WORK
----	PHASE 4 LIMIT OF WORK
----	PROPERTY LINE
----	BUILDING FOOTPRINT
----	GRADE BREAK
190	MAJOR CONTOUR
191	MINOR CONTOUR
136.75	SPOT ELEVATION
2.0%	SLOPE ARROW
	CATCH BASIN TYPE 1
	CATCH BASIN TYPE 2
	STORMWATER INFILTRATION FACILITY
	SWALE
PH 1 PH 2	PHASE 1 / PHASE 2 BOUNDARY

NOTES:

1. SEE SHEET C0.03 FOR GRADING NOTES.
2. REFER TO SURVEY DATED 11/5/2015 BY MTN2COAST, LLC. FOR LEGEND OF EXISTING IMPROVEMENTS.
3. REFER TO ARCHITECTURAL DRAWINGS FOR EXACT DOWNSPOUT LOCATIONS.
4. ALL GRADING ASSOCIATED WITH STREET LIGHTING IS INCLUDED IN PHASE 1 CONSTRUCTION.
5. ROOF DRAINS AND FOOTING DRAINS NOT SHOWN FOR CLARITY.

DATUM (BY OTHERS)

HORIZONTAL – WASHINGTON STATE PLANE COORDINATES, SOUTH ZONE, NAD 83/91 BASED ON TIES TO THURSTON COUNTY MONUMENTS 280, 6418, AND 6419.

VERTICAL – NGVD 29 BASED ON TIES TO THURSTON COUNTY MONUMENT 280 ELEVATION=190.05.

SHEET NOTES:

1. 6' WIDE BERM.
2. 40' WIDE OVERFLOW SPILLWAY AT ELEV. 190.00 PER DETAIL. 2/C5.09
3. 6' WIDE OVERFLOW SPILLWAY AT ELEV. 189.00 PER DETAIL. 2/C5.09
4. PROVIDE SWALE WITH 0.5% MINIMUM FLOWLINE SLOPE.
5. MATCH EXISTING GRADE.
6. ADA PARKING STALL AND RAMP GRADING PER DETAILS. 6/C5.07 5/C3.05 6/C3.05 7/C3.05
7. DRIVEWAY GRADING PER DETAILS. 1/C5.04
8. PROVIDE CAST IN PLACE CONCRETE PAD FOR EMERGENCY GENERATOR. REFER TO STRUCTURAL PLANS FOR DETAILS. TOP OF PAD ELEVATION:

1 REFER TO ATTACHED AS-BUILT SURVEY FOR TOPOGRAPHIC INFORMATION

FOR THE CITY OF TUMWATER

By: ______ Date: ______
BUILDING OFFICIAL
EXPIRES ONE YEAR FROM ACCEPTANCE DATE

FOR THE CITY OF TUMWATER

By: ______ Date: ______
CITY ENGINEER
EXPIRES ONE YEAR FROM ACCEPTANCE DATE

811 Know what's below. Call before you dig.

TUM-16-0216

BCRA
T 253.627.4367 F 253.627.4395 WWW.BCRADESIGN.COM
2106 PACIFIC AVENUE, SUITE 300, TACOMA, WA. 98402

REVISIONS
1 RECORD DOCUMENTS 12/27/2017

SEAL
JUSTIN JAN GOROCH
STATE OF WASHINGTON
43432
REGISTERED PROFESSIONAL ENGINEER

PROJECT
TUMWATER SCHOOL DISTRICT
GEORGE W. BUSH MIDDLE SCHOOL
RENOVATION AND ADDITIONS
2120 83RD AVE SW
TUMWATER, WA 98512

DRAWN:	RJB/RMB
DESIGNED:	ZMC/RMB/JFR
REVIEWED:	ABE/JJG
DATE:	12.29.2017
BCRA NO.	15284
CADD FILE:	15284C0301_BMS.dwg

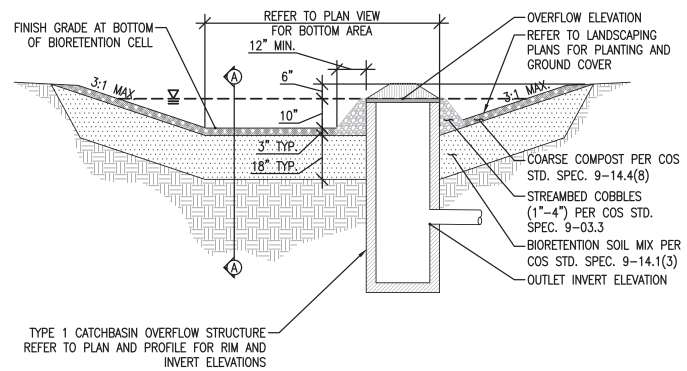
SHEET TITLE
GRADING PLAN

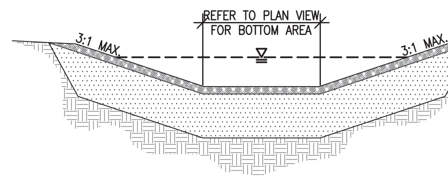
SHEET
C3.01
RECORD DOCUMENTS

Date Plotted: 12/13/2017 1:17:38 PM Filename: \\JUPITER\PROJECTS\15000\15284.A1.00 – TUMWATER MIDDLE SCHOOLS\CIVIL\07–CAD_BMS\CAD\BCRA\PRODUCTION DWGS\AS–BUILTS\15284C0301_BMS By: BBEALS

IF SHEET MEASURES LESS THAN 24"X36", IT IS A REDUCED PRINT. REDUCE SCALE ACCORDINGLY

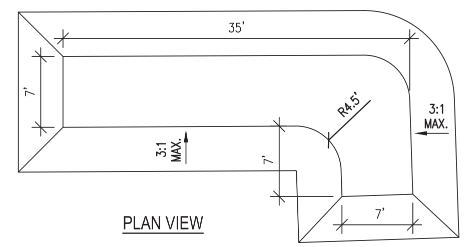
A PORTION OF THE SOUTHWEST QUARTER OF SECTION 10, TOWNSHIP 17 NORTH, RANGE 2 WEST, W.M.





SECTION A-A

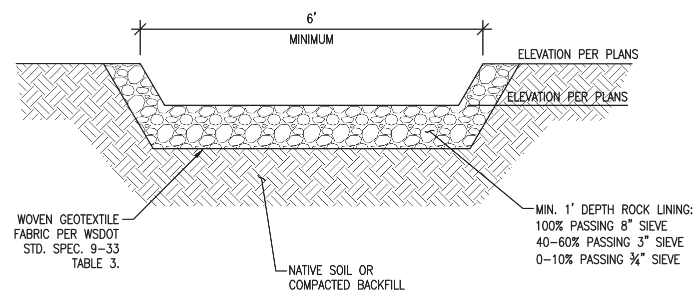
NOTES:
1. RUNOFF SHALL NOT BE ALLOWED TO ENTER BIORETENTION CELL UNTIL FINAL MULCHING AND PLANTING HAS BEEN COMPLETED.
2. BIORETENTION SOIL SHALL BE PROTECTED FROM RAINFALL, SURFACE RUNOFF AND OTHER SOURCES OF ADDED MOISTURE AT THE SUPPLIER'S SITE, IN COVERED CONVEYANCE, AND AT THE PROJECT SITE UNTIL PLACED IN THE BIORETENTION CELL.
3. NO HEAVY EQUIPMENT SHALL OPERATE WITHIN THE CELL OR EARTH BERM PERIMETER ONCE BIORETENTION CELL EXCAVATION HAS BEGUN, INCLUDING DURING EXCAVATION, BACKFILLING, TREE PIT PREPARATION, MULCHING, OR PLANTING.
4. NO MATERIALS OR SUBSTANCES OTHER THAN THE BIORETENTION SOIL SHALL BE MIXED OR DUMPED WITHIN THE CELL OR EARTH BERM AREA THAT MAY BE HARMFUL TO PLANT GROWTH, OR PROVE A HINDRANCE TO THE PLANTING OR MAINTENANCE OPERATIONS.
5. SUBMIT THE INFORMATION REQUIRED BY COS STD. SPEC. 7-21.3(1)A WITH THE EXCEPTION OF THE TWO FIVE (5) GALLON SAMPLES OF THE BIORETENTION SOIL MIX.
6. A PREINSTALLATION MEETING WITH THE ENGINEER IS REQUIRED PRIOR TO COMMENCING THE CONSTRUCTION OF THE BIORETENTION CELLS.
7. EXCAVATION SHALL BE PER COS STD. SPEC. 7-21.3(2)A2.
8. SUBGRADE PREPARATION SHALL BE PER COS STD. SPEC. 7-21.3(2)A3.
9. PLACEMENT OF BIORETENTION SOIL SHALL BE PER COS STD. SPEC. 7-21.3(2)A4 WITH THE EXCEPTION OF #1.
10. FINAL MULCHING AND PLANTING SHALL BE PER COS STD. SPEC. 7-21.3(2)A5.

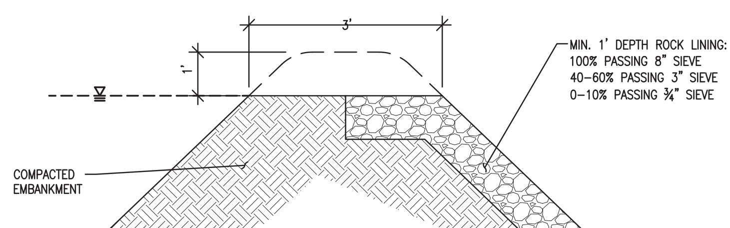


PLAN VIEW

BIORETENTION CELL

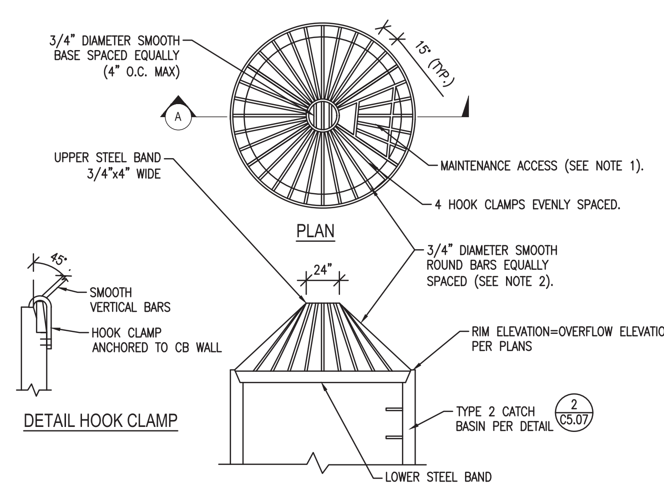
SCALE: NTS (1)





OVERFLOW SPILLWAY

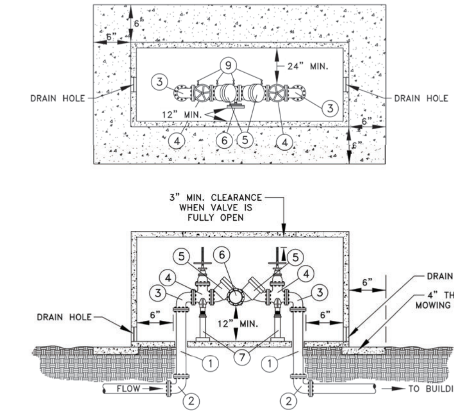
SCALE: NTS (2)



NOTES:
1. PROVIDE MAINTENANCE ACCESS BY WELDING 4 CROSSBARS TO 4 VERTICAL BARS AS SHOWN. HINGE UPPER ENDS WITH FLANGES/BOLTS AND PROVIDE LOCKING MECHANISM (PADLOCK) ON LOWER END. LOCATE STEP DIRECTLY BELOW.
2. BARS SHALL BE WELDED TO UPPER AND LOWER BANDS (24 BANDS EVENLY SPACED).
3. METAL PARTS MUST BE CORROSION RESISTANT; STEEL BARS MUST BE GALVANIZED.
4. 3/4"x4" WIDE STEEL BAND FORMED TO FIT INTO GROOVE OF CB RISER.

OVERFLOW STRUCTURE

SCALE: NTS (3)



GENERAL NOTES:

1. WHERE PIPING PASSES THROUGH THE VAULT WALL, PROVIDE WATERPROOF MASTIC OR FLEXIBLE SEALANT.
2. DIAMETER OF PIPE AND FITTINGS TO BE DETERMINED BY A CERTIFIED SPRINKLER DESIGNER.
3. REFER TO DEVELOPMENT GUIDE FOR FURTHER INFORMATION.
4. THOROUGHLY FLUSH LINES PRIOR TO INSTALLING BACKFLOW ASSEMBLY.
5. DRAIN HOLES SHALL BE 1.5 TIMES THE DIAMETER OF THE SERVICE LINE AND INCLUDE SCREENING.
6. DO NOT INSTALL IN AREAS SUBJECT TO FLOODING.
7. ALL MAIN LINES UP TO THE FIRST VALVE ON THE RPBA'S SHALL BE DISINFECTED, PRESSURE TESTED, FLUSHED AND TESTED FOR PURITY PER THE CITY OF TUMWATER STANDARDS.
8. THE PLACEMENT OF THE HOT BOX SHALL BE IN AN AREA WHERE OBSTACLES SUCH AS GATES, ETC. WILL NOT DAMAGE IT.
9. PVC PIPE AND FITTINGS SHALL NOT BE ALLOWED.
10. ALL RPBA'S SHALL BE INSTALLED IN A HOT BOX TO PREVENT THE UNIT FROM FREEZING. THE HOT BOX MAY BE EQUIPPED WITH ELECTRICAL COMPONENTS (CONDUITS, WIRING, ETC.) AND POWER SUPPLIED BY THE OWNER WHEN NECESSARY OR REQUIRED.

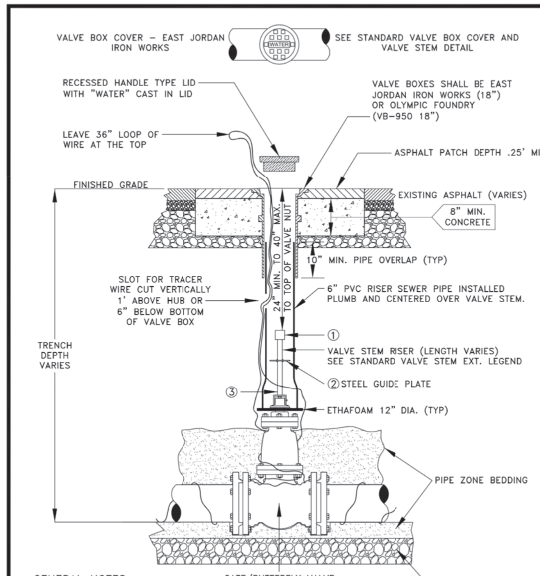
MATERIAL LIST:

1. PVC C900 OR CLASS 52 D.I. WALL PIPE FL X FL
2. 90° BEND FL X MEG-A-LUG
3. 90° BEND FL X FL
4. OS&Y GATE VALVE W/HANDWHEEL FL X FL
5. D.S.H.S. APPROVED CHECK VALVE FL X FL
6. RELIEF VALVE FL
7. ADJUSTABLE SUPPORT STANDS
8. TEST COCKS – 4 REQUIRED

CITY OF TUMWATER, WASHINGTON DEPT. OF PUBLIC WORKS				
REDUCED PRESSURE BACKFLOW ASSEMBLY FOR 3" & GREATER				
APPROVED BY: CITY ENGINEER				DWG. NO. WA-38
DES. PW	DWG. BY PW	CK'D BY KMC	DATE JULY 2014	NOT TO SCALE

REDUCED PRESSURE BACKFLOW ASSEMBLY

SCALE: NTS (4)



GENERAL NOTES:

1. ALL VALVES SHALL HAVE A U.S.E. 12 GAUGE BLUE COATED COPPER TRACER WIRE TIED OFF AT VALVE BODY. THE WIRE SHALL BE EXTENDED UP ON THE OUTSIDE RISER PIPE A FOOT ABOVE THE VALVE HUB BEFORE THE WIRE IS PUT INTO THE RISER THROUGH A SLOT CUT INTO THE RISER. LEAVE 36" OF WIRE ABOVE THE TOP OF VALVE BOX.
2. ALL WELDS TO THE SHAFT SHALL BE FILLET WELD, AROUND THE ENTIRE PLATE PER #2 BELOW,

VALVE STEM EXTENSION LEGEND

1. VALVE OPERATING NUT OR 1-7/8" X 1- 7/8" X 2" HIGH GRADE STEEL WELDED TO GUIDE PLATE.
2. 3/16" THICK X 5 1/5" DIA STEEL GUIDE PLATE WELDED TO RISER SHAFT.
3. 2"X2"X 3/16" SQUARE STRUCTURAL STEEL TUBING TO FIT OPERATING NUT. LENGTH AS REQUIRED.

CITY OF TUMWATER, WASHINGTON DEPT. OF PUBLIC WORKS				
STANDARD VALVE BOX				
APPROVED BY: CITY ENGINEER				DWG. NO. WA-12
DES. PW	DWG. BY PW	CK'D BY KMC	DATE JUNE 2014	NOT TO SCALE

STANDARD VALVE BOX

SCALE: NTS (5)

FOR THE CITY OF TUMWATER

By: ____________________ Date: __________
CITY ENGINEER
EXPIRES ONE YEAR FROM ACCEPTANCE DATE

811 Know what's below. Call before you dig.

TUM-16-0216

BCRA
T 253.627.4367 F 253.627.4395 WWW.BCRADESIGN.COM
2106 PACIFIC AVENUE, SUITE 300, TACOMA, WA 98402

REVISIONS
1 RECORD DOCUMENTS 12/27/2017

SEAL
JUSTIN JAN GOROCH STATE OF WASHINGTON 43432 REGISTERED PROFESSIONAL ENGINEER

PROJECT
TUMWATER SCHOOL DISTRICT
GEORGE W. BUSH MIDDLE SCHOOL
RENOVATION AND ADDITIONS
2120 83RD AVE SW
TUMWATER, WA 98512

DRAWN:	RJB/RMB
DESIGNED:	ZMC/RMB/JFR
REVIEWED:	ABE/JJG
DATE:	12.29.2017
BCRA NO.	15284
CADD FILE:	15284C0507-10_BMS.dwg

SHEET TITLE
CIVIL DETAILS

SHEET
C5.09
SHEET 25 OF 42
RECORD DOCUMENTS

APPENDIX B

Current Study Exploration Logs and Laboratory Testing Data

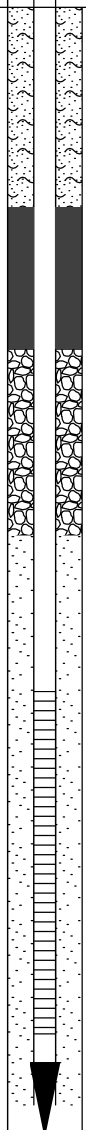
associated earth sciences incorporated

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
150387H007	TBM-HA-1/WP	1 of 1

Project Name	Bioretention Hydrologic Performance Study	Location	Tumwater, WA
Elevation (Top of Well Casing)	99.8 (Project Datum)	Surface Elevation (ft)	96.2 (Project Datum)
Water Level Elevation	Dry	Date Start/Finish	10/2/18,10/2/18
Drilling/Equipment	Hand Auger	Hole Diameter (in)	4 inches
Hammer Weight/Drop	N/A		

Depth (ft)	Water Level	WELL CONSTRUCTION	S T	Blows/ 6"	Graphic Symbol	DESCRIPTION
		Bioretention soil mix 0 to 1.4 feet Threaded steel pipe 1.25-inch I.D. with threaded and vented PVC cap -3.6 to 4.8 feet				**Bioretention Soil Mix** Loose, moist, dark brown, medium SAND, trace to some silt, trace to some gravel; massive; organic rich (SP/SP-SM). Some gravel present from 0.5 to 1 foot.
		Bentonite chips 1.4 to 2.4 feet Vashon Recessional Outwash sands 2.4 to 3.7 feet Silica sand 3.7 to 7.7				**Vashon Recessional Outwash** Medium dense, moist, lightly oxidized brown, fine SAND, some silt, trace gravel (SP-SM). Ranges to silty from 3.5 to 4 feet (SM).
5		Stainless steel jacket over stainless steel #60 gauze, welded to perforated steel pipe 4.8 to 7.2 feet				Increased moisture and grades to grayish brown below 6.5 feet.
		Driven into existing sediments 7.7 to 7.9 feet Threaded steel pipe 1.25-inch I.D. and drive point 7.2 to 7.9 feet Note: ~4 inches of "dead space" below bottom of perforated openings and total inside depth. Total inside depth = 11.2 feet.				Boring terminated at 7.7 feet Well completed at feet on 10/2/18. No seepage. No caving. Steel drive point placed in borehole and hand driven with slide hammer to depth of 7.9 feet.
10						



Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample

M - Moisture
Water Level ()
Water Level at time of drilling (ATD)

Logged by: ADY
Approved by: JHS

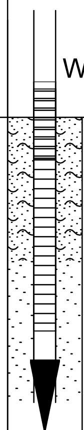
associated earth sciences incorporated

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
150387H007	TBM-HA-2/WP	1 of 1

Project Name	Bioretention Hydrologic Performance Study	Location	Tumwater, WA
Elevation (Top of Well Casing)	98.1 (Project Datum)	Surface Elevation (ft)	96.3 (Project Datum)
Water Level Elevation	Dry	Date Start/Finish	10/2/18,10/2/18
Drilling/Equipment	Hand Auger	Hole Diameter (in)	4 inches
Hammer Weight/Drop	N/A		

Depth (ft)	Water Level	WELL CONSTRUCTION	S T	Blows/ 6"	Graphic Symbol	DESCRIPTION



WELL CONSTRUCTION

Threaded steel pipe 1.25-inch I.D. with threaded and vented PVC cap -1.8 to -0.5 feet
Tape over well point screen -0.5 to 0.3 feet
Stainless steel jacket over stainless steel #60 gauze, welded to perforated steel pipe 0.3 to 1.5
Bioretention soil mix 0 to 1 foot
Vashon Recessional Outwash 1.5 to 2 feet
Threaded steel pipe 1.25-inch I.D with drive point 1.5 to 2.2 feet
Note: ~4 inches of "dead space" below bottom of perforated openings and total inside depth. Total inside depth = 3.7 feet.

DESCRIPTION

Bioretention Soil Mix

Loose, moist, dark brown, medium SAND, trace to some silt, trace gravel; massive; organic rich (SP/SP-SM).

Vashon Recessional Outwash

Medium dense, moist, lightly oxidized brown, fine SAND, some silt, trace gravel (SP-SM).

Boring terminated at 2 feet
Well completed at feet on 10/2/18.
No seepage. No caving.
Steel drive point placed in borehole and hand driven with slide hammer to depth of 2.2 feet.

Depth scale: 5, 10

Sampler Type (ST):

2" OD Split Spoon Sampler (SPT)	No Recovery	M - Moisture
3" OD Split Spoon Sampler (D & M)	Ring Sample	Water Level ()
Grab Sample	Shelby Tube Sample	Water Level at time of drilling (ATD)

Logged by: ADY
Approved by: JHS

associated earth sciences incorporated

Exploration Log

Project Number	Exploration Number	Sheet
150387H007	TBM-HA-3	1 of 1

Project Name: Bioretention Hydrologic Performance Study
Location: Tumwater, WA
Driller/Equipment: Hand Auger
Hammer Weight/Drop: N/A

Ground Surface Elevation (ft):
Datum: N/A
Date Start/Finish: 10/2/18,10/2/18
Hole Diameter (in): 4 inches

Depth (ft)	S T	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Water Level	Blows/6"	Blows/Foot 10 20 30 40	Other Tests
				Compost / Topsoil					
		S-1		**Bioretention Soil Mix** Loose, moist, dark brown, medium SAND, trace to some silt, trace gravel; massive; organic rich (SP/SP-SM).					
		S-2		**Fill ?** Medium dense, moist, dark brown, fine SAND, some silt, some gravel; unsorted (SP-SM).					
				Vashon Recessional Outwash Medium dense, moist, lightly oxidized brown silty, fine SAND, trace gravel (SM).					
				Bottom of exploration boring at 2.4 feet. No seepage. No caving.					
5									
10									

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample
- M - Moisture
- Water Level ()
- Water Level at time of drilling (ATD)

Logged by: ADY
Approved by: JHS

associated earth sciences incorporated

Moisture, Ash, and Organic Matter of Peat and Other Organic Soils - ASTM 2974

Date Sampled	Project	Project No.		Soil Description
10/2/2018	Bioretention Hydrologic Performance Monitoring Study	150387 E007		Bioretention soil mix
Tested By	**Location**	**EB/EP No.**	**Depth**	
BN	Onsite- TBM			

Moisture Content

Sample ID	**HA-1/WP (0'-0.5')**	**HA-3 (0.2'-0.7')**
Wet Weight + Pan	**1116.25**	**919.89**
Dry Weight + Pan	**996.82**	**868.00**
Weight of Pan	**465.60**	**421.66**
Weight of Moisture	**119.43**	**51.89**
Dry Weight of Soil	**531.22**	**446.34**
% Moisture	**18.4**	**10.4**

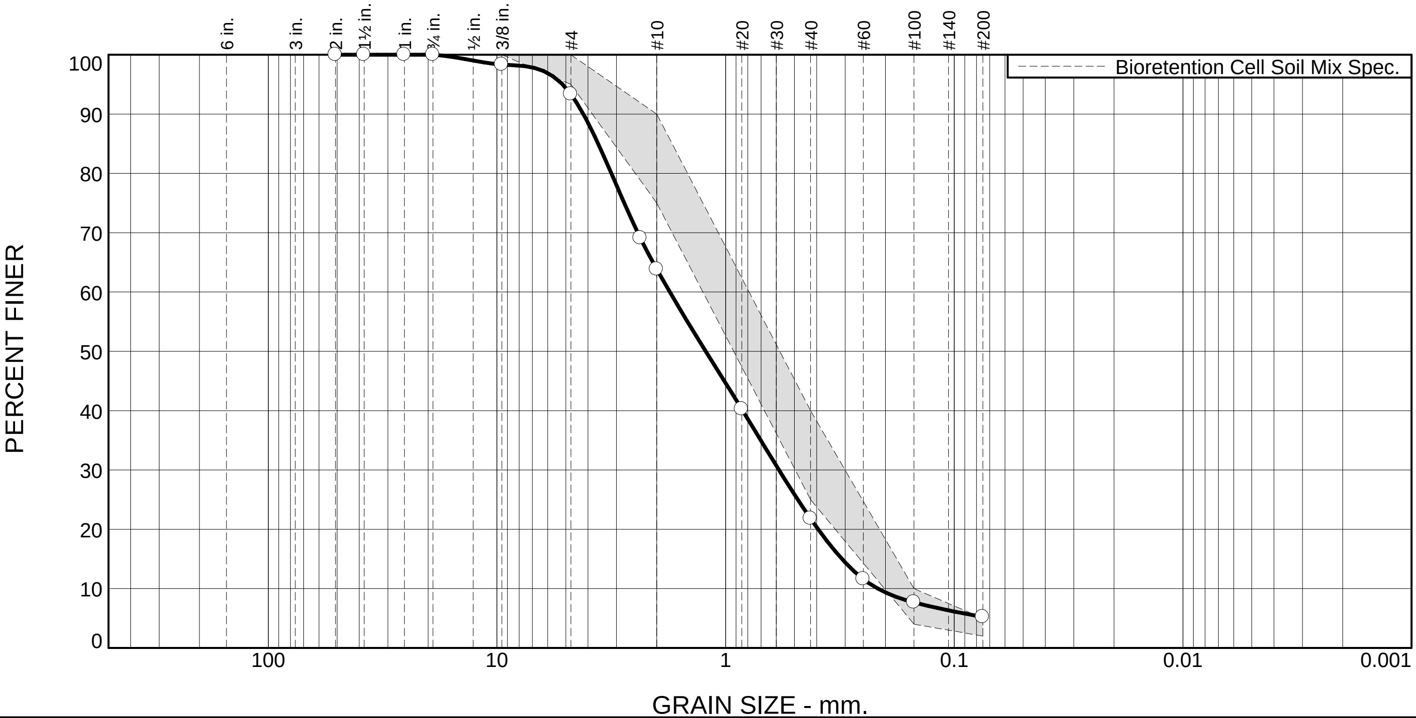
Organic Matter and Ash Content

Dry Soil Befor Burn + Pan	**618.01**	**593.26**
Dry Soil After Burn + Pan	**599.01**	**583.96**
Weight of Pan	**391.96**	**391.90**
Wt. Loss Due to Ignition	**19.00**	**9.30**
Actual Wt. Of Soil After Burr	**207.05**	**192.06**
% Organics	**8.4**	**4.6**

ASSOCIATED EARTH SCIENCES, INC.

911 5th Ave., Suite 100 Kirkland, WA 98033 425-827-7701 FAX 425-827-5424

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	6.7	29.4	42.1	16.6	5.2	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
2	100.0		
1.5	100.0		
1	100.0		
.75	100.0		
.375	98.3	100.0	X
#4	93.3	95.0 - 100.0	X
#8	69.1		
#10	63.9	75.0 - 90.0	X
#20	40.3		
#40	21.8	25.0 - 40.0	X
#60	11.6		
#100	7.7	4.0 - 10.0	
#200	5.2	2.0 - 5.0	X

* Bioretention Cell Soil Mix Spec.

Material Description

SAND, some gravel, some silt

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP-SM **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 4.1886 D_{85}= 3.6085 D_{60}= 1.7539
D_{50}= 1.2213 D_{30}= 0.5845 D_{15}= 0.3099
D_{10}= 0.2161 C_u= 8.12 C_c= 0.90

Remarks

Collected by: ADY

Bioretention soil mix burned first per ASTM D2974 then sieved.

Date Received: 10/08/2018 **Date Tested:** 11/09/2018

Tested By: BN

Checked By: JHS

Title:

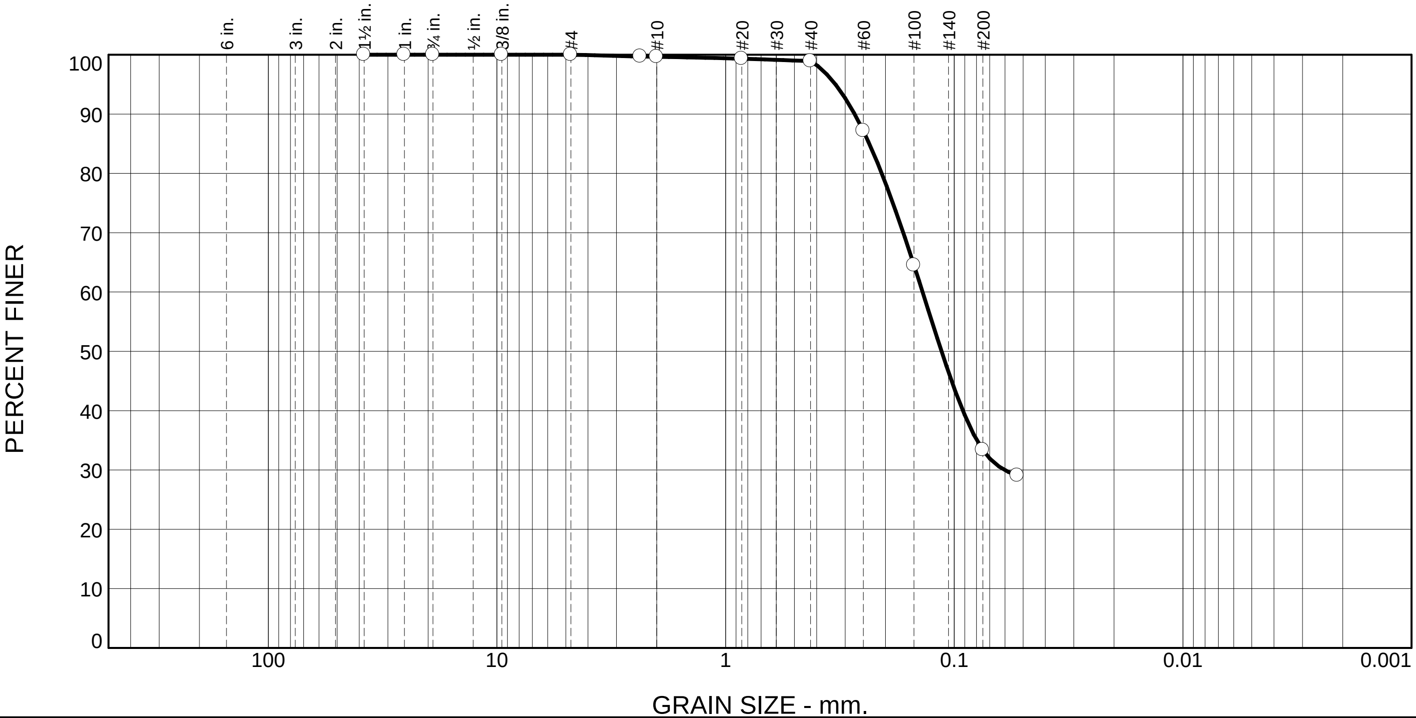
Source of Sample: (TBM) Tumwater- George W. Bush Middle School **Depth:** 0.1'-0.5' **Date Sampled:** 10/02/2018
Sample Number: HA-1/WP

a s s o c i a t e d
e a r t h s c i e n c e s
i n c o r p o r a t e d

Client: Clear Creek Solutions
Project: Bioretention Hydrologic Performance Study

Project No: 150387 H004 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.4	0.7	65.5	33.4	

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5	100.0		
1	100.0		
.75	100.0		
.375	100.0		
#4	100.0		
#8	99.7		
#10	99.6		
#20	99.3		
#40	98.9		
#60	87.2		
#100	64.5		
#200	33.4		
#270	29.0		

* (no specification provided)

Material Description

very silty SAND

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-2-4(0)

Coefficients

D_{90}= 0.2727 D_{85}= 0.2353 D_{60}= 0.1376
D_{50}= 0.1137 D_{30}= 0.0603 D_{15}=
D_{10}= C_u= C_c=

Remarks

Collected by: ADY

Date Received: 12/06/2018 **Date Tested:** 12/11/2018
Tested By: BN
Checked By: JHS
Title:

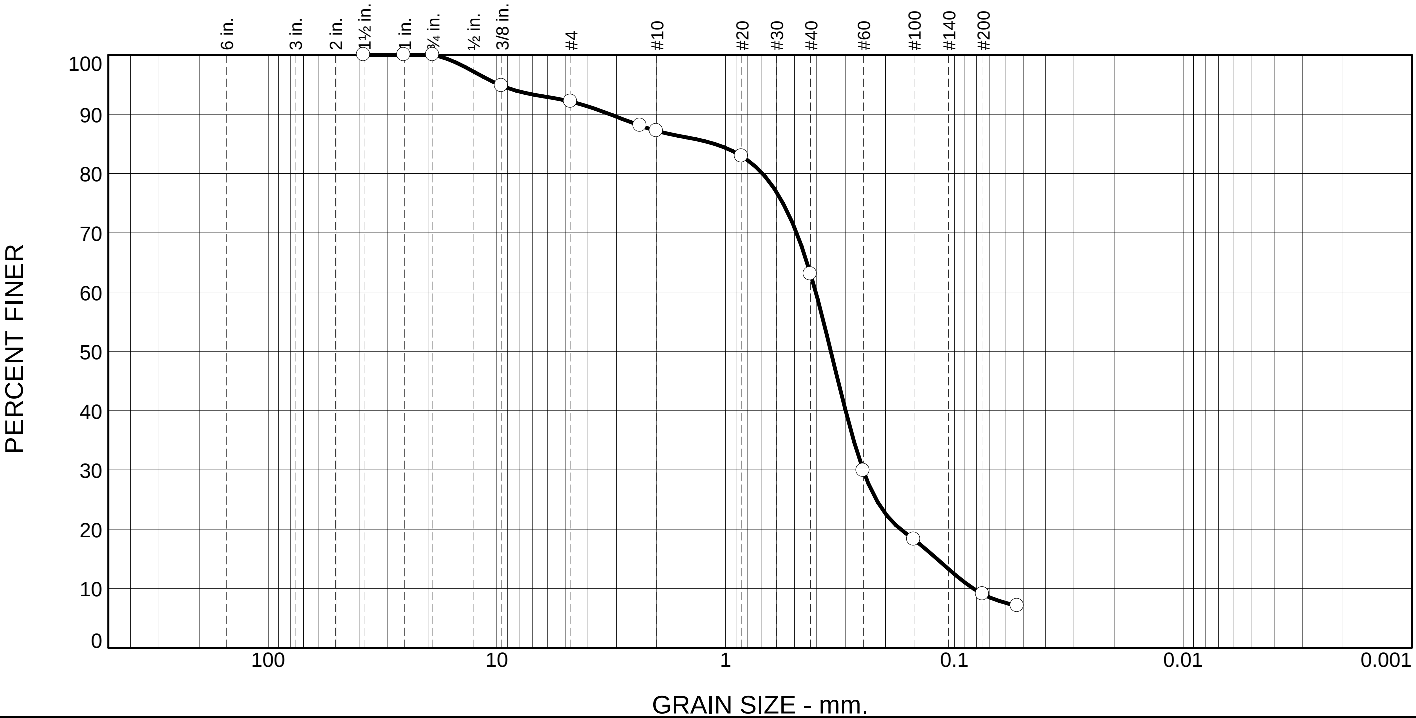
Source of Sample: (TBM) Tumwater- George W. Bush Middle School **Depth:** 3.5'-4' **Date Sampled:** 10/02/2018
Sample Number: HA-1/WP

a s s o c i a t e d
e a r t h s c i e n c e s
i n c o r p o r a t e d

Client: Clear Creek Solutions
Project: Bioretention Hydrologic Performance Study

Project No: 150387 H004 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	7.9	4.9	24.2	54.0	9.0	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5	100.0		
1	100.0		
.75	100.0		
.375	94.8		
#4	92.1		
#8	88.1		
#10	87.2		
#20	82.9		
#40	63.0		
#60	29.9		
#100	18.2		
#200	9.0		
#270	7.0		

* (no specification provided)

Material Description

SAND, some silt, some gravel

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP-SM **AASHTO (M 145)=** A-3

Coefficients

D_{90}= 3.2060 D_{85}= 1.1189 D_{60}= 0.4037
D_{50}= 0.3467 D_{30}= 0.2507 D_{15}= 0.1193
D_{10}= 0.0827 C_u= 4.88 C_c= 1.88

Remarks

Collected by: ADY

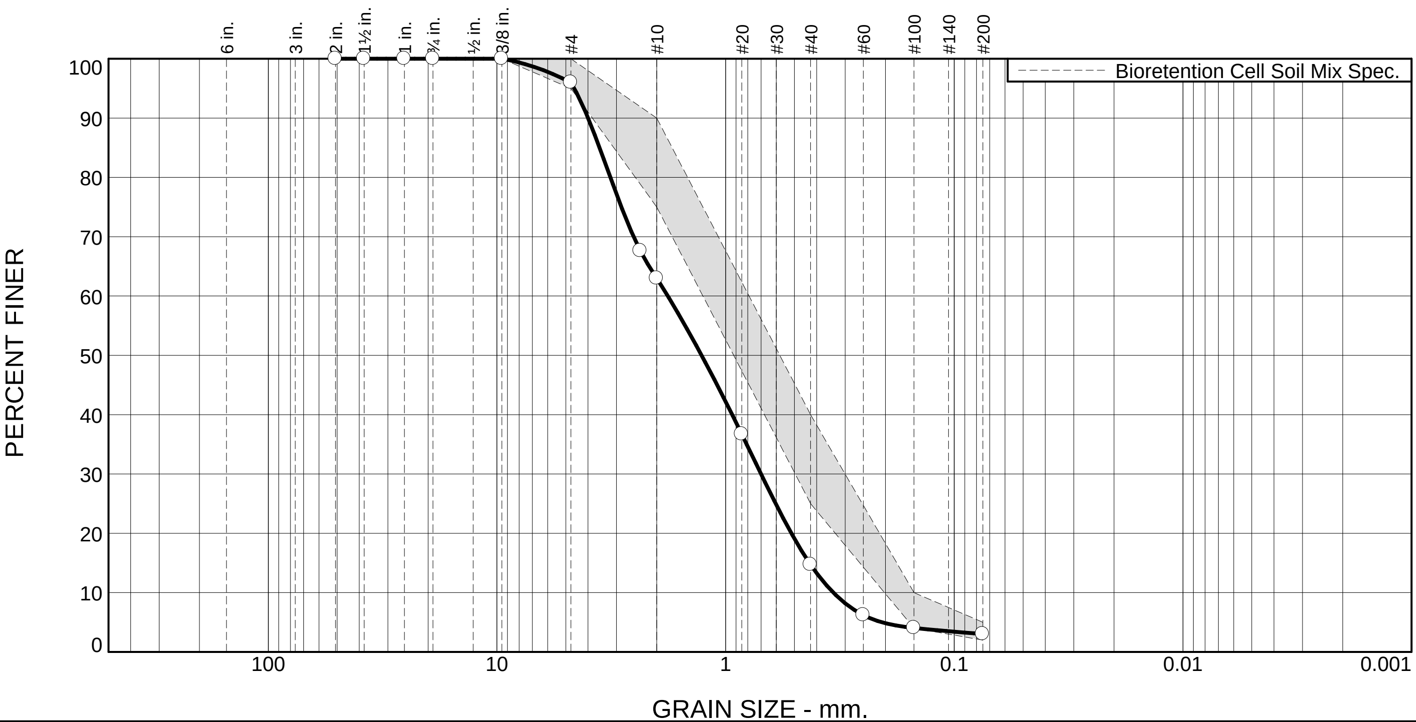
Date Received: 12/06/2018 **Date Tested:** 12/11/2018
Tested By: BN
Checked By: JHS
Title:

Source of Sample: (TBM) Tumwater- George W. Bush Middle School **Depth:** 1.5'-2.0' **Date Sampled:** 10/02/2018
Sample Number: HA-2/WP

associated earth sciences incorporated

Client: Clear Creek Solutions
Project: Bioretention Hydrologic Performance Study
Project No: 150387 H004 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	4.0	33.0	48.3	11.7	3.0	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
2	100.0		
1.5	100.0		
1	100.0		
.75	100.0		
.375	100.0	100.0	
#4	96.0	95.0 - 100.0	
#8	67.6		
#10	63.0	75.0 - 90.0	X
#20	36.7		
#40	14.7	25.0 - 40.0	X
#60	6.2		
#100	4.0	4.0 - 10.0	
#200	3.0	2.0 - 5.0	

* Bioretention Cell Soil Mix Spec.

Material Description

SAND, trace gravel, trace silt

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=**

Classification

USCS (D 2487)= SP **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 3.9949 D_{85}= 3.5576 D_{60}= 1.7899
D_{50}= 1.2741 D_{30}= 0.7000 D_{15}= 0.4303
D_{10}= 0.3381 C_u= 5.29 C_c= 0.81

Remarks

Collected by: ADY

Bioretention soil mix burned first per ASTM D2974 then sieved.

Date Received: 10/08/2018 **Date Tested:** 11/08/2018

Tested By: BN

Checked By: JHS

Title:

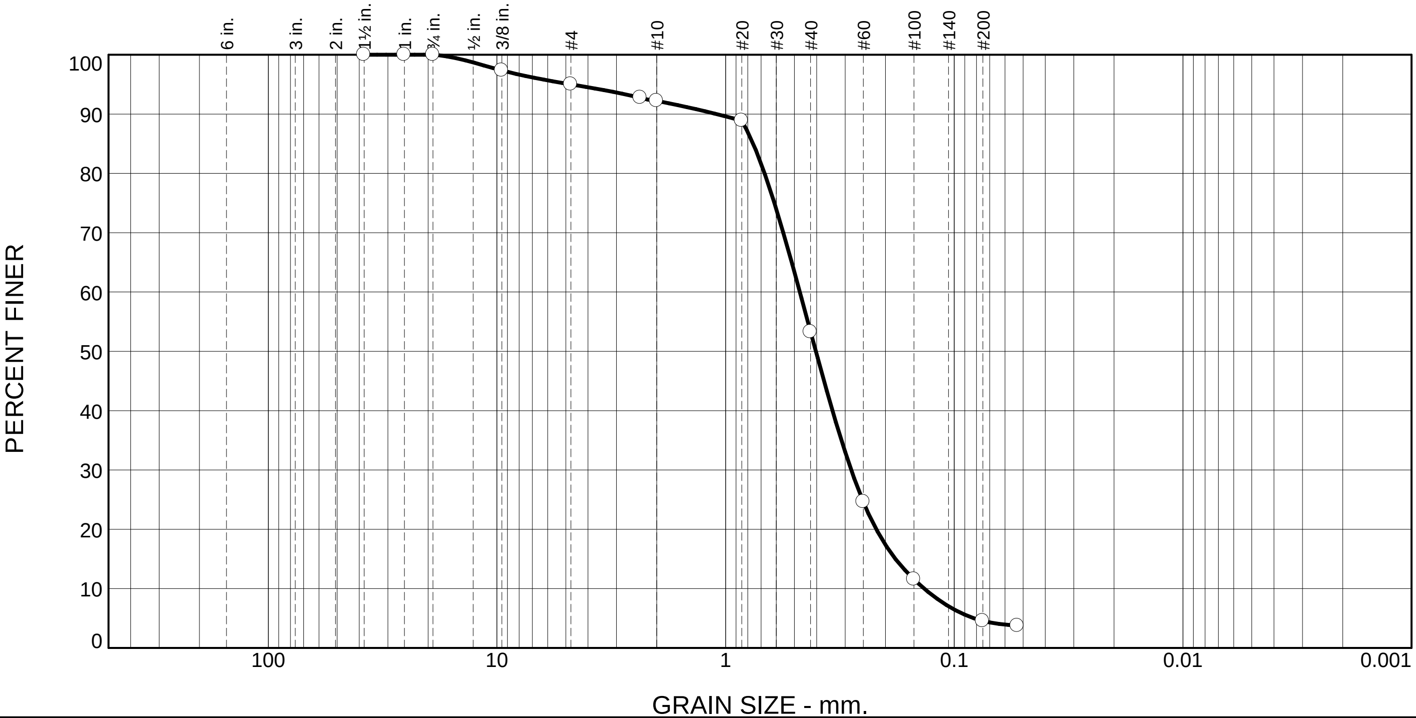
Source of Sample: (TBM) Tumwater- George W. Bush Middle School **Depth:** 0.2'-0.7' **Date Sampled:** 10/02/2018
Sample Number: HA-3

associated earth sciences incorporated

Client: Clear Creek Solutions
Project: Bioretention Hydrologic Performance Study

Project No: 150387 H004 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	5.0	2.8	38.9	48.7	4.6	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5	100.0		
1	100.0		
.75	100.0		
.375	97.4		
#4	95.0		
#8	92.7		
#10	92.2		
#20	88.9		
#40	53.3		
#60	24.6		
#100	11.6		
#200	4.6		
#270	3.7		

* (no specification provided)

Material Description

SAND, some gravel, trace silt

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP **AASHTO (M 145)=** A-3

Coefficients

D_{90}= 1.0983 D_{85}= 0.7574 D_{60}= 0.4737
D_{50}= 0.4030 D_{30}= 0.2823 D_{15}= 0.1808
D_{10}= 0.1354 C_u= 3.50 C_c= 1.24

Remarks

Collected by: ADY

Date Received: 12/06/2018 **Date Tested:** 12/11/2018

Tested By: BN

Checked By: JHS

Title:

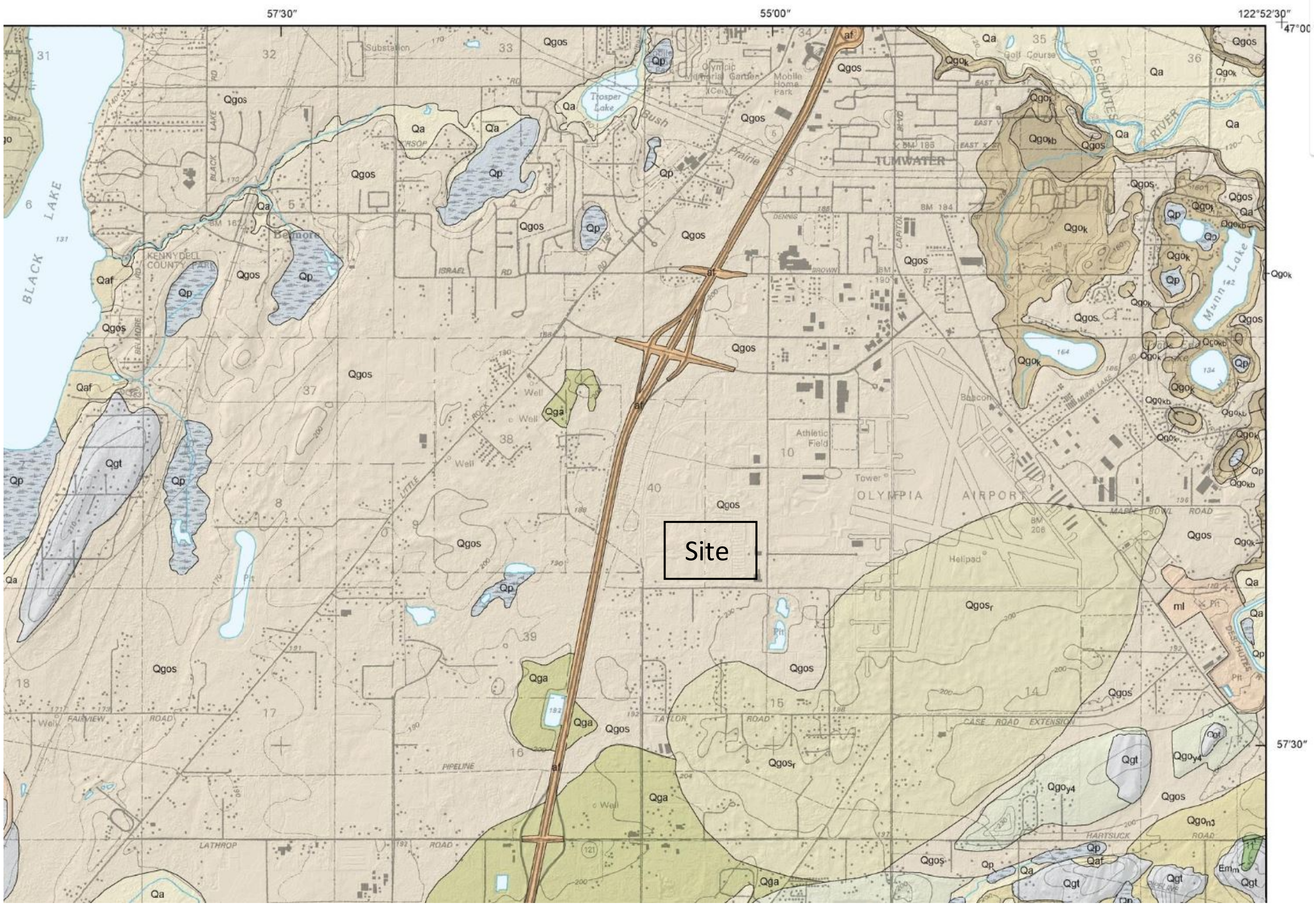
Source of Sample: (TBM) Tumwater- George W. Bush Middle School **Depth:** 1.8'-2.4' **Date Sampled:** 10/02/2018
Sample Number: HA-3

associated earth sciences incorporated

Client: Clear Creek Solutions
Project: Bioretention Hydrologic Performance Study
Project No: 150387 H004 **Figure**

APPENDIX C

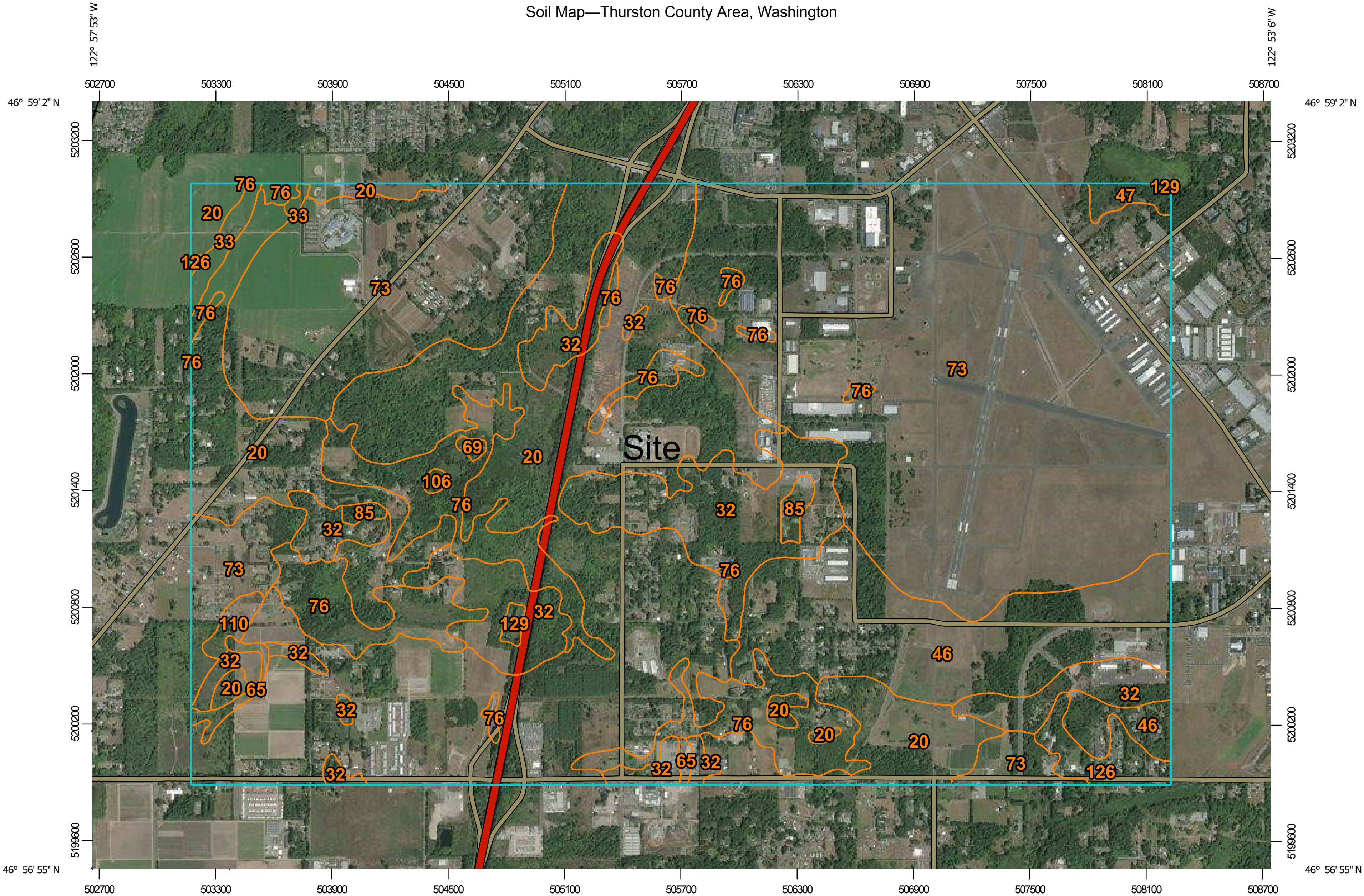
Background Soil, Geology, and Groundwater Data (Regional Maps, Previous Studies Exploration Logs and Laboratory Testing Data)



Site Unit: Qgos: Vashon Recessional Outwash sand and silt

Source:
Geologic map of the Maytown 7.5-minute quadrangle, Thurston County, Washington
Author(s): Logan, R.L., Walsh, T.J., Stanton, B.W., and Sarikhan, I.Y.
Publishing Organization: Washington Division of Geology and Earth Resources
Series and Number: Geologic Map GM-72
Publication Date: 2009
Map Scale: 1:24,000

Soil Map—Thurston County Area, Washington



Map Scale: 1:27,800 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 400 800 1600 2400

Feet: 0 1000 2000 4000 6000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
20	Cagey loamy sand	1,255.2	32.4%
32	Everett very gravelly sandy loam, 0 to 8 percent slopes	367.3	9.5%
33	Everett very gravelly sandy loam, 8 to 15 percent slopes	18.0	0.5%
46	Indianola loamy sand, 0 to 5 percent slopes	320.7	8.3%
47	Indianola loamy sand, 5 to 15 percent slopes	13.6	0.4%
65	McKenna gravelly silt loam, 0 to 5 percent slopes	13.8	0.4%
69	Mukilteo muck	3.1	0.1%
73	Nisqually loamy fine sand, 0 to 3 percent slopes	1,512.5	39.0%
76	Norma silt loam	301.0	7.8%
85	Pits, gravel	13.8	0.4%
106	Shalcar variant muck	2.7	0.1%
110	Spanaway gravelly sandy loam, 0 to 3 percent slopes	11.6	0.3%
126	Yelm fine sandy loam, 0 to 3 percent slopes	36.7	0.9%
129	Water	5.6	0.1%
Totals for Area of Interest		**3,875.7**	**100.0%**

G:\Projects\1467\003\020\021\Bush Middle School\F02SitePlan.mxd 10/26/2015 NAD 1983 StatePlane Washington South FIPS 4602 Feet

Legend

B-1 Approximate Borehole Location and Designation

B-8 Approximate Monitoring Well Location and Designation

Subject Property

0 200 400

Scale in Feet

LANDAU ASSOCIATES

Data Sources: Thurston County GIS; Esri World Imagery.

Note

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Bush Middle School Tumwater, Washington	**Site Plan**	Figure 2

B-1

SAMPLE DATA / SOIL PROFILE

Drilling Method: Hollow-Stem Auger
Ground Elevation (ft): 195
Drilled By: Holocene Drilling Inc.
Logged By: DAR Date: 08/24/15

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	USCS Symbol	Description	Groundwater
0	195					SM	2 inches of sod over 5 inches of topsoil (loose, damp) **(TOPSOIL)**	
						SM	Brown, silty, fine SAND (loose, damp) **(RECESSIONAL OUTWASH)**	
		S-1	b2	8				
5	190					SM	Mottled brown/gray SAND with silt (loose, moist)	
		S-2	b2	6	W = 26 GS			
						GP	Grayish-brown, fine to coarse GRAVEL with sand (dense, moist)	
		S-3	b2	42	W = 2 GS			
10	185	S-4	b2	41				
						GP-GM	Grayish-brown, fine to coarse GRAVEL with sand and silt (dense, moist)	
15	180	S-5	b2	48				
						SP	Gray, fine to coarse SAND with gravel (dense, wet)	17.0 ft ATD
20	175	S-6	b2	43				

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 08/24/15
Total Depth of Boring = 21.5 ft.

25

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

Bush Middle School
Tumwater, Washington

Log of Boring B-1

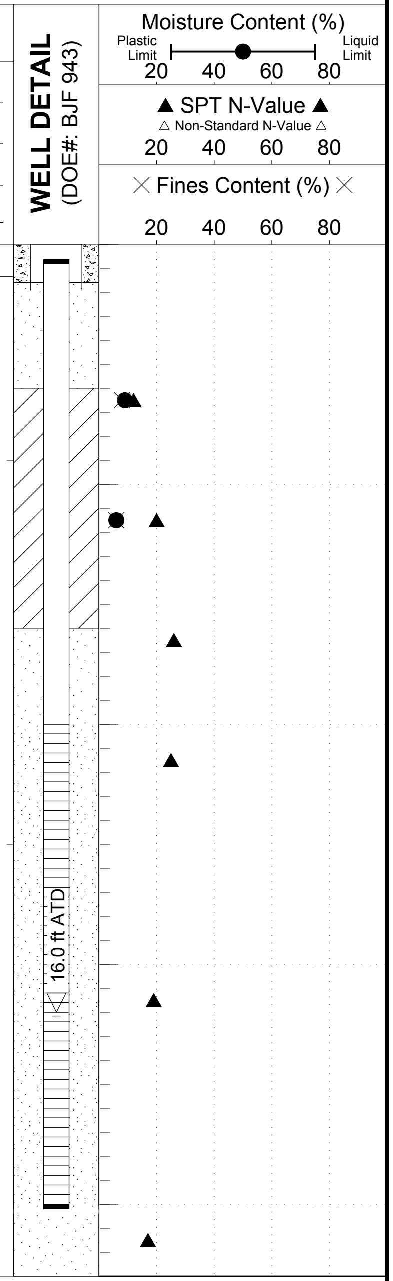
Figure A-2

B-8

SAMPLE DATA / SOIL PROFILE

Drilling Method: Hollow-Stem Auger
Ground Elevation (ft): 188
Drilled By: Holocene Drilling Inc.
Logged By: DAR   Date: 09/01/15

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	USCS Symbol	Description
0	188					SM	2 inches of sod over 6 inches of topsoil (loose, moist) **(TOPSOIL)**
						SP-SM	Brownish-gray, gravelly, fine to coarse SAND with silt (medium dense, moist) **(RECESSIONAL OUTWASH)**
	185	S-1	b2	12	W = 9 GS		
5						SP	Brownish-gray, fine to coarse SAND with gravel (medium dense, moist)
		S-2	b2	20	W = 6 GS		
	180	S-3	b2	26			-grades to gravelly
10		S-4	b2	25			
	175					GP	Gray, fine to coarse GRAVEL with sand (medium dense, moist to wet)
15		S-5	b2	19			
	170						
20		S-6	b2	17			-grades to wet
25							



Boring Completed 09/01/15
Total Depth of Boring = 21.5 ft.

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

Table 2
On-Site Piezometer Groundwater Elevation Data
Bush Middle School
Tumwater, Washington

Date of Observation	B-8	B-11	B-12	B-14	B-15	B-17
12/2/2015	176.1	176.0	175.9	176.2	176.2	176.3
12/11/2015	177.9	177.7	177.9	177.9	178.1	178.2
12/15/2015	178.9	178.8	178.9	178.9	179.1	179.1
12/22/2015	180.4	180.3	180.4	180.3	180.6	180.6
12/28/2015	181.6	181.4	181.6	181.4	181.7	181.8
1/5/2016	181.6	181.4	181.6	181.5	181.7	181.7
1/12/2016	181.09	180.94	180.73	180.94	181.12	181.17
1/18/2016	181.47	181.30	181.15	181.28	181.54	181.57
1/27/2016	183.04	182.96	182.81	182.78	183.09	183.12
2/2/2016	183.65	183.6	183.42	183.41	183.76	183.74
Average Difference Relative to B-15 (ft)	-0.1	-0.3	-0.2	-0.2	--	+0.1
Standard Deviation of Difference Relative to B-15 (ft)	0.1	0.1	0.1	0.1	--	0.1

ft = feet/foot
Notes:
1. All elevation data are shown in feet referenced to vertical datum National Geodetic Vertical Datum of 1929.
2. Groundwater elevation data recorded up to January 5, 2016 were measured relative to ground surface; data recorded after January 5, 2016 were measured relative to the top of the surveyed well casing.

B-8

SAMPLE DATA

Depth (ft)	Elevation	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data
0					
	185	S-1	b2	12	W = 9 GS
5		S-2	b2	20	W = 6 GS
	180	S-3	b2	26	
10		S-4	b2	25	
	175				
15		S-5	b2	19	
	170				
20		S-6	b2	17	
25					

SOIL PROFILE

Drilling Method: Hollow-Stem Auger

Ground Elevation (ft): 188

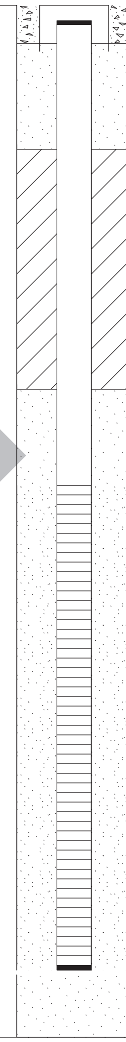
Drilled By: Holocene Drilling Inc.

USCS Symbol	Description
SM	2 inches of sod over 6 inches of topsoil (loose, moist) **(TOPSOIL)**
SP-SM	Brownish-gray, gravelly, fine to coarse SAND with silt (medium dense, moist) **(RECESSIONAL OUTWASH)**
SP	Brownish-gray, fine to coarse SAND with gravel (medium dense, moist)
	-grades to gravelly
GP	Gray, fine to coarse GRAVEL with sand (medium dense, moist to wet)
	-grades to wet

GROUNDWATER

Water Level: ATD ▽

On-Site Piezometer Detail
(DOE#: BJF 943)



Plastic monument

Soil backfill

Bentonite

20/40 Colorado sand pack

Boring Completed 09/01/15
Total Depth of Boring = 21.5 ft.

DRAFT

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

Bush Middle School
Tumwater, Washington

Log of On-Site Piezometer B-8

Figure 2-2

APPENDIX D

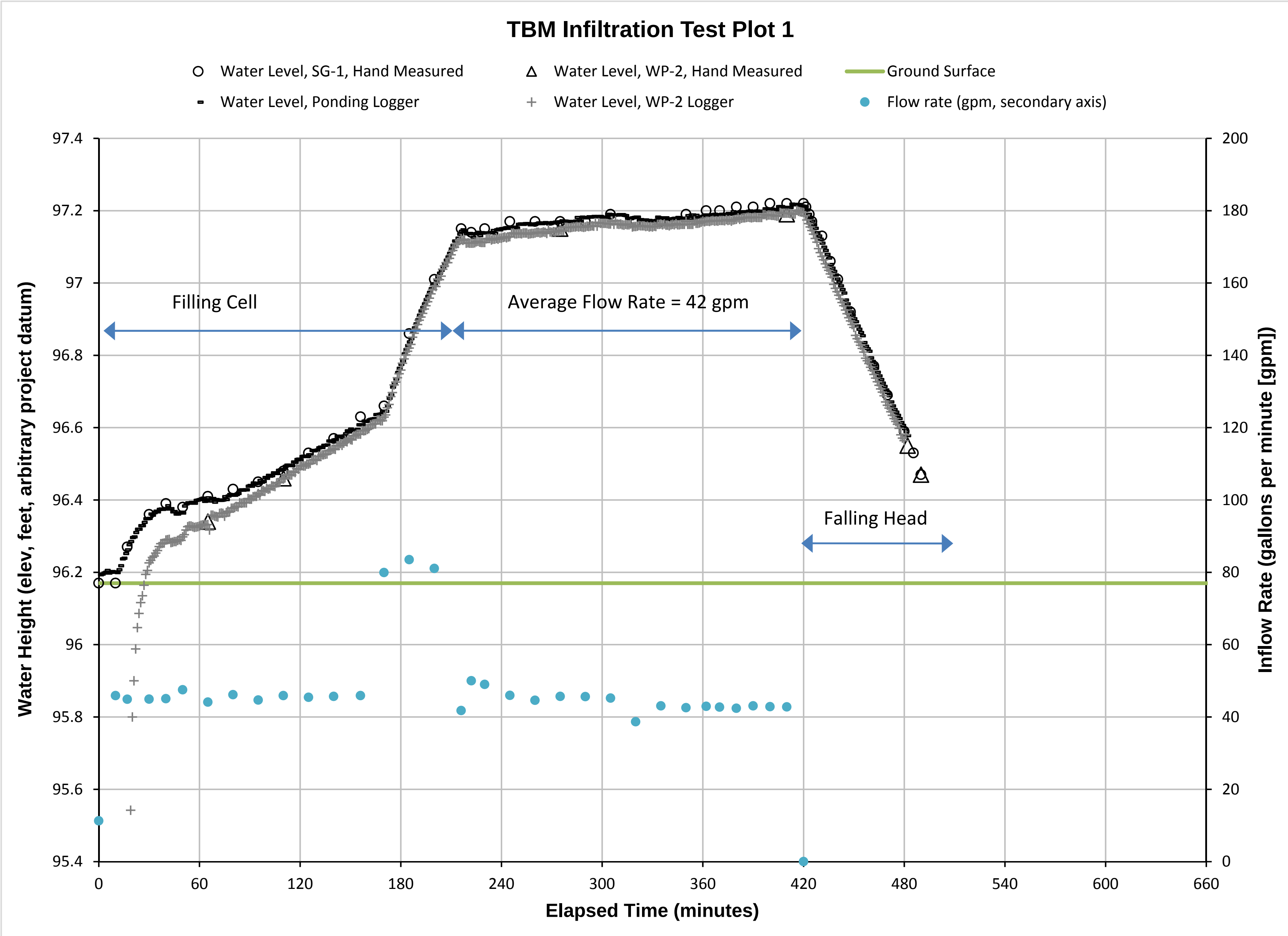
Soil Probe, Level Survey, and Field Infiltration Testing Data

Project Name:	BHPS	Water Source:	Hydrant
Project Number:	150387H007	Meter:	AESI FM5
Date:	10/25/2018	Base Area (sq.ft.):	NA
Weather:	Intermittent rain, 60's	Ponded Area(sq.ft.):	520.0
Test No.:	TBM	Test Depth (feet):	NA
Performed By:	ADY, SC	Receptor Soils:	Recessional Outwash

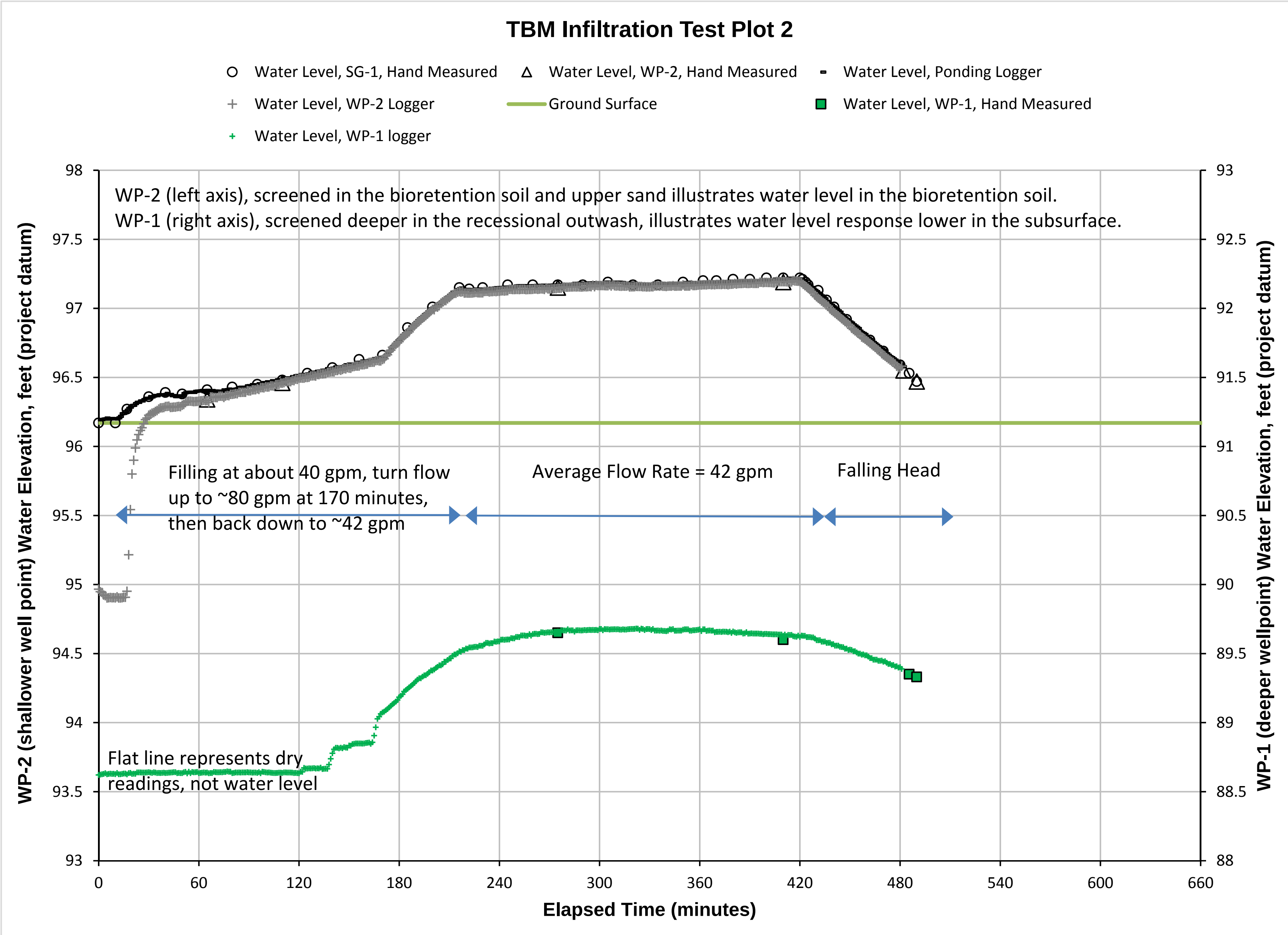
Time (24-hr)	Flow Rate (gpm)	Stage (feet)	Totalizer (gallons)	Comments
9:10	11.28	0	0	Flow on. Light rain.
9:20	45.89	0	111	
9:27	44.89	0.1	449	
9:40	44.94	0.19	998	
9:50	45.06	0.22	1445	
10:00	47.5	0.21	1782	Flow rate fluctuation
10:15	44.11	0.24	2460	Base fully wetted.
10:30	46.17	0.26	3134	No rain.
10:45	44.67	0.28	3809	
11:00	45.89	0.31	4490	No rain.
11:15	45.44	0.36	5184	
11:30	45.67	0.4	5848	Light rain resumes.
11:46	45.89	0.46	6593	
12:00	79.94	0.49	7201	Light rain. Flow rate increased.
12:15	83.5	0.69	8417	
12:30	81.06	0.84	9646	Rain stopped.
12:45	41.78	0.98	10870	Flow rate decreased.
12:52	50	0.97	11190	
13:00	49	0.98	11575	
13:15	45.98	1	12358	
13:30	44.61	1	13021	No rain.
13:45	45.67	1	13699	
14:00	45.61	1	14368	No rain.
14:15	45.22	1.02	15055	
14:30	38.67	1	15664	
14:45	43.06	1	16291	
15:00	42.56	1.02	16934	
15:12	42.94	1.03	17450	
15:20	42.72	1.03	17794	
15:30	42.39	1.04	18221	
15:40	43.06	1.04	18650	
15:50	42.83	1.05	19076	
16:00	42.78	1.05	19503	
16:10	0	1.05	19933	Flow off.
16:11		1.04		
16:13		1.02		
16:15		1		
16:21		0.96		Light rain begins.
16:26		0.89		Moderate rain, minimal inflow.
16:30		0.84		
16:38		0.75		
16:52		0.6		
17:00		0.52		
17:10		0.42		Heavy rain, inflow water is silty.
17:12				

17:15		0.36		
17:20		0.3		

	Average Infiltration Rate (in/hr) during last hour of inflow:	7.7
	Average Infiltration Rate (in/hr) during falling head:	7.7



TBM Infiltration Test Plot 1
Water Level, SG-1, Hand Measured
Water Level, WP-2, Hand Measured
Ground Surface
Water Level, Ponding Logger
Water Level, WP-2 Logger
Flow rate (gpm, secondary axis)
Filling Cell
Average Flow Rate = 42 gpm
Falling Head
Water Height (elev, feet, arbitrary project datum)
Inflow Rate (gallons per minute [gpm])
Elapsed Time (minutes)
97.4
97.2
97
96.8
96.6
96.4
96.2
96
95.8
95.6
95.4
200
180
160
140
120
100
80
60
40
20
0
0
60
120
180
240
300
360
420
480
540
600
660


TBM Infiltration Test Plot 2
Water Level, SG-1, Hand Measured
Water Level, WP-2, Hand Measured
Water Level, Ponding Logger
Water Level, WP-2 Logger
Ground Surface
Water Level, WP-1, Hand Measured
Water Level, WP-1 logger
WP-2 (left axis), screened in the bioretention soil and upper sand illustrates water level in the bioretention soil.
WP-1 (right axis), screened deeper in the recessional outwash, illustrates water level response lower in the subsurface.
Filling at about 40 gpm, turn flow up to ~80 gpm at 170 minutes, then back down to ~42 gpm
Average Flow Rate = 42 gpm
Falling Head
Flat line represents dry readings, not water level
WP-2 (shallower well point) Water Elevation, feet (project datum)
WP-1 (deeper wellpoint) Water Elevation, feet (project datum)
Elapsed Time (minutes)
98
97.5
97
96.5
96
95.5
95
94.5
94
93.5
93
92.5
92
91.5
91
90.5
90
89.5
89
88.5
88
0
60
120
180
240
300
360
420
480
540
600
660

APPENDIX E

Site Photos

Cell TBM, drainage area includes parking lot spaces.

Cell TBM, curb cut inlet.

Cell TBM during infiltration testing, looking southwest, after about 6.5 hours of inflow.

Cell TBM during infiltration testing, looking southeast, after about 1.5 hours of inflow.