Quality Assurance Project Plan

Geneva Bioretention Pilot Project

Prepared for
Whatcom County Public Works Department

Prepared by
Herrera Environmental Consultants, Inc.

HERRERA
Science + Planning + Design

Note:
Some pages in this document have been purposely skipped or blank pages inserted so that this document will print correctly when duplexed.

Quality Assurance Project Plan

Geneva Bioretention Pilot Project

Prepared for
Whatcom County Public Works Department
322 North Commercial Street, Suite 224
Bellingham, Washington 98225
Telephone: 360-778-6200

Prepared by
Herrera Environmental Consultants, Inc.
2200 Sixth Avenue, Suite 1100
Seattle, Washington 98121
Telephone: 206-441-9080

November 27, 2023

This page intentionally left blank

SIGNATURE PAGE

Approved by: Date

____________________ 11/27/2023

Chris Webb, Project Manager, Herrera Environmental Consultants, Inc.

____________________ 11/27/2023

Dylan Ahearn, Project Quality Assurance Coordinator,
Herrera Environmental Consultants, Inc.

____________________ __________

Shelby Giltner, Project Manager, Washington State Department of Ecology

____________________ 11/27/2023

Cody Swan, Project Manager, Whatcom County Public Works

____________________ __________

Fionna Bestwick, Laboratory Manager, Exact Science

____________________ __________

Shelly Fishel, Laboratory Manager, Analytical Resources, Inc.

____________________ __________

Greg Conrad, Environmental Technical Services. Inc.

DISTRIBUTION LIST

Name	Affiliation	Title	Phone	Address/E-Mail
Chris Webb	Herrera Environmental Consultants, Inc.	Herrera Project Manager	360-684-1740	Herrera Environmental Consultants, Inc. 2200 Sixth Avenue, Suite 1100 Seattle, WA 98121 cwebb@herrerainc.com
Dylan Ahearn	Herrera Environmental Consultants, Inc.	Herrera Project Quality Assurance Coordinator	206-441-9080	Herrera Environmental Consultants, Inc. 2200 Sixth Avenue, Suite 1100 Seattle, WA 98121 dahearn@herrerainc.com
Shelby Giltner	Washington State Department of Ecology	Project Manager	360-746-9182	Ecology – Bellingham Field Office 913 Squalicum Way #101 Bellingham, WA 98225 sgil461@ECY.WA.GOV
Cody Swan	Whatcom County Public Works	Project Manager	360-778-6265	322 North Commercial Street, Suite 224 Bellingham, Washington 98225 cswan@co.whatcom.wa.us
Fiona Bestwick	Exact Scientific Services	Laboratory Manager	360-733-1205	1355 Pacific Place, Suite 101 Ferndale, WA 98248 info@exactscientific.com
Shelly Fishel	Analytical Resources, Inc.	Laboratory Manager	206-695-6210	Analytical Resources, Inc. 4611 South 134th Place Tukwila, WA 98168-3240 shelly.fishel@arilabs.com
Greg Conrad	Environmental Technical Services, Inc.	Director of Operations	707-778-9605	ETS, Inc 975 Transport Way, Suite 2 Petaluma, CA entech@pacbell.net

Contents

Appendices

Tables

Figures

INTRODUCTION

Lake Whatcom, the drinking water source for over 100,000 Whatcom County residents, has seen a marked decline in water quality because of residential development in its watershed. In 1998, Lake Whatcom was added to the Clean Water Act's 303(d) list due to inadequate dissolved oxygen levels. Lake Whatcom is listed with a Total Maximum Daily Load (TMDL) for phosphorus and bacteria. Studies have identified the conversion of land from a "forested condition" to a "developed condition" as the primary driver of this decline. Whatcom County is part of a multi-jurisdictional effort to restore the Lake Whatcom watershed and has been planning and implementing projects and programs aimed at reducing phosphorus loads in stormwater runoff. These efforts include retrofitting existing stormwater infrastructure to maximize nutrient-removal opportunities.

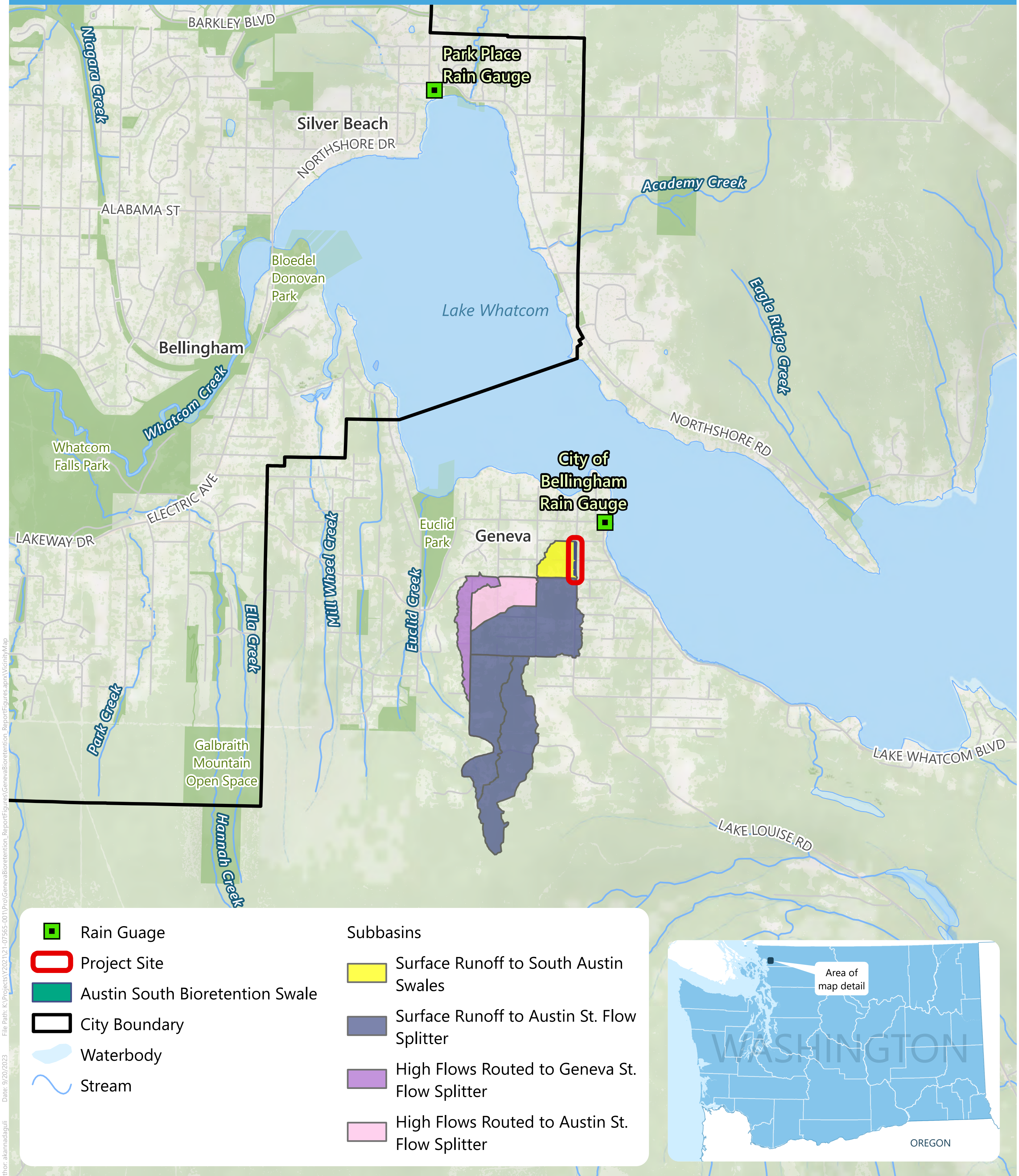
The Geneva Bioretention Pilot Project will improve the water quality of runoff flowing into Lake Whatcom by reconstructing a series of underutilized bioretention swale cells in Whatcom County's Geneva neighborhood, located on the southern shore of the lake's western end (Figure 1). A comprehensive evaluation of the existing stormwater treatment infrastructure in the Geneva neighborhood was completed in 2021. In addition to basin and infrastructure characterization, the existing bioretention swales and filter cartridge vaults in the Geneva neighborhood were evaluated for their performance in removing total suspended solids (TSS), total and dissolved copper, total and dissolved zinc, and total and orthophosphorus. The evaluation results can be found in the Comprehensive Bioswale and Filter Vault Evaluation Report (Herrera 2021). As part of the evaluation, it was recommended that a series of bioretention swale cells on Austin Street between Cable and Morgan Streets be reconstructed.

The "Austin South" bioretention swale is the focus of this Quality Assurance Project Plan (QAPP), which is referred to as the "'Austin South swale" in the 2021 evaluation report to differentiate the project swale from other local swales.

A majority of the "Austin South" bioretention swale cells were previously taken offline using an overland bypass pipe shortly after their construction due to sedimentation and local flooding issues. As part of the Austin Street bioretention swale reconstruction effort, reconstruction of the existing "Austin South" bioretention swale included excavation of existing bioretention soil media; removal of obstructions; and installation of a liner, underdrain, bioretention swale cell weirs, and High Performance Bioretention Soil Media (HPBSM) with an additional polishing media layer. In addition, the "Austin South" bioretention swale will implement an inflow dosing system that will increase the overall capacity of the bioretention facilities by regulating inflow rates while allowing the treatment media to intermittently dry. The dosing system includes a pretreatment vault, dosing vault, dosing siphon, and regulating valve, two flow splitters, and associated drainage piping. The "Austin South" bioretention swale is referred to as the Project herein.

HERRERA Science + Planning + Design

Figure 1.
Vicinity Map of the Geneva Bioretention Pilot Project.



Produced by Herrera Environmental Consultants (herrerainc.com) | Sources: ESRI (Basemap), City of Bellingham

0 820 1,640 3,280 Feet

The Project will be monitored to verify treatment performance following this Washington State Department of Ecology (Ecology)-approved QAPP (Ecology 2004) and the Technology Assessment Protocol-Ecology (TAPE) guidelines (Ecology 2018c); however, the results will not be submitted for TAPE review. This Project monitoring will test whether the performance of the HPBSM observed in laboratory experiments can be replicated in a large-scale treatment facility using the same specifications. In addition, this Project will function as a case study for implementation of the HPBSM specification and will document the HPBSM material costs, procurement, and the installation process.

The Project is funded by a grant from the Washington State Department of Ecology. All Project elements within the construction contract are eligible for grant reimbursement.

Monitoring of the Project will initiate in November 2023 and continue for approximately 18 months. This Quality Assurance Project Plan (QAPP) documents procedures used for the field testing to ensure that all results obtained from this performance verification are scientifically and legally defensible. It was prepared in accordance with Ecology's TAPE and *Guidelines for Quality Assurance Project Plans* (Ecology 2018c), and includes the following:

- **Background:** An explanation of why the project is needed.
- **Project Description:** Project goals and objectives, and the information required to meet the objectives.
- **Organization and Schedule:** Project roles and responsibilities, and the schedule for completing the work.
- **Quality Objectives:** Performance (or acceptance) thresholds for collected data.
- **Experimental Design:** The sampling process design for the study, including sample types, monitoring locations, and sampling frequency.
- **Sampling Procedures:** A detailed description of sampling procedures and associated equipment requirements.
- **Measurement Procedures:** Laboratory procedures that will be performed on collected samples.
- **Quality Control:** Quality control (QC) requirements for both laboratory and field measurements.
- **Data Management Procedures:** How data will be managed from field or laboratory recording to final use and archiving.
- **Audits and Reports:** The process that will be followed to ensure this QAPP is being implemented correctly and the quality of the data is acceptable.
- **Data Verification and Validation:** The data evaluation process, including the steps required for verification, validation, and data quality assessment.
- **Data Quality (Usability) Assessment:** The procedures that will be used to determine if collected data are of the right type, quality, and quantity to meet project objectives.
- **Data Analysis Procedures:** The method that will be used to determine relationships among the data and in relation to the TAPE criteria.

This page intentionally left blank

BACKGROUND

This section provides background information on the Project including its physical components, treatment processes, sizing methods, expected treatment capabilities, expected design life, and maintenance procedures.

Bioretention Swale System Overview

This section describes the contributing subbasins, physical components, treatment processes, sizing considerations, and maintenance requirements of the Project.

Contributing Subbasins

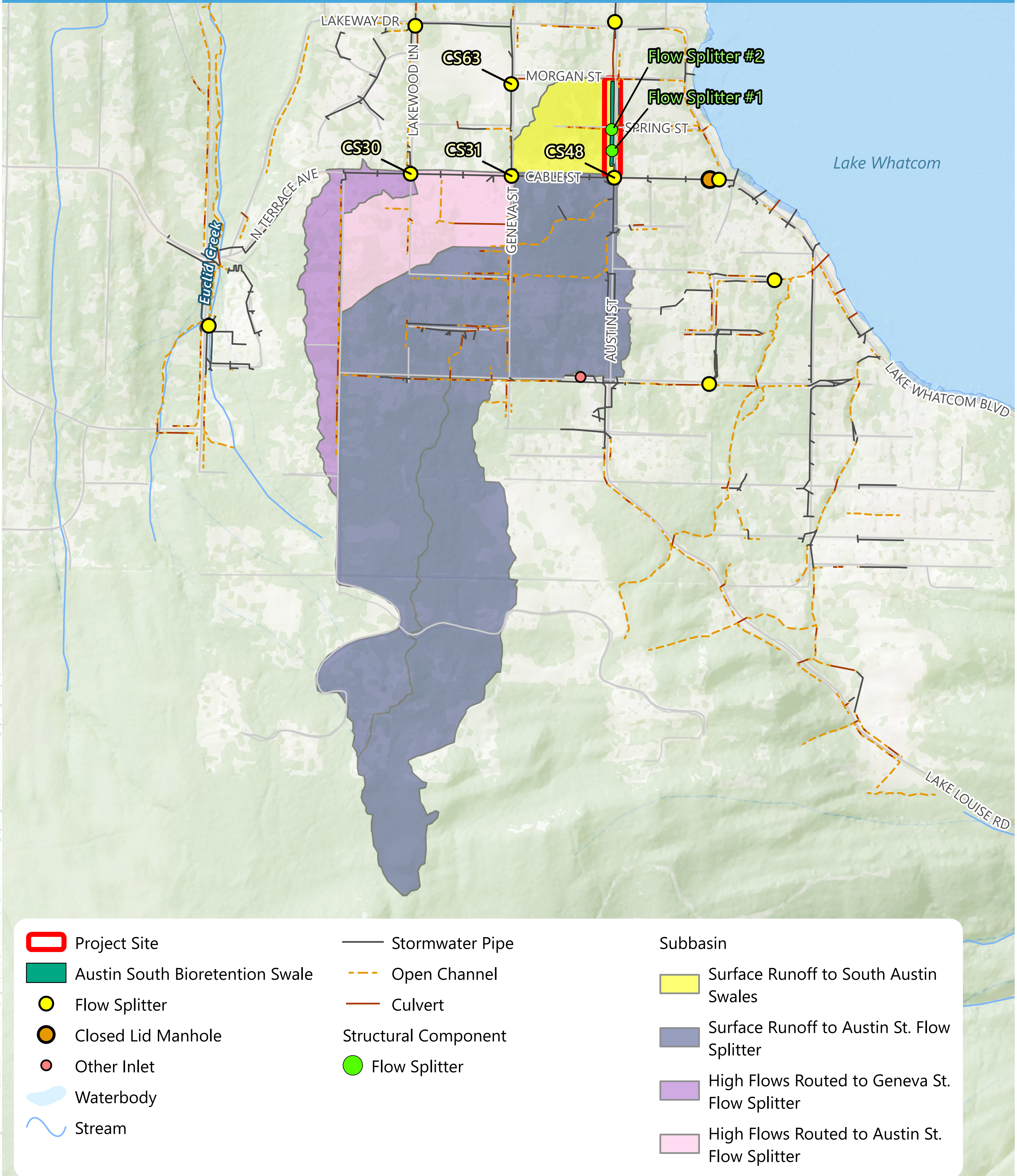
Subbasin areas contributing stormwater runoff to the Project consist of:

- Surface runoff that flows directly onto the surface of the Project bioretention swales
- Surface runoff that enters flow splitter CS48 at the intersection of Cable Street and Austin Street. Flow Splitter CS48 sends low flows up to 0.81 cubic feet per second (cfs) to the project swales. Above 0.81 cfs, a weir within CS48 overtops and diverts higher inflow rates east. Runoff from most storms will be from this subbasin.
- High flows from subbasins that enter flow splitter CS30 (located at Lakewood Lane and Cable Street) are routed to flow splitter CS31 (located at Geneva and Cable Streets). High flows from runoff entering CS31 is routed to CS48.

  The Project is sized to maximize the treatment of inflowing runoff. The existing CS48 flow splitter (shown in Figure 2 and the plan set provided in Appendix A) routes inflows up to 0.81 cfs to the Project before the flow splitter high-flow weir is engaged. The 2,996 square feet (sf) total bioretention bottom area can treat 0.57 cfs, based on a 12 inches per hour (in/hr) HPBSM infiltration rate with a saturated hydraulic conductivity (K_{sat}) safety factor of two (6 in/hr effective infiltration rate). The total basin area tributary to the Project is approximately 134.2 acres; runoff from 126.1 acres enters the dosing vault and runoff from 8.1 acres directly enters the swale via overland flow.

HERRERA
Science + Planning + Design

Figure 2.
Subbasins Contributing to the Project.



Produced by Herrera Environmental Consultants (herrerainc.com) | Sources: City of Bellingham

Author: akannadaguli Date: 9/20/2023 File Path: K:\Projects\Y2021\21-07565-001\Pro\GenevaBioretention_ReportFigures\GenevaBioretention_ReportFigures.aprx\Subbasins

Physical Components

The Project is an aboveground stormwater filtration system that consists of three swale "Cascades" (a Cascade consists of 6 or 7 level bioretention cells), which are described in detail in this section of the QAPP. The Project is designed to treat 92.1 percent of the average annual inflowing runoff volume before Cascade weirs are overtopped and runoff discharges via the bioretention swale overflow. For inflowing runoff not treated by the Project (i.e., overflowing the swale), an existing bioretention swale ("Austin North" Swale) and filter cartridge vault are located downstream to provide additional runoff treatment. "Austin North" Swale is not part of the Project design or monitoring and is therefore not detailed in this QAPP.

Pretreatment Device

A pretreatment device with a General Use Level Designation (GULD) (Contech Vortechs) is included in the design to reduce the sediment load on the swale media and therefore reduce its maintenance frequency. Sediment and debris maintenance will occur primarily in the pretreatment device and dosing vault (discussed below), which will be relatively easy locations to perform sediment removal. The dosing siphon located downstream of the dosing vault can also capture some TSS that is not retained in the pretreatment device or dosing vault.

Bioretention Swale Cascades

The reconstructed bioretention swale will incorporate HPBSM, which is composed of a primary media layer (18-inch depth) and polishing media layer (12-inch depth) to maximize phosphorus treatment performance. The HPBSM with polishing media was approved by Ecology for phosphorus-sensitive receiving waters in 2021 (Ecology 2021). A 6-inch ponding depth, compared to the existing as-designed depth of 2 inches, will increase the total ponded volume and therefore increase the total runoff volume receiving treatment.

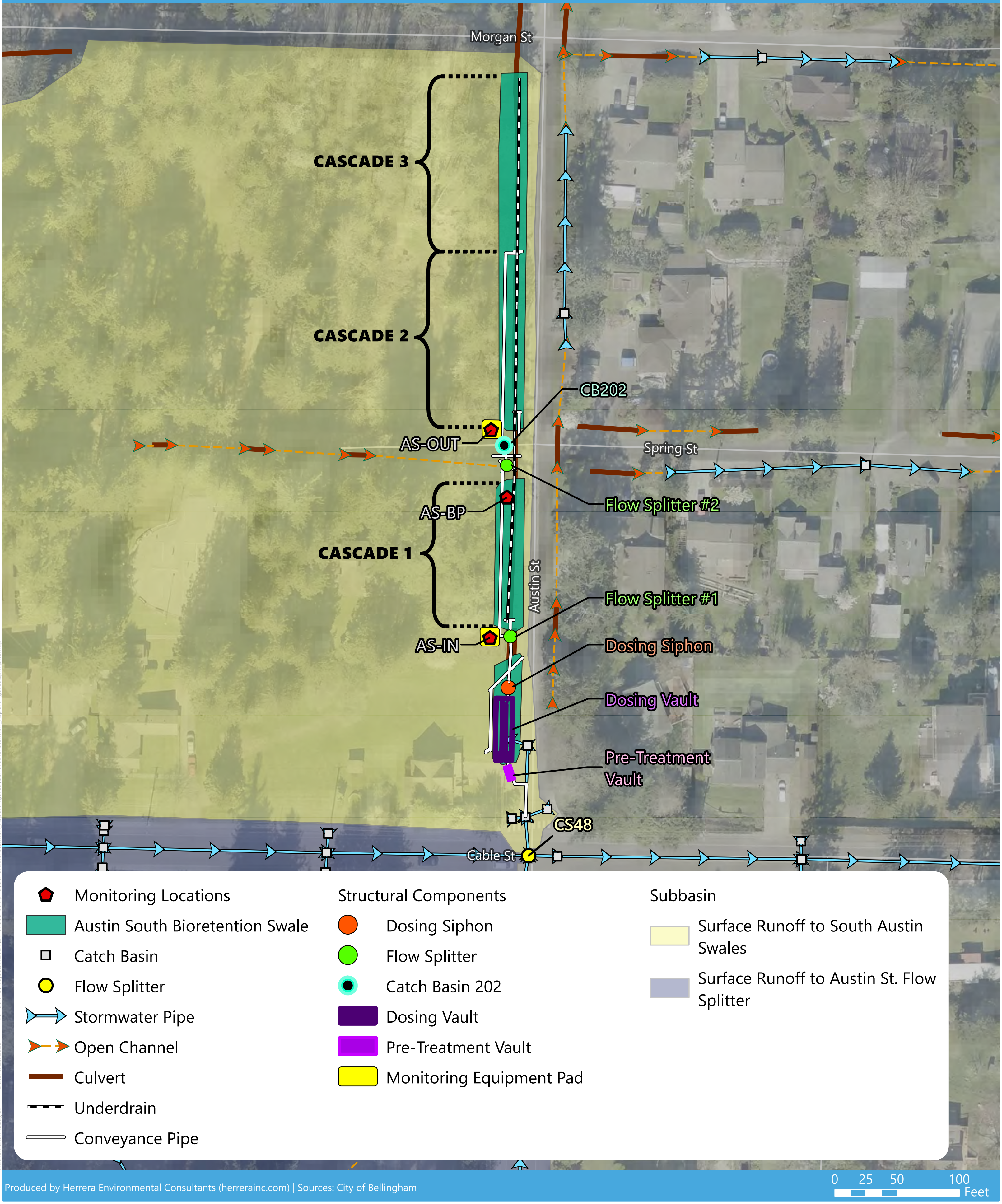
The reconstructed bioretention swale will be lined with an impermeable liner to prevent infiltration to native soils due to local basement flooding concerns. An underdrain will collect treated runoff and route it to an existing pipe for treated runoff under the "Austin North" swale.

The Project consists of three bioretention swale Cascades (Figure 3). Cascade 1 is the southernmost and receives the first 28 percent of runoff, flow is then split to Cascade 2 (37.4 percent of runoff) and, finally, Cascade 3 (34.6 percent of runoff). Cascade 1 has 6 level bioretention ells separated by weirs, Cascades 2 and 3 have 7 and 6 cells, respectively.

Appendix B, Figure B-1 shows the bioretention swale impermeable liner, underdrain, and Cascade weirs during construction.

HERRERA
Science + Planning + Design

Figure 3.
Site Map.



Produced by Herrera Environmental Consultants (herrerainc.com) | Sources: City of Bellingham

Flow Distribution

The Project site encompasses a bioretention swale that receives stormwater runoff via direct overland flow as well as from a 12-inch pipe routing the low-flow discharge of flow splitter CS48 (Figure 2). Flow spitter CS48 receives stormwater runoff from the high-flow discharge of a series of two other flow splitters (CS30 and CS31) in Cable Street and piped connections from tributary basins. Flow splitter CS30 sends low flows to bioretention swales on Lakewood Lane and Wall Street and high flows to flow splitter CS31. Flow splitter CS31 sends low flows to flow splitter CS63 and high flows to flow splitter CS48 (see Figure 2.)

The characteristics of the Project tributary subbasins (size, known sediment load, and presence of baseflows that require treatment) necessitates a bioretention swale design that distributes inflowing runoff across three swale Cascades to prevent overloading any one Cascade with runoff and/or sediment. The presence of baseflow is of concern because extended periods of runoff flow could lead to anoxic conditions in the swale due to insufficient drawdown and drying time for the HPBSM and polishing layer media. Designers should be concerned when subjecting stormwater treatment media containing organic material to extended periods of saturation as this can degrade the structure of the organics in the media (the HPBSM contains coconut coir). Additionally, the HPBSM's polishing layer media contains activated alumina and iron and under anoxic conditions, iron-phosphorous complexes may dissociate and release the bound phosphorus.

To avoid overloading any one swale Cascade and avoid prolonged saturation or anoxic conditions, the Project includes a flow distribution system to spread inflowing runoff across several swale Cascades and employs a dosing siphon to pulse-dose the Cascades and increase treatment media drying time. The dosing vault and siphon are located downstream of the pretreatment device and upstream of the bioretention swale. The dosing vault is a corrugated steel pipe tank with an internal bell siphon. A bell siphon uses atmospheric pressure and vacuums to automatically discharge a preset volume of water from a detention vault. As the dosing vault fills with inflow from flow splitter CS48, runoff is not discharged to the downstream flow splitters and ultimately the bioretention swale Cascades, until the preset dosing volume is reached, at which point the bell siphon is engaged and the full dosing volume is discharged.

Appendix B, Figure B-2 shows the dosing siphon and Flow Splitter #1 locations.

Runoff discharged from the dosing vault and siphon is sent to a series of two flow splitters to divide the discharge into thirds. Each flow splitter is a perpendicular weir style flow splitter. Perpendicular weir flow splitters split all flows, not just high and low flows as with traditional flow splitters. Flow Splitter #1 sends 28 percent of dosing siphon discharge to the first Cascade and 72 percent to Flow Splitter #2. Flow Splitter #2 divides the remaining runoff between the second (37.4 percent of dosing siphon discharge) and third (34.6 percent of dosing siphon discharge) Cascades. The upstream-most cell in each Cascade (there are 6 to 7 cells per Cascade) receives the inflowing runoff volume. Inflows greater than the infiltration and ponding capacities of a bioretention swale cell spill over a weir to the next downstream cell regardless of cell location (e.g., overflow from the downstream-most cell in the first Cascade spills over to the upstream-most cell in the second Cascade). See Figure 3.

Site Installation Requirements

Necessary Soil Characteristics

The Project bioretention swale is lined by an impervious liner and has an underdrain; therefore, in situ soil conditions are not relevant to the functionality of the project.

Hydraulic Grade Requirements

Since this is a passive system, the design of the Project is based on the elevational difference between the inlet and outlet inverts. The difference in elevation between the pretreatment vault invert and the existing concrete culvert at the outlet end of the Project is approximately 30 feet at an average approximate slope of 5 percent.

Depth to Groundwater Limitations

The Project is installed above ground, is lined by an impervious liner, and has an underdrain; therefore, groundwater limitations are not relevant to the functionality of the project.

Utility Requirements

The Biofiltration System is a passive system that requires no power and has a free-draining outlet.

Treatment Processes

Treatment of runoff that enters the Project namely occurs within the pretreatment vault, dosing vault, bioretention swale surface, and bioretention swale HPBSM. The treatment processes that occur in these Project components are detailed below.

Settling

Runoff from the contributing subbasins' storm drain network (Figure 2) first enters the Project's Contech Vortechs pretreatment vault, which settles larger debris out of the Project influent and reduces the sediment load to the bioretention swale media. The dosing siphon upstream of the bioretention swales will also allow for settling and capture of some TSS that is not captured by the pretreatment vault. Solids settling from direct run-on will also occur behind the weirs that are placed perpendicularly along the length of the bioretention swales.

Adsorption

Based on chemical reactions involving positive and negative particle attraction/repulsion within the organic and non-organic matrix of the HPBSM, adsorption and sequestration may take place, rendering pollutants immobile and/or potentially bioavailable (Hua et al. 2012).

Filtration

Filtration occurs as runoff travels through the HPBSM, which consist of an 18-inch-deep primary media layer and a 12-inch-deep polishing media layer. The primary media layer is composed of approximately 70 percent sand, 20 percent coconut coir fiber, and 10 percent biochar (Ecology 2021). The polishing media layer is composed of 90 percent sand, 7.5 percent activated alumina, and 2.5 percent iron. On the surface of the HPBSM is a 2-inch-deep hardwood mulch layer. As flow passes through the HPBSM, finer particulate material is removed by filtration through the multi-gradation particles. Some of these particles may be held in suspension or broken down further and/or made bioavailable.

System Discharge

The Project discharges its untreated bypass flows aboveground to an existing 18-inch culvert that routes flow to another bioretention swale ("Austin North" swale) and filter cartridge vault. The Project discharges treated runoff belowground in a 12-inch underdrain. Both above- and belowground discharge routes eventually discharge in an existing 24-inch outfall to Lake Whatcom located at the north end of Austin Lane.

System Sizing

The Project is sized to maximize the treatment of inflowing runoff. The existing CS48 flow splitter routes inflows up to 0.81 cfs to the Project before the flow splitter high-flow weir is engaged. Additionally, the drainage basins directly contributing to the Project (connected via overland flow) have an online water quality flow rate of 0.276 cfs. The 2,996 sf total bioretention bottom area within the bioretention swale cells can treat 0.57 cfs, based on a 12 in/hr HPBSM infiltration rate with a saturated hydraulic conductivity (K_{sat}) safety factor of two (6 in/hr effective infiltration rate).

The Project is designed to treat 70.1 percent of the average annual inflowing runoff volume (inflows from CS48 and directly tributary basins) before the bioretention swale Cascade weirs are overtopped and runoff discharges via the bioretention swale overflow, calculated using the Western Washington Hydrology Model (WWHM) (Ecology 2012) and accounting for the impacts of the dosing vault and dosing siphon.

For inflowing runoff not treated by the Project (i.e., overflowing the bioretention swale), an existing bioretention swale ("Austin North" Swale) and filter cartridge vault are located downstream to provide additional runoff treatment. "Austin North" Swale is not part of the Project design or monitoring and therefore is not detailed in this QAPP.

Maintenance Requirements

Regular maintenance of the sampling infrastructure and equipment is required to minimize equipment failure and instrument drift by resetting and calibrating measurement equipment at regular intervals. Field calibration and maintenance protocols per the Automatic Sampling for Stormwater Monitoring (Ecology 2018a) will be implemented to ensure routine inspection of the equipment is done to inspect for potential invasive species. If, for some reason, an invasive species is identified, field staff will use the appropriate decontamination method(s) per Ecology's SOP EAP070, Version 2.2 to remove the invasive species from the equipment and/or gear (Ecology 2018b).

After completing maintenance, the service operator should prepare a service record including the maintenance activities performed.

PROJECT DESCRIPTION

The primary goal of this Project monitoring is to collect data through field testing to quantify the performance of the "Austin South" bioretention swale to test whether the HPBSM performance observed in laboratory experiments can be replicated in a large-scale treatment facility using the same specifications. The following objectives have been defined for the field testing:

- Evaluate influent and effluent stormwater pollutant concentrations for the Project using flow-weighted composite sampling.
- Evaluate system bypass frequency, duration, and volume in relation to design expectations.
- Evaluate the ability of the HPBSM to support acceptable vegetation performance.

To meet these objectives, the experimental design for the field testing involves the monitoring of water chemistry and flow at the following locations:

- At the inlet of the "Austin South" bioretention swale (downstream of the pretreatment vault, dosing vault, and dosing siphon) for characterizing influent pollutant concentrations entering the bioretention swale.
- At the approximate midpoint of the "Austin South" bioretention swale underdrain to estimate pollutant concentrations in the treated effluent of the bioretention swale.

The number of representative influent and effluent water samples to be collected over the duration of the field testing period is provided in Table 4 in the Quality Control section of this report. The field testing is scheduled to begin in November 2023 and continue for 18 months or until the targeted number of storm events have been sampled.

This page intentionally left blank

PROJECT ORGANIZATION AND SCHEDULE

This section describes how the project is organized, key personnel, and the project schedule.

Organization and Key Personnel

Herrera is responsible for developing and implementing this QAPP with oversight from Whatcom County Public Works Department and Ecology. Required laboratory services for this project will be provided by Exact Scientific Services, Analytical Resources, Inc. (ARI), and ETS, Inc. Key personnel that will be involved in this effort are identified below with their respective roles:

Whatcom County Public Works 322 North Commercial Street Bellingham, Washington 98225 360-778-6265 Cody Swan, Project Manager	Exact Scientific Services 1355 Pacific Place, Suite 101 Ferndale, Washington 98248 360-733-1205 Fiona Bestwick, Laboratory Manager
Herrera Environmental Consultants, Inc. 2200 Sixth Avenue, Suite 1100 Seattle, Washington 98121 206-441-9080 Chris Webb, Herrera Project Manager Dylan Ahearn, Data Quality Assurance Coordinator	Analytical Resources, Inc. 4611 South 134th Place Tukwila, Washington 98168-3240 206-441-9080 Shelly Fishel, Laboratory Manager
Washington State Department of Ecology Headquarters Office P.O. Box 47600 Olympia, Washington 98504-7600 360-407-6439 Arati Kaza, QAPP Reviewer	Environmental Technical Services 975 Transport Way, Suite 2 Petaluma, California 360-733-1205 707-778-9605 Greg Conrad, Director of Operations

Schedule

Field testing is scheduled to begin in November 2023 and over an 18-month period; however, testing may be extended depending upon sample results and other contingencies that might impact collection of the target number of samples. Reporting for this project will be coordinated to evaluate and present the results of data collected over this period. The following project milestones have been identified:

- **November 2023:** QAPP submitted to Whatcom County Department of Public Works
- **November 2023:** Monitoring begins
- **April 2025:** Monitoring ends
- **June 2025:** Draft Final Report submitted to Whatcom County Public Works
- **July 2025:** Final revised Report submitted to Whatcom County Public Works

QUALITY OBJECTIVES

The goal of this QAPP is to ensure that the data collected for this study are scientifically accurate, useful for the intended analysis, and legally defensible. To achieve this goal, the collected data will be evaluated relative to the following indicators of quality assurance:

- Precision: A measure of the variability in the results of replicate measurements due to random error.
- Bias: The systematic or persistent distortion of a measurement process that causes errors in one direction (i.e., the measured mean is different from the true value).
- Representativeness: The degree to which the data accurately describe the conditions being evaluated based on the selected sampling locations, sampling frequency and duration, and sampling methods.
- Completeness: The amount of data obtained from the measurement system.
- Comparability: The ability to compare data from the current study to data from other similar studies, regulatory requirements, and historical data.

Measurement quality objectives (MQOs) are performance or acceptance criteria that are established for each of these quality assurance indicators. These MQOs are described below in separate subsections for hydrologic and laboratory data.

Measurement Quality Objectives for Hydrologic Data

Hydrologic monitoring will involve measurements of water level, water velocity, and precipitation depth. The water level and velocity data will be used to estimate flow rate. Flow measurement error can be introduced through two primary pathways: error associated with the control structure (primary measurement device), or error associated with the level gauge or velocity sensor (secondary measurement device). Error associated with precipitation depth data can be introduced from the placement and/or improper functioning of the rain gauge.

The data quality indicators for these measurements are expressed in terms of precision, bias, representativeness, completeness, and comparability. Assessments of precision and bias will be conducted before equipment is deployed in the field and again at the end of the project when the monitoring equipment is retrieved from the field. The MQOs for hydrologic monitoring are defined below.

Precision

The precision of the water level gauges used will be assessed by submerging the gauges in a 2-liter graduated cylinder covered with foil. The gauge reading will be recorded on a 5-minute time step for 4 hours at approximately 25 degrees Celsius (°C). Subsequently, the coefficient of variation will be calculated using the following equation:

$$C_v = \frac{\sigma}{\mu} \times 100\%$$

Where: C_v = Coefficient of variation

σ = Standard deviation

μ = The average gauge reading

The MQO will be a C_v of no more that 5 percent.

Rain gauge precision is estimated by repeatedly releasing a known volume of water into the tipping bucket mechanism and recording the volume required to tip it. This process will be repeated five times at the Park Place Rain Gauge, and the resultant C_v will be calculated using the above equation. The MQO for rain gauge precision will be 5 percent.

Because control structures are rigid devices that do not vary under repeated measurement, the data quality indicator of precision does not apply to these devices. However, due to the potential for irregular construction of the device, control structures are subject to bias, which is addressed below.

Bias

Bias will be assessed based on a comparison of monitoring equipment readings to an independently measured "true" value. To assess bias associated with the water level gauges, the gauges will be placed in a 2-liter graduated cylinder. The cylinder will be filled with water to three different known depths and the resultant level gauge readings will be compared with the "true" measured values. Three readings will be recorded at each water level. The MQO for level measurements will be a difference of no more than 5 percent between the instrument reading and an independently measured level value.

To assess bias of the velocity signal, water from a water truck or nearby hydrant will be discharged into the dosing vault upstream of the area-velocity sensor at the inlet station. A calibrated FHM closed channel rotameter will be used to determine the '"true" flow rate passing each sensor. Once the level is calibrated for the area-velocity sensor through manual measurement, the flow rate from the area-velocity sensor will be compared with the rotameter flow rate. If the bias is greater than 5 percent, the velocity will be calibrated until the flow rates agree. Three separate flow rates will be assessed for the sensor.

Bias in precipitation depth data collected through this study will be assessed based on a comparison of the rain gauge's actual readings to its theoretical accuracy as specified by the manufacturer. This bias test will involve releasing a known volume of water into the rain gauge using a dripping calibration vessel specifically designed for the test. The vessel will release the known volume over a 5-minute period. The known volume should theoretically result in a specified number of tips. This theoretical number of tips will be compared with the actual number of tips to derive an estimate of the instrument bias. The MQO for precipitation depth will be a difference of no more than 5 percent between the rain gauge's actual reading and the volume specified by the manufacturer.

Bias associated with the control structures (underdrain Thel-Mar weir and bioretention swale bypass weir) will be estimated by precisely measuring the dimensions of the devices. The MQO for these measurements is a difference of no greater than 5 percent between manual measurements and the dimensions specified by the manufacturer.

Representativeness

The representativeness of the hydrologic and continuous water quality data will be ensured by the proper installation of the monitoring equipment.

Completeness

Completeness will be assessed based on occurrence of gaps in the data record for all monitoring equipment. The associated MQO is less than 10 percent of the total data record missing due to equipment malfunctions or other operational problems. Completeness will be ensured through routine maintenance of all monitoring equipment and the immediate implementation of corrective actions if problems arise.

Comparability

There is no numeric MQO for this data quality indicator; however, standard monitoring procedures, units of measurement, and reporting conventions will be applied in this study to meet the goal of data comparability.

Measurement Quality Objectives for Laboratory Data

Quality assurance indicators for laboratory data are expressed in terms of precision, bias, representativeness, completeness, and comparability. The specific MQOs that have been identified for this project are described below and summarized for water quality data in Table 1. Note that the term "reporting limit" in this document refers to the practical quantification limit established by the laboratory, not the method detection limit.

Precision

In this study, overall project data quality will be based on analytical precision and total precision. The following sections describes the MQOs associated with each type of precision.

Table 1. Measurement Quality Objectives for Water Quality Data.					
Parameter	Laboratory Method Blank[a]	Equipment Rinsate Blank[a]	Control Standard Recovery	Matrix Spike Recovery[b]	Laboratory and Field Duplicate *RPD*[c]
Total suspended solids	≤RL	NA	80 to 108%	NA	≤10% or ±2 x RL
Particle size distribution	≤RL	NA	NA	NA	≤20% or ±2 x RL
pH	NA	NA	NA	NA	NA
Total phosphorus	≤RL	≤2 x RL	90 to 110%	80 to 120%	≤20% or ±2 x RL
Orthophosphorus	≤RL	≤2 x RL	90 to 110%	80 to 120%	≤20% or ±2 x RL
Nitrate+nitrite	≤RL	≤2 x RL	80 to 120%	80 to 120%	≤20% or ±2 x RL
Copper, dissolved	≤RL	≤2 x RL	90 to 110%	75 to 125%	≤20% or ±2 x RL
Copper, total	≤RL	≤2 x RL	90 to 110%	75 to 125%	≤20% or ±2 x RL
Zinc, dissolved	≤RL	≤2 x RL	90 to 110%	75 to 125%	≤20% or ±2 x RL
Zinc, total	≤RL	≤2 x RL	90 to 110%	75 to 125%	≤20% or ±2 x RL
Hardness	≤RL	NA	90 to 110%	75 to 125%	≤20% or ±2 x RL
Total petroleum hydrocarbons	≤RL	≤2 x RL	79 to 130%	NA	≤20% or ±2 x RL
Fecal coliform bacteria	≤RL	NA	NA	NA	≤35% lab; ≤50% field
Escherichia coliform bacteria	≤RL	NA	NA	NA	≤35% lab; ≤50% field

[a] If criterion is not met, associated blank concentration is defined as the new reporting limit, and project sample data within 5 times this de facto reporting limit are flagged with a *J*.

[b] For inorganics, the CLP Functional Guidelines state that the spike recovery limits do not apply when the sample concentration exceeds the spike concentration by a factor of four or more (Ecology 2005).

[c] The relative percent difference must be less than or equal to the indicated percentage for values greater than 5 times the reporting limit. *RPD* must be ±2 times the reporting limit for values less than or equal to 5 times the reporting limit

NA = not applicable.

RL = reporting limit.

RPD = relative percent difference.

Analytical Precision

Analytical precision will be assessed by laboratory splits of samples, matrix spikes, and laboratory control samples (see below, under Bias). These will be assessed using relative percent difference (*RPD*).

$$RPD = \left(\frac{\left| C_1 - C_2 \right|}{C_1 + C_2} \right) \times 200\%$$

Where: *RPD* = Relative percent difference
C_1 and C_2 = Concentration values
For TSS, RPD ≤25%
For all other parameters, RPD ≤20%

If split sample concentrations are both within 5 times the reporting limit the RPD goal for all parameters is <2 times the reporting limit. If either of the split samples is at or below the reporting limit the MQO cannot be calculated. *RPD* values exceeding those described herein and in Table 1 will trigger an assessment as to whether there are any problems with laboratory methodology, which might warrant remediation.

Bias

Bias will be assessed based on analyses of method blanks, equipment rinsate blanks, matrix spikes, and laboratory control samples (LCS).

Field Sample Bias

Equipment rinsate blank results greater than 2 times the laboratory reporting limit (RL) will be flagged as a de facto detection limit (*U*), and associated project samples within 5 times the de facto reporting limit will be labeled with a *J*. For details regarding remedial steps if contamination from field equipment is detected, refer to the Data Verification and Validation section.

Laboratory Bias

The values for method blanks will not exceed the reporting limit. The percent recovery of matrix spikes will be between 75 and 125 percent. The percent recovery of LCS will be within 90 and 110 percent for all applicable parameters. Percent recovery for matrix spikes will be calculated using the following equation:

$$\%R = \frac{(S - U)}{C_{sa}} \times 100\%$$

Where: %R = Percent recovery
S = Measured concentration in spike sample
U = Measured concentration in unspiked sample
C_{sa} = Actual concentration of spike added

If the analyte is not detected in the unspiked sample, then a value of zero will be used in the equation.

Percent recovery for LCS will be calculated using the following equation:

$$\%R = \frac{M}{T} \times 100\%$$

Where: %R = Percent recovery
M = Measured value
T = True value

Representativeness

The sampling design will provide samples that represent a wide range of water quality conditions during storm flow conditions. Sample representativeness will be ensured by adequate sample size over a sufficient time span, and by employing consistent and standard sampling procedures.

One of the goals of this project is to collect flow-weighted composite samples that are representative of event-mean concentrations (EMCs). For a composite sample to be representative of an EMC, certain sampling criteria are recommended. The sampling criteria for this project as defined by the TAPE (Ecology 2018c) are as follows:

- At least **7 to 10 flow-weighted sub-samples** (or aliquots) must be collected during the duration of the event.
- Samples shall be collected for at least **75 percent of the storm event hydrograph** as measured by volume for the first 24 hours of the event.
- Maximum sample duration will be **36 hours** from the time of the collection of the first aliquot to the last.

Sampling events will be selected to represent a range of conditions with respect to rainfall volume and intensity to ensure the representativeness of the data and to meet or exceed the TAPE criteria. The following criteria will serve as guidelines for defining the acceptability of specific storm events for sampling. These criteria are identical to the storm criteria listed in the TAPE (Ecology 2018c).

- Target storm depth: A **minimum of 0.15 inch** of precipitation over a 24-hour period.
- Antecedent conditions: A period of **at least 6 hours** preceding the event **with less than 0.04 inch** of precipitation.
- Minimum duration: Target storms must have **a duration of at least 1 hour**.
- End of storm: A continuous **6-hour period with less than 0.04 inch** of precipitation.

The TAPE also states that at least half of the sampled storm events should have an average intensity >0.03 inch per hour. Data from a minimum of 20 storm events will be considered adequate to meet the objectives of this sampling program and the statistical goals specified in the TAPE (Ecology 2018c).

Completeness

Completeness will be calculated by dividing the number of valid values by the total number of values. Valid sample data consists of unflagged data and estimated data that has been assigned a *J* qualifier. A qualitative assessment will be made as to which *J* flagged data may need to be excluded from this calculation before the production of the final report. If less than 95 percent of the samples submitted to the laboratory are judged to be valid, then additional samples will be collected until at least 95 percent are judged to be valid.

Comparability

Standard sampling procedures, analytical methods, units of measurement, and reporting limits will be applied in this study to meet the goal of data comparability. The results will be tabulated in standard spreadsheets to facilitate analysis and comparison with performance goals identified in the TAPE (Ecology 2018c).

This page intentionally left blank

EXPERIMENTAL DESIGN

This section describes the experimental design that will be used for the field testing.

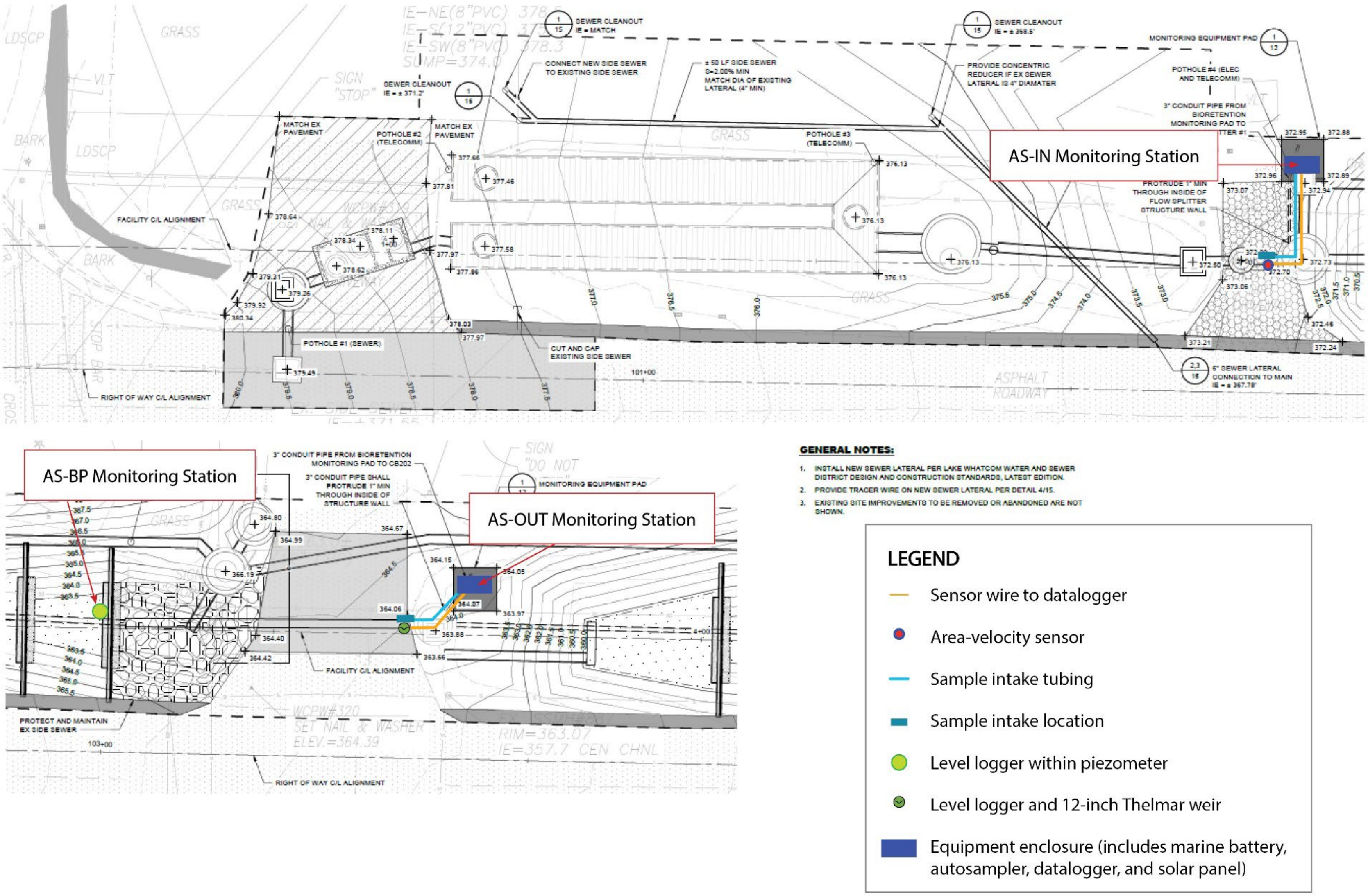
Study Site Description

The Geneva Bioretention Pilot Project is located on the west side of Austin Street between Cable and Morgan Streets in Whatcom County's Geneva neighborhood, located on the southern shore of Lake Whatcom's western end. The Geneva Bioretention Pilot Project will improve the water quality of runoff flowing into Lake Whatcom by reconstructing a series of underutilized bioretention swale cells in Whatcom County's Geneva neighborhood. The "Austin South" bioretention swale Project location is within the Austin Street right-of-way (ROW) except for minor grading and utility service relocations on adjacent parcels. The County obtained the proper easements to allow for reconstruction of the bioretention swales on the property adjacent to the ROW. Three access driveways are within the Project site and were disturbed during reconstruction of the underutilized bioretention swales.

Sampling Process Design

In general, this Project will require that hydrologic and water quality monitoring be performed in association with the bioretention swales to meet the overall objectives of this study. Separate sections below describe the sampling process design that will be used in conjunction with each of these monitoring elements. Figure 4 illustrates monitoring equipment configurations.

Figure 4. “Austin South” Monitoring Equipment Configuration.



Hydrologic Monitoring

In accordance with the TAPE guidelines, flow monitoring equipment will be installed at the inlet (AS-IN) and outlet (AS-OUT) of the southern section of the "Austin South" bioretention swale that extends between Flow Splitter #1 and Flow Splitter #2 (Figure 4) to facilitate the collection of flow-weighted composite samples.

Flowrate at the influent monitoring station (AS-IN) will be measured using a Starflow QSD AV sensor and a Campbell Scientific CR350 datalogger. At this location the total flow to all 3 Cascades in the Project will be measured. Of this flow, 28 percent will be delivered to the southernmost cell of Cascade 1 (Cascade 1 is between Flow Splitter #1 and Flow Splitter #2). Flowrate at the effluent monitoring station (AS-OUT) will be measured using a Keller America AccuLevel pressure transducer, a 12-inch Thel-Mar weir, and a Campbell Scientific CR350 datalogger. This flow will capture only what is filtered in Cascade 1. The dataloggers installed at both the inlet and outlet monitoring locations will be programmed to record flow rates at each monitoring location and to trigger the automated samplers at predefined pacing intervals. The dataloggers will use integrated digital cellular modems to download data automatically and send text message alarms to field technicians and the project manager.

The influent and effluent monitoring equipment will run on 12-volt deep-cycle marine batteries that are charged using a 100-watt solar panel installed at each station. The dataloggers, batteries, and samplers will be stored in secure, aboveground environmental enclosures (Knaack Model 4836 or equivalent). The enclosures will be bolted to the ground with conduit installed to convey pressure transducer cabling and autosampler suction lines from the base of the enclosure to the monitoring locations. The dataloggers will be programmed to send text message alerts when sampling is initiated, when the last sample is collected, and when battery voltage falls below 11.5 volts. Influent and effluent flows from the bioretention swale (AS-IN and AS-OUT, respectively) will be monitored continuously over an approximately 18-month period extending through the test period that is scheduled to begin in November 2023.

Additionally, an In-Situ TROLL 200 level logger will be installed to measure representative bypass flows from the outlet of the southern section of the "Austin South" bioretention swale (AS-BP). A separate datalogger, In-Situ VuLink, will be installed in association with, and at the location of, the bypass flow level logger (see Figure 4).

Precipitation depths at the Project site will be monitored continuously over this same period at the Park Place rain gauge (PP-RG) (Figure 1) to facilitate continuous monitoring of precipitation depths. Precipitation depths will be monitored at PP-RG by a Texas Electronics TE-525 rain gauge. The rain gauge is installed on an 8-foot steel pole and interfaced with a separate Campbell Scientific CR1000X datalogger. The datalogger is be programmed to scan every 10 seconds and record precipitation depth at the performance verification site on a 5-minute time step. If errors occur at the Park Place rain gauge during a monitored event, the City of Bellingham rain gauge (Figure 1) will be used as backup for the period of time that the errors occur.

All discharge data and rainfall data stored on the dataloggers will be remotely downloaded at least daily via digital cell phone link. These data will then be processed and validated in accordance with procedures described later in this QAPP.

Equipment Specification Sheets are provided in Appendix C.

Water Quality Monitoring

In accordance with the TAPE guidelines, an automated sampler (ISCO 6712) will be installed at both the bioretention swale inlet (AS-IN) and outlet (AS-OUT) to collect flow-weighted composite samples of the facility during up to 20 discrete storm events to obtain 40 samples (20 storm events × 2 samples per storm event = 40 samples).

These samples will be analyzed for the following suite of parameters: total suspended solids, particle size distribution, pH, total phosphorus, orthophosphorus, nitrate+nitrite, total and dissolved zinc, total and dissolved copper, and hardness. Grab samples will also be collected at AS-IN and AS-OUT stations during individual storm events and analyzed for pH, fecal coliform bacteria, *Escherichia coliform* (*E. coli*) bacteria, and total petroleum hydrocarbons.

Additional samples will also be collected through the course of the monitoring for quality assurance purposes (e.g., field duplicates and equipment rinsate blanks) and analyzed for a subset of these parameters, as appropriate. Each sampled event will require a pre-event trip to deploy ice and check level sensor calibration, a during-event sampling trip to collect grab samples (fecal coliform, *E. coli*, and total petroleum hydrocarbons), and a post-event trip to pick up the composite sample. See Table 4 in the Quality Control section for details on the anticipated number of water samples for each parameter at each sample location.

To facilitate the collection of flow-weighted composite samples, two ISCO 6712 automated samplers (Appendix C) will be installed in association with the AS-IN and AS-OUT stations (see Figure 4). Influent samples will be collected at a monitoring station in the inlet pipe to Flow Splitter #1 conveying water into the first Cascade of the bioretention swale (AS-IN). The influent sample will be taken downstream of the pretreatment device, dosing vault, and dosing siphon. For effluent water quality sample collection at the AS-OUT station, a sample intake will be positioned inside the underdrain pipe behind the Thel-Mar weir just before entering CB202 (Figure 4). Effluent samples will represent the treated flows from the southern section of the “Austin South” bioretention swale that extends between Flow Splitter #1 and Flow Splitter #2 (AS-OUT). In this manner, a representative section of the project will be monitored. To assess total project load reductions, the monitored results will be scaled up as described in the Data Analysis Procedures section.

This water quality monitoring protocol will follow the Automatic Sampling for Stormwater Monitoring SOP (Ecology 2018a) for collecting flow-weighted composite samples. Each sampler will use a decontaminated 20-liter high-density polyethylene (HDPE) bottle to collect composite samples from each sampling storm event (Appendix C). Composite sample bottles will be decontaminated with acid wash prior to each sampling event.

The dataloggers previously described will control the ISCO 6712 automated samplers. The Campbell Scientific CR350 dataloggers will be programmed to trigger their respective automated samplers based on a predefined pacing volume. Once triggered, both automated samplers will collect a 200 mL sub-sample for compositing into separate 20-liter HDPE bottles. Samplers will be programmed to collect a sample at initiation to account for the volume of water that passed the monitoring stations before initiation. Pumped sub-sample volume will be calibrated at installation and then approximately once per month following. Equipment will be inspected before and after a sampling storm event. Before a sampling storm event, field staff will clear debris from the weirs and velocity sensor to remove any blockages. Every time field staff calibrate the equipment, they will record the date of calibration in the field notebook for record management.

Both automated samplers will be housed in aboveground environmental enclosures that were described above in connection with the hydrologic monitoring. Each automated sampler will be powered by a 12-volt deep-cycle marine battery that will also be housed in its enclosure. The dataloggers will be programmed to record hydrological measurements and to trigger the inlet and outlet automated samplers at predefined pacing intervals (Walkowiak 2006.).

Poly(tetrafluoroethylene) (PTFE)-lined sample tubing will be routed from the automated samplers in the enclosures to the AS-IN and AS-OUT stations, respectively (see Figure 4). Care will be taken to ensure the tubing is installed with a positive linear grade so that water completely drains through the sample tube during rinse, purge, and sampling cycles. The sampler intakes will be carefully positioned at each station to also ensure the homogeneity and representativeness of the samples.

The chemistry data from samples collected at the AS-IN station will be used to characterize pollutant concentrations from the basin runoff after pretreatment and solids settling. The chemistry data from the AS-OUT station will be used to evaluate the water quality treatment performance of Cascade 1 of the Project (Figure 3 and Figure 4).

Vegetation Monitoring

Herrera will monitor and report on the health and vigor of vegetation of the "Austin South" bioretention swale through visual assessments. These visual assessments will take place three times during the monitoring period—once during the fall of 2023, once during the spring/ early summer of 2024, and once during the spring of 2025. Data will be collected using ArcGIS Survey123 digital field forms on mobile devices such as tablets or phones. Data forms will be used to collect data and track collection progress. The forms will capture the bioretention swale identification, data collector identity, weather, and other information pertaining to the bioretention swale, as well as facility monitoring data unique to each cell within the bioretention swale, which will be the scale at which each survey will be conducted. Bioretention swale cells have three separate areas for evaluation:

1. Cell Tops: The top of bank and landscaped areas above the cell side slopes and within continuous adjacent landscaped areas.
2. Side Slopes: The sloped areas of the cells that provide a transition zone between cell tops and cell bottoms.

3. Cell Bottoms: The flat or gently sloped bottom of the cell that holds and infiltrates the majority of stormwater runoff.
4. The following site-specific information will be collected for each bioretention swale cell:
    - Total percentage of weedy species cover over the cell (0 to 10 percent, 11 to 30 percent, 31 to 50 percent, 51 to 75 percent, and 76 to 100 percent)
    - For Cell Top, Side Slope, and Cell Bottom:
        - Visual estimates of survival and cover within cover thresholds (0 to 25 percent, 26 to 50 percent, 51 to 75 percent, and 76 to 100 percent)
        - Dominant species present (defined as a species that covers 20 percent or greater of a Cell Top, Side Slope, or Cell Bottom area)
        - Visual estimate percentage bare ground (0 to 25 percent, 26 to 50 percent, 51 to 75 percent, and 76 to 100 percent)
        - Visual estimate of vegetation health

See Appendix D for example field data that will be collected in ArcGIS Survey123 digital forms.

In addition to the data collected in ArcGIS Survey123, photographic documentation of vegetation in each cell will also be collected during each vegetation monitoring event. Photographs will be taken at permanently marked points in each cell to achieve repeatability and consistency between events.

SAMPLING PROCEDURES

The specific field safety and sample collection procedures that will be used in connection with this study are described in the following subsections.

Field Safety Procedures

Herrera's Safety Policy is that health and safety of the staff is of paramount importance. Activities performed under potentially hazardous conditions shall be acknowledged and planned to mitigate personal injury. Herrera's Safety Policy shall apply during company-approved field work only.

- Prior to working on site, a general inspection of hazards will be made by the project manager.
- Onsite field personnel must have a communication device (i.e., cell phone, satellite phone) capable of connecting to an emergency contact (i.e., Herrera office, local emergency service).
- Designate at least one vehicle for emergency use.
- Roof-mounted flasher will be present on vehicles
- Care will be taken when parking on the Austin Street shoulder. There is parallel street parking to the south of the Project along Austin Street. However, there is not a designated crosswalk to cross Cable Street.
- Field staff must visually and audibly confirm there is no traffic coming from either direction of Cable Street before crossing. Both streets are straight so sightlines are not limited in the vicinity.
- At a minimum, field personnel will follow the general requirements for personal protective equipment (PPE) by dressing appropriately for close proximity to vehicular traffic (WAC 296-155-200).
    - Protective footwear
    - High-visibility safety vest

All installation and monitoring work will be conducted in accordance with WSDOT safety protocols (WSDOT 2006). At least two field personnel will always be present when confined-space entry occurs at the site. All personnel entering maintenance holes for equipment installations, maintenance, and repairs will have confined-space entry training in accordance with Occupational Safety and Health Administration requirements (WAC 296-809).

Table 2 provides potential hazards and control measures identified for this work site.

Table 2. Potential Site Hazards and Control Measures.	
Hazards	**Hazard Control Measures**
Motor Vehicle Driving	• Drive defensively. • If you need to place or receive a phone call, pull off the road to a safe location and stop the vehicle before using your cell phone. Allow voicemail to handle your calls. • Be aware of weather and road conditions when driving (i.e., heavy rain, snow; large puddles in roadway, black ice). • Driver and passengers must wear seatbelts.
Weather Extremes	• Establish site-specific contingencies for severe weather situations. • Provide for frequent weather broadcasts. • Weatherize safety gear, as necessary • Identify special PPE needs. • Discontinue work during severe weather.
Heat Stress	• Provide cool break area and adequate breaks. • Promote heat stress awareness. • Use active cooling devices (e.g., cooling vests) where specified.
Sunburn	• Apply sunscreen. • Wear hats/caps and long-sleeved shirts.
Cold Exposure	• Provide warm break area and adequate breaks. • Provide warm, non-caffeinated beverages. • Promote cold stress awareness.
Slips, Trips, Falls	• Be aware of obstacles, such as cords, tools, and other equipment that may be present on the ground in the work area. • Identify and mark areas that are potentially slippery (e.g., wet or oily surfaces) with spray paint or flagging and walk around them. • Use handholds. • Wear boots with good traction.
Traffic Hazards	• Establish and follow a traffic control plan for equipment removal. • Wear bright orange reflective vests, when working within or alongside traffic.

Training

All field workers have received health and safety training required by OSHA (29 CFR 1910.120) and Washington State Division of Occupational Safety and Health (DOSH) (Chapter 296-843-200 WAC), including some or all of the following:

- First Aid and CPR training
- Annual Medical Clearance

Field Sampling Procedures

Water and sediment sampling procedures are described in the following sections.

Water Sampling Procedures

As described above, this project involves the collection of flow-weighted composite samples during discrete storm events. Antecedent conditions and storm predictions will be monitored via the Internet, and a determination will be made as to whether to target an approaching storm. Before each targeted storm event, field staff will conduct site visits to set up the automated samplers at the AS-IN and AS-OUT stations. During these pre-storm site visits, field staff will perform the following activities:

- Remove any blockages in the rain gauge and weirs
- Calibrate the AS-IN and AS-OUT velocity sensors, as needed
- Backflush the sample lines with deionized water
- Check the state of the desiccant associated with the equipment
- Place a clean sample bottle in the samplers
- Pack ice around the sample bottles within each sampler

Ice is estimated to keep the interior of the samplers cool for 48 hours; therefore, ice will be added to the samplers not more than 24 hours before a targeted storm event.

Sample pacing for the automated samplers will be determined based on rainfall versus runoff relationships that are developed using linear regressions of data that were collected during previous storm events. These regressions will be continually updated throughout the year to reflect changing hydrologic conditions. The rainfall versus runoff regressions are used to convert forecast rainfall totals into runoff volumes. The resultant runoff volume (gallons) is then divided by 50 (the median number of 200 mL aliquots that a 20-liter bottle will hold) to estimate the sample pacing (cubic feet) volume necessary to collect an adequate number (greater than 10) of aliquots across at least 75 percent of the storm hydrograph.

When the first aliquot is collected during a targeted storm event, the datalogger described above in Sampling Process Design section will send an alarm via text message to alert field personnel that stormwater is now flowing into Flow Splitter #1 (AS-IN monitoring location).

Flow-weighted composite sampling criteria will be assessed before post-storm sample retrieval by accessing sampling data with a remote cellular link (Campbell CR350-CELL210 digital cellular modem). If sampling criteria are not met, the samples will be retrieved before the next storm event. If sampling criteria are met, field personnel will return to the site and make visual and operational checks of the system and collect detailed field notes using standardized field forms (see Field Quality Control Procedures). Field personnel will then remove the 20-liter HDPE bottles from each automated sampler, label each HDPE bottle with station ID, date, and time of last sample, then transport them on ice to the laboratory within the allowable limits for sample holding times (see Table 3). Additional samples will also be collected through the course of the performance verification for quality assurance purposes (e.g., field duplicates and equipment rinsate blanks).

In general, the laboratory will be given prior notice of a pending sampling event to ensure that adequate laboratory staff will be available to process the incoming samples. Once in the laboratory, water from the 20-liter HDPE bottles will be used to fill decontaminated, preserved (where appropriate) sample bottles for the required analyses. The samples will be analyzed for the suite of parameters that is identified in the Sampling Process Design section.

Table 3. Water Quality Analysis Methods and Detection Limits.

Parameter	Analytical Method	Method Number[a]	Field Sample Container[b]	Pre-Filtration Holding Time	Total Holding Time[c]	Field Preservation	Laboratory Preservation	Actual Reporting Limit/ Resolution	Target Reporting Limit/ Resolution	Units
Total suspended solids	Gravimetric[d]	SM 2540D	20-liter HDPE bottle	NA	7 days	Cool ≤6°C	Maintain ≤4°C	1.0	1.0	mg/L
Particle size distribution	Sieve and filter – coulter counter	ASTM 3977 – TAPE, Appendix F		NA	7 days		Maintain ≤4°C	NA	NA	μm
pH	Potentiometric	SM 4500 H+ (field)	No container	NA	NA	NA	NA	0.01	0.01	Standard units
Total phosphorus	Colorimetric	SM 4500-P J	20-liter HDPE bottle	NA	28 days	Cool ≤6°C	Maintain ≤6°C, H_2SO_4 to pH <2	0.005	0.005	mg/L
Orthophosphorus	Colorimetric	SM 4500-P G		24 hours[e]	28 days		Filter, Cool, ≤6°C	0.003	0.003	mg P/L
Nitrate+nitrite	Colorimetric	SM 4500-NO_3I		28 days	28 days		Maintain ≤6°C, H_2SO_4 to pH <2	0.01	0.01	mg/L
Hardness as $CaCO_3$	Titration	SM 2340B		NA	28 days		Maintain ≤4°C, H_2SO_4 to pH <2	1.0	1.0	mg/L
Copper, dissolved	ICP-MS	EPA 200.8		24 hours[e]	6 months		Maintain ≤4°C, HNO_3 to pH <2 after filtration[f]	0.002	0.001	mg/L
Copper, total				NA			Maintain ≤4°C, HNO_3 to pH <2	0.002	0.001	mg/L
Zinc, dissolved	ICP-MS	EPA 200.8		24 hours[e]	6 months		Maintain ≤4°C, HNO_3 to pH <2 after filtration[f]	0.0025	0.001	mg/L
Zinc, total				NA			Maintain ≤4°C, HNO_3 to pH <2	0.0025	0.005	
Total petroleum hydrocarbons	GC/FID	NWTPH-Dx	Two 500-mL amber glass bottle	7 days	40 days		Maintain ≤6°C, HCL to pH <2	100	100	μg/L
Fecal coliform bacteria	Membrane filtration	SM 9222D	100 mL sterile Idexx	NA	24 hours		Maintain <4°C	1	NA	cfu/100 ml
E. coli bacteria	Membrane filtration	EPA Method 1604	100 mL sterile Idexx	NA	24 hours		Maintain <4°C	1	NA	cfu/100 ml

[a] SM method numbers are from APHA et al. (1998); EPA method numbers are from the U.S. Environmental Protection Agency (U.S. EPA [1983, 1984]). The 18th edition of *Standard Methods for the Examination of Water and Wastewater* (APHA et al. 1992) is the current legally adopted version in the *Code of Federal Regulations*. ASTM 2007 (SSC).

[b] Sample bottles that share the same numeric notation will be used for multiple parameters.

[c] Holding time specified in U.S. EPA guidance (U.S. EPA 1983, 1984 or referenced in APHWA et al. [1992]) for equivalent method.

[d] A G4 glass fiber filter will be used for the total suspended solids filtration.

[e] EPA requires filtering for orthophosphorus and dissolved metals within 15 minutes of the collection of the last aliquot. This goal is exceedingly difficult to meet when conducting flow-weighted sampling. A more practical proxy goal for this study is 24 hours. Both goals will be reported with the data.

[f] A 0.45 μm fiber nylon filter will be used for dissolved metals (copper and zinc) filtration.

C = Celsius
cfu = colony forming unit
GC/FID = gas chromatography/flame ionization detection
HDPE = High-Density Polyethylene
ICP = inductively coupled plasma – atomic emission spectroscopy
ICP-MS = inductively coupled plasma/mass spectrometry
LC-MS/MS = liquid chromatograph mass spectrometry/mass spectrometry
μm = micrometers
mg/L = milligrams per liter
ml = milliliter
NA = not applicable

This page intentionally left blank

MEASUREMENT PROCEDURES

Laboratory analytical procedures for this project will follow EPA-approved methods (APHA et al. 1992, U.S. EPA 1983, 1984; ASTM 2007). These methods provide reporting limits that are low enough to assess water quality at low pollutant concentrations, and below the state and federal regulatory criteria or guidelines, which will allow comparison of the analytical results with these levels. The preservation methods, analytical methods, reporting limits, and sample holding times are presented in Table 3.

Samples for the parameters requiring filtration (e.g., dissolved copper and zinc, nitrate+nitrite, and orthophosphorus) will be delivered to the laboratory (Exact Scientific Services) within 24 hours of their collection. Upon their receipt, laboratory personnel will immediately filter and preserve these samples.

The laboratories identified for this project (Exact Scientific Services, ARI, and ETS, Inc.) are certified by Ecology and participate in audits and inter-laboratory studies by Ecology and U.S. Environmental Protection Agency (U.S. EPA). Performance and system audits have verified the adequacy of the laboratories' standard operating procedures, which include preventive maintenance, data reduction, and QA/QC procedures.

ARI laboratory will be used for total phosphorus and orthophosphorus analysis, ETS, Inc. will be used for particle size distribution, and Exact Scientific Services will analyze all other parameters, spilt, process, and ship samples, and be responsible for managing the laboratory data from ETS, Inc. and ARI.

The laboratories will report the analytical results within 30 days of receipt of the samples. The laboratories will provide all sample and quality control data in standardized reports that are suitable for evaluating the project data. Submittals will include all raw data, including but not limited to:

- All raw values including those below the reporting limit and between the method detection limit and the laboratory reporting limit
- The laboratory method detection limits and reporting limits for all analytes for each batch
- All field duplicate and laboratory split results

Data are to be submitted electronic format in MS Excel and PDF via the ESdat® data management platform. The reports will also include a case narrative summarizing any problems encountered in the analyses.

This page intentionally left blank

QUALITY CONTROL

Quality control procedures are identified in separate subsections below for field and laboratory activities. The overall objective of these procedures is to ensure that data collected for this project are of a known and acceptable quality.

Field Quality Control Procedures

Quality control procedures that will be implemented for field activities are described in the following subsections. The frequency and type of quality control samples to be collected in the field are also summarized in Table 4.

Instrument Maintenance and Calibration

Before and after each targeted event, routine maintenance and operational inspections will be performed to ensure that the equipment is functioning properly. Maintenance activities and operational inspections will include:

- Inspection of battery and battery connections
- Check desiccant for the data loggers and autosamplers and replace as needed
- Inspection of the rain gauge, including level check and debris removal
- Inspection of Thel-Mar weirs and AV sensor, including level check and debris removal

The calibration of the pressure transducers will also be checked monthly. The procedure for calibrating the Thel-Mar weir at AS-OUT will entail filling the space behind the Thel-Mar weirs with water until the water level just reaches the height of the weir crest. The stage will then be recorded on field forms and the offset calibrated so that stage is reset to zero. Instrument maintenance and calibration activities will be documented on standardized field forms (see Appendix D).Calibration of the transducer at AS-BP will be checked by measuring down to the water surface elevation within the well/piezometer. Measure down values will be compared with sensor readings over time to assess drift and calibrations applied as necessary. The level sensor at AS-IN (integrated with the Starflow QSD AV sensor) will be calibrated by placing a sandbag downstream of the sensor and filling the upstream prism with water to submerge the sensor. A manual measurement of depth will be compared with the sensor-measured depth and calibrations applied as necessary. In general, calibrations will only be applied when measured depth differs from sensor depth by greater than 0.01 feet. Instrument maintenance and calibration activities will be documented on standardized field forms (see Appendix D).

The rain gauge is a robust instrument that will only require annual calibration. On an annual basis, water will metered into the Park Place rain gauge using a rain gauge calibration device containing a known volume of water. The measured number of tips will then be compared with the theoretical number of tips and adjustments to the tipping mechanism will be made if necessary. All calibration information will be recorded and previously collected data corrected, if necessary. All rain gauge measurements will be compared with a nearby City of Bellingham rain gauge.

Table 4. Quality Assurance Requirements and Anticipated Number of Water Samples for Each Parameter.									
	Project Samples		Field QA Samples			Lab QA Samples			
Parameter	**Flow-Weighted Composite Samples**	**Grab Samples**	**Field Equipment Rinsate Blanks[b]**	**Field Duplicates[c]**	**Total Number of Samples Submitted to Lab**	**Laboratory Method Blanks**	**Laboratory Control Standard**	**Matrix Spike**	**Lab Duplicates**
Total suspended solids	40	0	NA	4	44	1 per batch[a]	1 per batch[a]	NA	1 per batch[a]
Particle size distribution	3	NA	NA	1	4	1 per batch[a]	1 per batch[a]	1 per batch[a]	1 per batch[a]
pH	NA	6	NA	1	7	NA	NA	NA	NA
Total phosphorus	40	0	3	4	47	1 per batch[a]	1 per batch[a]	1 per batch[a]	1 per batch[a]
Orthophosphorus	40	0	3	4	47	1 per batch[a]	1 per batch[a]	1 per batch[a]	1 per batch[a]
Nitrate+nitrite	6	NA	3	1	10	1 per batch[a]	1 per batch[a]	1 per batch[a]	1 per batch[a]
Hardness as $CaCO_3$	6	NA	NA	1	7	1 per batch[a]	1 per batch[a]	1 per batch[a]	1 per batch[a]
Copper, dissolved	40	0	3	4	47	1 per batch[a]	1 per batch[a]	1 per batch[a]	1 per batch[a]
Copper, total	40	0	3	4	47	1 per batch[a]	1 per batch[a]	1 per batch[a]	1 per batch[a]
Zinc, dissolved	40	0	3	4	47	1 per batch[a]	1 per batch[a]	1 per batch[a]	1 per batch[a]
Zinc, total	40	0	3	4	47	1 per batch[a]	1 per batch[a]	1 per batch[a]	1 per batch[a]
Total petroleum hydrocarbons	NA	6	NA	1	7	1 per batch[a]	1 per batch[a]	1 per batch[a]	1 per batch[a]
Fecal coliform bacteria	NA	40	NA	4	44	1 per batch[a]	NA	NA	1 per batch[a]
E. coli bacteria	NA	40	NA	4	44	1 per batch[a]	NA	NA	1 per batch[a]

[a] Laboratory QA samples will be analyzed with each batch of samples submitted to the laboratory for analysis. A laboratory batch will consist of no more than 20 samples.

[b] Equipment rinsate blanks will be collected before the first event, in the middle of the study, and at the end of the study.

[c] Field duplicates will be collected and analyzed for at least 10 percent of the total number of submitted samples.

NA = not applicable

Field Notes

During each pre- and post-storm site visit to each monitoring station, the following information will be recorded on a waterproof standardized field form (see Appendix D):

- Site name
- Date/time of visit and last sample collected
- Name(s) of field personnel present
- Weather and flow conditions
- System battery voltage
- Rain gauge condition
- Desiccant condition
- Number of aliquots (if sampled)
- Sampling errors? (if sampled)
- Sample duplicated? (if sampled)
- Estimated sample volume (if sampled)
- Presence of obstructions in weir, or sample tubing and remedial actions taken
- Unusual conditions (e.g., oily sheen, odor, color, turbidity, discharges or spills, and land disturbances)
- Modifications of sampling procedures

Field notes will be included as an appendix in the final report produced for this project.

Equipment Rinsate Blanks

Equipment rinsate blanks will be collected to verify that the automated sampler tubing is not a source of contamination. To collect the sample, the sample line will be rinsed in the same manner that it is during pre-storm site visits. The sample line will then be detached at the point of sample collection and placed in a carboy of reagent grade water. The sampler will be programmed to collect 20 liters of reagent grade water using normal sample collection procedures. Rinsate blanks will be collected before the first targeted storm event, after the first sampled event, and at the end of the study. All rinsate blank samples will be submitted to the laboratory and labeled as separate (blind) samples.

Field Duplicates

Field duplicates will be collected at a sufficient frequency to represent 10 percent of the total number of project samples analyzed. The number of field duplicates to be collected during each year of field testing is listed in Table 4. For water quality samples, field duplicates will be collected as follows:

- Initially, at least the first four field duplicates will be taken only from the AS-IN station.
- If pollutant concentrations at AS-OUT are in excess of 5 times the reporting limit, duplicates will be alternated between AS-IN and AS-OUT to capture duplicates from each station.

All duplicate samples will be submitted to the laboratory and labeled as separate (blind) samples. The resultant data from these samples will then be used to assess variation in the analytical results that is attributable to environmental (natural), sub-sampling, and analytical variability.

Sample Handling

Automated samplers will be filled with ice before each sampled storm event. Ice will not be allowed to sit within autosamplers for more than 24 hours before the initiation of an event (with the goal of keeping sample temperatures below 6°C). After each targeted storm event, all samples will be minimally processed in the field to prevent potential contamination from trace pollutants in the atmosphere.

All sample bottles will be transported in coolers with ice and kept below 6°C until delivery to the laboratory. The temperature of the samples will be measured upon sample delivery and recorded on the chain of custody form. Once in the laboratory, the composite samples will be transferred from the sampler carboy to precleaned sample bottles for the required analyses. The carboy will be vigorously agitated and poured through a splitter into separate bottles for analysis. This transfer process will ensure the sample is well mixed before filling the individual sample bottles. For sediment samples, all sample bottles will be transported in coolers with ice and kept below 6°C until delivery to the laboratory. To minimize exposure of the samples to human, atmospheric, and other potential sources of contamination, laboratory staff will process the samples using "clean" techniques pursuant to protocols developed by the U.S. EPA (1996) for the low-level detection of metals.

Sample Identification and Labeling

All sample containers will be labeled with the following information using indelible ink and labeling tape:

- Site/station name (e.g., AS-IN and AS-OUT)
- Date of sample collection (year/month/day: yyyy/mm/dd)
- Time of sample collection (international format [24 hour])
- Field personnel initials (e.g., DSA)

QA samples (field duplicates and blanks) will only be labeled as QA1, QA2, etc., for delivery to lab, but field staff will maintain a cross-check list of which stations and sample types that the QA samples represent. When results are returned from the laboratory, the consultant will associate full label information with the results and populate database fields for QA sample and type.

Waterproof labels will be placed on dry sample container lids by self-adhesion or with tape. Waterproof labeling tape may be employed. Any written marks will be made with waterproof ink.

Sample Containers and Preservation

Clean, decontaminated sample bottles will be obtained from the analytical laboratory in advance of each storm event. Spare sample bottles will be carried by the sampling team in case of breakage or possible contamination. Sample containers and preservation techniques will follow U.S. EPA (2007) guidelines. After samples are processed laboratory personnel will clean the sample bottles with a four-step process: 1) Liquinox detergent rinse, 2) reagent grade water rinse, 3) two molar nitric acid rinse, 4) reagent grade water rinse.

Sample Packing and Shipping

Samples for the particle size distribution analysis will be shipped by Exact Scientific to ETS, Inc. in Petaluma, California. Recommended steps for packing and shipping samples include:

- Fold the field-sampling sheets and chain of custody record form and place them in plastic bags to protect the sheets during transport.
- Clearly mark the analyses to be performed for each sample.
- Pack samples to prevent breakage or leakage (samples should already be labeled).
- Securely seal shipping containers and affix identification labels to each shipping container.
- Mark containers THIS END UP and number containers in a shipment.

Chain-of-Custody Record

A chain-of-custody record will be maintained for each sample batch listing the sampling date and time, sample identification numbers, analytical parameters and methods, persons relinquishing and receiving custody, dates and times of custody transfer, and temperature of sample upon delivery.

Laboratory Quality Control Procedures

Quality control procedures that will be implemented in the laboratory are described in the following subsections. The frequency and type of quality control samples to be analyzed by the laboratory are also summarized in Table 4.

Method Blanks

Method blanks consisting of de-ionized and micro-filtered pure water will be analyzed with every laboratory sample batch. A laboratory sample batch will consist of no more than 20 samples and may include samples from other projects. The total number of method blanks anticipated for this study is shown in Table 4 by parameter. Blank values will be presented in each laboratory report.

Control Standards

Control standards for each parameter will be analyzed by the laboratory with every sample batch. A laboratory sample batch will consist of no more than 20 samples and may include samples from other projects. The total number of control standards anticipated for this study is shown in Table 4 by parameter. Raw values and percent recovery (see formula in the Quality Objectives section) for the control standards will be presented in each laboratory report.

Matrix Spikes

For applicable parameters, matrix spikes will be analyzed by the laboratory with every sample batch. A laboratory sample batch will consist of no more than 20 samples and may include samples from other projects. The total number of matrix spikes anticipated for this study is shown in Table 4 by parameter. Raw values and percent recovery (see formula in the Quality Objectives section) for the matrix spikes will be presented in each laboratory report.

Laboratory Duplicates (split project samples)

Laboratory split-sample duplicates for each parameter will be analyzed for specifically labeled QA samples submitted with every sample batch. This will represent no less than 10 percent of the project submitted samples. The total number of laboratory duplicates anticipated for this study is shown in Table 4 by parameter. Raw values and relative percent difference (see formula in the Quality Objectives section) of the duplicate results will be presented in each laboratory report.

DATA MANAGEMENT PROCEDURES

Data from the data logger will be remotely downloaded on a daily time step. The hydrologic data from each monitoring station will be imported directly into a database (Aquarius data management software) for subsequent analysis and archiving purposes. These data will be checked for evidence of an equipment malfunction or other operational problem. Gaps in flow data may need to be interpolated; if this occurs, data will be stored and presented in a manner that makes it clear what data are from measurement, and what have been interpolated. The database will be used to produce event based hydrologic summary statistics (e.g., station runoff volume, storm precipitation total, storm duration) for each applicable station. These summary statistics will ultimately be stored in a database (ESdat data management software) with other water quality data collected through the project (see description below). If gaps in flow data occur during a sample event, the data will be dumped and not included in the analysis.

The laboratories will report the analytical results within 30 days of receipt of the samples. The laboratories will provide sample and quality control data in standardized reports that are suitable for evaluating the project data. These reports will include all raw data including raw quality assurance data, and all quality control results associated with the data. The reports will also include a case narrative summarizing any problems encountered in the analyses, corrective actions taken, changes to the referenced method, and an explanation of data qualifiers. Laboratory analytical and QA results will be delivered from the laboratory in electronic form.

Analytical data for the project will be stored in a SQL database and spreadsheet (Microsoft Excel) format with related event-based hydrologic data from each storm. A continuous hydrologic record will also be stored. The Herrera quality assurance officer will perform an independent review of the data to ensure that all sample values were entered without error. Specifically, 10 percent of the sample values will be randomly selected for rechecking and crosschecking with laboratory reports. If errors are detected, they will be corrected, and then an additional 10 percent will be selected for validation. This process will be repeated until no errors are found in the data. This review will consist of checking that all laboratory data were entered into the database correctly and all data in the database agree with the data presented in Individual Storm Reports (ISRs) (see example in Appendix E). ISRs will include an event hydrograph, chemistry data, and all associated sampling, flow, and precipitation characteristics of the event.

Both the laboratory and Herrera will retain project related data for 5 years after completion of the project.

This page intentionally left blank

AUDITS AND REPORTS

Audits will be performed to detect potential deficiencies in the hydrologic and water quality data collected for this project. Audits will occur following each storm event. In connection with these audits, data collected from each monitoring station over the sampled storm events will be compared to data from prior storms and data from the rain gauge station to identify potential data quality issues. This audit will specifically include an examination of the data record for gaps, anomalies, or inconsistencies between the discharge and water level data from previous monitoring events. Any data generated from calibration checks that were performed at a particular monitoring station will also be entered into control charts and reviewed to detect potential instrument drift or other operational problems. In addition, sample collection and hydrologic data will be reviewed to assess whether MQOs have been met.

If QA issues are identified on the basis of these audits, measures will be taken to troubleshoot the problem(s) and to implement corrective actions if possible. Further, bias detected in the hydrologic record will be corrected by calibration if possible, and these corrective actions will be documented in the database and reported in the final report.

Audits performed for water quality data will be performed to ensure that all data are consistent, correct, and complete, and that all required quality control information has been provided. Specific quality control elements for the data (see Table 1) and raw data will also be examined to determine if the MQOs for the project have been met. Results from these audits will be documented in QA worksheets (see Appendix D) that will be prepared for each batch of samples.

If a potential QA issue is identified through these audits, Herrera's data quality assurance officer will review the data to determine if any response actions are required. Response actions in this case might include the collection of additional samples, reanalysis of existing samples if not yet past holding time, eliminating the data from the overall performance assessment, or advising the laboratory that methodologies or QA/QC procedures need to be improved.

This page intentionally left blank

DATA VERIFICATION AND VALIDATION

Data verification and validation will be performed on both the hydrologic and water quality data that are collected through the duration of this project. The specific procedures that will be used to verify and validate each type of data are described in the following sections.

Verification and Validation Methods for Hydrologic Data

The verification and validation process for hydrologic data will involve the following steps:

- Precipitation data from the study will be reviewed to identify any significant gaps. If possible, these gaps will be filled using data obtained from a nearby rain gauge (City of Bellingham Rain Gauge), located approximately 0.2 miles north of the Project.
- The available discharge and water level data from AS-IN and AS-OUT will be verified based on comparisons of the associated hydrographs to the hyetographs for individual storm events. Gross anomalies (e.g., data spikes), gaps, or inconsistencies that are identified through this review will be investigated to determine if there are quality assurance issues associated with the data that limit their usability.
- If minor quality assurance issues are identified in any portion of the discharge record or in the water level data from a particular station and storm event, the data from that station and event will be considered as an estimate and assigned a (*j*) qualifier. If major quality assurance issues are identified in any portion of the data from a particular station and/or storm event, the data from that station and event will be rejected and assigned an (*r*) qualifier. Estimated values will be used for evaluation purposes while rejected values will not.

Verification and Validation Methods for Water Quality Data

Data will be reviewed and audited within 14 business days of receiving the results from the field or laboratory. This review will be performed to ensure that all data are consistent, correct and complete, and that all required quality control information has been provided. Specific quality control elements for the data (see Table 1) will also be examined to determine if the MQOs for the project have been met. Results from these data validation reviews will be summarized in quality assurance worksheets that are prepared for each sample batch (see Appendix D). Values associated with minor quality control problems will be considered estimates and assigned *J* qualifiers. Values associated with major quality control problems will be rejected and qualified *R*. Estimated values may be used for evaluation purposes, while rejected values will not be used. The following sections describe in detail the data validation procedures for these quality control elements:

- Completeness
- Methodology
- Holding times
- Blanks
- Reporting limits
- Duplicates
- Matrix spikes and matrix spike duplicates
- Calibration and control standards
- Sample representativeness

Completeness

Completeness will be assessed by comparing valid sample data with this QAPP and the chain-of-custody records. Completeness will be calculated by dividing the number of valid values by the total number of values. If less than 95 percent of the samples submitted to the laboratory are judged to be valid, then more samples will be collected until at least 95 percent are judged to be valid. If less than 95 percent of the collected flow data is complete, additional monitoring will be implemented until 95 percent of the flow record has been collected.

Methodology

Methodologies for analytical procedures will follow U.S. EPA approved methods (APHA et al. 1992, U.S. EPA 1983, 1984; ASTM 2007) specified in Table 3. Field procedures will follow the methodologies described in this QAPP. Any deviations from these methodologies must be approved by Ecology and documented in an addendum to this QAPP. The database will include a field for identifying analytical method. Deviations that are deemed unacceptable will result in rejected values (*R*) and will be corrected for future analyses.

Holding Times

Holding times for each analytical parameter in this study are summarized in Table 3. Holding time compliance will be assessed by comparing sample collection dates and times to filtration (pre-filtration) and analytical dates and times (post-filtration or total). Sample collection times will be based on the date and time that the last aliquot was collected, but date and time of start of sampling will be recorded as well.

Pre-Filtration Holding Times

Samples requiring filtration should be filtered within 24 hours of collection of the last aliquot. Total suspended solids may exceed the 24-hour limit but will be considered an estimate (*J*). EPA requires that dissolved metals, orthophosphate, and nitrate-nitrite should be filtered within 15 minutes of the collection of the last aliquot. Meeting this holding time goal would be exceedingly difficult for this project given that the time of last aliquot collection is unknown when samples are collected on a flow-weighted basis. Consequently, a proxy holding time of 24 hours will be used for this study. Dissolved metals and orthophosphate samples exceeding the 24-hour limit will be considered rejected (*R*).

Post-Filtration or Total Holding Times

- For analytes with holding times over 7 days:

  Data from samples that exceed the specified maximum post-filtration holding times by less than 48 hours will be considered estimates (*J*). Data from samples that exceed the maximum post-filtration holding times by more than 48 hours will be rejected values (*R*).

- For analytes with holding equal to or less than 7 days:

  Data from samples that exceed the specified maximum post-filtration holding times by less than 24 hours will be considered estimates (*J*). Data from samples that exceed the maximum post-filtration holding times by more than 24 hours will be rejected values (*R*).

Method Blanks

Method blank values will be compared to the MQOs that have been identified for this project (see Table 1). If an analyte is detected in a method blank at or below the reporting limit, no action will be taken. If blank concentrations are greater than the reporting limit, the associated data will be labeled with a *U* (thus increasing the reporting limit for the affected samples), and associated project samples within 5 times the de facto reporting limit will be flagged with a *J* (Grepogrove 2007). In each of these cases, the de facto reporting limit for that analyte will be recorded along with the raw data, equipment will be decontaminated, and samples will be rerun if possible.

Rinsate Blanks

Rinsate blank values will be compared to the MQOs that have been identified for this project (see Table 1). If constituents are detected in the rinsate blanks at concentrations that exceed 2 times the reporting limit, then associated sample tubing will be cleaned or replaced and associated samples collected since the previous rinsate blank that are within 5 times the new reporting limit will be flagged with a *J*. At the monitoring stations where corrective actions (e.g., replacement or cleaning of sample tubing) were taken, a follow-up rinsate blank will be collected and analyzed for any parameters exceeding 2 times the reporting limit in the midpoint rinsate blank.

Reporting Limits

Both raw values and reporting limits will be presented in each laboratory report. If the proposed reporting limits are not met by the laboratory will be requested to reanalyze the samples or revise the method, if time permits. Proposed reporting limits for this project are summarized in Table 3.

Duplicates

Duplicate results exceeding the MQOs for this project (see Table 1) will be recorded in the raw data tables and noted in the quality assurance worksheets; and associated values will be flagged as estimates (*J*). If the objectives are severely exceeded (e.g., more than twice the objective), then associated values will be rejected (*R*).

Matrix Spikes

Matrix spike results exceeding the MQOs for this project (see Table 1) will be noted in the quality assurance worksheets, and associated values will be flagged as estimates (*J*). However, if the percent recovery exceeds the MQOs and a value is less than the reporting limit, the result will not be flagged as an estimate. Non-detected values will be rejected (*R*) if the percent recovery is less than 30 percent.

Control Standards

Control standard results exceeding the MQOs for this project (see Table 1) will be noted in the quality assurance worksheets, and associated values will be flagged as estimates (*J*). If the objectives are severely exceeded (e.g., more than twice the objective), then associated values will be rejected (*R*).

Sample Representativeness

Each flow-weighted composite sample is interpreted to represent the mean concentration for the sampled storm event. However, flow gauge or laboratory error can lead to compromised data. The data collected for this study will be labeled with unique quality assurance flags for both laboratory and field data quality issues. Table 5 presents the flagging scheme that will be used in the final report produced for this project.

Table 5. Data Qualifier Definitions and Usage Criteria.		
Data Qualifier	**Definition**	**Criteria for Use**
J	Value is an estimate based on analytical results.	MQOs for field duplicates, laboratory duplicates, matrix spikes, laboratory control samples, holding times, or blanks have not been met.
R	Value is rejected based on analytical results.	Major quality control problems with the analytical results.
j	Value is an estimate based on storm sampling criteria.	Hydrograph is compromised from gauge error but is still deemed an adequate estimate.
r	Value is rejected based on storm sampling criteria.	Hydrograph is compromised from gauge error and has rendered the EMC non-representative.
Jj	Value is an estimate based on analytical results and storm sampling criteria.	Analytical and storm sampling criteria have not been met, but data is still usable.
Jr	Value is an estimate based on analytical results and rejected based on storm sampling criteria.	Analytical criteria have not been met but data is still usable; hydrograph is compromised from gauge error and has rendered the EMC non-representative.
U	Value is below the reporting limit.	Based on laboratory method reporting limit.
UJ	Value is below the reporting limit and is an estimate based on analytical results.	Based on laboratory method reporting limit; MQOs for analytical results have not been met.
Ur	Value is below the reporting limit and is rejected based on storm sampling criteria.	Based on laboratory method reporting limit; hydrograph is compromised from gauge error and has rendered the EMC non-representative.
Uj	Value is below the reporting limit and is an estimate based on storm sampling criteria.	Based on laboratory method reporting limit; analytical and storm sampling criteria have not been met, but data is still usable.

This page intentionally left blank

DATA QUALITY ASSESSMENT

Separate subsections herein describe the procedures that will be used to assess the usability of the data, analyze the data, and report the associated results.

Data Usability Assessment

The Herrera quality assurance officer will provide an independent review of the water quality QC data from each sampling event using the MQOs that have been identified in this QAPP. The results will be presented in a data quality assessment report that will be prepared prior to analyzing the data. The report will summarize quality control results, identify when data quality objectives were not met, and discuss the resulting limitations (if any) on the use or interpretation of the data. Specific quality assurance information that will be noted in the data quality assessment report includes the following:

- Changes in and deviations from the QAPP
- Results of performance or system audits
- Significant quality assurance problems and recommended solutions
- Data quality assessment results in terms of precision, bias, representativeness, completeness, comparability, and reporting limits
- Discussion of whether the quality assurance objectives were met, and the resulting impact on decision making
- Limitations on use of the measurement data

To assess the quality of the flow data, Herrera will compile flow QA worksheets (see Audits and Reports section) for inclusion in the final report. The QA worksheets will be summarized and presented in a tabular format. A brief narrative accompanying the table will summarize quality control results, identify when data quality objectives were not met, and discuss the resulting limitations, if any, on the use or interpretation of the data.

Data Analysis Procedures

Data analyses will be performed to evaluate the water quality treatment performance of the test system following procedures identified by Ecology (2018) in *Guidance for Evaluating Emerging Stormwater Treatment Technologies: Technology Assessment Protocol – Ecology (TAPE)*, and the U.S. EPA (2009) in *Urban Stormwater BMP Performance Monitoring*. The specific procedures that will be used in these analyses are:

- Analysis of bypass frequency
- Statistical analyses to compare influent and effluent concentrations
- Calculation of pollutant removal efficiency
- Pollutant removal as a function of flow rate
- Comparisons of percent removal to treatment goals

Each of these procedures is described in more detail in the following subsections.

Analysis of Bypass Frequency

The frequency of bypass will be assessed through the duration of the project to quantify if the system was sized correctly and to assess progressive clogging of the media. Specifically, the treated flow rate during bypass conditions will be plotted against time. If the system does not clog over the course of the study, then this value should remain the same over the 18 months.

Statistical Comparisons of Influent and Effluent Pollutant Concentrations

Statistical analyses will be performed to assess significance of differences in pollutant concentrations between the influent and effluent stations across individual storm events. The specific null hypothesis (H_o) and alternative hypothesis (H_a) for these analyses are as follows:

H_o: Effluent pollutant concentrations are equal to or higher than influent concentrations.

H_a: Effluent concentrations are lower than influent concentrations.

To evaluate these hypotheses, a Wilcoxon signed rank test (Helsel and Hirsch 2002) will be used to compare performance data from AS-IN and AS-OUT. The Wilcoxon test is a non-parametric analogue to the paired t-test. Statistical significance will be assessed based on an alpha (α) level of 0.05. Values less than or equal to the reporting limit will be set to negative 1 prior to the analysis so that they are ranked below reported values and are set to be equivalent in rank with one another.

Calculation of the Pollutant Removal Efficiency

Pursuant to guidance from Ecology (2018), the reduction (in percent) in pollutant concentration during each individual storm (ΔC) will be calculated as:

$$\Delta C = 100 \times \frac{(C_{in} - C_{eff})}{C_{in}}$$

Where:

C_{in} = Flow-weighted influent pollutant concentration
C_{eff} = Flow-weighted effluent pollutant concentration

To isolate the performance of the bioretention swale, this calculation will be performed for AS-IN and AS-OUT.

Pollutant Removal as a Function of Flow Rate

Following the TAPE, a regression analysis will be performed to evaluate pollutant removal performance as a function of flow rate. The goal of this analysis is to determine if the applicable performance goal for a given parameter is being met at the design hydraulic loading rate for the treatment system. To perform this analysis, treated effluent flow rates measured across each flow-weighted composite influent sample will be tabulated and the 90th percentile value computed from the entire range. Linear regression models will then be developed using the 90th percentile value for each sample as the independent variable and pollutant removal performance data as the dependent variable. These models will be used to determine whether treatment performance varies as a function of flow. The suitability of the regression equation should be evaluated using the diagnostics described in Helsel and Hirsch (2002).

Comparison of Percent Removal to Treatment Goals

In this project, a statistically small (20) number of storms will be sampled. Rather than simply describing the population of event-based percent removal estimates by their mean and normal theory confidence interval, the mean and its confidence intervals will be estimated by bootstrapping as required by the TAPE.

For parameters with percent removal goals (e.g., total phosphorus), the bootstrapped 95 percent lower confidence interval for the mean percent removal will be compared to the treatment goal. If the lower confidence limit is higher than the treatment goal, it can be concluded that the system met the treatment goal with the required 95 percent confidence.

For parameters with effluent concentration goals (e.g., influent TSS less than 100 mg/L), the bootstrapped 95 percent upper confidence interval for the mean effluent concentration will be compared to the treatment goal. If the upper confidence limit is lower than the effluent concentration goal, it can be concluded that the system met the treatment goal with the required 95 percent confidence.

Values at or below the reporting limit will be set equal to one-half the reporting limit prior to bootstrap analyses.

Pollutant Load Reduction

The pollutant removal efficiency of the Project for each analyte measured, except hardness and bacteria, will be calculated by the following methods. For each storm event successfully sampled:

Step 1. Calculate the pollutant load at AS-IN and AS-OUT.

To assess the overall pollutant load reduction of the facility the

$$L_{in} = EMC_{in} \times V_{in} \times C$$
$$L_{out} = EMC_{out} \times V_{out}$$

Where:

L_{in}	=	inlet load
L_{out}	=	outlet load
EMC_{in}	=	event mean concentration for each parameter sampled at the inlet
EMC_{out}	=	event mean concentration for each parameter sampled at the outlet
V_{in}	=	inlet stormwater volume for each storm sampled
V_{out}	=	outlet volume for each storm sampled
C	=	0.28, the scaling factor of the monitored Cascade to all Cascades

Step 2. Calculate pollutant load reduction for monitored Cascade

$$R_{cas} = L_{out} - L_{in}$$

Where:

R_{cas} = pollutant load reduction for monitored Cascade

Step 3. Scale results to the entire project.

$$R_{tot} = R_{cas}/C$$

Where:

R_{tot} = pollutant load reduction for entire project

Analysis of Plant Heath and Vigor

Data collected during vegetation monitoring will be summarized based on vegetation species, number of species, and their health/vigor. The health/vigor of the vegetation will be evaluated based on the following criteria:

- Poor health: Signs of irreversible decline due to drought stress and/or damage
- Fair health: Shows signs of drought stress, and/or damage, and/or some branch dieback
- Average health: Shows minimal signs of drought stress and/or branch dieback
- Excellent health: Shows positive signs of growth and minimal to no signs of drought stress

The vegetation health/vigor can then be compiled into a summary of findings and key takeaways. The results can be compared between each of the vegetation monitoring events and recommendations can be made for maintenance and future planting.

Reporting Procedures

Herrera will prepare a final report to document the performance characteristics of the test system relative to the goals identified for basic treatment, phosphorous treatment, and enhanced treatment. The final report will specifically include the following information:

- Performance data from the effectiveness monitoring site
- A through description of the technology, including sizing methodology, flow diagrams, and appropriate illustrations
- All relevant performance test results, statistical analyses, factors other than performance, and operation and maintenance (O&M) activities
- Conclusions and recommendations including the technology's development level, recommended O&M procedures and frequency, pretreatment requirements, and use limitations
- Additional testing recommendations, if needed

This page intentionally left blank

REFERENCES

APHA, AWWA, and WEF. 1992. Standard Methods for the Examination of Water and Wastewater. 18th edition. Edited by A.E. Greenberg, American Public Health Association; A.D. Eaton, American Water Works Association; and L.S. Clesceri, Water Environment Federation.

APHA, AWWA, and WEF. 1998. Standard Methods for the Examination of Water and Wastewater. 20th edition. Edited by A. Greenberg, A.D. Eaton and L. Clesceri. American Public Health Association, American Water Works Association, Water Environment Federation, Washington, DC.

ASTM. 2007. Book of Standards. Volume 7.02 – Water and Environmental Technology: Water (II). American Society for Testing and Materials, International, West Conshohocken, Pennsylvania.

Ecology. 2004. Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies. Publication No. 04-03-030. Washington State Department of Ecology, Olympia, Washington. Revised December 2016.

Ecology. 2005. Manchester Environmental Laboratory Lab User's Manual, Eighth Edition. Washington State Department of Ecology, Olympia, Washington.

Ecology. 2012. Western Washington Hydrology Model. <https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Stormwater-manuals/Western-Washington-Hydrology-Model>.

Ecology. 2018a. Automatic Sampling for Stormwater Monitoring: Standard Operating Procedure Version 1.1. Water Quality Program, Washington State Department of Ecology, Olympia, Washington.

Ecology. 2018b. Minimize the Spread of Invasive Species Standard Operating Procedures EAP070 Version 2.2. Environmental Assessment Program, Olympia, Washington.

Ecology. 2018c. Technical Guidance Manual for Evaluating Emerging Stormwater Treatment Technologies: Technology Assessment Protocol – Ecology (TAPE). Water Quality Program, Washington State Department of Ecology, Olympia, Washington.

Ecology. 2021. Guidance on Using New High Performance Bioretention Soil Mixes. Publication 21-10-023. Washington State Department of Ecology, Olympia, Washington.

Grepogrove, G. 2007. Manchester Laboratory, personal communication. September 4.

Helsel, D.R., and R.M. Hirsch. 2002. Statistical Methods in Water Resources. Elsevier, Amsterdam.

Herrera. 2021. Capitol Hill Water Quality Project: Water Year 2020 Monitoring. Prepared for Seattle Public Utilities. Herrera Environmental Consultants, Inc., Seattle, Washington.

Hua, X.Y., D.M. Dong, L. Liu, M. Gao, and D.P. Liang. 2012. Comparison of Trace Metal Adsorption onto Different Solid Materials and Their Chemical Components in a Natural Aquatic Environment. Applied Geochemistry 27(5):1005–1012.

U.S. EPA. 1983. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020. U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio.

U.S. EPA. 1984. Guidelines Establishing Test Procedures for the Analysis of Pollutants under the Clean Water Act; Final Rule and Interim Final Rule. CFR Part 136. U.S. Environmental Protection Agency. October 26.

U.S. EPA. 1996. Sampling ambient water for trace metals at EPA water quality criteria levels. (Method 1669). U.S. Environmental Protection Agency, Office of Water, Office of Science and Technology, Washington, DC.

U.S. EPA. 2007. 40 CFR Part 122, 136, 141, 143, 430, 455, and 456; Guidelines Establishing Test Procedures for the Analysis of Pollutants under the Clean Water Act; National Primary Drinking Water Regulations; and National Secondary Drinking Water Regulations; Analysis and Sampling Procedures; Final Rule. Federal Register. U.S. Environmental Protection Agency, Washington, DC.

U.S. EPA. 2009. Urban Stormwater BMP Performance Monitoring. EP-C-05-046. U.S. Environmental Protection Agency, Washington, DC.

Walkowiak, D.K. (editor). 2006. Isco Open Channel Flow Measurement Handbook. Teledyne Isco, Inc., Lincoln, Nebraska.

WSDOT. 2006. Work Zone Traffic Control Guidelines. Publication M 54-44. Washington State Department of Transportation, Olympia, Washington.

APPENDIX A

Geneva
Bioretention Pilot Project
Plan Set

Science + Planning + Design

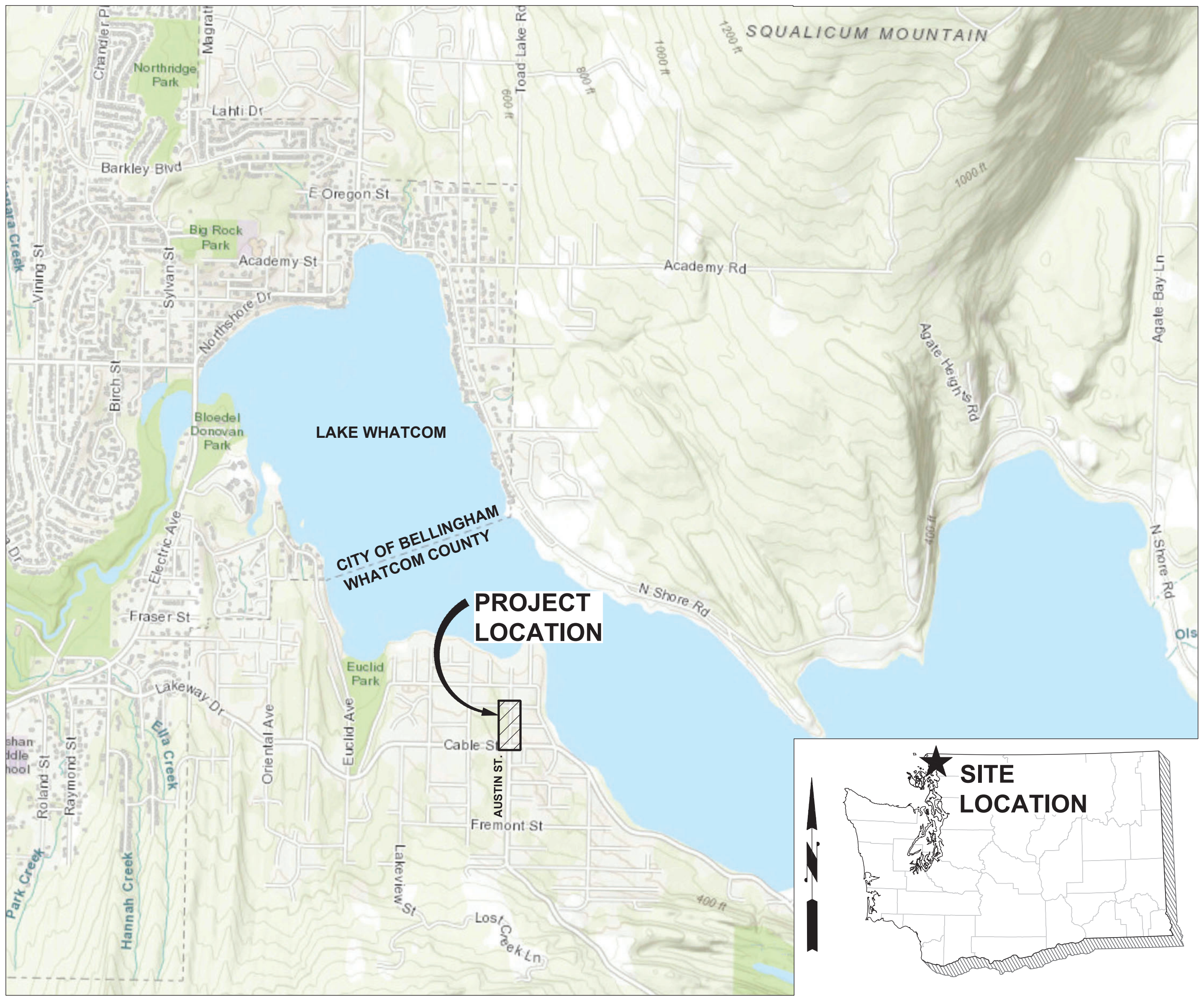
This page intentionally left blank

GENEVA BIORETENTION PILOT PROJECT

FUNDED IN PART BY THE WASHINGTON STATE DEPARTMENT OF ECOLOGY
ECOLOGY GRANT NUMBER WQC-2022-WhCoPW-00118

WHATCOM COUNTY PUBLIC WORKS - STORMWATER
WHATCOM COUNTY, WASHINGTON
SECTION 27, T 38N, R 3E, W.M.

BID NO. 23-17



VICINITY MAP
SCALE: 1"=1/4 MILE

OWNER:

WHATCOM COUNTY PUBLIC WORKS
322 N. COMMERCIAL STREET, SUITE 301
BELLINGHAM, WA 98225
PHONE: (360) 778-6265
EMAIL: cswan@co.whatcom.wa.us
CONTACT: CODY SWAN

ENGINEER:

HERRERA ENVIRONMENTAL CONSULTANTS
1329 N. STATE STREET, SUITE 200
BELLINGHAM, WA 98225
PHONE: (360) 684-1740
EMAIL: cwebb@herrerainc.com
CONTACT: CHRIS WEBB, PE

SURVEYOR:

WHATCOM COUNTY PUBLIC WORKS
322 N. COMMERCIAL STREET, SUITE 301
BELLINGHAM, WA 98225
PHONE: (360) 296-6302
EMAIL: jjallen@co.whatcom.wa.us
CONTACT: JESSE ALLEN, PLS

SHEET INDEX

CHRISTOPHER J. WEBB, STATE OF WASHINGTON, 35712, REGISTERED PROFESSIONAL ENGINEER
23-0323

SATPAL SINGH SIDHU
WHATCOM COUNTY EXECUTIVE

KRAIG OLASON
STORMWATER PROGRAM MANAGER

O:\proj\Y2021\21-07565-001\CAD\Sheet\Cover.dwg | 3/23/2023 12:56 PM | Neil Schaner

No.	SHEET REVISION	DATE	BY
1			
2			
3			
4			

PLAN SET ISSUE	DATE

DESIGN	DRAWN	CHECK
NAS	CPM	CJW

DRAWING SCALE: AS NOTED
HORZ. DATUM: NAD83
VERT. DATUM: NAVD88

CONTRACT DATE: N/A
PROJECT No: N/A
ROAD/BRIDGE No: N/A
DRAWING FILE: N/A

PUBLIC WORKS DIRECTOR: ELIZABETH KOSA
PROGRAM MANAGER: KRAIG OLASON
PROJECT ENGINEER: CODY SWAN

HERRERA Science + Planning + Design
herrerainc.com

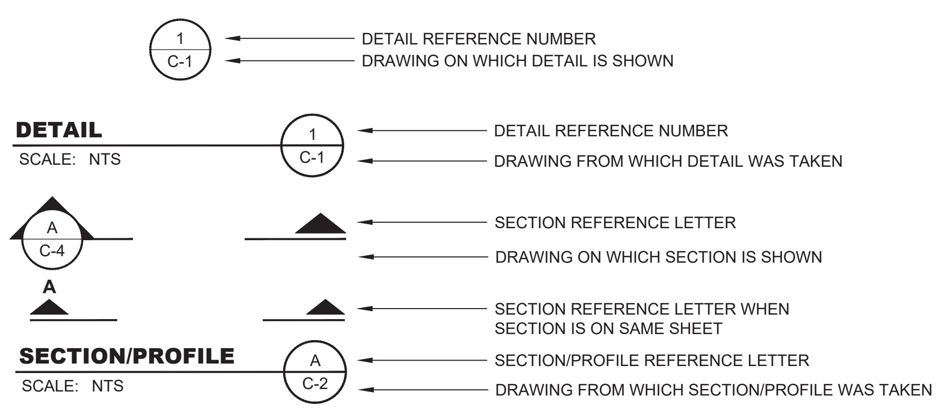
WHATCOM COUNTY WASHINGTON
WHATCOM COUNTY
DEPARTMENT OF PUBLIC WORKS
322 N. COMMERCIAL ST., SUITE 301 BELLINGHAM, WA 98225
(360) 778-6210

PROJECT: GENEVA BIORETENTION PILOT PROJECT, BID NO. 23-17

TITLE: COVER

WHATCOM COUNTY GENERAL NOTES

1. ALL WORK AND MATERIALS SHALL BE IN ACCORDANCE WITH CURRENT WSDOT/APWA STANDARD SPECIFICATIONS, WHATCOM COUNTY DEVELOPMENT STANDARDS (WCDS), AND SHALL BE SUBJECT TO APPROVAL BY WHATCOM COUNTY PUBLIC WORKS DEPARTMENT.
2. ALL LAND DISTURBING ACTIVITY SHALL OCCUR AND BE COMPLETED WITHIN THE LAKE WHATCOM WATERSHED EARTHWORK WINDOW (JUNE 1 TO SEPTEMBER 30).
3. SIGHT DISTANCE REQUIRED AT ALL INTERSECTIONS PER WCDS CHAPTER 5 AND MUTCD.
4. THE CONTRACTOR SHALL CONTACT UTILITY LOCATION SERVICE 48 HOURS PRIOR TO STARTING WORK AT (800) 424-5555 OR 811.
5. A COPY OF THE COUNTY-APPROVED DRAWINGS AND PERMITS MUST BE ON THE JOB SITE WHENEVER WORK IS IN PROCESS.
6. ALL TESTING, INCLUDING MATERIALS TESTING, SHALL BE IN COMPLIANCE WITH THE PROJECT SPECIFICATIONS AND WSDOT SPECIFICATIONS AND GUIDELINES.
7. THE CONTRACTOR SHALL RESTORE ALL PRIVATE AND PUBLIC PROPERTY DISTURBED BY THE WORK IMMEDIATELY AFTER CONSTRUCTION. THE CONTRACTOR SHALL NOT LEAVE ANY PART OF A ROADWAY USED BY OTHERS UN-PASSABLE WITHOUT NOTIFICATIONS AND AGREEMENT OF PROJECT ENGINEER AND OTHER USERS. CONTRACTOR SHALL COORDINATE WITH PRIVATE PROPERTY OWNERS AS NEEDED AND INFORM COUNTY OF COORDINATION EFFORTS. ANY ADDITIONAL DISTURBED AREAS NOT SHOWN ON THE PLANS SHALL BE RESTORED AT CONTRACTOR EXPENSE.
8. THE CONTRACTOR SHALL BE RESPONSIBLE FOR SLOPE EROSION AND SOIL STABILIZATION UNTIL VEGETATION IS FIRMLY ESTABLISHED.
9. CONTRACTOR SHALL SWEEP AND REMOVE ALL DEBRIS TRACKED ONTO EXISTING ROADS AND SIDEWALKS DURING ALL PHASES OF CONSTRUCTION. ALL REMOVED TREES SHALL BE OFFERED TO THE PROPERTY OWNER. IF PROPERTY OWNER REFUSES THE TREE, THEN THE TREE SHALL BECOME THE PROPERTY OF THE CONTRACTOR.
10. THE CONTRACTOR SHALL INFORM AND OBTAIN APPROVAL FROM PROJECT ENGINEER PRIOR TO IMPLEMENTATION OF ANY PLAN CHANGES. THE CONTRACTOR SHALL KEEP RECORDS OF DEVIATIONS AND FORWARD TO THE ENGINEER OF RECORD AND WHATCOM COUNTY ENGINEERING DIVISION.
11. TRAFFIC CONTROL IS TO BE MAINTAINED IN ACCORDANCE WITH WSDOT/APWA STANDARD SPECIFICATIONS, MUTCD, RCW, AND CONTRACT DOCUMENTS.



"-" INDICATES THAT THE DETAIL/SECTION IS SHOWN ON THE SAME SHEET

"TYP" INDICATES THAT THE DETAIL/SECTION IS UNIFORMLY TYPICAL THROUGHOUT PROJECT EXCEPT WHERE OTHERWISE NOTED

"VAR" SPECIFIES THAT DETAIL/SECTION WAS TAKEN FROM VARIOUS DRAWINGS

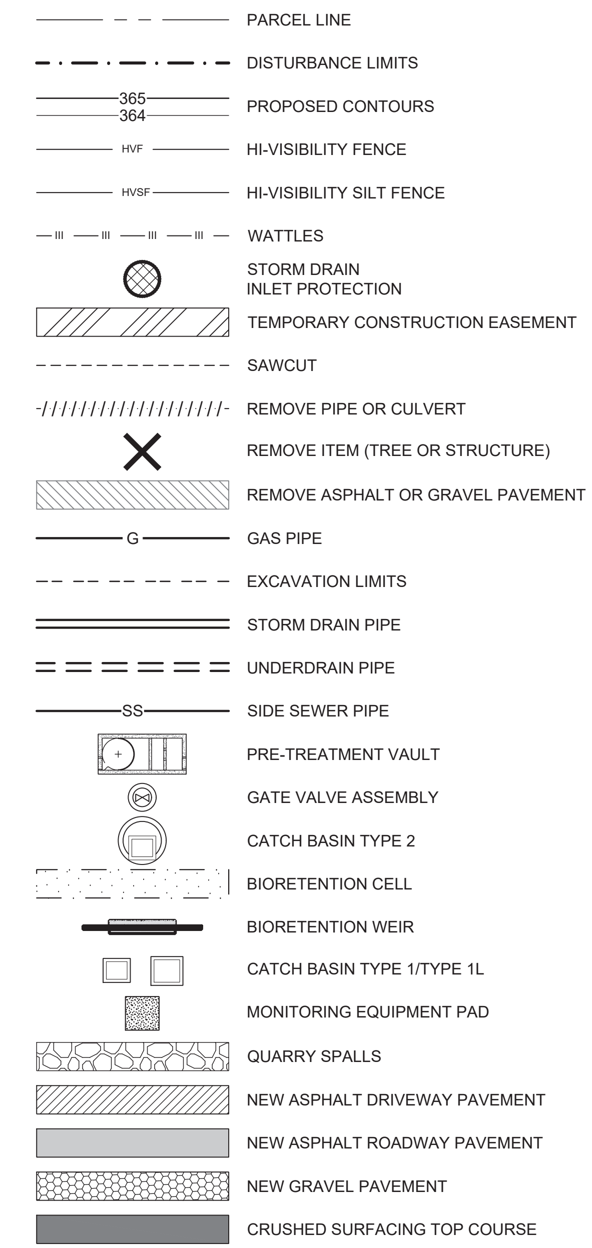
NOTE AND DETAIL/SECTION REFERENCING

ABBREVIATIONS

APPROX	APPPROXIMATE
AVG	AVERAGE
BLDG	BUILDING
BMP	BEST MANAGEMENT PRACTICE
CB	CATCH BASIN
CG	CLEAR AND GRUB
C/L, CL	CENTERLINE
COMM	COMMUNICATION
CONC	CONCRETE
CONST	CONSTRUCT, CONSTRUCTION
CO	CLEANOUT
CP	CONTROL POINT
CPSSP	CORRUGATED POLYETHYLENE STORM SEWER PIPE
DI	DUCTILE IRON
DIA	DIAMETER
DS	DOWNSTREAM
DWG	DRAWING
E	EAST, EASTING
EA	EACH
EL/ELEV	ELEVATION
EX	EXISTING
FT	FEET/FOOT
GV	GATE VALVE
HOR	HORIZONTAL
HT	HEIGHT
IE	INVERT ELEVATION
IN	INCH/INCHES
L	LENGTH
LF	LINEAL FOOT/FEET
LT	LEFT
MAX	MAXIMUM
MH	MANHOLE
MIN	MINIMUM
N	NORTH/NORTHING
NA	NOT APPLICABLE
NO	NUMBER
NTS	NOT TO SCALE
OC	ON CENTER
OHW	ORDINARY HIGH WATER
P	POWER
PVC	POLYVINYL CHLORIDE
QTY	QUANTITY
REF	REFERENCE
ROW	RIGHT-OF-WAY
RT	RIGHT
S	SOUTH, SLOPE
SD	STORM DRAIN
SPEC	SPECIFICATION
SS	SANITARY SEWER
ST	STREET
STA	STATION
STD	STANDARD
TESC	TEMPORARY EROSION AND SEDIMENT CONTROL
TYP	TYPICAL
US	UPSTREAM
W	WEST, WATER
WSDOT	WASHINGTON STATE DEPARTMENT OF TRANSPORTATION
WSE	WATER SURFACE ELEVATION

PROPOSED LEGEND

SEE SHEET 3 FOR EXISTING CONDITIONS LEGEND
SEE SHEET 17 FOR PLANTING LEGEND



CHRISTOPHER J. WEBB, STATE OF WASHINGTON, 35712, REGISTERED PROFESSIONAL ENGINEER
23-0323

No.	SHEET REVISION	DATE	BY	PLAN SET ISSUE	DATE
1					
2					
3					
4					

DESIGN	DRAWN	CHECK
NAS	CPM	CJW

DRAWING SCALE: AS NOTED
HORZ. DATUM: NAD83
VERT. DATUM: NAVD88

CONTRACT DATE: N/A
PROJECT No: N/A
ROAD/BRIDGE No: N/A
DRAWING FILE: N/A

PUBLIC WORKS DIRECTOR: ELIZABETH KOSA
PROGRAM MANAGER: KRAIG OLASON
PROJECT ENGINEER: CODY SWAN

HERRERA Science + Planning + Design herrerainc.com

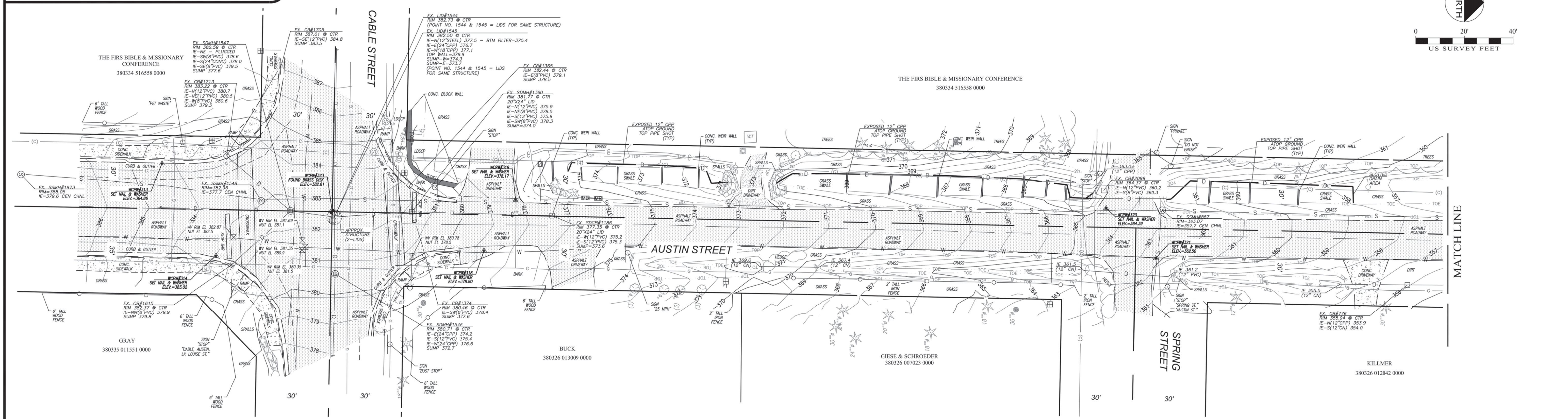
WHATCOM COUNTY
DEPARTMENT OF PUBLIC WORKS
322 N. COMMERCIAL ST., SUITE 301 BELLINGHAM, WA 98225
(360) 778-6210

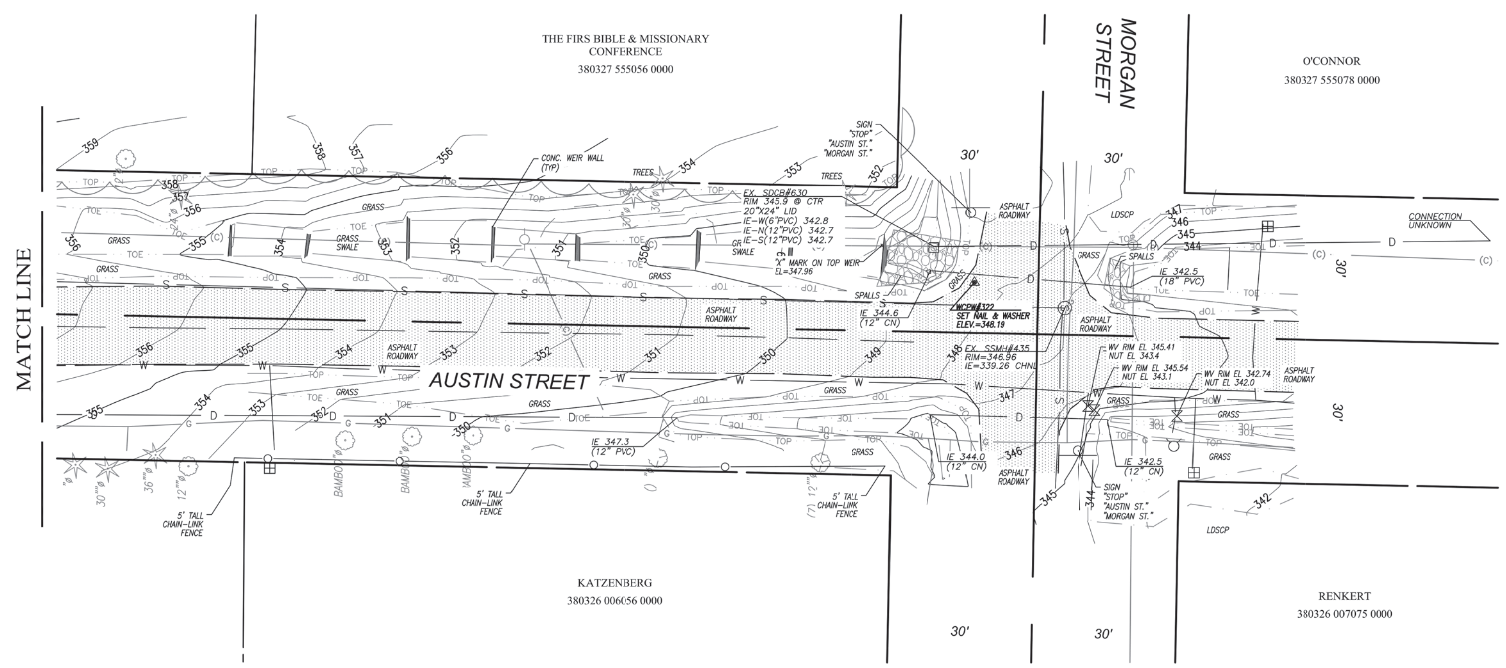
PROJECT: GENEVA BIORETENTION PILOT PROJECT, BID NO. 23-17
TITLE: GENERAL NOTES, LEGEND, AND ABBREVIATIONS

SHEET: 2
OF: 19

EXISTING CONDITIONS SURVEY

SITUATE IN A PORTION OF SECTION 26, 27, 34 & 35, TOWNSHIP 38 NORTH, RANGE 3 EAST, W.M., WHATCOM COUNTY, WASHINGTON.





SURVEY NOTES

1. DATA FOR THIS SURVEY WAS GATHERED BY FIELD TRAVERSE UTILIZING ELECTRONIC DATA COLLECTION IN APRIL & MAY 2022.

2. EQUIPMENT USED: TOPCON DS-201 TOTAL STATION

3. HORIZONTAL DATUM & BASIS OF BEARINGS: NAD 83/11 USFT

PER RIGHT OF WAY PLAN "LAKE WHATCOM BOULEVARD CABLE STREET TO STRAWBERRY POINT" BY LARRY STEELE AND ASSOCIATES IN MARCH OF 2016

4. VERTICAL DATUM: NAVD 88 USFT

HOLDING COB#4502 – ELEVATION 318.95' USFT, (NOT SHOWN) SW QUADRANT LK WHATCOM BLVD & CORONADO AVE.

5. THE PURPOSE OF THIS EXISTING CONDITIONS SURVEY IS TO SHOW TOPOGRAPHIC ELEMENTS FOR USE IN A CIVIL ENGINEERING DESIGN.

6. CONTOUR INTERVALS ARE ONE-FOOT AND ARE COMPUTER GENERATED FROM GROUND TOPOGRAPHY GATHERED FOR THIS SURVEY UTILIZING ELECTRONIC DATA COLLECTION.

7. ELEVATION AND CONTOUR ACCURACY: ONE-HALF THE CONTOUR INTERVAL.

8. LIMITATION OF USE: THIS IS NOT A BOUNDARY SURVEY AND SHOULD ONLY BE USED FOR TOPOGRAPHICAL INFORMATION. APPROXIMATE PARCEL LINES SHOWN PER MAPS OF RECORD AND LOCAL SITE CONTROL.

9. UTILITIES SHOWN WERE LOCATED PER FIELD MEASUREMENTS OF ABOVE GROUND APPURTENANCES AND GROUND PAINT MARKINGS AND SUPPLEMENTED BY AS-BUILT DRAWINGS OF RECORD AS AVAILABLE. NO UTILITIES WERE EXCLUDED.

10. ONLY SIGNIFICANT TREES WERE LOCATED ONSITE AND NOT ALL TREES ARE DEPICTED HEREON.

SURVEY CONTROL

POINT #	NORTHING	EASTING	ELEVATION	DESCRIPTION
313	640748.71	1262682.22	384.26	SET NAIL & WASHER (WCPW)
314	640770.73	1262720.02	383.02	SET NAIL & WASHER (WCPW)
318	640880.72	1262717.92	378.80	SET NAIL & WASHER (WCPW)
319	640893.73	1262697.17	378.17	SET NAIL & WASHER (WCPW)
320	641136.03	1262700.54	364.39	SET NAIL & WASHER (WCPW)
321	641156.47	1262721.08	362.50	SET NAIL & WASHER (WCPW)
322	641465.17	1262704.56	348.19	SET NAIL & WASHER (WCPW)
323	640818.42	1262701.94	382.81	FOUND BRASS DISK

LINE LEGEND

- APPROX. GIS PARCEL LINE
- RIGHT OF WAY MARGIN
- RIGHT OF WAY CENTERLINE
- STORM DRAIN LINE (D)
- GROUND GRADE BREAK LINE
- TOE OF SLOPE LINE (TOE)
- TOP OF SLOPE LINE (TOP)
- FENCE LINE
- QUARRY SPALL ROCK EDGE LINE
- RETAINING WALL/BULKHEAD EDGE LINE
- RETAINING WALL TOE FACE EDGE LINE ([TOE])
- CURB LINE
- CURB GUTTER FLOWLINE
- EDGE OF ASPHALT PAVEMENT LINE
- EDGE OF CONCRETE PAVEMENT LINE
- EDGE OF UNIMPROVED ACCESS LINE
- CONCRETE SIDEWALK EDGE LINE
- SANITARY SEWER LINE (S)
- CENTERLINE STRIPE
- EDGE STRIPE WHITE
- EDGE STRIPE YELLOW
- STOP BAR MARKING LINE
- CROSS WALK MARKING LINE
- OVERHEAD LINE ((C))
- UNDERGROUND COMMUNICATIONS LINE (C)
- UNDERGROUND GAS LINE (G)
- UTILITY STRUCTURE EDGE LINE
- WATER MAIN LINE (W)
- GARDEN/FLOWER BED EDGE LINE
- WOODS/TREE TRUNKS EDGE LINE

SYMBOL LEGEND

- MONUMENT (SURFACE)
- NAIL & SHINER/WASHER
- MAILBOX
- SIGN POST (GENERAL)
- STUMP
- TREE DEAD SNAG
- CONIFEROUS TREE
- CONIFEROUS TREES GROUP
- DECIDUOUS TREE
- DECIDUOUS TREES GROUP
- UTILITY MANHOLE
- UTILITY PEDISTAL / HANDHOLE
- UTILITY/SERVICE POLE
- UTILITY POLE W/ DROP
- GUY POLE
- GUY ANCHOR
- CATCH BASIN
- STORM DRAIN MANHOLE
- SANITARY SEWER CLEANOUT
- SANITARY SEWER MANHOLE
- FIRE HYDRANT
- WATER VALVE
- WATER METER

JESSE JOEL ALLEN — STATE OF WASHINGTON — 50978 — REGISTERED PROFESSIONAL LAND SURVEYOR

JAMES P. KARCHER — STATE OF WASHINGTON — 34410 — REGISTERED PROFESSIONAL ENGINEER

No.	SHEET REVISION	DATE	BY	PLAN SET ISSUE	DATE

DESIGN	DRAWN	CHECK
N/A	J.ALLEN	T.MILLER

DRAWING SCALE: AS SHOWN
HORZ. DATUM: NAD 83/11 USFT
VERT. DATUM: NAVD 88 USFT

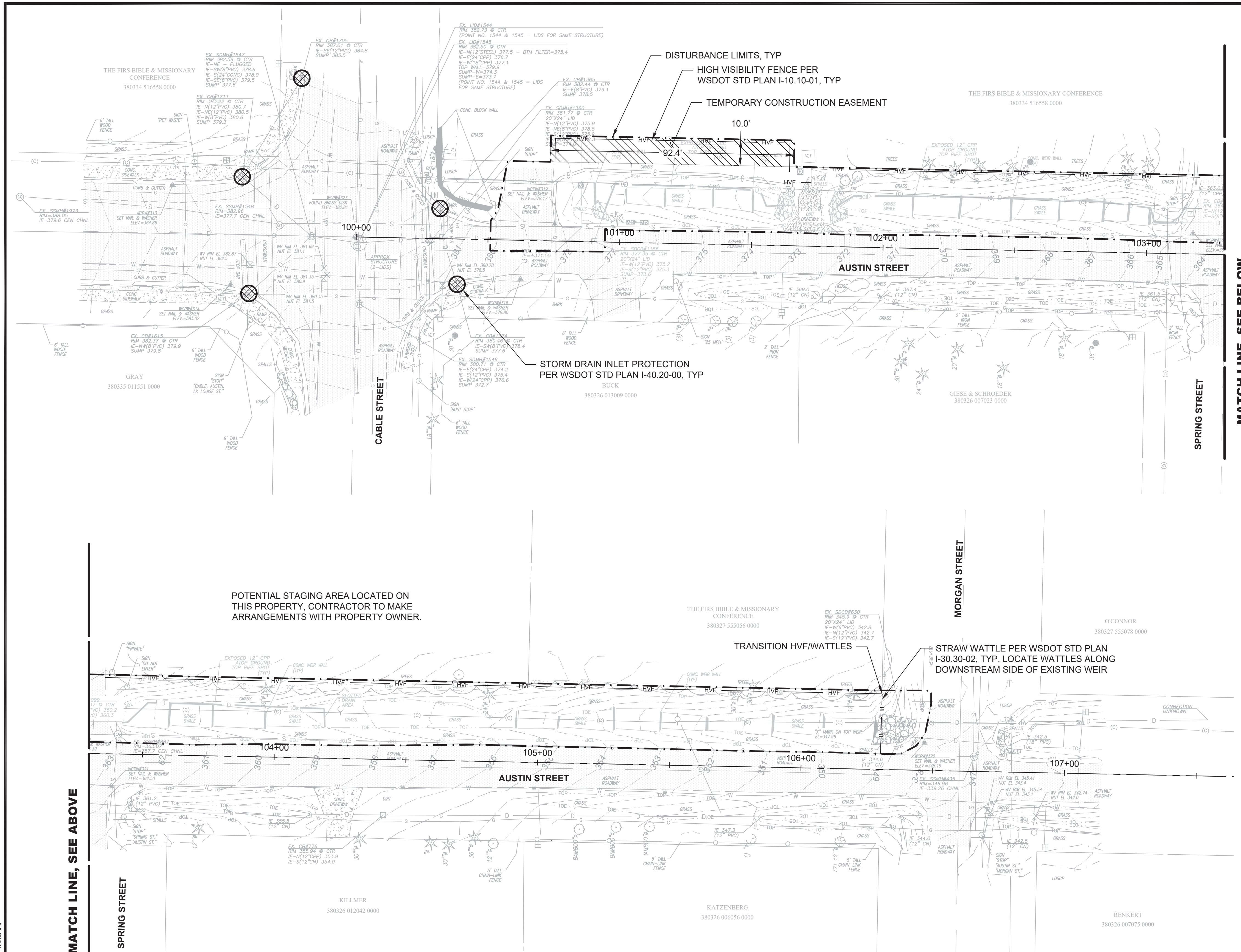
CONTRACT DATE: N/A
PROJECT No: PB0123
ROAD/BRIDGE No: N/A
DRAWING FILE: PB0123_X_EX.dwg

PUBLIC WORKS DIRECTOR: JON HUTCHINGS
COUNTY ENGINEER: JAMES P. KARCHER, P.E.
PROJECT ENGINEER: BEN KUIKEN, P.E.

WHATCOM COUNTY WASHINGTON

WHATCOM COUNTY
DEPARTMENT OF PUBLIC WORKS
322 N. COMMERCIAL ST., SUITE 301 BELLINGHAM, WA 98225
(360) 778-6210

PROJECT: GENEVA BIORETENTION PILOT PROJECT - PB 0123
SECTION 26, 27, 34 & 35, TOWNSHIP 38 NORTH, RANGE 3 EAST, W.M.
TITLE: EXISTING CONDITIONS SURVEY



NOTES:

1. CONTRACTOR SHALL INSTALL HIGH VISIBILITY FENCE IN A MANNER TO ALLOW CONTRACTOR ACCESS FOR PROJECT WORK.
2. CONTRACTOR SHALL INSTALL HIGH VISIBILITY FENCE IN A MANNER TO ALLOW UTILITY OWNERS ACCESS TO UTILITIES AS NEEDED.

CHRISTOPHER J. WEBB, STATE OF WASHINGTON, REGISTERED PROFESSIONAL ENGINEER, 35712, 23-0323

No.	SHEET REVISION	DATE	BY
1			
2			
3			
4			

PLAN SET ISSUE	DATE

DESIGN	DRAWN	CHECK
NAS	CPM	CJW

DRAWING SCALE: AS NOTED
HORZ. DATUM: NAD83
VERT. DATUM: NAVD88

CONTRACT DATE: N/A
PROJECT No: N/A
ROAD/BRIDGE No: N/A
DRAWING FILE: N/A

PUBLIC WORKS DIRECTOR: ELIZABETH KOSA
PROGRAM MANAGER: KRAIG OLASON
PROJECT ENGINEER: CODY SWAN

HERRERA
Science + Planning + Design
herrerainc.com

WHATCOM COUNTY
DEPARTMENT OF PUBLIC WORKS
322 N. COMMERCIAL ST., SUITE 301 BELLINGHAM, WA 98225
(360) 778-6210

PROJECT: GENEVA BIORETENTION PILOT PROJECT, BID NO. 23-17
TITLE: TEMPORARY EROSION AND SEDIMENT CONTROL (TESC) PLAN

SHEET: 4 OF: 19

STORMWATER POLLUTION PREVENTION PLAN (SWPPP) NOTES IN COMPLIANCE WITH THE WHATCOM COUNTY CODE 16.36.050

PROTECTION OF THE ENVIRONMENT	NO CONSTRUCTION RELATED ACTIVITY SHALL CONTRIBUTE TO THE DEGRADATION OF THE ENVIRONMENT, ALLOW MATERIAL TO ENTER SURFACE OR GROUND WATER, OR ALLOW PARTICULATE EMISSIONS TO THE ATMOSPHERE, WHICH EXCEED STATE OR FEDERAL STANDARDS. ANY ACTIONS THAT POTENTIALLY ALLOW DISCHARGE TO STATE WATERS MUST HAVE PRIOR APPROVAL OF THE WASHINGTON STATE DEPARTMENT OF ECOLOGY.

ELEMENT REQUIREMENTS	BEST MANAGEMENT PRACTICES - (BMPs)
ELEMENT #1 "PRESERVE VEGETATION AND MARK CLEARING LIMITS"	PRIOR TO BEGINNING LAND DISTURBING ACTIVITIES, INCLUDING CLEARING AND GRADING, ALL CLEARING LIMITS, SENSITIVE AREAS AND THEIR BUFFERS, AND TREES THAT ARE TO BE PRESERVED WITHIN THE CONSTRUCTION AREA SHOULD BE CLEARLY MARKED, BOTH IN THE FIELD AND ON THE PLANS, TO PREVENT DAMAGE AND OFF-SITE IMPACTS. PLASTIC, METAL, OR STAKE WIRE FENCE MAY BE USED TO MARK THE CLEARING LIMITS. RETAIN THE DUFF LAYER, NATIVE TOPSOIL, AND NATURAL VEGETATION IN AN UNDISTURBED STATE TO THE MAXIMUM DEGREE PRACTICABLE.
ELEMENT #2 "ESTABLISH CONSTRUCTION ACCESS"	(A) EQUIPMENT SHALL OPERATE FROM THE PAVED ROADWAY AS MUCH AS POSSIBLE TO MINIMIZE TRACKOUT. (B) PUBLIC ROADS SHALL AT A MINIMUM BE CLEANED THOROUGHLY AT THE END OF EACH DAY OF EARTHWORK ACTIVITY. SEDIMENT SHALL BE REMOVED FROM ROADS BY SHOVELING OR PICKUP SWEEPING AND SHALL BE TRANSPORTED TO A CONTROLLED SEDIMENT DISPOSAL AREA. STREET WASHING WILL BE ALLOWED ONLY AFTER SEDIMENT IS REMOVED IN THIS MANNER. (C) STREET WASH WASTEWATER SHALL BE MANAGED IN ACCORDANCE WITH LOCAL, STATE, AND FEDERAL STANDARDS, AND PREVENTED FROM DISCHARGING INTO SYSTEMS TRIBUTARY TO STATE SURFACE WATERS. CONSTRUCTION STAGING AREAS LOCATED OUTSIDE OF THE PAVED ROADWAY SHALL BE STABILIZED TO ENSURE SEDIMENT DOES NOT LEAVE THE SITE.
ELEMENT #3 "CONTROL FLOW RATES"	(A) PROPERTIES AND WATERWAYS DOWNSTREAM FROM DEVELOPMENT SITES SHALL BE PROTECTED FROM EROSION DUE TO INCREASES IN THE VOLUME, VELOCITY, AND PEAK FLOW RATE OF STORMWATER RUNOFF FROM THE PROJECT SITE. PROPERTIES SUBJECT TO MINIMUM REQUIREMENT NO. 5 AND/OR NO. 7 SHALL IMPLEMENT CONTROLS AS EARLY IN THE DEVELOPMENT AS IS PRACTICABLE TO MITIGATE FOR FLOW RATES. (B) DOWNSTREAM ANALYSIS IS NECESSARY IF CHANGES IN FLOWS COULD IMPAIR OR ALTER CONVEYANCE SYSTEMS, STREAM BANKS, BED SEDIMENT, OR AQUATIC HABITAT. SEE THE ECOLOGY MANUAL FOR OFF-SITE ANALYSIS GUIDANCE. (C) WHERE NECESSARY TO COMPLY WITH MINIMUM REQUIREMENT NO. 7, STORMWATER RETENTION/DETENTION FACILITIES SHALL BE CONSTRUCTED AS ONE OF THE FIRST STEPS IN GRADING. DETENTION FACILITIES SHALL BE FUNCTIONAL PRIOR TO CONSTRUCTION OF SITE IMPROVEMENTS (E.G., IMPERVIOUS SURFACES). (D) IF PERMANENT INFILTRATION PONDS ARE USED FOR FLOW CONTROL DURING CONSTRUCTION, THESE FACILITIES SHOULD BE PROTECTED FROM SILTATION DURING THE CONSTRUCTION PHASE.

ELEMENT REQUIREMENTS	BEST MANAGEMENT PRACTICES - (BMPs)
ELEMENT #4 "INSTALL SEDIMENT CONTROLS"	(A) THE DUFF LAYER, NATIVE TOPSOIL, AND NATURAL VEGETATION SHALL BE RETAINED IN AN UNDISTURBED STATE TO THE MAXIMUM EXTENT PRACTICABLE. (B) PRIOR TO LEAVING A CONSTRUCTION SITE, OR PRIOR TO DISCHARGE TO AN INFILTRATION FACILITY, STORMWATER RUNOFF FROM DISTURBED AREAS SHALL PASS THROUGH A SEDIMENT POND OR OTHER APPROPRIATE SEDIMENT REMOVAL BMP. RUNOFF FROM FULLY STABILIZED AREAS MAY BE DISCHARGED WITHOUT A SEDIMENT REMOVAL BMP, BUT MUST MEET THE FLOW CONTROL PERFORMANCE STANDARD OF SUBSECTION (F)(2)(E)(III)(A) OF THIS SECTION (ELEMENT 3). FULL STABILIZATION MEANS CONCRETE OR ASPHALT PAVING; QUARRY SPALLS USED AS DITCH LINING; OR THE USE OF ROLLED EROSION PRODUCTS, A BONDED FIBER MATRIX PRODUCT, OR VEGETATIVE COVER IN A MANNER THAT WILL FULLY PREVENT SOIL EROSION. SEDIMENT PONDS, VEGETATED BUFFER STRIPS, SEDIMENT BARRIERS OR FILTERS, DIKES, AND OTHER BMPS INTENDED TO TRAP SEDIMENT ON SITE SHALL BE CONSTRUCTED AS ONE OF THE FIRST STEPS IN GRADING. THESE BMPS SHALL BE FUNCTIONAL BEFORE OTHER LAND-DISTURBING ACTIVITIES TAKE PLACE. (C) EARTHEN STRUCTURES SUCH AS DAMS, DIKES, AND DIVERSIONS SHALL BE SEEDED AND MULCHED ACCORDING TO THE TIMING INDICATED IN ELEMENT 5 BELOW.
ELEMENT #5 "STABILIZE SOILS"	(A) ALL EXPOSED AND UNWORKED SOILS SHALL BE STABILIZED BY APPLICATION OF EFFECTIVE BMPS THAT PROTECT THE SOIL FROM THE EROSIVE FORCES OF RAINDROP IMPACT AND FLOWING WATER, AND WIND EROSION. (B) FROM OCTOBER 1ST THROUGH APRIL 30TH OF EACH YEAR, NO SOILS SHALL REMAIN EXPOSED AND UNWORKED FOR MORE THAN TWO DAYS. FROM MAY 1ST TO SEPTEMBER 30TH OF EACH YEAR, NO SOILS SHALL REMAIN EXPOSED AND UNWORKED FOR MORE THAN SEVEN DAYS. THIS CONDITION APPLIES TO ALL SOILS ON SITE, WHETHER AT FINAL GRADE OR NOT. (C) APPLICABLE PRACTICES INCLUDE, BUT ARE NOT LIMITED TO, TEMPORARY AND PERMANENT SEEDING, SODDING, MULCHING, PLASTIC COVERING, EARLY APPLICATION OF GRAVEL BASE ON AREAS TO BE PAVED, AND DUST CONTROL. (D) SOIL STABILIZATION MEASURES SELECTED SHOULD BE APPROPRIATE FOR THE TIME OF YEAR, SITE CONDITIONS, ESTIMATED DURATION OF USE, AND POTENTIAL WATER QUALITY IMPACTS THAT STABILIZATION AGENTS MAY HAVE ON DOWNSTREAM WATERS OR GROUND WATER. (E) SOIL STOCKPILES MUST BE STABILIZED AND PROTECTED WITH SEDIMENT TRAPPING MEASURES. (F) WORK ON LINEAR CONSTRUCTION SITES AND ACTIVITIES, INCLUDING RIGHT-OF-WAY AND EASEMENT CLEARING, ROADWAY DEVELOPMENT, PIPELINES, AND TRENCHING FOR UTILITIES, SHALL NOT EXCEED THE CAPABILITY OF THE INDIVIDUAL CONTRACTOR FOR HIS PORTION OF THE PROJECT TO INSTALL THE BEDDING MATERIALS, ROADBEDS, STRUCTURES, PIPELINES, AND/OR UTILITIES, AND TO RESTABILIZE THE DISTURBED SOILS, MEETING THE TIMING CONDITIONS LISTED ABOVE. (G) IN ADDITION, AT THE DISCRETION OF THE PROJECT ENGINEER, THOSE SITES UNABLE TO MAINTAIN THE QUALITY OF THEIR STORMWATER DISCHARGE MAY BE REQUIRED TO PROVIDE SOIL STABILIZATION TO ALL EXPOSED SOIL AREAS REGARDLESS OF THE WORKING STATUS OF THE AREA. UPON WRITTEN NOTIFICATION, THE CONTRACTOR SHALL PROVIDE FULL STABILIZATION OF ALL EXPOSED SOIL AREAS WITHIN 24 HOURS.
ELEMENT #6 "PROTECT SLOPES"	(A) CUT AND FILL SLOPES SHALL BE DESIGNED AND CONSTRUCTED IN A MANNER THAT WILL MINIMIZE EROSION. (B) CONSIDER SOIL TYPE AND ITS POTENTIAL FOR EROSION. (C) REDUCE SLOPE RUNOFF VELOCITIES BY REDUCING THE CONTINUOUS LENGTH OF SLOPE WITH TERRACING AND DIVERSIONS, REDUCE SLOPE STEEPNESS, AND ROUGHEN SLOPE SURFACE. (D) DIVERT UPSLOPE DRAINAGE AND RUN-ON WATERS FROM OFF SITE WITH INTERCEPTORS AT TOP OF SLOPE. OFF-SITE STORMWATER SHOULD BE HANDLED SEPARATELY FROM STORMWATER GENERATED ON THE SITE. DIVERSION OF OFF-SITE STORMWATER AROUND THE SITE MAY BE A VIABLE OPTION. DIVERTED FLOWS SHALL BE REDIRECTED TO THE NATURAL DRAINAGE LOCATION AT OR BEFORE THE PROPERTY BOUNDARY. (E) CONTAIN DOWN SLOPE COLLECTED FLOWS IN PIPES, SLOPE DRAINS, OR PROTECTED CHANNELS. (F) PROVIDE DRAINAGE TO REMOVE GROUND WATER INTERSECTING THE SLOPE SURFACE OF EXPOSED SOIL AREAS. (G) EXCAVATED MATERIAL SHALL BE PLACED ON THE UPHILL SIDE OF TRENCHES, CONSISTENT WITH SAFETY AND SPACE CONSIDERATIONS. (H) CHECK DAMS SHALL BE PLACED AT REGULAR INTERVALS WITHIN TRENCHES THAT ARE CUT DOWN A SLOPE. (I) STABILIZE SOILS ON SLOPES, AS SPECIFIED IN ELEMENT NO. 5.

ELEMENT REQUIREMENTS	BEST MANAGEMENT PRACTICES - (BMPs)
ELEMENT #7 "PROTECT DRAIN INLETS"	(A) ALL STORM DRAIN INLETS MADE OPERABLE DURING CONSTRUCTION SHALL BE PROTECTED SO THAT STORMWATER RUNOFF SHALL NOT ENTER THE CONVEYANCE SYSTEM WITHOUT FIRST BEING FILTERED OR TREATED TO REMOVE SEDIMENT. (B) ALL APPROACH ROADS SHALL BE KEPT CLEAN, AND ALL SEDIMENT AND STREET WASH WATER SHALL NOT BE ALLOWED TO ENTER STORM DRAINS.
ELEMENT #8 "STABILIZE CHANNELS AND OUTLETS"	(A) ALL TEMPORARY ON-SITE CONVEYANCE CHANNELS SHALL BE DESIGNED, CONSTRUCTED, AND STABILIZED TO PREVENT EROSION FROM THE EXPECTED VELOCITY OF FLOW FROM A TWO-YEAR, 24-HOUR FREQUENCY STORM FOR THE DEVELOPED CONDITION. (B) STABILIZATION, INCLUDING ARMORING MATERIAL, ADEQUATE TO PREVENT EROSION OF OUTLETS, ADJACENT STREAM BANKS, SLOPES AND DOWNSTREAM REACHES SHALL BE PROVIDED AT THE OUTLETS OF ALL CONVEYANCE SYSTEMS.
ELEMENT #9 "CONTROL POLLUTANTS"	(A) ALL POLLUTANTS, INCLUDING WASTE MATERIALS AND DEMOLITION DEBRIS, THAT OCCUR ON SITE DURING CONSTRUCTION SHALL BE HANDLED AND DISPOSED OF IN A MANNER THAT DOES NOT CAUSE CONTAMINATION OF STORMWATER. (B) COVER, CONTAINMENT, AND PROTECTION FROM VANDALISM SHALL BE PROVIDED FOR ALL CHEMICALS, LIQUID PRODUCTS, PETROLEUM PRODUCTS, AND NON-INERT WASTES PRESENT ON THE SITE (SEE CHAPTER 173-304 WAC, AS CURRENTLY ENACTED OR HEREAFTER MODIFIED, FOR THE DEFINITION OF INERT WASTE, WHICH IS INCORPORATED HEREIN BY THIS REFERENCE). (C) MAINTENANCE AND REPAIR OF HEAVY EQUIPMENT AND VEHICLES INVOLVING OIL CHANGES, HYDRAULIC SYSTEM DRAIN DOWN, SOLVENT AND DE-GREASING CLEANING OPERATIONS, FUEL TANK DRAIN DOWN AND REMOVAL, AND OTHER ACTIVITIES WHICH MAY RESULT IN DISCHARGE OR SPILLAGE OF POLLUTANTS TO THE GROUND OR INTO STORMWATER RUNOFF MUST BE CONDUCTED USING SPILL PREVENTION MEASURES, SUCH AS DRIP PANS. CONTAMINATED SURFACES SHALL BE CLEANED IMMEDIATELY FOLLOWING ANY DISCHARGE OR SPILL INCIDENT. EMERGENCY REPAIRS MAY BE PERFORMED ON SITE USING TEMPORARY PLASTIC PLACED BENEATH AND, IF RAINING, OVER THE VEHICLE. (D) WHEEL WASH, OR TIRE BATH WASTEWATER, SHALL BE DISCHARGED TO A SEPARATE ON-SITE TREATMENT SYSTEM OR TO THE SANITARY SEWER. (E) APPLICATION OF AGRICULTURAL CHEMICALS, INCLUDING FERTILIZERS AND PESTICIDES, SHALL BE CONDUCTED IN A MANNER AND AT APPLICATION RATES THAT WILL NOT RESULT IN LOSS OF CHEMICAL TO STORMWATER RUNOFF. MANUFACTURERS' RECOMMENDATIONS SHALL BE FOLLOWED FOR APPLICATION RATES AND PROCEDURES. (F) MANAGEMENT OF PH-MODIFYING SOURCES SHALL PREVENT CONTAMINATION OF RUNOFF AND STORMWATER COLLECTED ON THE SITE. THESE SOURCES INCLUDE, BUT ARE NOT LIMITED TO, BULK CEMENT, CEMENT KILN DUST, FLY ASH, NEW CONCRETE WASHING AND CURING WATERS, WASTE STREAMS GENERATED FROM CONCRETE GRINDING AND SAWING, EXPOSED AGGREGATE PROCESSES, AND CONCRETE PUMPING AND MIXER WASHOUT WATERS.
ELEMENT #10 "CONTROL DEWATERING"	(A) ALL FOUNDATION, VAULT, AND TRENCH DEWATERING WATER, WHICH HAS SIMILAR CHARACTERISTICS TO STORMWATER RUNOFF AT THE SITE, SHALL BE DISCHARGED INTO A CONTROLLED CONVEYANCE SYSTEM, PRIOR TO DISCHARGE TO A SEDIMENT TRAP OR SEDIMENT POND. CHANNELS MUST BE STABILIZED, AS SPECIFIED IN ELEMENT NO. 8. (B) CLEAN, NONTURBID DEWATERING WATER, SUCH AS WELL-POINT GROUND WATER, CAN BE DISCHARGED TO SYSTEMS TRIBUTARY TO STATE SURFACE WATERS, AS SPECIFIED IN ELEMENT NO. 8, PROVIDED THE DEWATERING FLOW DOES NOT CAUSE EROSION OR FLOODING OF THE RECEIVING WATERS. THESE CLEAN WATERS SHOULD NOT BE ROUTED THROUGH SEDIMENT PONDS WITH STORMWATER. (C) HIGHLY TURBID OR OTHERWISE CONTAMINATED DEWATERING WATER, SUCH AS FROM CONSTRUCTION EQUIPMENT OPERATION, CLAMSHELL DIGGING, CONCRETE TREMIE POUR, OR WORK INSIDE A COFFERDAM, SHALL BE HANDLED SEPARATELY FROM STORMWATER AT THE SITE. (D) OTHER DISPOSAL OPTIONS, DEPENDING ON SITE CONSTRAINTS, MAY INCLUDE, BY WAY OF EXAMPLE: (1) INFILTRATION, (2) TRANSPORT OFF SITE IN VEHICLE, SUCH AS A VACUUM FLUSH TRUCK, FOR LEGAL DISPOSAL IN A MANNER THAT DOES NOT POLLUTE STATE WATERS, (3) ON-SITE TREATMENT USING CHEMICAL TREATMENT OR OTHER SUITABLE TREATMENT TECHNOLOGIES.

ELEMENT REQUIREMENTS	BEST MANAGEMENT PRACTICES - (BMPs)
ELEMENT #11 "MAINTAIN BMPS"	(A) ALL TEMPORARY AND PERMANENT EROSION AND SEDIMENT CONTROL BMPS SHALL BE MAINTAINED AND REPAIRED AS NEEDED TO ASSURE CONTINUED PERFORMANCE OF THEIR INTENDED FUNCTION. ALL MAINTENANCE AND REPAIR SHALL BE CONDUCTED IN ACCORDANCE WITH BMPS. (B) SEDIMENT CONTROL BMPS SHALL BE INSPECTED WEEKLY OR AFTER A RUNOFF-PRODUCING STORM EVENT DURING THE DRY SEASON AND DAILY DURING THE WET SEASON. ALL PROJECTS THAT DISTURB AN AREA GREATER THAN ONE ACRE SHALL HAVE A CERTIFIED EROSION CONTROL LEAD AVAILABLE TO THE SITE. THIS EROSION CONTROL LEAD SHALL BE RESPONSIBLE TO PROVIDE OVERVIEW OF ONGOING DAY-TO-DAY EROSION CONTROL REQUIREMENTS. THE EROSION CONTROL LEAD SHALL (WITHIN 24 HOURS) REPORT TO THE COUNTY AND DEPARTMENT OF ECOLOGY ANY SITE DISCHARGES THAT EXCEED STATE WATER QUALITY STANDARDS THAT HAVE OR ARE LIKELY TO HAVE ENTERED WATERS OF THE STATE. (C) ALL TEMPORARY EROSION AND SEDIMENT CONTROL BMPS SHALL BE REMOVED WITHIN 30 DAYS AFTER FINAL SITE STABILIZATION IS ACHIEVED OR AFTER THE TEMPORARY BMPS ARE NO LONGER NEEDED. TRAPPED SEDIMENT SHALL BE REMOVED OR STABILIZED ON SITE. DISTURBED SOIL AREAS RESULTING FROM REMOVAL OF BMPS OR VEGETATION SHALL BE PERMANENTLY STABILIZED.
ELEMENT #12 "MANAGE THE PROJECT"	(A) PHASING OF CONSTRUCTION. DEVELOPMENT PROJECTS SHALL BE PHASED WHERE FEASIBLE IN ORDER TO PREVENT, TO THE MAXIMUM EXTENT PRACTICABLE, THE TRANSPORT OF SEDIMENT FROM THE DEVELOPMENT SITE DURING CONSTRUCTION. REVEGETATION OF EXPOSED AREAS AND MAINTENANCE OF THAT VEGETATION SHALL BE AN INTEGRAL PART OF THE CLEARING ACTIVITIES FOR ANY PHASE. (B) WHEN ESTABLISHING THESE PERMITTED CLEARING AND GRADING AREAS, CONSIDERATION SHOULD BE GIVEN TO MINIMIZING REMOVAL OF EXISTING TREES AND MINIMIZING DISTURBANCE/COMPACTION OF NATIVE SOILS EXCEPT AS NEEDED FOR BUILDING PURPOSES. PERMITTED CLEARING AND GRADING AREAS AND ANY OTHER AREAS REQUIRED TO PRESERVE CRITICAL OR SENSITIVE AREAS, BUFFERS, NATIVE GROWTH PROTECTION EASEMENTS, OR TREE RETENTION AREAS, SHALL BE DELINEATED ON THE SITE PLANS AND THE DEVELOPMENT SITE. (C) COORDINATION WITH UTILITIES AND OTHER CONTRACTORS. THE PRIMARY PROJECT PROPONENT SHALL EVALUATE, WITH INPUT FROM UTILITIES AND OTHER CONTRACTORS, THE STORMWATER MANAGEMENT REQUIREMENTS FOR THE ENTIRE PROJECT, INCLUDING THE UTILITIES, WHEN PREPARING THE CONSTRUCTION SWPPP. (D) INSPECTION AND MONITORING. ALL BMPS SHALL BE INSPECTED, MAINTAINED, AND REPAIRED AS NEEDED TO ASSURE CONTINUED PERFORMANCE OF THEIR INTENDED FUNCTION. (E) FOR ANY PROJECT DISTURBING MORE THAN ONE ACRE, A CERTIFIED PROFESSIONAL IN EROSION AND SEDIMENT CONTROL SHALL BE IDENTIFIED IN THE CONSTRUCTION SWPPP AND SHALL BE ON SITE OR ON CALL AT ALL TIMES. CERTIFICATION MAY BE THROUGH THE WASHINGTON STATE DEPARTMENT OF TRANSPORTATION/ASSOCIATED GENERAL CONTRACTORS (WSDOT/AGC) CONSTRUCTION SITE EROSION AND SEDIMENT CONTROL CERTIFICATION PROGRAM OR ANY EQUIVALENT LOCAL OR NATIONAL CERTIFICATION AND/OR TRAINING PROGRAM, IN THE COUNTY'S DISCRETION. (F) WHENEVER INSPECTION AND/OR MONITORING REVEALS THAT THE BMPS IDENTIFIED IN THE CONSTRUCTION SWPPP ARE INADEQUATE, DUE TO THE ACTUAL DISCHARGE OF OR POTENTIAL TO DISCHARGE A SIGNIFICANT AMOUNT OF ANY POLLUTANT, THE SWPPP SHALL BE MODIFIED, AS APPROPRIATE, IN A TIMELY MANNER. (G) MAINTENANCE OF THE CONSTRUCTION SWPPP. THE CONSTRUCTION SWPPP SHALL BE RETAINED ON SITE. THE CONSTRUCTION SWPPP SHALL BE MODIFIED WHENEVER THERE IS A SIGNIFICANT CHANGE IN THE DESIGN, CONSTRUCTION, OPERATION, OR MAINTENANCE OF ANY BMP.
ELEMENT #13 "PROTECT LOW IMPACT DEVELOPMENT BMPS"	INSTALL AND MAINTAIN ONSITE BMPS TO PROTECT EXISTING, DOWNGRADIENT LOW IMPACT DEVELOPMENT BMPS.

CHRISTOPHER J. WEBB
STATE OF WASHINGTON
35712
REGISTERED PROFESSIONAL ENGINEER
23-0323

No.	SHEET REVISION	DATE	BY
1			
2			
3			
4			

PLAN SET ISSUE	DATE

DESIGN	DRAWN	CHECK
NAS	CPM	CJW

DRAWING SCALE: AS NOTED
HORZ. DATUM: NAD83
VERT. DATUM: NAVD88

CONTRACT DATE: N/A
PROJECT No: N/A
ROAD/BRIDGE No: N/A
DRAWING FILE: N/A

PUBLIC WORKS DIRECTOR: ELIZABETH KOSA
PROGRAM MANAGER: KRAIG OLASON
PROJECT ENGINEER: CODY SWAN

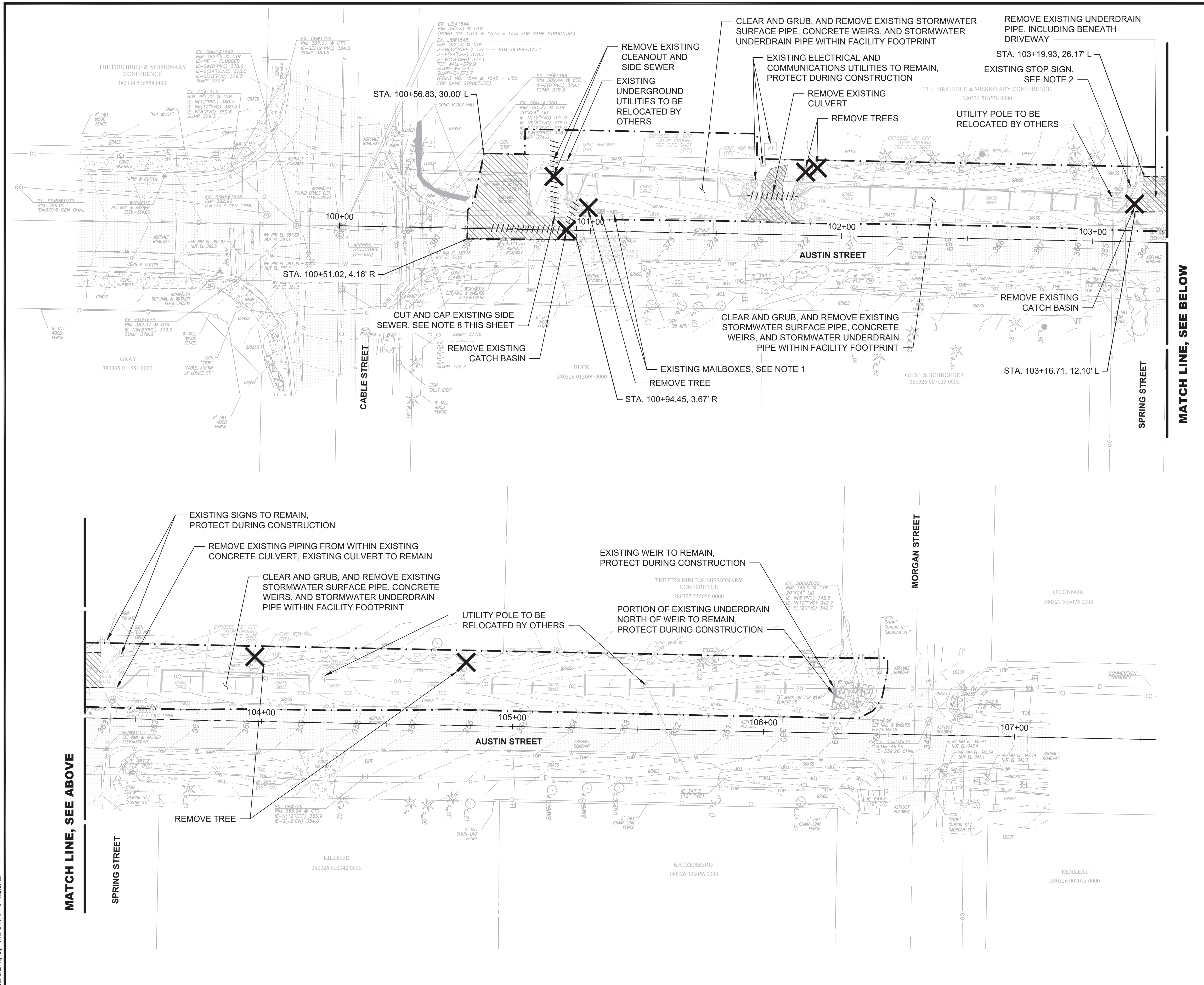
HERRERA
Science + Planning + Design
herrerainc.com

WHATCOM COUNTY
DEPARTMENT OF PUBLIC WORKS
322 N. COMMERCIAL ST., SUITE 301 BELLINGHAM, WA 98225
(360) 778-6210

PROJECT: GENEVA BIORETENTION PILOT PROJECT, BID NO. 23-17

TITLE: STORMWATER POLLUTION PREVENTION PLAN

O:\proj\Y2021\21-07565-001\CAD\Sheet\TESC.dwg | 3/23/2023 12:57 PM



NOTES:

1. EXISTING MAILBOXES TO REMAIN, PROTECT DURING CONSTRUCTION. EXISTING MAILBOXES SHALL BE RELOCATED TO ALLOW SAFE PEDESTRIAN ACCESS AT ALL TIMES DURING CONSTRUCTION. TEMPORARILY RELOCATED MAILBOXES SHALL BE LOCATED WITHIN 50 FEET OF EXISTING LOCATION. NOTIFY PROPERTY OWNERS AND RESIDENTS. REINSTALL MAILBOXES AT ORIGINAL LOCATION AS SOON AS CONSTRUCTION ACTIVITIES ALLOW.
2. EXISTING STOP SIGN TO REMAIN, PROTECT DURING CONSTRUCTION. EXISTING STOP SIGN MAY BE TEMPORARILY RELOCATED TO ACCOMMODATE CONSTRUCTION ACTIVITIES. IF REMOVED, A TEMPORARY STOP SIGN SHALL BE INSTALLED. REINSTALL STOP SIGN AT ORIGINAL LOCATION PER WSDOT STD PLAN G-22.10-04 AS SOON AS CONSTRUCTION ACTIVITIES ALLOW.
3. TREES OUTSIDE THE AREA TO BE CLEARED AND GRUBBED SHALL REMAIN AND BE PROTECTED DURING CONSTRUCTION.
4. CONTRACTOR SHALL COORDINATE WITH UTILITY OWNER FOR ANY UTILITY POLE SUPPORT NEEDED DURING CONSTRUCTION. CONTACT UTILITY PRIOR TO CONSTRUCTION FOR ANY UTILITY POLE LOCATED WITHIN 10 FEET OF PROPOSED IMPROVEMENTS.
5. CEMENT CONCRETE CURB AND GUTTER REMOVAL SHALL BE TO THE NEAREST JOINT BEYOND THE IMPROVEMENTS, TYPICAL.
6. PAVEMENT SAWCUTS SHALL BE MADE PERPENDICULAR TO THE DIRECTION OF TRAVEL.
7. ALL AREAS WITHIN THE FACILITY FOOTPRINT AND THE AREA TO BE GRADED SHALL BE CLEARED AND GRUBBED.
8. CUT AND CAP EXISTING SIDE SEWER AT MAIN. POTHOLE TO CONFIRM CONNECTION REQUIREMENTS. COORDINATE WORK AND INSPECTION WITH LAKE WHATCOM WATER AND SEWER DISTRICT.

CHRISTOPHER J. WEBB, STATE OF WASHINGTON, 35712, REGISTERED PROFESSIONAL ENGINEER
23-0323

No.	SHEET REVISION	DATE	BY	PLAN SET ISSUE	DATE
1					
2					
3					
4					

DESIGN	DRAWN	CHECK
NAS	CPM	CJW

DRAWING SCALE: AS NOTED
HORZ. DATUM: NAD83
VERT. DATUM: NAVD88

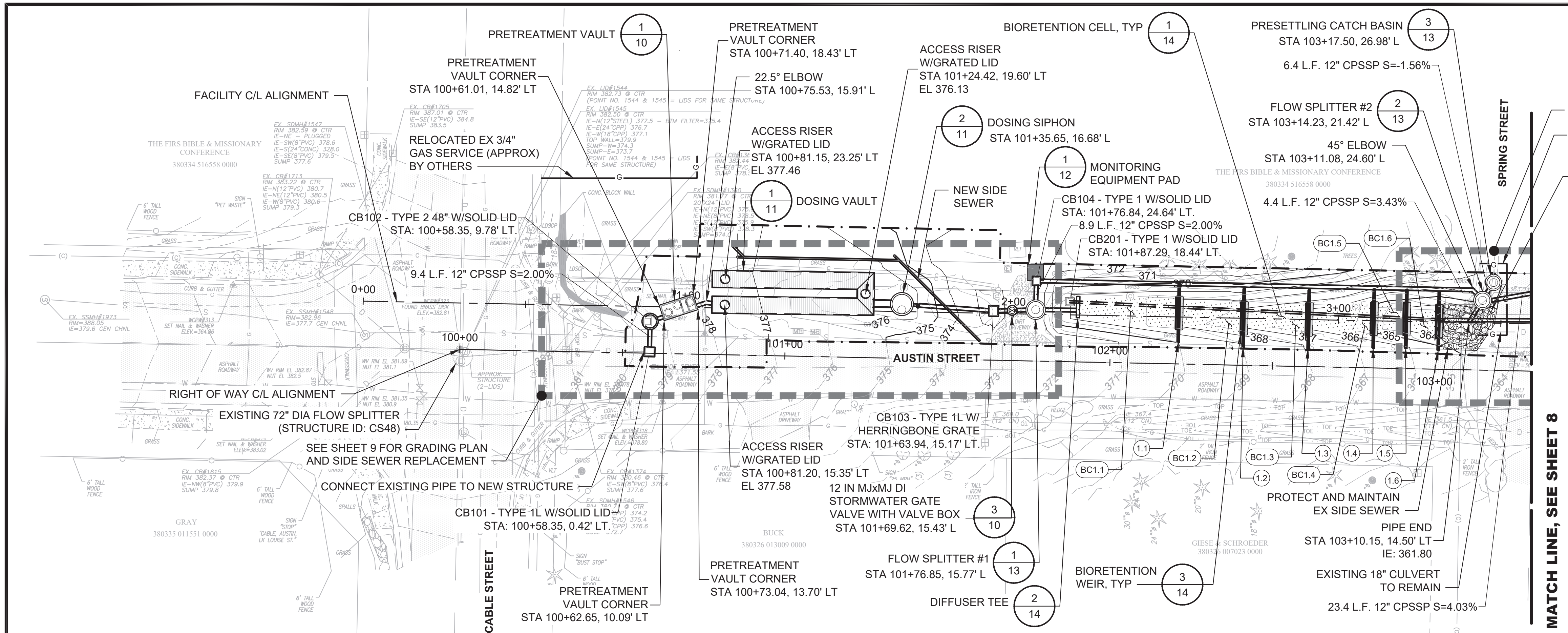
CONTRACT DATE: N/A
PROJECT No: N/A
ROAD/BRIDGE No: N/A
DRAWING FILE: N/A

PUBLIC WORKS DIRECTOR: ELIZABETH KOSA
PROGRAM MANAGER: KRAIG OLASON
PROJECT ENGINEER: CODY SWAN

HERRERA Science + Planning + Design
herrerainc.com

WHATCOM COUNTY
DEPARTMENT OF PUBLIC WORKS
322 N. COMMERCIAL ST., SUITE 301 BELLINGHAM, WA 98225
(360) 778-6210

PROJECT: GENEVA BIORETENTION PILOT PROJECT, BID NO. 23-17
TITLE: SITE PREPARATION PLAN
SHEET: 6 OF: 19



PLAN

BIORETENTION CASCADE 1

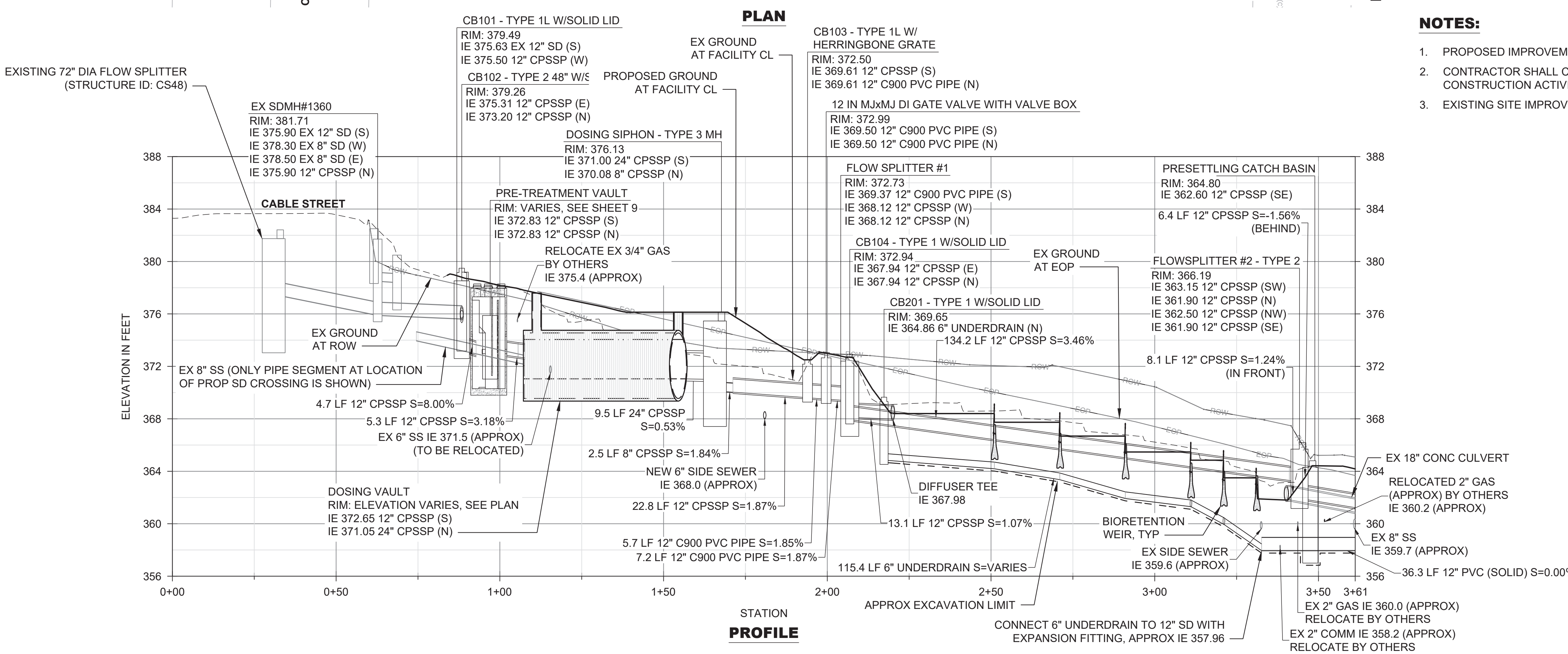
CELL NUMBER	TOP OF MULCH ELEV	CELL BOTTOM AREA (SQ FT)	CELL BOTTOM WIDTH AT DS END (FT)
BC1.1	368.40	239.48	10.2
BC1.2	367.74	165.98	9.6
BC1.3	366.92	140.13	9.6
BC1.4	365.47	137.20	11.0
BC1.5	364.85	98.05	11.3
BC1.6	363.50	60.90	7.6

BIORETENTION WEIRS - CASCADE 1

WEIR	STATION	OFFSET	CREST ELEV	WEIR FOOTING BOTTOM ELEV
1.1	102+20.97	15.672	368.90	364.99
1.2	102+40.97	14.528	368.24	364.17
1.3	102+60.97	14.547	367.42	362.72
1.4	102+80.97	15.161	365.97	362.10
1.5	102+90.97	15.275	365.35	360.75
1.6	103+00.97	14.836	364.00	359.05

NOTES:

1. PROPOSED IMPROVEMENTS REFERENCE THE RIGHT-OF-WAY CENTERLINE ALIGNMENT.
2. CONTRACTOR SHALL CONFIRM PROPOSED UTILITY RELOCATIONS PRIOR TO INITIATING CONSTRUCTION ACTIVITIES.
3. EXISTING SITE IMPROVEMENTS TO BE REMOVED OR ABANDONED ARE NOT SHOWN.



PROFILE

CHRISTOPHER J. WEBB, STATE OF WASHINGTON, 35712, REGISTERED PROFESSIONAL ENGINEER, 23-0323

No.	SHEET REVISION	DATE	BY	PLAN SET ISSUE	DATE
1					
2					
3					
4					

DESIGN	DRAWN	CHECK
NAS	CPM	CJW

DRAWING SCALE: AS NOTED
HORZ. DATUM: NAD83
VERT. DATUM: NAVD88

CONTRACT DATE: N/A
PROJECT No: N/A
ROAD/BRIDGE No: N/A
DRAWING FILE: N/A

PUBLIC WORKS DIRECTOR: ELIZABETH KOSA
PROGRAM MANAGER: KRAIG OLASON
PROJECT ENGINEER: CODY SWAN

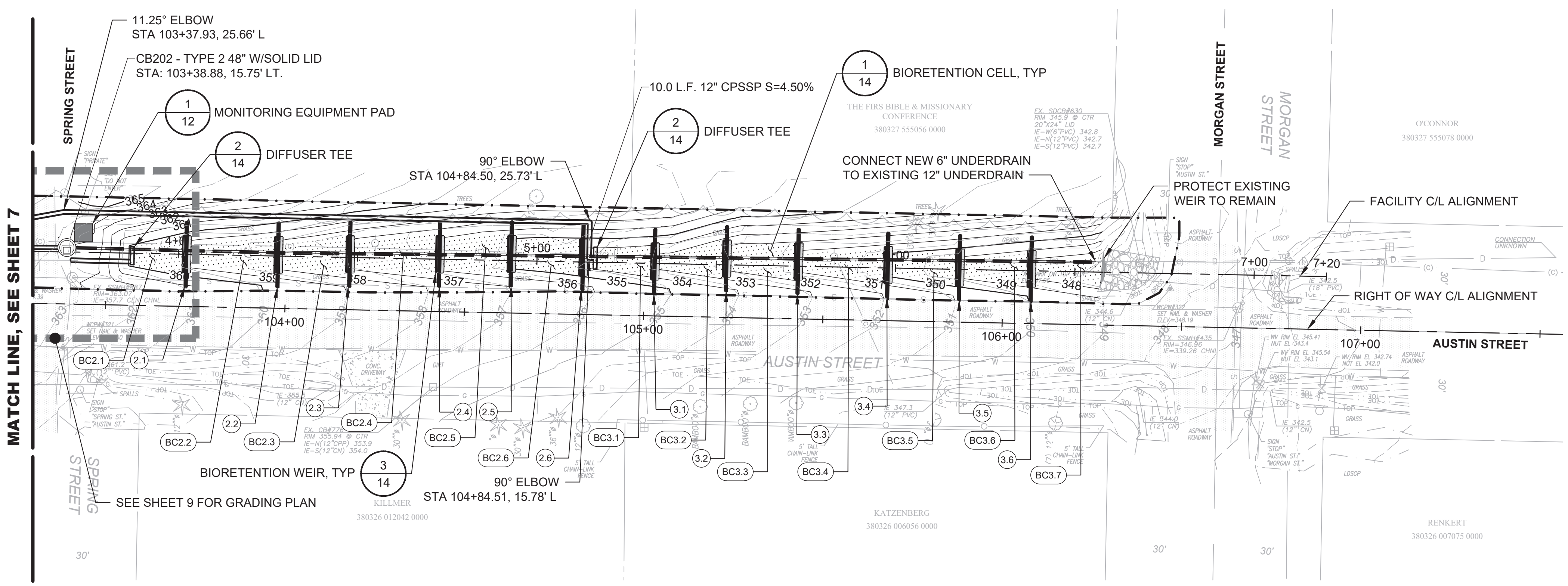
HERRERA Science + Planning + Design herrerainc.com

WHATCOM COUNTY DEPARTMENT OF PUBLIC WORKS
322 N. COMMERCIAL ST., SUITE 301 BELLINGHAM, WA 98225 (360) 778-6210

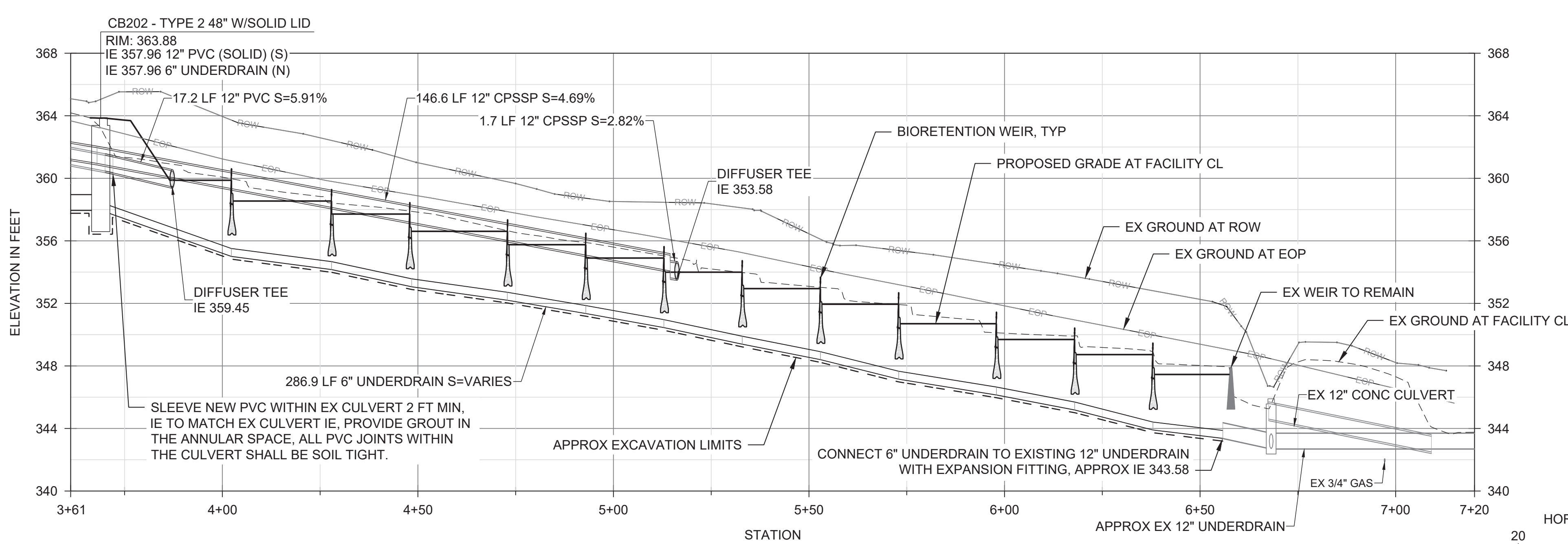
PROJECT: GENEVA BIORETENTION PILOT PROJECT, BID NO. 23-17

TITLE: DRAINAGE PLAN AND PROFILE 1

SHEET: 7 OF: 19



PLAN



PROFILE

BIORETENTION CELLS - CASCADE 2

CELL NUMBER	TOP OF MULCH ELEV	CELL BOTTOM AREA (SQ FT)	CELL BOTTOM WIDTH AT DS END (FT)
BC2.1	359.87	133.08	11.6
BC2.2	358.55	202.56	10.8
BC2.3	357.71	183.86	11.9
BC2.4	356.61	231.63	12.1
BC2.5	355.75	202.42	12.1
BC2.6	354.90	181.63	10.2

BIORETENTION WEIRS - CASCADE 2

WEIR	STATION	OFFSET	CREST ELEV	WEIR FOOTING BOTTOM ELEV
2.1	103+72.14	14.530	360.37	355.80
2.2	103+97.89	14.882	359.05	354.96
2.3	104+17.89	15.467	358.21	353.86
2.4	104+42.89	15.996	357.11	353.00
2.5	104+62.89	16.504	356.25	352.15
2.6	104+82.89	15.942	355.40	351.25

BIORETENTION CELLS - CASCADE 3

CELL NUMBER	TOP OF MULCH ELEV	CELL BOTTOM AREA (SQ FT)	CELL BOTTOM WITH AT DS END (FT)
BC3.1	354.00	143.94	9.0
BC3.2	352.94	144.13	11.4
BC3.3	351.95	175.04	10.7
BC3.4	350.70	177.94	9.9
BC3.5	349.69	141.94	9.3
BC3.6	348.73	135.73	9.1
BC3.7	347.45	100.38	8.3

BIORETENTION WEIRS - CASCADE 3

WEIR	STATION	OFFSET	CREST ELEV	WEIR FOOTING BOTTOM ELEV
3.1	105+02.92	14.854	354.50	350.19
3.2	105+22.88	16.340	353.44	349.20
3.3	105+42.89	16.046	352.45	347.95
3.4	105+67.89	15.529	351.20	346.94
3.5	105+87.89	15.242	350.19	345.98
3.6	106+07.89	15.244	349.23	344.70

NOTES:

1. PROPOSED IMPROVEMENTS REFERENCE THE RIGHT-OF-WAY CENTERLINE ALIGNMENT.
2. CONTRACTOR SHALL CONFIRM PROPOSED UTILITY RELOCATIONS PRIOR TO INITIATING CONSTRUCTION ACTIVITIES.
3. EXISTING SITE IMPROVEMENTS TO BE REMOVED OR ABANDONED ARE NOT SHOWN.

CHRISTOPHER J. WEBB, STATE OF WASHINGTON, 35712, REGISTERED PROFESSIONAL ENGINEER, 23-0323

No.	SHEET REVISION	DATE	BY	PLAN SET ISSUE	DATE
1					
2					
3					
4					

DESIGN	DRAWN	CHECK
NAS	CPM	CJW

DRAWING SCALE: AS NOTED
HORZ. DATUM: NAD83
VERT. DATUM: NAVD88

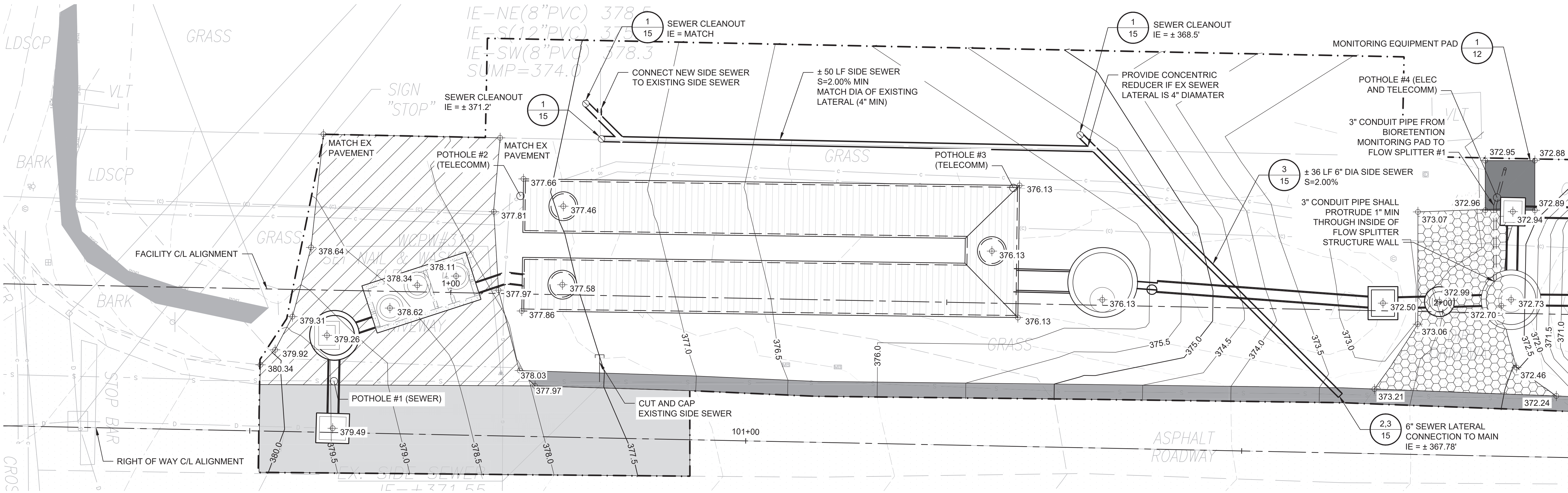
CONTRACT DATE: N/A
PROJECT No: N/A
ROAD/BRIDGE No: N/A
DRAWING FILE: N/A

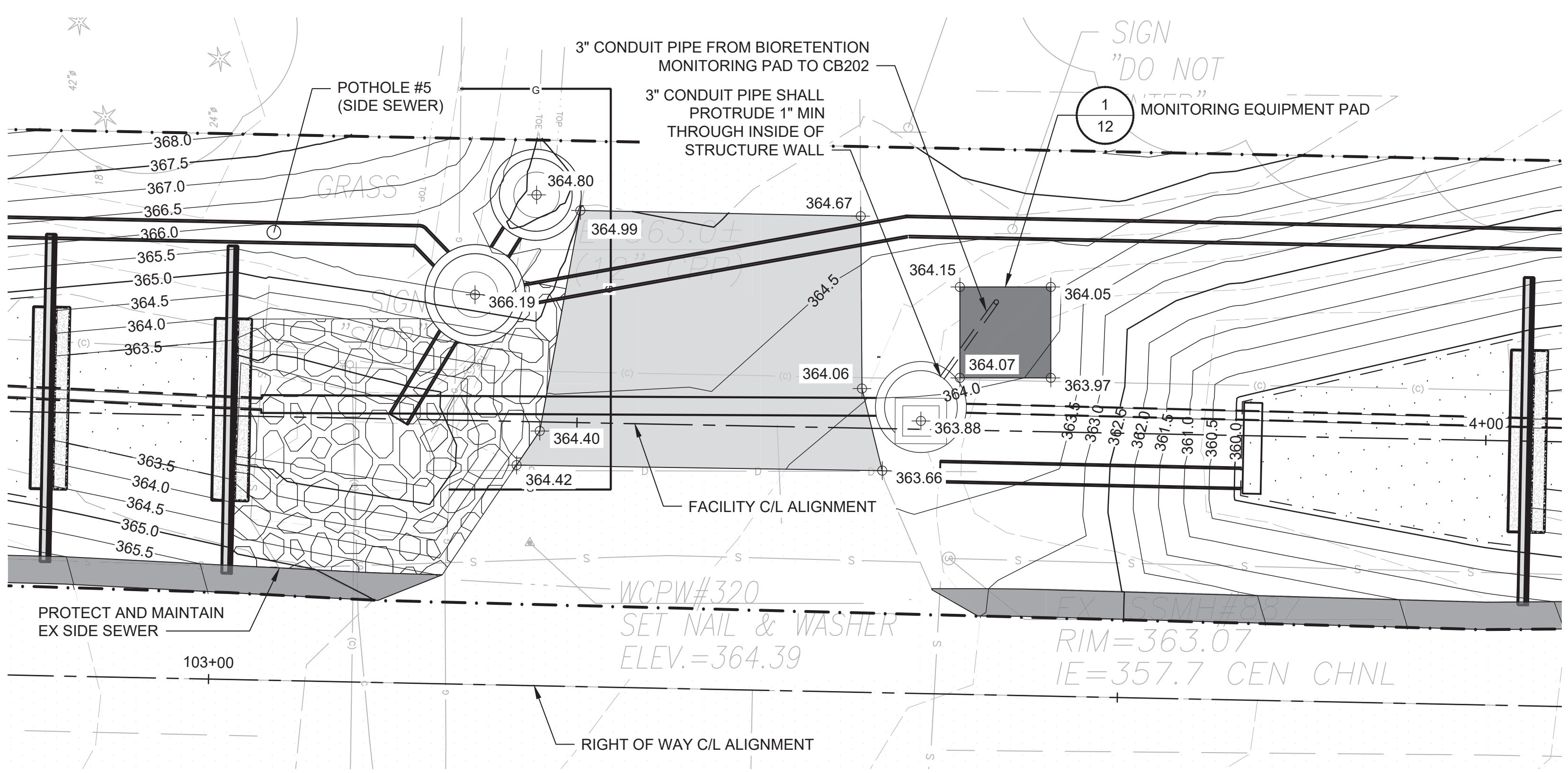
PUBLIC WORKS DIRECTOR: ELIZABETH KOSA
PROGRAM MANAGER: KRAIG OLASON
PROJECT ENGINEER: CODY SWAN

HERRERA Science + Planning + Design herrerainc.com

WHATCOM COUNTY
DEPARTMENT OF PUBLIC WORKS
322 N. COMMERCIAL ST., SUITE 301 BELLINGHAM, WA 98225
(360) 778-6210

PROJECT: GENEVA BIORETENTION PILOT PROJECT, BID NO. 23-17
TITLE: DRAINAGE PLAN AND PROFILE 2





GENERAL NOTES:

1. INSTALL NEW SEWER LATERAL PER LAKE WHATCOM WATER AND SEWER DISTRICT DESIGN AND CONSTRUCTION STANDARDS, LATEST EDITION.
2. PROVIDE TRACER WIRE ON NEW SEWER LATERAL PER DETAIL 4/15.
3. EXISTING SITE IMPROVEMENTS TO BE REMOVED OR ABANDONED ARE NOT SHOWN.

NORTH

0 5' 10'
US SURVEY FEET

23-0323

No.	SHEET REVISION	DATE	BY	PLAN SET ISSUE	DATE
1					
2					
3					
4					

DESIGN	DRAWN	CHECK
NAS	CPM	CJW

DRAWING SCALE: AS NOTED
HORZ. DATUM: NAD83
VERT. DATUM: NAVD88

CONTRACT DATE: N/A
PROJECT No: N/A
ROAD/BRIDGE No: N/A
DRAWING FILE: N/A

PUBLIC WORKS DIRECTOR: ELIZABETH KOSA
PROGRAM MANAGER: KRAIG OLASON
PROJECT ENGINEER: CODY SWAN

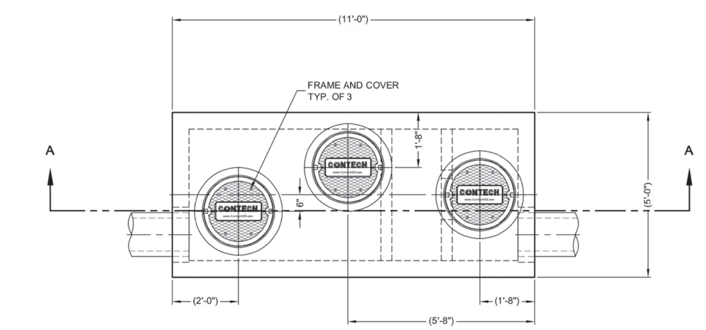
HERRERA
Science + Planning + Design
herrerainc.com

WHATCOM COUNTY
DEPARTMENT OF PUBLIC WORKS
322 N. COMMERCIAL ST., SUITE 301 BELLINGHAM, WA 98225
(360) 778-6210

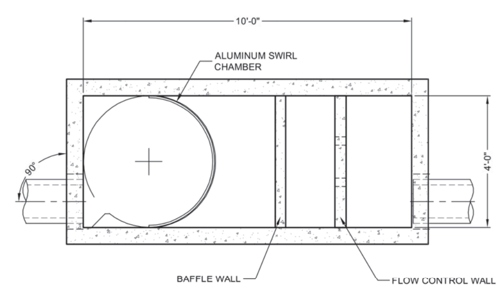
PROJECT: GENEVA BIORETENTION PILOT PROJECT, BID NO. 23-17

TITLE: DETAILED GRADING

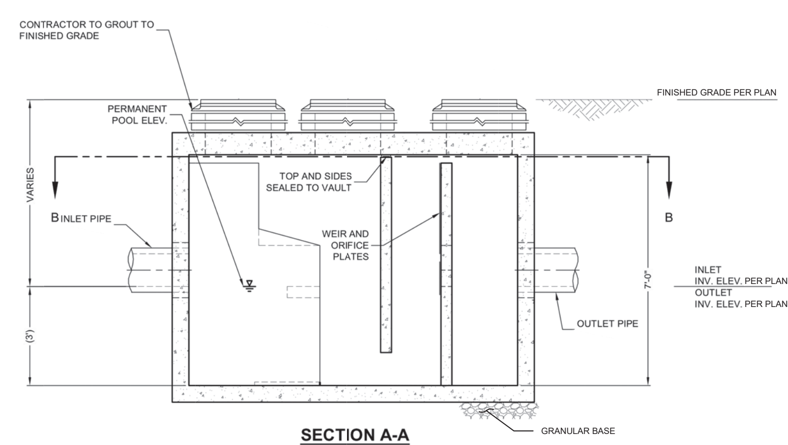
SHEET: 9
OF: 19



PLAN VIEW



SECTION B-B



SECTION A-A

MATERIALS LIST - PROVIDED BY CONTECH

COUNT	DESCRIPTION	INSTALLED BY
1	ALUMINUM SWIRL CHAMBER	CONTECH
1	ALUMINUM WEIR PLATE	CONTECH
1	ALUMINUM ORIFICE PLATE	CONTECH
1	SWIRL CHAMBER SEALANT	CONTECH
1	SEALANT FOR JOINTS	CONTRACTOR
3	Ø24" x 4" FRAME AND COVER	CONTRACTOR

SITE DESIGN DATA

WATER QUALITY FLOW RATE	0.879 cfs
PEAK FLOW RATE	1.145 cfs
RETURN PERIOD OF PEAK FLOW	100 yrs

GENERAL NOTES
1. CONTECH TO PROVIDE ALL MATERIALS UNLESS NOTED OTHERWISE.
2. DIMENSIONS MARKED WITH ( ) ARE REFERENCE DIMENSIONS. ACTUAL DIMENSIONS MAY VARY.
3. FOR FABRICATION DRAWINGS WITH DETAILED VAULT DIMENSIONS AND WEIGHT, PLEASE CONTACT YOUR CONTECH REPRESENTATIVE. www.ContechES.com
4. VORTECHS WATER QUALITY VAULT SHALL BE IN ACCORDANCE WITH ALL DESIGN DATA AND INFORMATION CONTAINED IN THIS DRAWING.
5. STRUCTURE SHALL MEET AASHTO HS20 AND CASTINGS SHALL MEET AASHTO M306 LOAD RATING, ASSUMING EARTH COVER OF 0' - 5', AND GROUNDWATER ELEVATION AT, OR BELOW, THE OUTLET PIPE INVERT ELEVATION. ENGINEER OF RECORD TO CONFIRM
6. ACTUAL GROUNDWATER ELEVATION.
7. WATER SURFACE ELEVATION IN THE VORTECHS SYSTEM IS EXPECTED TO BE AT OR BELOW TOP OF FLOW CONTROL WALL DURING THE DESIGN STORM.
8. GROUND WATER ELEVATION ASSUMED AT INLET PIPE INVERT.

INSTALLATION NOTES
1. ANY SUB-BASE, BACKFILL DEPTH, AND/OR ANTI-FLOTATION PROVISIONS ARE SITE-SPECIFIC DESIGN CONSIDERATIONS AND SHALL BE SPECIFIED BY ENGINEER OF RECORD.
2. CONTRACTOR TO PROVIDE EQUIPMENT WITH SUFFICIENT LIFTING AND REACH CAPACITY TO LIFT AND SET THE VORTECHS VAULT (LIFTING CLUTCHES PROVIDED).
3. CONTRACTOR TO INSTALL JOINT SEALANT BETWEEN ALL VAULT JOINTS AND ASSEMBLE VAULT.
4. CONTRACTOR TO PROVIDE, INSTALL, AND GROUT PIPES. MATCH PIPE INVERTS WITH ELEVATIONS SHOWN.
5. CONTRACTOR TO PROVIDE ANY EXTERNAL BYPASS VAULTS REQUIRED FOR OFFLINE LAYOUT (UNLESS OTHERWISE SPECIFIED.
6. CONTRACTOR TO PROVIDE AND INSTALL MANHOLE RISERS, GRADE RINGS OR BLOCK REQUIRED BETWEEN THE TOP OF THE VORTECHS SYSTEM AND THE BASE OF THE MANHOLE FRAMES. TOP SLAB OPENING DIAMETER MAY BE DIFFERENT FROM THOSE SHOWN.

STRUCTURE WEIGHT
APPROXIMATE HEAVIEST PICK = TBD LBS.

CONTECH
PROPOSAL
DRAWING

XXXX

VX2000 - 740728-20
GENEVA BIORETENTION PILOT PROJECT
BELLINGHAM, WA
SITE DESIGNATION: PRETREATMENT VAULT

CONTECH ENGINEERED SOLUTIONS LLC
Vortechs

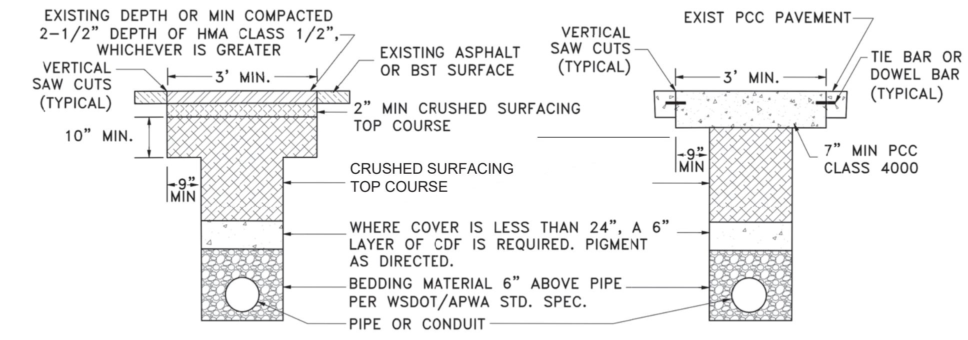
DATE: 1/27/23	
DESIGNED: SKJ	DRAWN: N/A
CHECKED:	APPROVED:
PROJECT NUMBER: 740728	
SHEET: 1 OF 1	

MARK | DATE | REVISION DESCRIPTION | BY

DETAIL - PRETREATMENT VAULT

SCALE: NTS

1 / 7



FLEXIBLE PAVEMENT REPAIR

Not to Scale

CONCRETE PAVEMENT REPAIR

NOTES:
1. All depth and type of materials shall match existing road cross section or minimum shown, unless the County Engineer specifies otherwise.
2. A revocable encroachment permit is required for all work in County rights-of-way.
3. Any disruption of 1/6 or more of the traveled way may require a pavement overlay or restoration, see Drawing 512.F-2.
4. No longitudinal trenching in traveled way wheel tracks is permitted without County Engineer approval.
5. Steel plates may be used to cover trench with County Engineer approval.
6. All backfill and bedding shall be compacted with a with a vibratory compactor, per WSDOT Specifications.
7. Existing pavement shall be saw cut to achieve neat vertical edges prior to patching.
8. Tack coat shall be applied to all edges to be joined before asphalt placement.
9. Asphalt shall meet WSDOT/APWA Standard Specificaitons HMA Class 1/2" and be placed in lifts not more than 3 compacted depth inches.
10. Trenches in concrete pavement shall be repaired using tie bars or dowel bars and sealed joints, in accordance with Sec. 5-05 of the WSDOT/APWA Standard Specifications.
11. See Section 515 for Definitions and Acronyms.

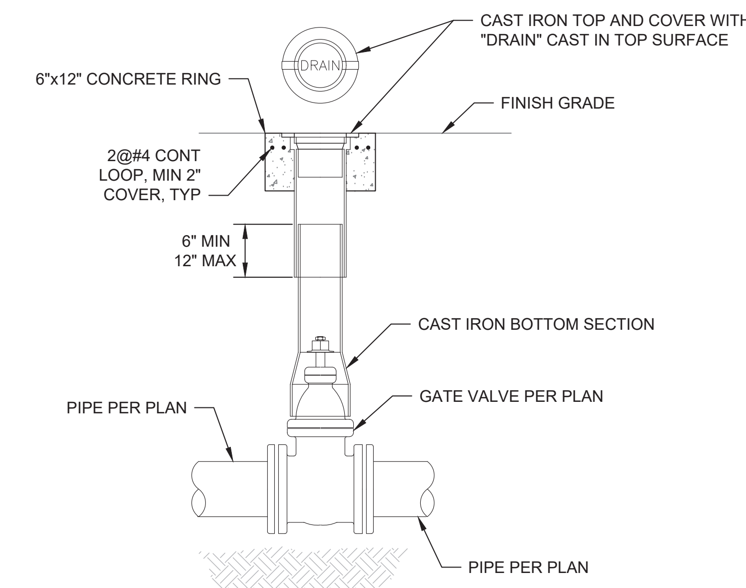
DRAWING 512.F-1
COUNTY MAINTAINED ROADWAY
OPEN CUT REPAIR
WHATCOM COUNTY DEPARTMENT OF PUBLIC WORKS

09/23/2015

DETAIL - COUNTY MAINTAINED OPEN CUT REPAIR (MODIFIED)

SCALE: NTS

2 / 7



NOTES:

1. VALVE BOX SHALL NOT SIT ON OPERATING ASSEMBLY.
2. INSTALL VALVE NUT STEM TO WITHIN 6 INCHES OF FINISHED GRADE. INSTALL VALVE STEM GUIDES PER MANUFACTURER SPECIFICATIONS.
3. CENTER VALVE BOX ON AXIS OF OPERATING NUT.
4. VALVE BOX COVER SHALL BE A MINIMUM OF 41/2 INCHES IN LENGTH.

DETAIL - GATE VALVE WITH VALVE BOX

SCALE: NTS

3 / 7

CHRISTOPHER J. WEBB, STATE OF WASHINGTON, 35712, REGISTERED PROFESSIONAL ENGINEER
23-0323

No.	SHEET REVISION	DATE	BY
1			
2			
3			
4			

PLAN SET ISSUE	DATE

DESIGN	DRAWN	CHECK
NAS	CPM	CJW

DRAWING SCALE: AS NOTED
HORZ. DATUM: NAD83
VERT. DATUM: NAVD88

CONTRACT DATE: N/A
PROJECT No: N/A
ROAD/BRIDGE No: N/A
DRAWING FILE: N/A

PUBLIC WORKS DIRECTOR: ELIZABETH KOSA
PROGRAM MANAGER: KRAIG OLASON
PROJECT ENGINEER: CODY SWAN

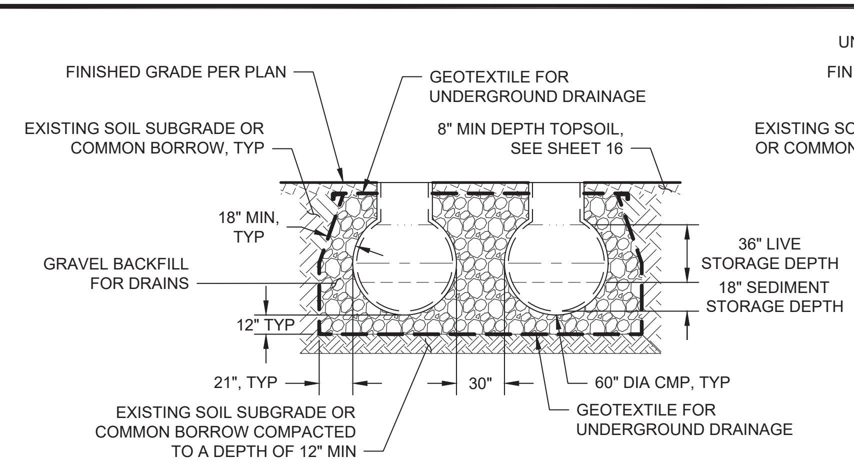
HERRERA
Science + Planning + Design
herrerainc.com

WHATCOM COUNTY
DEPARTMENT OF PUBLIC WORKS
322 N. COMMERCIAL ST., SUITE 301 BELLINGHAM, WA 98225
(360) 778-6210

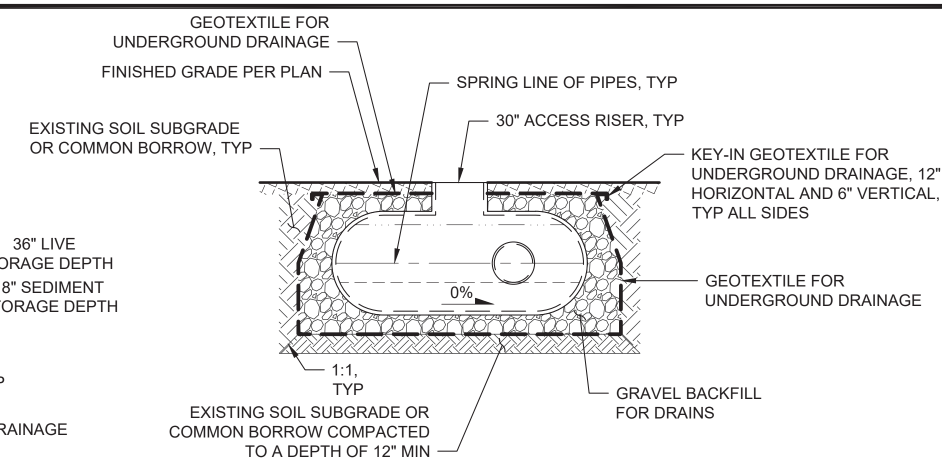
PROJECT: GENEVA BIORETENTION PILOT PROJECT, BID NO. 23-17

TITLE: DRAINAGE DETAILS 1

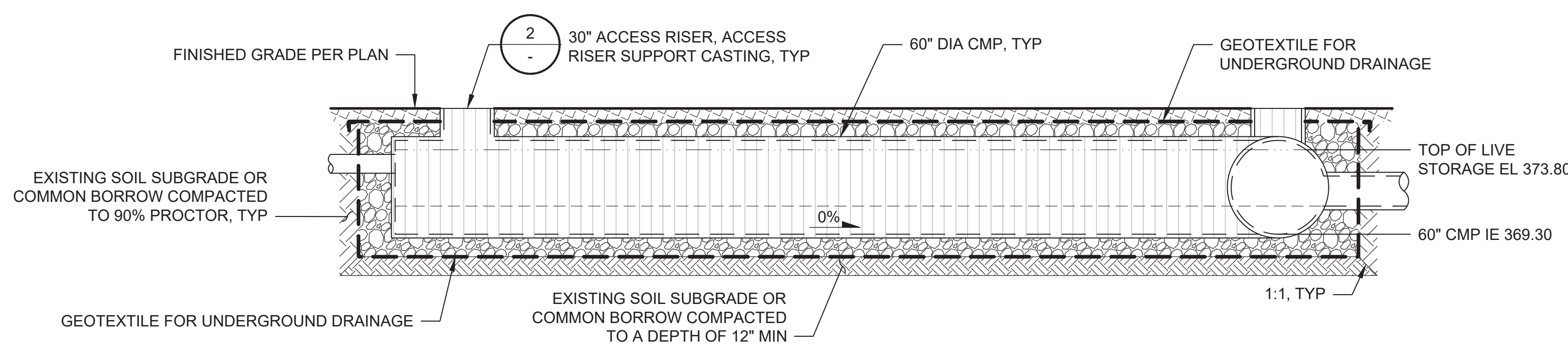
SHEET: 10
OF: 19



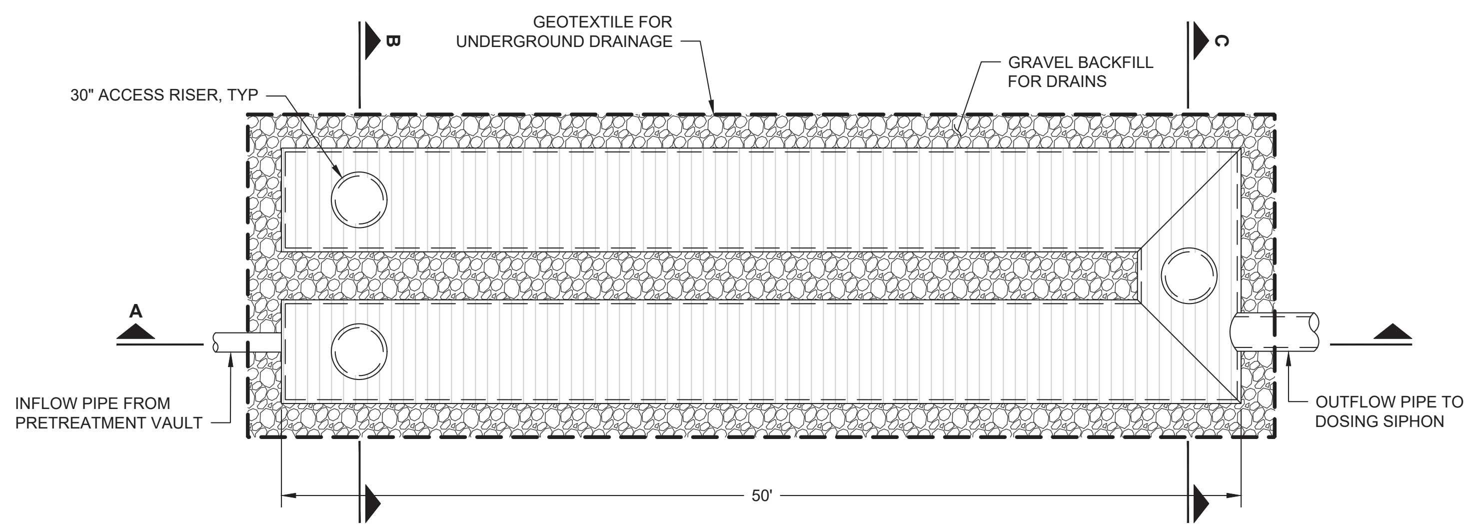
SECTION B



SECTION C



SECTION A

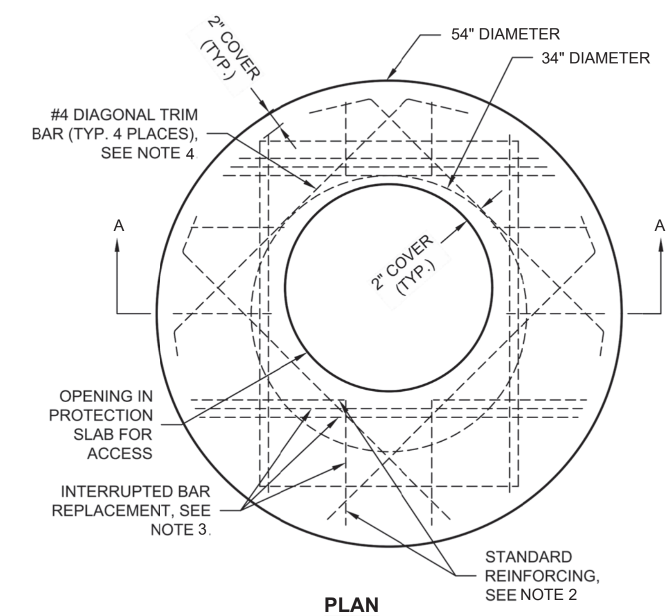


PLAN

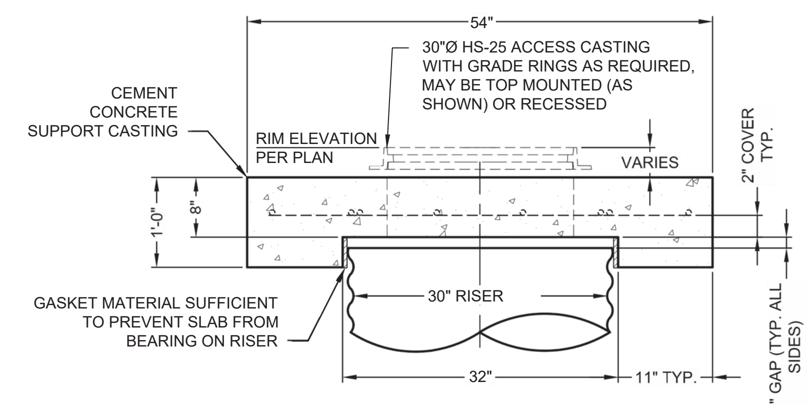
DETAIL - DOSING VAULT

SCALE: NTS

1
VAR



PLAN



SECTION A-A

NOTES:

1. DOSING VAULT ACCESS CASTING SHALL USE 4,000 PSI CEMENT CONCRETE AND REINFORCING STEEL MEETING ASTM A615, GRADE 60.
2. STANDARD REINFORCING SHALL BE #5@10" ON CENTER EACH WAY.
3. PROVIDE ADDITIONAL REINFORCING AROUND OPENINGS EQUAL TO THE BARS INTERRUPTED, HALF EACH SIDE. ADDITIONAL BARS SHALL BE IN THE SAME PLANE.
4. TRIM OPENING WITH DIAGONAL #4 BARS. EXTEND BARS A MINIMUM OF 12 INCHES BEYOND OPENING. BEND BARS AS REQUIRED TO MAINTAIN BAR COVER.

DETAIL - ACCESS RISER SUPPORT CASTING

SCALE: NTS

2
-

CHRISTOPHER J. WEBB, STATE OF WASHINGTON, 35712, REGISTERED PROFESSIONAL ENGINEER
23-0323

No.	SHEET REVISION	DATE	BY
1			
2			
3			
4			

PLAN SET ISSUE	DATE

DESIGN	DRAWN	CHECK
NAS	CPM	CJW

DRAWING SCALE: AS NOTED
HORZ. DATUM: NAD83
VERT. DATUM: NAVD88

CONTRACT DATE: N/A
PROJECT No: N/A
ROAD/BRIDGE No: N/A
DRAWING FILE: N/A

PUBLIC WORKS DIRECTOR: ELIZABETH KOSA
PROGRAM MANAGER: KRAIG OLASON
PROJECT ENGINEER: CODY SWAN

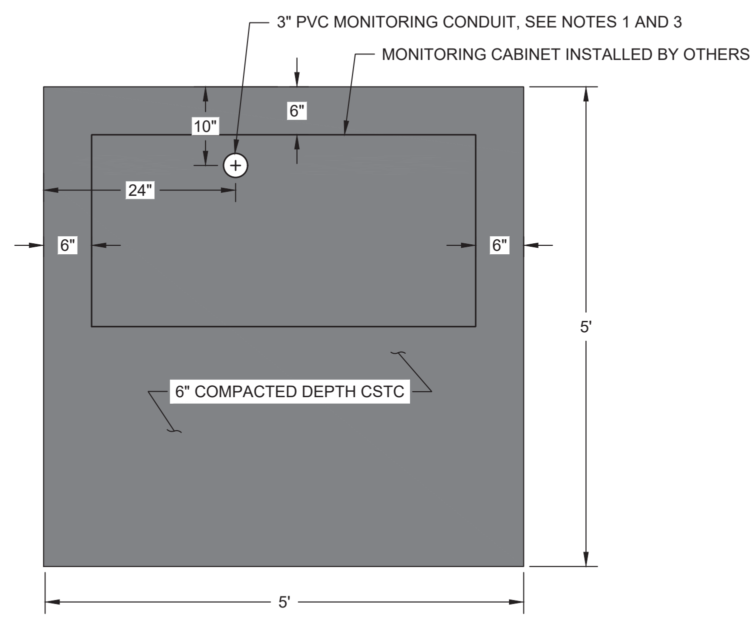
HERRERA Science + Planning + Design herrerainc.com

WHATCOM COUNTY DEPARTMENT OF PUBLIC WORKS
322 N. COMMERCIAL ST., SUITE 301 BELLINGHAM, WA 98225
(360) 778-6210

PROJECT: GENEVA BIORETENTION PILOT PROJECT, BID NO. 23-17

TITLE: DRAINAGE DETAILS 2

SHEET: 11
OF: 19



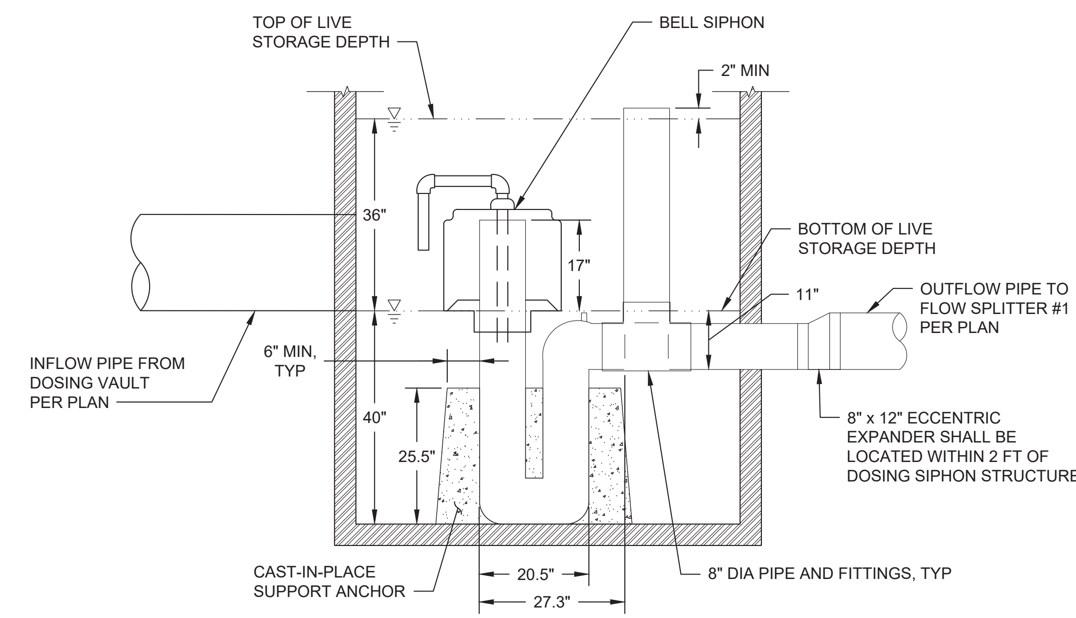
NOTES:

1. CONDUIT TO EXTEND 8" ABOVE GROUND SURFACE.
2. MAXIMUM SLOPE IN ANY DIRECTION ON FINISH GRAVEL PAD IS 2% SLOPE.
3. INSTALL PULL TAPE IN ALL PVC CONDUIT.
4. NO CONDUIT BEND SHALL BE GREATER THAN 45 DEGREES.

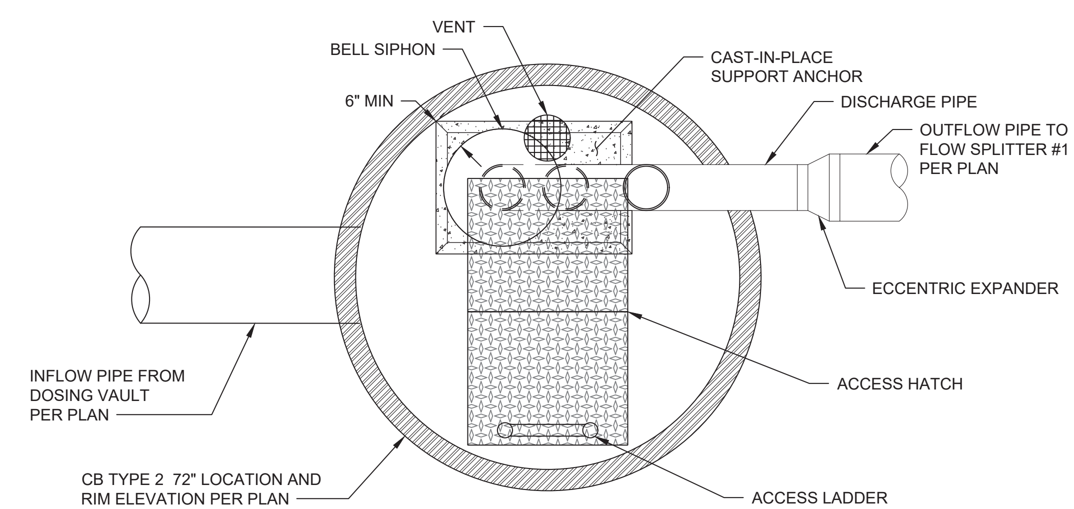
DETAIL - MONITORING EQUIPMENT PAD

SCALE: NTS

1 VAR



PROFILE



PLAN

DETAIL - DOSING SIPHON

SCALE: NTS

2 VAR

CHRISTOPHER J. WEBB, STATE OF WASHINGTON, 35712, REGISTERED PROFESSIONAL ENGINEER
23-0323

No.	SHEET REVISION	DATE	BY
1			
2			
3			
4			

PLAN SET ISSUE	DATE

DESIGN	DRAWN	CHECK
NAS	CPM	CJW

DRAWING SCALE: AS NOTED
HORZ. DATUM: NAD83
VERT. DATUM: NAVD88

CONTRACT DATE: N/A
PROJECT No: N/A
ROAD/BRIDGE No: N/A
DRAWING FILE: N/A

PUBLIC WORKS DIRECTOR: ELIZABETH KOSA
PROGRAM MANAGER: KRAIG OLASON
PROJECT ENGINEER: CODY SWAN

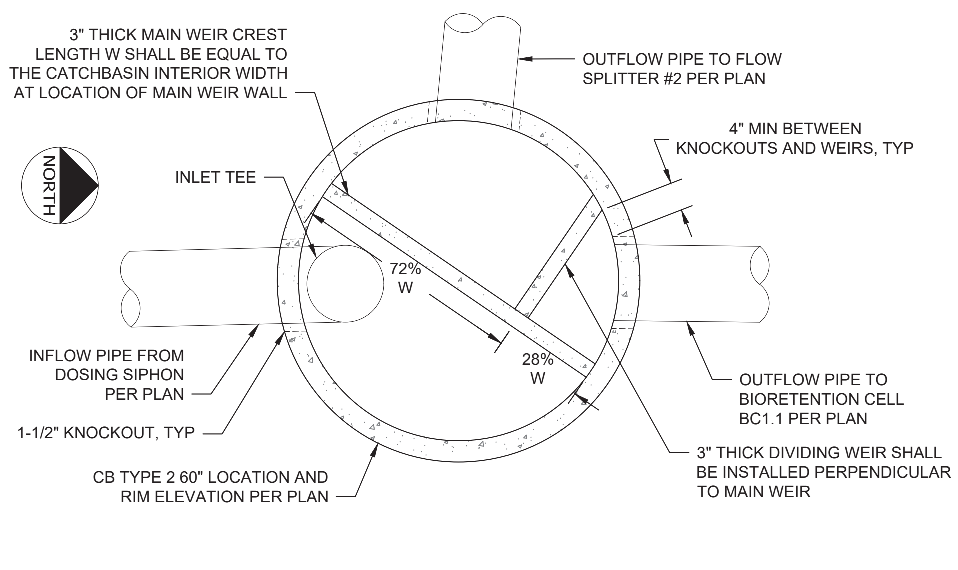
HERRERA Science + Planning + Design
herrerainc.com

WHATCOM COUNTY
DEPARTMENT OF PUBLIC WORKS
322 N. COMMERCIAL ST., SUITE 301 BELLINGHAM, WA 98225
(360) 778-6210

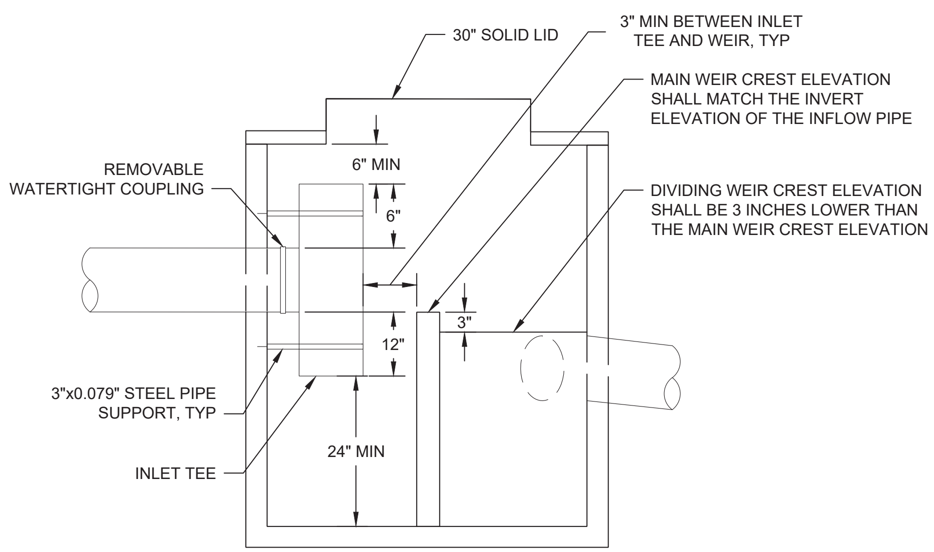
PROJECT: GENEVA BIORETENTION PILOT PROJECT, BID NO. 23-17

TITLE: DRAINAGE DETAILS 3

SHEET: 12
OF: 19



PLAN

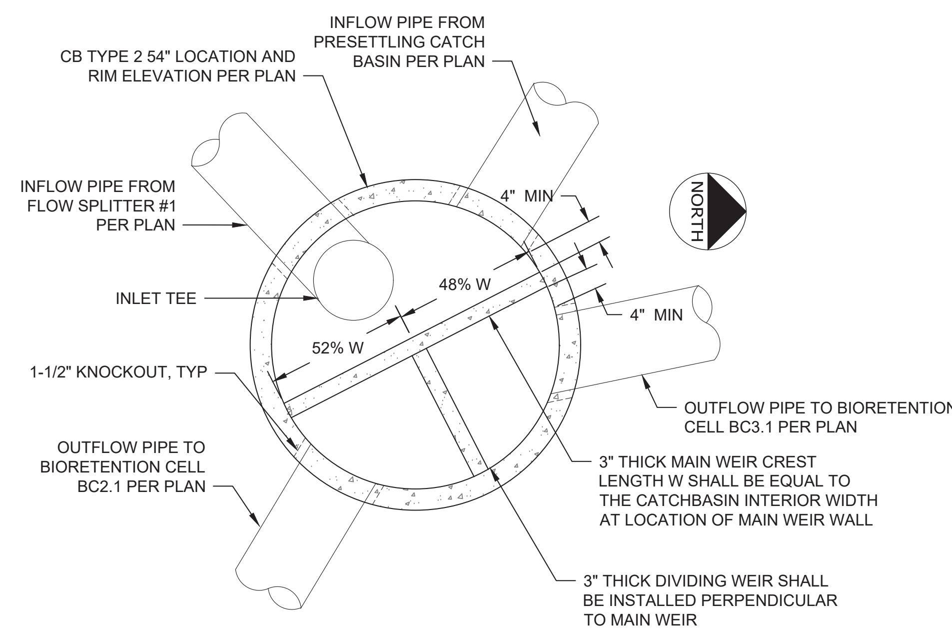


PROFILE

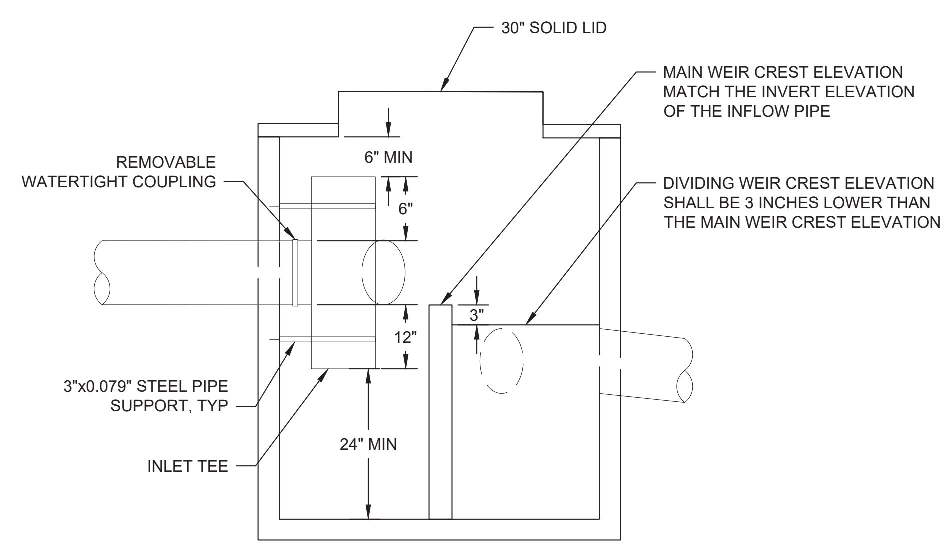
DETAIL - FLOW SPLITTER #1

SCALE: NTS

1
VAR



PLAN



PROFILE

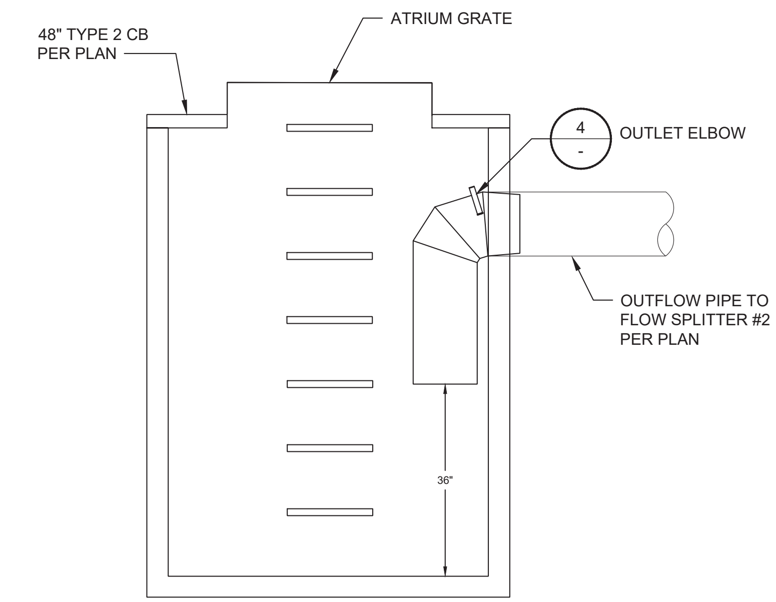
FLOW SPLITTER NOTES:

1. WEIRS SHALL BE CONSTRUCTED OF 3-INCH THICK CAST-IN-PLACE OR PRECAST CONCRETE INSTALLED IN A MANNER THAT PREVENTS SEEPAGE.
2. WEIR CRESTS SHALL BE FLAT AND LEVEL WITH A 1/2-INCH CHAMFER ON ALL EDGES.
3. INLET TEE SHALL BE CONSTRUCTED OF THE SAME MATERIAL AS THE CONNECTING INLET PIPE.
4. INLET TEE VERTICAL RISER STEM SHALL BE THE SAME DIAMETER AS THE CONNECTING INLET PIPE.
5. ONE INLET TEE PIPE SUPPORT SHALL BE INSTALLED 1-INCH FROM EACH INLET TEE END. ATTACH PIPE SUPPORTS TO THE CATCH BASIN WALL WITH 5/8-INCH STAINLESS STEEL EXPANSION BOLTS.
6. INLET TEE SHALL BE OPEN AT BOTH ENDS.
7. INLET TEE SHALL BE 3-INCH MIN CLEAR FROM MAIN WEIR WALL.

DETAIL - FLOW SPLITTER #2

SCALE: NTS

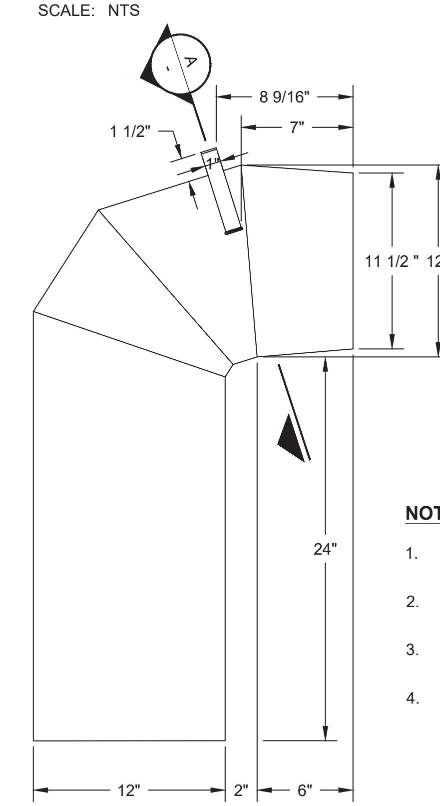
2
VAR

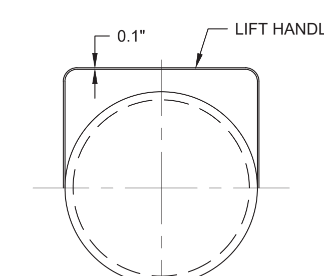


DETAIL - PRESETTLING CATCH BASIN

SCALE: NTS

3
VAR





SECTION A

NOTES:

1. OUTLET ELBOW SHALL BE MADE OF 16 GA ALUMINUM.
2. ALL JOINTS TO BE SEAMED AND SOLDERED, OR WELDED.
3. ALL LONGITUDINAL JOINTS TO BE RIVETED OR WELDED.
4. LIFT HANDLE MUST BE WELDED TO OUTSIDE OF TRAP (1" WIDE X 0.1" THICK.)

DETAIL - OUTLET ELBOW

SCALE: NTS

4
-

No.	SHEET REVISION	DATE	BY	PLAN SET ISSUE	DATE
1					
2					
3					
4					

DESIGN	DRAWN	CHECK
NAS	CPM	CJW

DRAWING SCALE: AS NOTED
HORZ. DATUM: NAD83
VERT. DATUM: NAVD88

CONTRACT DATE: N/A
PROJECT No: N/A
ROAD/BRIDGE No: N/A
DRAWING FILE: N/A

PUBLIC WORKS DIRECTOR: ELIZABETH KOSA
PROGRAM MANAGER: KRAIG OLASON
PROJECT ENGINEER: CODY SWAN

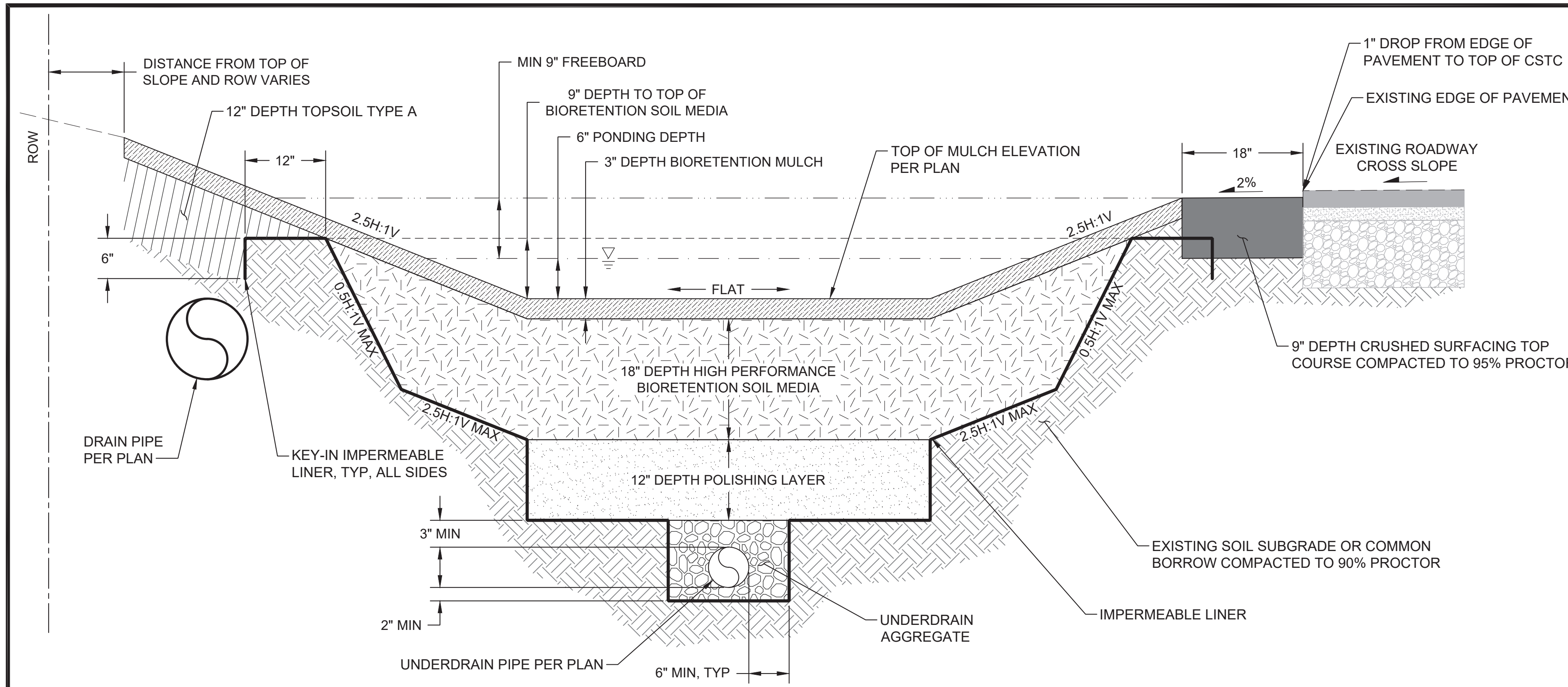
HERRERA
Science + Planning + Design
herrerainc.com

WHATCOM COUNTY
DEPARTMENT OF PUBLIC WORKS
322 N. COMMERCIAL ST., SUITE 301 BELLINGHAM, WA 98225
(360) 778-6210

PROJECT: GENEVA BIORETENTION PILOT PROJECT, BID NO. 23-17

TITLE: DRAINAGE DETAILS 4

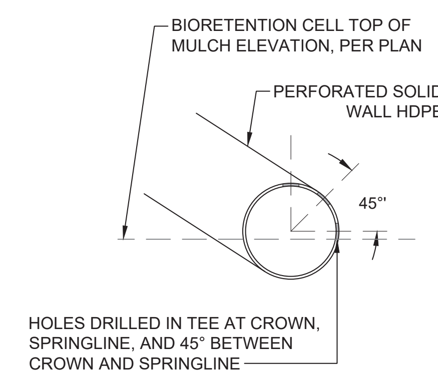
SHEET: 13
OF: 19



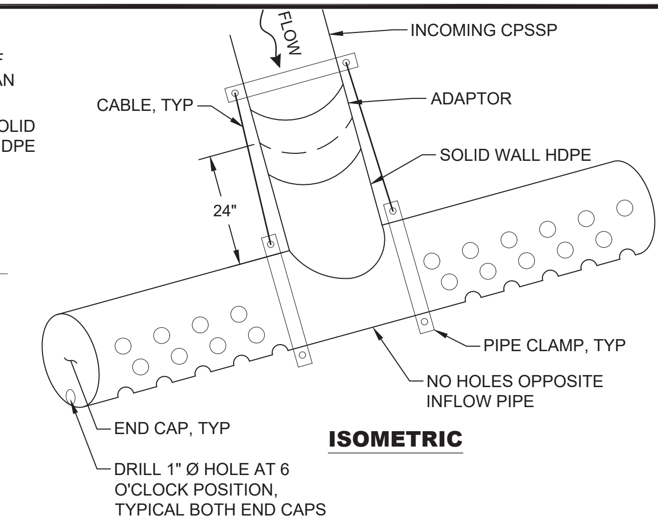
DETAIL - BIORETENTION CELL

SCALE: NTS

1 / VAR



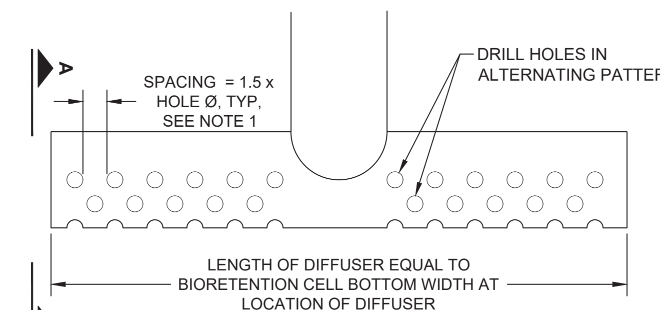
SECTION A



ISOMETRIC

NOTES:

1. HOLE DIAMETER (INCHES) = TEE DIAMETER (INCHES) DIVIDED BY 6. (EX: 12 INCH TEE = 2 INCH HOLES, 18 INCH TEE = 3 INCH HOLES)
2. DIFFUSER TEE SHALL BE INSTALLED FLAT AND LEVEL.
3. PIPE END CAPS SHALL BE PRESSURE FIT TO ALLOW REMOVAL FOR MAINTENANCE.
4. DIFFUSER TEE PIPE SHALL BE PARTIALLY BURIED SUCH THAT IE OF HOLES DRILLED AT PIPE SPRINGLINE SHALL MATCH BIORETENTION CELL TOP OF MULCH ELEVATION AS PER SECTION A ABOVE.

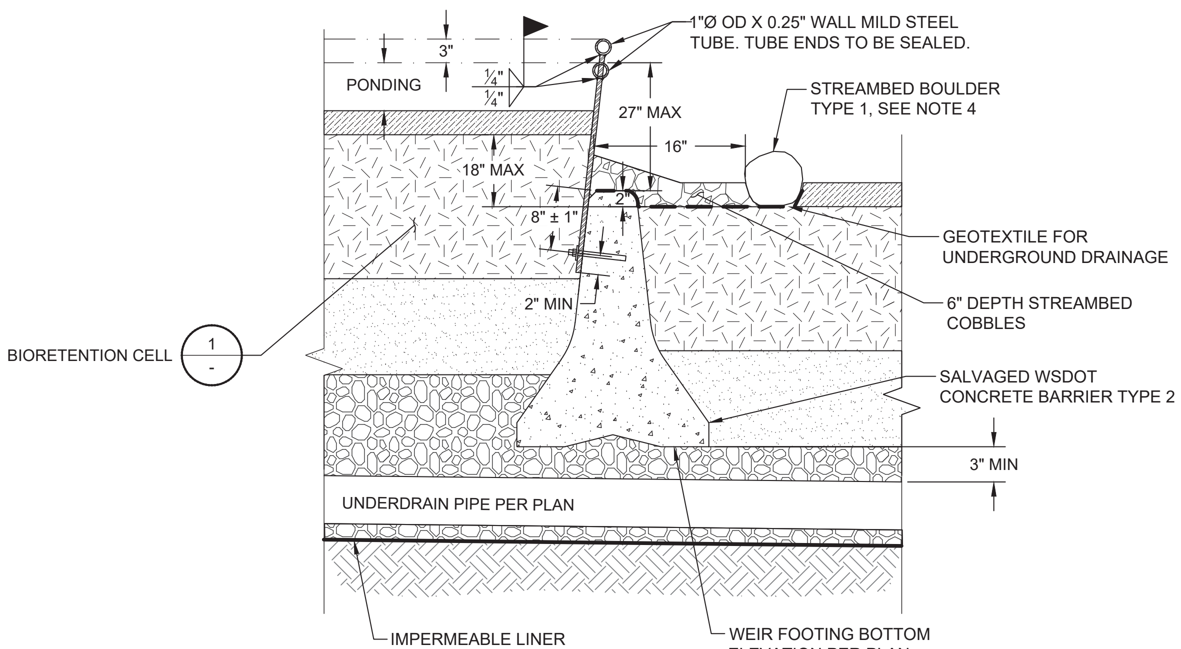


PLAN

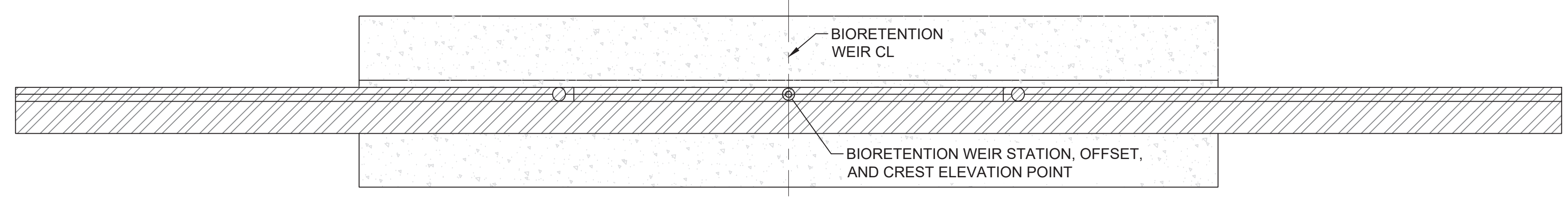
DETAIL - DIFFUSER TEE

SCALE: NTS

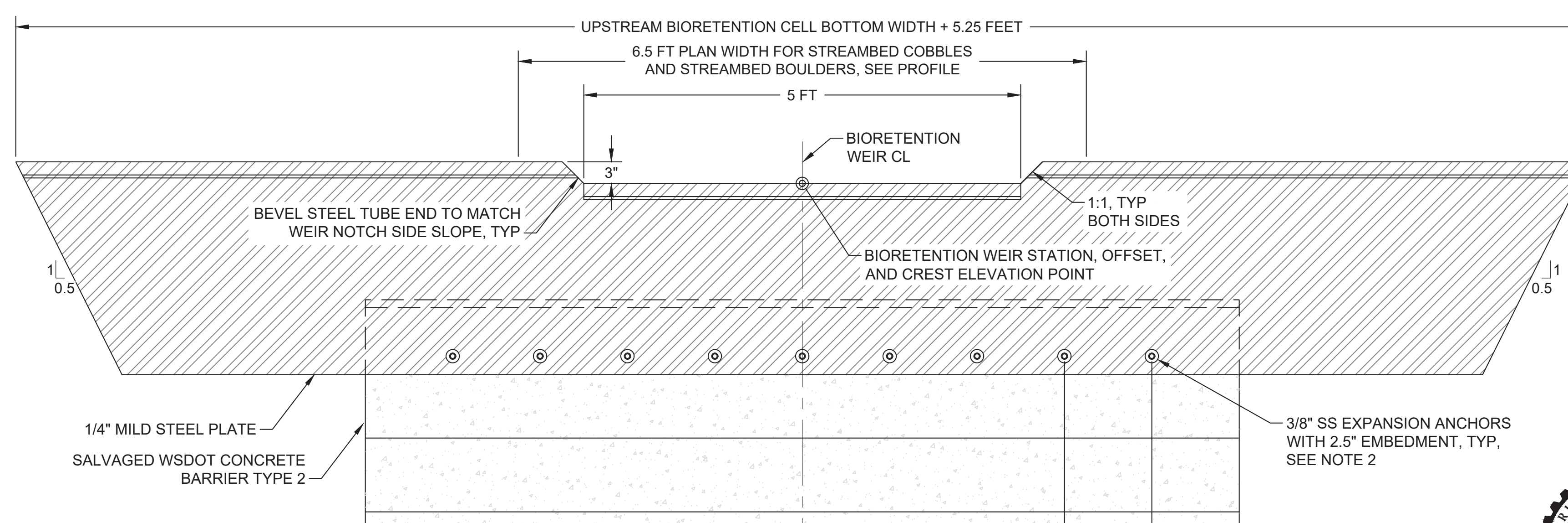
2 / VAR



PROFILE



PLAN



SECTION

NOTES:

1. BIORETENTION WEIR SHALL BE INSTALLED WITH CENTERLINE PARALLEL TO ROADWAY CENTERLINE.
2. PROVIDE 3-INCH MINIMUM CLEARANCE FROM ANY CONCRETE EDGE TO EXPANSION BOLT, TYP.
3. BIORETENTION WEIR DESIGN IS BASED ON A WSDOT CONCRETE BARRIER TYPE 2 HEIGHT OF 32 INCHES. CONTRACTOR SHALL INFORM ENGINEER IF BARRIER HEIGHT IS NOT 32 INCHES.
4. STREAMBED BOULDERS SHALL BE INSTALLED IN A SINGLE LINE WITH EACH BOULDER IN CONTACT WITH ADJACENT BOULDERS.
5. BIORETENTION WEIR STEEL PLATE ENDS SHALL BE BURIED 3-INCHES MINIMUM INTO BIORETENTION CELL SIDE SLOPE.

DETAIL - BIORETENTION WEIR

SCALE: NTS

3 / VAR

CHRISTOPHER J. WEBB, STATE OF WASHINGTON, 35712, REGISTERED PROFESSIONAL ENGINEER, 23-0323

No.	SHEET REVISION	DATE	BY	PLAN SET ISSUE	DATE
1					
2					
3					
4					

DESIGN	DRAWN	CHECK
NAS	CPM	CJW

DRAWING SCALE: AS NOTED
HORZ. DATUM: NAD83
VERT. DATUM: NAVD88

CONTRACT DATE: N/A
PROJECT No: N/A
ROAD/BRIDGE No: N/A
DRAWING FILE: N/A

PUBLIC WORKS DIRECTOR: ELIZABETH KOSA
PROGRAM MANAGER: KRAIG OLASON
PROJECT ENGINEER: CODY SWAN

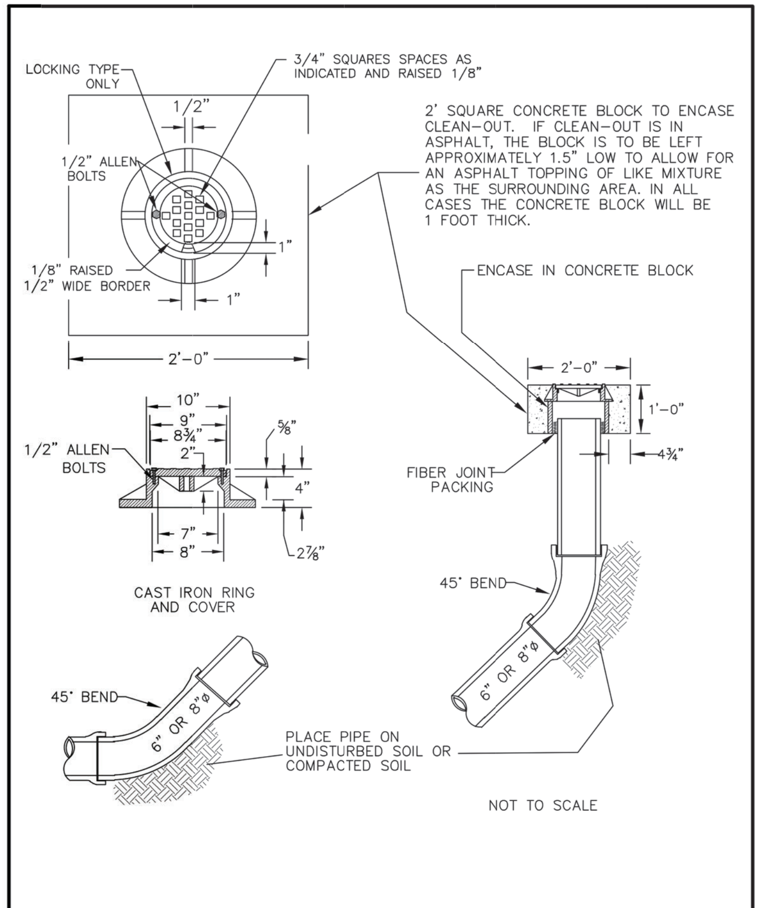
HERRERA Science + Planning + Design herrerainc.com

WHATCOM COUNTY
DEPARTMENT OF PUBLIC WORKS
322 N. COMMERCIAL ST., SUITE 301 BELLINGHAM, WA 98225
(360) 778-6210

PROJECT: GENEVA BIORETENTION PILOT PROJECT, BID NO. 23-17

TITLE: DRAINAGE DETAILS 5

SHEET: 14 OF: 19

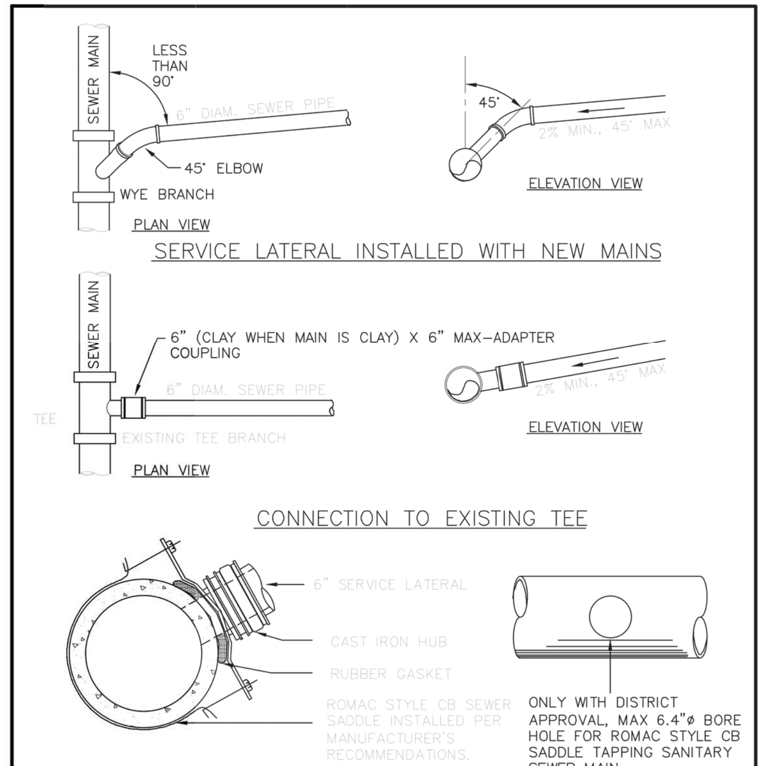


SEWER MAIN CLEANOUT

STANDARD DETAIL **S7** 5/1/2014

DETAIL - SEWER CLEANOUT (1/9)

SCALE: NTS



NOTES;
1. Install wye fitting with gaskets for new sewer installations
2. Pipe bedding shall Gravel Backfill for Pipe Zone Bedding per WSDOT 9-03.12(3).
3. Minimum cover to finish grade is 30".
4. Core drill hole then remove coupon. Do not drop coupon into pipe.

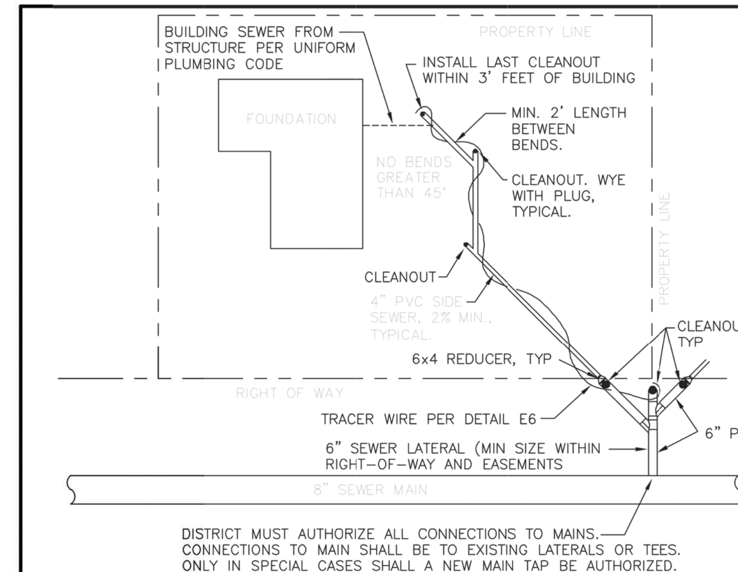
CONNECTION TO EXISTING SEWER (TAP)

SEWER LATERAL CONNECTION TO MAIN

STANDARD DETAIL **S8** 2/23/2022

DETAIL - SEWER LATERAL CONNECTION TO MAIN (2/9)

SCALE: NTS



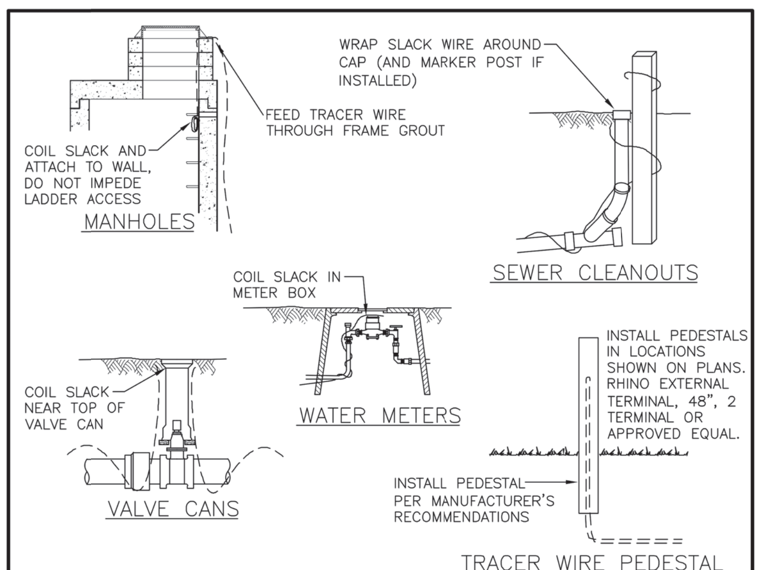
Notes:
1. All pipe from main to cleanout at foundation shall be PVC ASTM D3034 SDR 35, joints shall conform to ASTM D3212 using elastomeric gaskets conforming to ASTM F477. Fittings shall be injection molded, factory welded, or factory solvent cemented.
2. Minimum 18" of cover from property line to building.
3. Down spouts, sump pumps, outside drains and storm drainage shall not be connected to the sewer line.
4. Bends greater than 45° will not be accepted.
5. Minimum size for sewer lines will be 4" for single family residence and 6" for multi-family residence up to a 4 plex.
6. Cleanouts on service lines shall be installed at every change in horizontal alignment in excess of 22 1/2 degrees.
7. Cleanouts shall be installed at intervals not to exceed 100 feet.
8. Cleanouts shall be installed for each aggregate horizontal change in direction exceeding 135 degrees.
9. A cleanout shall be installed within 3' of the building.
10. Transitions of different material type shall be with a MAXADAPTER coupling.
11. Side sewers passing under existing or future retaining walls must be installed within a District approved casing pipe.
12. Contractor shall prepare Record Drawings, per Sheet S-2.

GRAVITY SIDE SEWER INSTALLATION

STANDARD DETAIL **S10** 2/23/2022

DETAIL - GRAVITY SIDE SEWER INSTALLATION (3/9)

SCALE: NTS



NOTES:

1. Tracer wire installation is required on all District owned pipe and communication lines. Tracer wire is also required on private side sewers and water service lines.

2. Tracer wire shall be 10 AWG insulated copper wire rated for direct burial in wet locations. Use green insulation for sewer, blue insulation for water, and orange insulation for fiber/communication related utilities.

3. Install tracer wire in continuous lengths (no splices) between surface access points. Any direct bury splices shall be approved and inspected by the District Engineer prior to cover. Splices shall be made with silicone filled wire nuts rated for direct burial in wet locations such as "Ideal Underground Wire Connectors", "Ideal Mudbug Connectors," "Copperhead Snakebite Connectors," or "3M DBR Direct Bury Splice Kit."

4. Tape tracer wire to pipe at 10-foot intervals.

5. Provide at least 2-feet of coiled tracer wire slack at surface access points.

6. Wrap tracker wire on the outside of valve cans, tape secure.

TRACER WIRE

STANDARD DETAIL **E6** 3/11/2020

DETAIL - TRACER WIRE (4/9)

SCALE: NTS

No.	SHEET REVISION	DATE	BY	PLAN SET ISSUE	DATE
1					
2					
3					
4					

DESIGN	DRAWN	CHECK
NAS	CPM	CJW

DRAWING SCALE: AS NOTED
HORZ. DATUM: NAD83
VERT. DATUM: NAVD88

CONTRACT DATE: N/A
PROJECT No: N/A
ROAD/BRIDGE No: N/A
DRAWING FILE: N/A

PUBLIC WORKS DIRECTOR: ELIZABETH KOSA
PROGRAM MANAGER: KRAIG OLASON
PROJECT ENGINEER: CODY SWAN

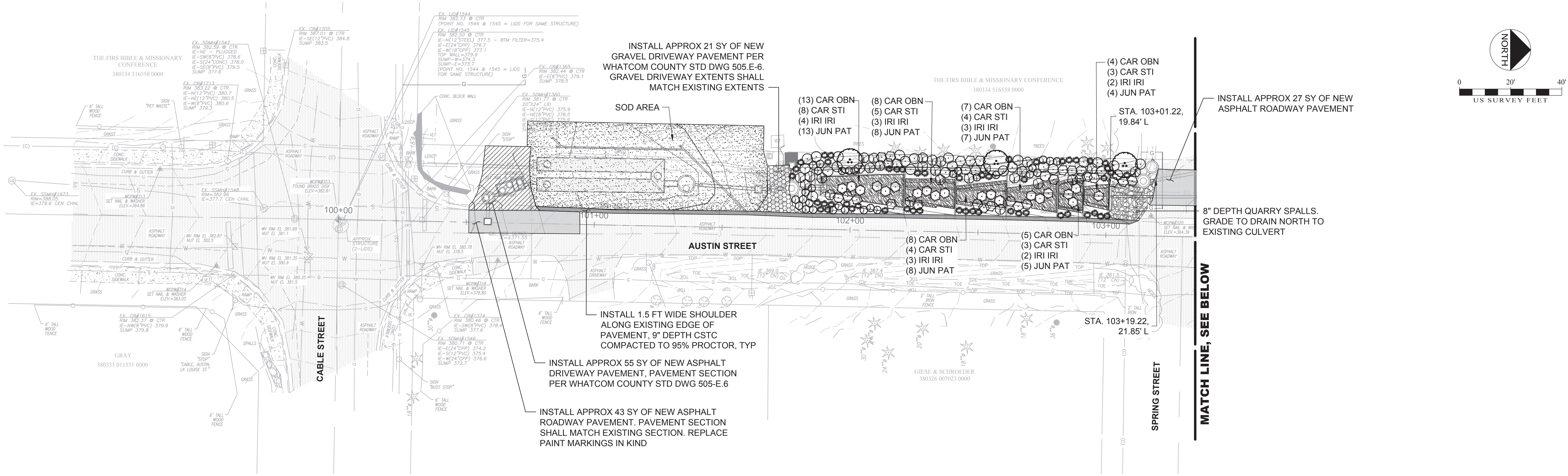
HERRERA Science + Planning + Design herrerainc.com

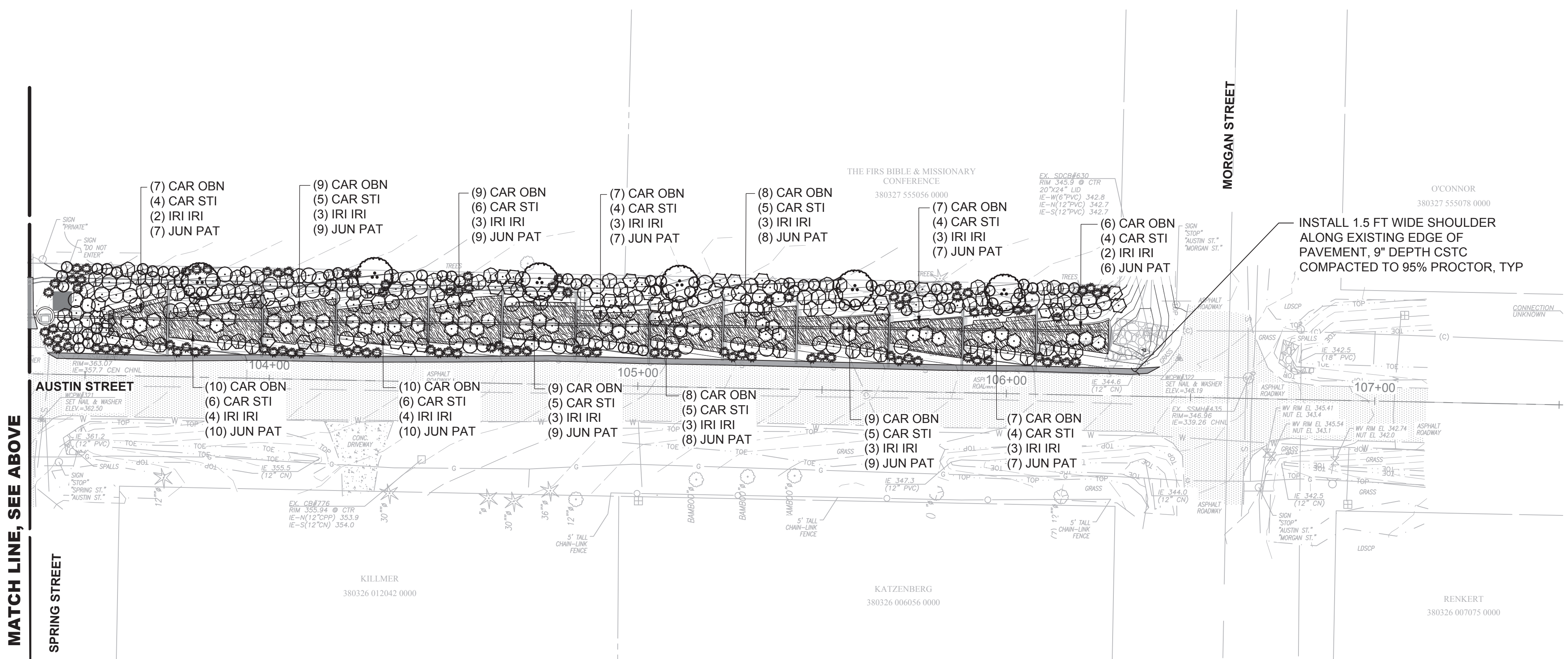
WHATCOM COUNTY
DEPARTMENT OF PUBLIC WORKS
322 N. COMMERCIAL ST., SUITE 301 BELLINGHAM, WA 98225
(360) 778-6210

PROJECT: GENEVA BIORETENTION PILOT PROJECT, BID NO. 23-17

TITLE: SANITARY SEWER DETAILS

SHEET: 15 OF: 19





NOTES:

1. PROPOSED IMPROVEMENTS REFERENCE THE RIGHT-OF-WAY CENTERLINE ALIGNMENT.
2. ALL PLANTING AREA PREPARATION AND INSTALLATION SHALL BE COMPLETED PER DETAILS ON SHEETS 17 AND 18.
3. SEE SHEET 18 FOR PLANT SCHEDULE AND LEGEND.

PLANTING NOTES:

1. PLANTS SHALL BE THE GENUS, SPECIES AS SPECIFIED ON THE PLANT SCHEDULE ON SHEET 18.
2. PLANTS SHALL BE WELL SHAPED, VIGOROUS, AND HEALTHY WITH A HEALTHY, WELL BRANCHED ROOT SYSTEM, FREE FROM DISEASE, HARMFUL INSECT AND INSECT EGGS, SUN-SCALD INJURY DISFIGUREMENT, OR ABRASION. ROOTBOUND CONTAINER PLANTS OR PLANTS WITH POORLY DEVELOPED ROOTS SHALL BE REJECTED.
3. PLANTS SHALL BE GROWN FROM SEED TO ENSURE GENETIC DIVERSITY.
4. PLANTS SHALL BE DELIVERED IN A COVERED TRUCK AND LABELED WITH BOTH BOTANICAL AND COMMON NAMES.
5. UNACCEPTABLE PLANTS (THOSE NOT MEETING THE SPECIFICATIONS LISTED ABOVE) SHALL BE REJECTED AND REPLACED AT NO EXPENSE.
6. PLANTS SHALL BE PLACED ACCORDING TO THE PLANTING PLAN ON THIS SHEET.
7. IMMEDIATELY AFTER PLANTING, ALL PLANTS SHALL BE WATERED UNTIL THE SOIL IS FULLY WETTED AROUND THE PLANT.
8. ALL MATERIALS SHALL BE LISTED ON THE CURRENT "CITY OF BELLINGHAM APPROVED MULCH, TOPSOIL, AND COMPOST FOR USE IN THE LAKE WHATCOM WATERSHED" LIST INCLUDED IN THE APPENDIX TO THE SPECIAL PROVISIONS, AND SHALL NOT CONTAIN ANY ANIMAL WASTE.
9. MULCH SHALL BE KEPT APPROXIMATELY 3-INCHES AWAY FROM THE TRUNKS AND STEMS OF PLANTS.
10. PLANTING SHALL BE PERFORMED IN A MANNER THAT PROTECTS AND PRESERVES THE IMPERMEABLE LINER WITHIN THE BIORETENTION CELLS. SEE DETAIL 1, SHEET 14 FOR LOCATION OF IMPERMEABLE LINER.
11. SEE SPECIAL PROVISION 8-02.3(5)B LAWN AREA PREPARATION AND 8-02.3(5)C PLANTING AREA PREPARATION FOR SOIL PREP IN THE SOD AND PLANTING AREAS OUTSIDE OF BIORETENTION SOIL MEDIA AREA.

No.	SHEET REVISION	DATE	BY	PLAN SET ISSUE	DATE
1					
2					
3					
4					

DESIGN	DRAWN	CHECK
NAS	CPM	CJW

DRAWING SCALE: AS NOTED
HORZ. DATUM: NAD83
VERT. DATUM: NAVD88

CONTRACT DATE: N/A
PROJECT No: N/A
ROAD/BRIDGE No: N/A
DRAWING FILE: N/A

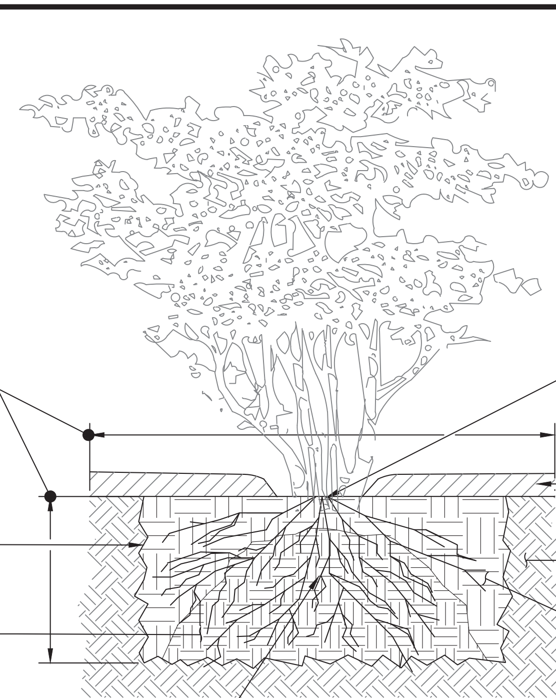
PUBLIC WORKS DIRECTOR: ELIZABETH KOSA
PROGRAM MANAGER: KRAIG OLASON
PROJECT ENGINEER: CODY SWAN

HERRERA Science + Planning + Design herrerainc.com

WHATCOM COUNTY
DEPARTMENT OF PUBLIC WORKS
322 N. COMMERCIAL ST., SUITE 301 BELLINGHAM, WA 98225
(360) 778-6210

PROJECT: GENEVA BIORETENTION PILOT PROJECT, BID NO. 23-17
TITLE: RESTORATION PLAN

SHEET: 16
OF: 19



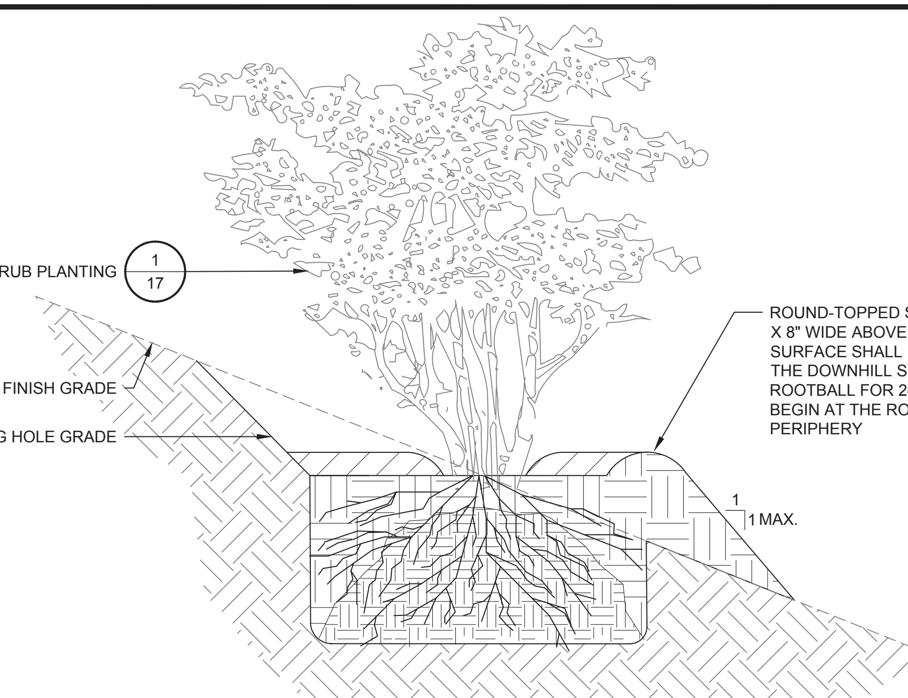
NOTES:

1. CONTRACTOR SHALL NOT DAMAGE IMPERMEABLE LINER LOCATED IN THE BIORETENTION CELLS AS SHOWN ON DETAIL 1, SHEET 14.
2. ONLY BAREROOT PLANTINGS SHALL BE INSTALLED IN AREAS OF BIORETENTION CELLS CONTAINING HIGH PERFORMANCE BIORETENTION SOIL MEDIA.
3. IT IS IMPERATIVE TO THE SUCCESS OF THIS PROJECT THAT NO PLANTING SOIL FROM POTTED PLANTS SHALL CONTAMINATE THE HIGH PERFORMANCE BIORETENTION SOIL BEFORE, DURING OR AFTER ALL PLANT INSTALLATION.

DETAIL - BAREROOT TREE OR SHRUB PLANTING

SCALE: NTS

1 / -



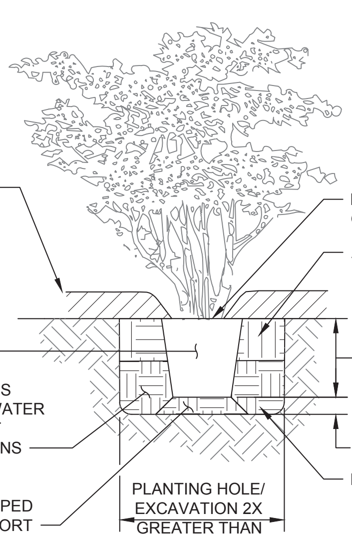
NOTES:

1. CONTRACTOR SHALL NOT DAMAGE IMPERMEABLE LINER LOCATED IN THE BIORETENTION CELLS AS SHOWN ON DETAIL 1, SHEET 14.
2. ONLY BAREROOT PLANTINGS SHALL BE INSTALLED IN AREAS OF BIORETENTION CELLS CONTAINING HIGH PERFORMANCE BIORETENTION SOIL MEDIA.
3. IT IS IMPERATIVE TO THE SUCCESS OF THIS PROJECT THAT NO PLANTING SOIL FROM POTTED PLANTS SHALL CONTAMINATE THE HIGH PERFORMANCE BIORETENTION SOIL BEFORE, DURING OR AFTER ALL PLANT INSTALLATION.

DETAIL - BARE ROOT TREE OR SHRUB PLANTING ON SLOPE

SCALE: NTS

3 / -

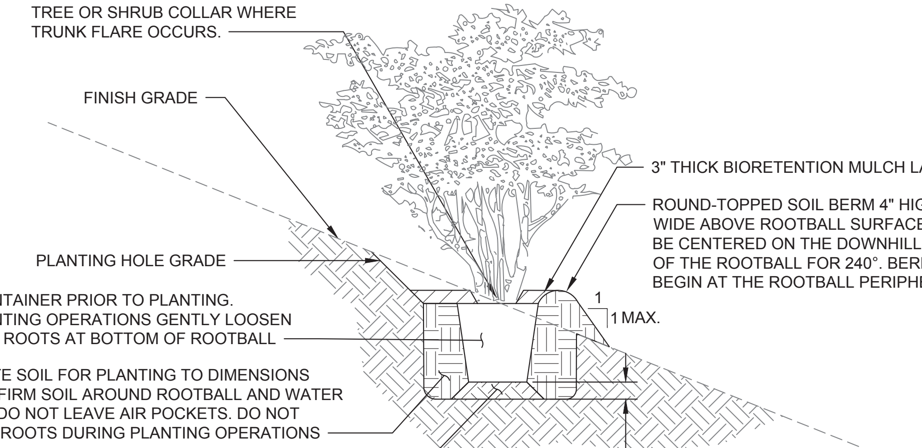


1. CONTRACTOR SHALL NOT DAMAGE IMPERMEABLE LINER LOCATED IN THE BIORETENTION CELLS AS SHOWN ON DETAIL 1, SHEET 14.
2. ONLY BAREROOT PLANTINGS SHALL BE INSTALLED IN AREAS OF BIORETENTION CELLS CONTAINING HIGH PERFORMANCE BIORETENTION SOIL MEDIA.
3. IT IS IMPERATIVE TO THE SUCCESS OF THIS PROJECT THAT NO PLANTING SOIL FROM POTTED PLANTS SHALL CONTAMINATE THE HIGH PERFORMANCE BIORETENTION SOIL BEFORE, DURING OR AFTER ALL PLANT INSTALLATION.

DETAIL - CONTAINERIZED TREE OR SHRUB PLANTING

SCALE: NTS

1 / -



1. CONTRACTOR SHALL NOT DAMAGE IMPERMEABLE LINER LOCATED IN THE BIORETENTION CELLS AS SHOWN ON DETAIL 1, SHEET 14.
2. ONLY BAREROOT PLANTINGS SHALL BE INSTALLED IN AREAS OF BIORETENTION CELLS CONTAINING HIGH PERFORMANCE BIORETENTION SOIL MEDIA.
3. IT IS IMPERATIVE TO THE SUCCESS OF THIS PROJECT THAT NO PLANTING SOIL FROM POTTED PLANTS SHALL CONTAMINATE THE HIGH PERFORMANCE BIORETENTION SOIL BEFORE, DURING OR AFTER ALL PLANT INSTALLATION.

DETAIL - CONTAINER TREE OR SHRUB PLANTING ON SLOPE

SCALE: NTS

2 / -

STATE OF WASHINGTON — RANDALL TAYLOR — LICENSED LANDSCAPE ARCHITECT

No.	SHEET REVISION	DATE	BY
1			
2			
3			
4			

PLAN SET ISSUE	DATE

DESIGN	DRAWN	CHECK
NAS	CPM	CJW

DRAWING SCALE: AS NOTED
HORZ. DATUM: NAD83
VERT. DATUM: NAVD88

CONTRACT DATE: N/A
PROJECT No: N/A
ROAD/BRIDGE No: N/A
DRAWING FILE: N/A

PUBLIC WORKS DIRECTOR: ELIZABETH KOSA
PROGRAM MANAGER: KRAIG OLASON
PROJECT ENGINEER: CODY SWAN

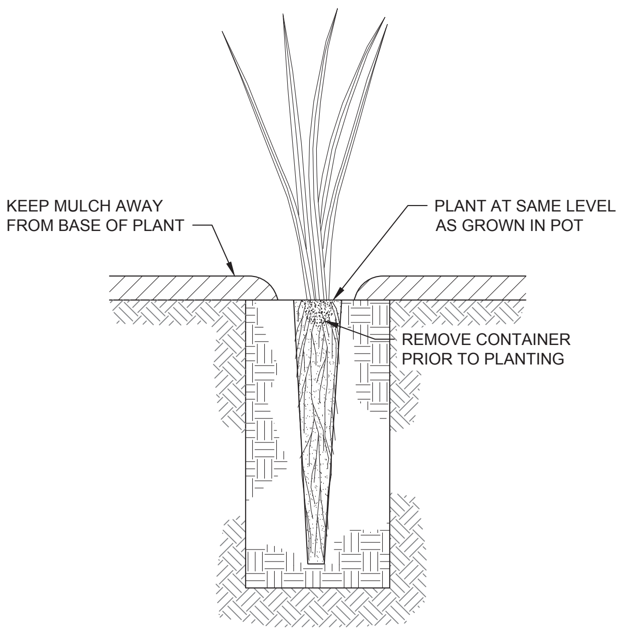
HERRERA Science + Planning + Design herrerainc.com

WHATCOM COUNTY
DEPARTMENT OF PUBLIC WORKS
322 N. COMMERCIAL ST., SUITE 301 BELLINGHAM, WA 98225
(360) 778-6210

PROJECT: GENEVA BIORETENTION PILOT PROJECT, BID NO. 23-17

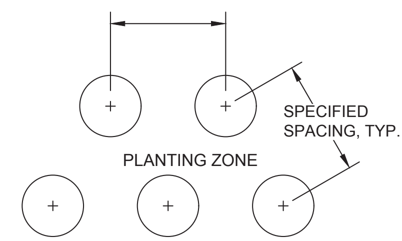
TITLE: RESTORATION DETAILS 1

SHEET: 17
OF: 19



DETAIL - 10 INCH PLUG PLANTING (1/-)

SCALE: NTS

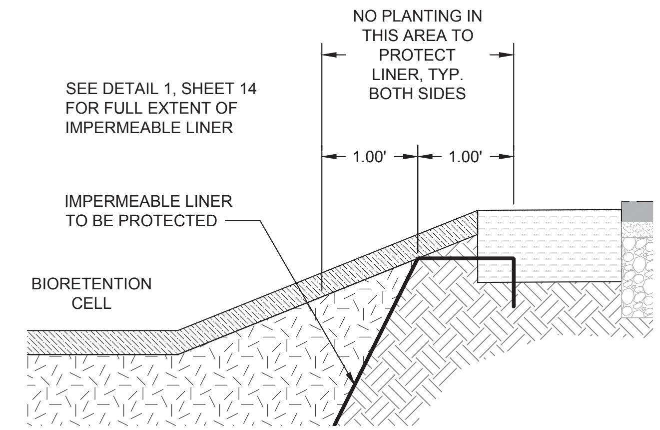


NOTES:

1. PLANT BARE ROOT AND PLUGS IN CLUSTERS OF THREE, FIVE, OR SEVEN PLANTS OF SAME SPECIES.
2. EVENLY SPACE CLUSTERS THROUGHOUT PLANTING AREA.
3. INTENT OF THE PLANTING IS TO APPEAR NATURAL AND INFORMAL. PLANTS SHOULD GROW INTO MASSINGS TO PROTECT SOIL AND PREVENT WEED ESTABLISHMENT.

DETAIL - GROUNDCOVER LAYOUT (2/-)

SCALE: NTS



DETAIL - NO PLANTING ZONE IMPERMEABLE LINER PROTECTION (3/-)

SCALE: NTS

PLANT SCHEDULE

TREES	QTY	BOTANICAL NAME	COMMON NAME	SIZE	CONTAINER	
	9	Acer circinatum	Vine Maple	1 gal.	Pot	
SHRUBS	QTY	BOTANICAL NAME	COMMON NAME	SIZE	CONTAINER	
	100	Mahonia repens	Creeping Mahonia	10"	Plug	
	100	Philadelphus lewisii	Wild Mockorange	18"-36"	BRS	
	152	Polystichum munitum	Western Sword Fern	4"	Pot	
	150	Rosa gymnocarpa	Wood Rose	18"-36"	BRS	
	100	Symphoricarpos albus	Common Snowberry	36"+	BRS	
	QTY	BOTANICAL NAME	COMMON NAME	SIZE	CONTAINER	SPACING
	3,023 sf	ZONE 1 PLANTING				
	150	Carex obnupta	Slough Sedge		BRS	36" o.c.
	100	Carex stipata	Awl-fruited Sedge		BRS	36" o.c.
	50	Iris douglasiana	Douglas Iris		BRS	24" o.c.
	150	Juncus patens	California Gray Rush		BRS	36" o.c.
	3,090 sf	SOD BLEND SHALL CONSIST OF 60% PERENNIAL RYE GRASS, 20% KENTUCKY BLUEGRASS, AND 20% HARD FESCUE				

No.	SHEET REVISION	DATE	BY	PLAN SET ISSUE	DATE
1					
2					
3					
4					

DESIGN	DRAWN	CHECK
NAS	CPM	CJW

DRAWING SCALE: AS NOTED
HORZ. DATUM: NAD83
VERT. DATUM: NAVD88

CONTRACT DATE: N/A
PROJECT No: N/A
ROAD/BRIDGE No: N/A
DRAWING FILE: N/A

PUBLIC WORKS DIRECTOR: ELIZABETH KOSA
PROGRAM MANAGER: KRAIG OLASON
PROJECT ENGINEER: CODY SWAN

HERRERA Science + Planning + Design herrerainc.com

WHATCOM COUNTY
DEPARTMENT OF PUBLIC WORKS
322 N. COMMERCIAL ST., SUITE 301 BELLINGHAM, WA 98225
(360) 778-6210

PROJECT: GENEVA BIORETENTION PILOT PROJECT, BID NO. 23-17

TITLE: RESTORATION DETAILS 2

SHEET: 18 OF: 19

TRAFFIC CONTROL NOTES:

1. TRAFFIC CONTROLS SHOWN ARE THE MINIMUM REQUIRED AND SHALL BE AUGMENTED BY THE CONTRACTOR IN ACCORDANCE WITH CONTRACTOR'S TRAFFIC CONTROL PLAN (TCP).
2. ALL SIGN CODES REFERENCE THE MUTCD.
3. CONTRACTOR SHALL SUBMIT TRAFFIC CONTROL PLAN PER MUTCD, WSDOT WORK ZONE TYPICAL TRAFFIC CONTROL PLANS AND STANDARD PLANS, AND SPECIAL PROVISIONS.
4. CONTRACTOR SHALL PROVIDE AND MAINTAIN SIGNAGE PER APPROVED TCP AND WSDOT TRAFFIC MANUAL, FOR ALL WORK THAT WILL IMPACT OR DELAY TRAFFIC ON AFFECTED ROADS. THIS PLAN SHOWS MINIMUM SIGNAGE TO BE INSTALLED FOR THE DURATION OF AUSTIN STREET CLOSURE. ADDITIONAL SIGNAGE AND TRAFFIC CONTROL MEASURES, INCLUDING, BUT NOT LIMITED TO, FLAGGERS, ROAD CLOSURE SIGNAGE, AND FLAGGING SIGNAGE REQUIRED TO PERFORM THE WORK, SHALL BE IDENTIFIED IN THE CONTRACTOR'S TCP.
5. IMPLEMENTATION OF ROAD CLOSURE TRAFFIC CONTROLS SHALL BE RESTRICTED TO THE TIME BETWEEN 7:00 AM AND 6:00 PM.
6. CONTRACTOR SHALL MAINTAIN A 4 FT WIDE (MIN) PEDESTRIAN ACCESS ROUTE ALONG THE EAST SIDE OF AUSTIN STREET AT ALL TIMES. CONTRACTOR SHALL INSTALL APPROPRIATE SIGNAGE TO DIRECT PEDESTRIANS TO THE ACCESS ROUTE. ANY TEMPORARY PEDESTRIAN WAY SURFACING SHALL BE ADA COMPLIANT.

GENERAL NOTES:

1. SEE SHEET 2 FOR LEGEND AND ABBREVATIONS.

CHRISTOPHER J. WEBB, STATE OF WASHINGTON, 35712, REGISTERED PROFESSIONAL ENGINEER
23-0323

No.	SHEET REVISION	DATE	BY
1			
2			
3			
4			

PLAN SET ISSUE	DATE

DESIGN	DRAWN	CHECK
NAS	CPM	CJW

DRAWING SCALE: AS NOTED
HORZ. DATUM: NAD83
VERT. DATUM: NAVD88

CONTRACT DATE: N/A
PROJECT No: N/A
ROAD/BRIDGE No: N/A
DRAWING FILE: N/A

PUBLIC WORKS DIRECTOR: ELIZABETH KOSA
PROGRAM MANAGER: KRAIG OLASON
PROJECT ENGINEER: CODY SWAN

HERRERA Science + Planning + Design
herrerainc.com

WHATCOM COUNTY
DEPARTMENT OF PUBLIC WORKS
322 N. COMMERCIAL ST., SUITE 301 BELLINGHAM, WA 98225
(360) 778-6210

PROJECT: GENEVA BIORETENTION PILOT PROJECT, BID NO. 23-17
TITLE: TRAFFIC CONTROL PLAN

SHEET: 19
OF: 19

O:\proj\Y2021\21-07565-001\CAD\Sheet\TrafficControl.dwg | 3/23/2023 1:07 PM | Neil Scherer

This page intentionally left blank

APPENDIX B

"Austin South" Bioretention Swale Site Photographs

This page intentionally left blank

Figure B-1. Photograph of the "Austin South" Bioretention Swale Under Construction.

Figure B-2. Photograph of the “Austin South” Bioretention Swale Dosing Siphon and Flow Splitter #1.

APPENDIX C

Equipment Specification Sheets

This page intentionally left blank

6527

STARFLOW QSD ULTRASONIC DOPPLER VELOCITY AND DEPTH INSTRUMENT

MODEL B

The Unidata 6527 Starflow QSD SDI-12 and Modbus Instrument is used to measure water velocity, depth and temperature of water flowing in rivers, streams, open channels and large pipes. When used with a companion Unidata IP data logger, flow rate and total flow can also be calculated.

The 6527 Instrument is robust, reliable and easy to use. It is completely sealed against water ingress, low maintenance, low power, no calibration and no fussy power arrangements required.

Ultrasonic Doppler Principle in Quadrature Sampling Mode is utilised to measure water velocity. The 6527 Instrument transmits ultrasonic energy through its epoxy casing into the water. Suspended sediment particles, or small gas bubbles in the water reflect some of the transmitted ultrasonic energy back to the 6527 Instrument's ultrasonic receiver instrument that processes this received signal and calculates the water velocity.

The 6527 Starflow QSD incorporates ultrasonic depth sensor and an absolute pressure depth sensor. An ultrasonic depth sensor measures water depth using the ultrasonic principle and has a range of up to 5m. An absolute pressure sensor measures pressure forces applied to the strain gauge. Absolute, non-vented, sensor reports a value equal to the sum of the water pressure and the atmospheric pressure above the water. In order to compensate for the atmospheric (barometric) pressure fluctuation, the 6527 Starflow QSD should be connected to the 6515 Starflow QSD barometric reference. The absolute pressure sensor has a range of up to 10m. Having sensors using different depth measurement methods provides flexibility in depth measurement.

The 6527 instrument's low profile form factor minimises disturbance to the flow it's measuring. Furthermore, 6527 instrument measures velocity in both directions and is suitable for use in wide range of water qualities, from sewage to potable water, sea water too.

With a companion Unidata data logger or a telemetered Neon Remote Logger the instrument can be programmed to compute flow rate and total flow in pipes and open channels of known dimensions.

SPECIFICATIONS

PHYSICAL SPECIFICATIONS	
MATERIAL:	Epoxy-sealed body, Marine Grade 316 Stainless Steel Mounting Bracket
SIZE:	135mm x 55mm x 22mm (LxWxH)
WEIGHT:	1kg with 15m of Cable
OPERATING TEMPERATURE:	0°C to 60°C water temperature
VELOCITY RANGE:	20mm/sec to 0.8 m/sec 20mm/sec to 1.6 m/sec (default) 20mm/sec to 3.2 m/sec 20mm/sec to 13.2 m/sec Bidirectional velocity capability, set using configuration tools
VELOCITY ACCURACY:	±1% typical
DEPTH RANGE: Ultrasonic Sensor:	20mm up to 5m above top surface of the instrument 40mm up to 5m from base of the instrument
DEPTH ACCURACY:	Typical ±1%

DEPTH RANGE: Absolute Pressure sensor:	0 to 10m
DEPTH ACCURACY:	Typical ±0.19% for 0m to 5m range Typical ±0.38% for 0m to 10m range
TEMPERATURE:	0°C to 60°C
TEMPERATURE RESOLUTION:	0.1°C
FLOW COMPUTATION:	Flow rate, totalised flow with companion NRT/NRL
CHANNEL TYPE:	Pipe, open channel, natural stream
CABLE:	15 metre, 6 way
CABLE OPTIONS:	User specified up to 50 metres
ELECTRICAL SPECIFICATIONS	
POWER SOURCE:	External Battery 12V – 24V DC
POWER USAGE:	10V to 24V DC, 50µA standby, 100mA active for 1 sec
SDI-12:	SDI-12V 1.3
RS 485:	Modbus RTU

AVAILABLE FROM: Unidata Pty Ltd | 40 Ladner Street, O'Connor, 6163 Western Australia | Tel: +61 8 9331 8600 | info@unidata.com.au | www.unidata.com.au

KELLER

HIGH ACCURACY SDI-12 LEVEL TRANSMITTER

ACCULEVEL SDI

SDI-12 OR RS485 DIGITAL OUTPUT SUBMERSIBLE

The Acculevel SDI by KELLER America provides outstanding Total Error Band (TEB)[2] accuracy for reliable, accurate measurements in real-world conditions. This level transmitter is certified to NSF/ANSI 61 and 372[6] standards for water quality and includes KELLER America's guaranteed lightning protection, making the Acculevel SDI an outstanding value for liquid level measurement.

The Acculevel SDI combines SDI-12 and RS485, two industry standard digital communication protocols, making it ideally suited for liquid level applications including surface water, streams, drinking water, stream and reservoir level, environmental monitoring, and reservoirs using existing SDI-12 monitoring equipment.

The Acculevel SDI is ideal for remote applications where battery-powered operation with minimal current draw and networking multiple sensors to a data recorder are required. Moreover, the included lightning protection makes it more robust for installation in areas prone to high current and voltage transients.

For more information on the Acculevel SDI, or any other KELLER product, please contact KELLER America. You may also see the complete line up of KELLER products at kelleramerica.com.

FEATURES

Standard ±0.1% FS TEB or optional USGS OSW accuracies available

- ±0.1% FS TEB on ranges up to 900 ft W.C.
- Meets OSW spec on ranges up to 70 ft W.C. from 0...40°C.

NSF/ANSI 61 and 372 certified construction for use in drinking water applications[7]

16-bit internal digital error correction for cost-effective low Total Error Band (TEB)[2]

Selectable digital outputs (SDI-12 or RS485) for maximum versatility.

RS485 modified-MODBUS and SDI-12 V1.3 protocol compatibility.

316L stainless construction standard - Optional titanium for severe applications.

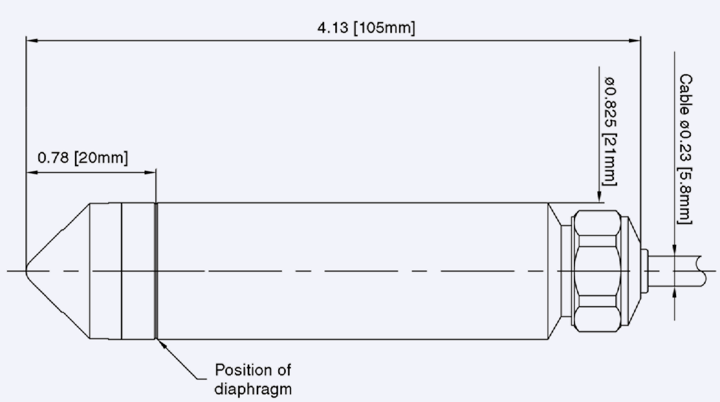
2-year warranty covers defects in materials and workmanship.

Lightning protection included at no additional cost.

Built in the U.S.A. ARRA Section 1605 Compliant.

CE

CLASSIFIED UL WATER QUALITY



Red	Black	White	Blue	Yellow
+Vcc	GND	SDI-12	RS485A	RS485B

Colors refer to 26AWG PE-jacketed cable conductors.

Braided shield wire connected to transmitter housing. For lightning protection to function properly the shield wire must be connected to a good earth ground!

KELLER America Inc.
Newport News, Virginia
www.kelleramerica.com
sales@kelleramerica.com

Edition 03/2021
Subject to alterations
877-253-5537
757-596-6659

KELLER

Pressure Ranges[1]

Relative	Infinite between 0...3 and 0...900 ft W.C.
Absolute	Available on request

1. Level range may be specified in units of bar, mbar, mH2O, psi, ftWC, or inWC

Accuracy[2,3]

Pressure	Standard ±0.1% FS TEB
	Optional ±0.01 ft WC when reading ≤ 10ftWC or ±0.1% of reading >10 ftWC
Temperature	typ. ± 0.3 °C

2. Total Error Band (TEB) includes the combined effects of non-linearity, hysteresis, and non-repeatability as well as thermal dependencies, over the compensated temperature range.

3. Optional accuracy is written in compliance with USGS OSW specification mandates and limited to a maximum range of 70 ftWC and a compensated temperature range of 0...40° C.

Output[4]

Digital	SDI-12 + RS485
Pressure Resolution	0.0005% FS
Temp. Resolution	< 0.01 °C
Comm. Protocol	SDI-12 V1.3, MODBUS RTU
Baud Rate	1200 bits/s

4. The Acculevel SDI can communicate in either SDI-12 or RS485 at any one time. By default, the Acculevel SDI will ship in SDI-12 mode. A USB Dongle is required to change to RS485 mode.

Certifications

CE	EN50081-1, EN50082-2
NSF / ANSI[7]	61, 372

Electrical[5]

Supply	6...32 VDC
Power Consumption	<0.1mA (Sleep)
	< 5.5 mA (active)
Startup Time	< 5 ms (interface ready)
Load Resistance (mA)	<(Supply-6V)/0.0055A
Insulation GND-CASE	> 10 MΩ @ 300 V

5. Nominal values may be higher depending upon cable length. Cable resistance (~70Ω / 1000ft) adds to the supply requirement. In order to insure proper system operation, calculate the minimum required supply voltage (at the source) as follows: MINIMUM SUPPLY VOLTAGE = 6 + 0.022 (CABLE LENGTH x 0.07) VDC

Environmental

Protection Rating	IP68
Storage Temp.	-20...80° C
Compensated Temp.	Standard -10...80° C
	Optional 0...40° C[6]
Wetted Materials	316 L Stainless Steel
	Titanium Optional
	Polyamide
Cable & Sealing	PE & EPDM for water / wastewater
	Hytrel & Viton for hydrocarbons
	Tefzel & Viton or EPDM as required for chemical interaction

6. Optional compensated temperature range applies to transmitters built to USGS OSW accuracy specification.

7. NSF/ANSI 61 and 372 approval applies to both 316L stainless steel & titanium construction with PE & EPDM cable sealing option, which is standard on this instrument unless otherwise specified.

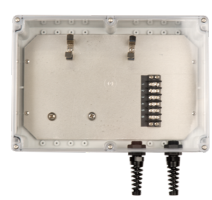
Optional Accessories


1/2" NPT Conduit Fitting


Drying Tube Assembly


Bellows Assembly


Cable Hanger


Termination Enclosure


Pressure Test Adapter


Stabilizing Weight


Interface Converter (RS485)

Process Meter


Open-faced Nose Cap

Signal Line Surge Protector

USB Dongle (SDI-12)

KELLER America Inc.
Newport News, Virginia
www.kelleramerica.com
sales@kelleramerica.com

Edition 03/2021
Subject to alterations
877-253-5537
757-596-6659

GRAINGER

Products Based on Your Search

KNAACK Jobsite Box: 48 in Overall Wd, 24 in...

Compare

Web Price

$894.27 / each

KNAACK Jobsite Box: 16 in Overall Wd, 30 in...

Compare

Web Price

$270.36 / each

KNAACK Jobsite Box: 36 in Overall Wd, 19 in...

Compare

Web Price

$714.46 / each

Related Categories

Jobsite Boxes & Cabinets

Tool Storage

Tools

Jobsite Boxes & Cabinets / KNAACK Jobsite Box: 48 in Overall Wd, 30...

KNAACK Jobsite Box: 48 in Overall Wd, 30 in Overall Dp, 34 1/4 in Overall Ht, Padlockable

Item **13R528** Mfr. Model **4830**

Compare

Web Price

$1,047.84 / each

This item requires special shipping, additional charges may apply.

Qty 1

Add to Cart

Ship

Pickup

Expected to arrive
Mon. Aug 14.

Ship to **98101** | Change

Shipping Weight **196 lbs**

Ship Availability Terms

Add to List

Product Details

Catalog Page 741

Body Finish **Gloss**

Body Gauge **16 ga**

Color **Tan**

Compatible Caster Manufacturer Model No. **495; 695**

Features

4-Way Pre-Punched Skids with 7-Gauge Construction Allow for Fast; Convenient Transport and Easy Caster Installation (Available as Optional Accessories); Heavy-Duty 16-Gauge Steel Chest Box Construction with Fully Arc-Welded Seams; Heavy-Duty Piano Hinge Offers Best-In-Class Jobsite Tool Chest Protection Against Break-Ins; Powder-Coat Finish for Superior Durability and Corrosion Resistance; Pre-Punched Skids Allow for Easy Installation of Optional Casters

Documents

Instruction Manual

Parts Li

Chat with an Agent

Handle Type **Recessed Side**

Includes **Electrical Grommet**

Includes Casters **No**

Jobsite Storage Type **Jobsite Box**

Lid Style **Hinged**

Locking System **Padlockable**

Material **Steel**

Maximum Padlock Shackle Diameter **3/8 in**

Number of Doors **0**

Number of Shelves **0**

Overall Depth **30 in**

Overall Height **34-1/4 in**

Overall Height with Lid Open **61 in**

Overall Width **48 in**

Total Storage Capacity **25.25 cu ft**

UNSPSC **24112401**

Country of Origin **Mexico (subject to change)**

Product Description
Chest-style jobsite boxes have a wide, undivided interior to store tool boxes, tool organizers, and long or bulky tools and equipment. Their hinged lid lifts for access to load and unload the box.

Compatible Products

Chat with an Agent

KNAACK Caster Set: 6 in Caster Dia, 6 in Caster Ht, (2) Rigid Casters/(2) Swivel Casters/Hardware

Item **13R539**

Compare

Web Price

$256.32 / each

Qty

1

Add to Cart

KNAACK Caster Set: 4 in Caster Dia, 4 in Caster Ht, (2) Rigid Casters/(2) Swivel Casters, Black

Item **13R540**

Compare

Web Price

$219.75 / each

Qty

1

Add to Cart

KNAACK Tool Tray: 8 in Overall Wd, 27 5/8 in Overall Lg, 4 in Overall Ht, Built-In Handle, Steel

Item **13R542**

Compare

Web Price

$108.46 / each

Qty

1

Add to Cart

KNAACK Grommet: 4 in Overall Wd, 4 in Overall Lg, 4 in Overall Ht, Rubber, Black

Item **14V883**

Compare

Web Price

$45.84 / each

Qty

1

Add to Cart

Chat with an Agent

This page intentionally left blank

TE525-L

Rain Gage with 6 in. Orifice

Overview

The TE525, manufactured by Texas Electronics, has a 6 in. orifice and measures rainfall in 0.01 in. increments. It is compatible with all Campbell Scientific data loggers, and it is widely used in environmental monitoring applications.

Benefits and Features

- Accuracy is ±1 percent at rates up to 1 in./hr
- Compatible with most Campbell Scientific data loggers
- High precision—tips at 0.01-in. increments
- Compatible with the CWS900-series interfaces, allowing it to be used in a wireless sensor network

Detailed Description

The TE525 funnels precipitation into a bucket mechanism that tips when filled to its calibrated level. A magnet attached to the tipping mechanism actuates a switch as the bucket tips. The momentary switch closure is counted by the pulse-counting circuitry of our data loggers.

Specifications

Sensor Type	Tipping bucket with magnetic reed switch
Material	Anodized aluminum
Operating Temperature Range	0° to 50°C
Resolution	1 tip
Volume per Tip	4.73 ml/tip (0.16 fl. oz/tip)
Rainfall per Tip	0.254 mm (0.01 in.)
Measurement Uncertainty	1.0% up to 50 mm/h (2 in./h)
Cable Type	2-conductor shielded
Orifice Diameter	15.4 cm (6.06 in.)
Height	24.1 cm (9.5 in.)
Cable Weight	0.1 kg (0.2 lb) per 3.05 m (10 ft) length
Tipping Bucket Weight	0.9 kg (2.0 lb)

For comprehensive details, visit: www.campbellsci.com/te525-l

© 2022 Campbell Scientific, Inc. | 04/10/2022

This page intentionally left blank

Rugged TROLL® 100 and 200 Data Loggers

RUGGED TROLL 100 AND 200 DATA LOGGERS ARE DESIGNED FOR LONG- AND SHORT-TERM GROUNDWATER AND SURFACE WATER MONITORING. THESE NON-VENTED (ABSOLUTE) WATER LEVEL DATA LOGGERS MEASURE AND RECORD CHANGES IN WATER LEVEL, PRESSURE, AND TEMPERATURE. ENSURE ACCURATE RESULTS BY USING A RUGGED BAROTROLL® DATA LOGGER. ALL LOGGERS ARE COMPATIBLE WITH THE USER-FRIENDLY VUSITU® MOBILE APP.

AFFORDABLE TITANIUM DATA LOGGERS

- Get reliable data at a budget-friendly price.
- Use in harsh environments. Solid titanium construction offers chemical- and corrosion-resistance and outlasts specially-coated data loggers.
- Select the appropriate logging mode for your project: Linear, Fast Linear, or Event.

FLEXIBLE DEPLOYMENT OPTIONS

- Deploy zero-maintenance loggers in flood-prone areas, high-humidity environments, and remote locations.
- Choose the cable length and termination type that works best for your project.
- Use suspension wire and backshell hanger for applications requiring minimal instrument access.

TOTAL FIELD SUPPORT

- Receive quick-response technical support and online resources.
- Order data loggers and accessories directly from our website.
- Get guaranteed 7-day service for maintenance.

SIMPLIFIED SETUP AND DATA RETRIEVAL

- The mobile app guides you through instrument and log setup, and data management. Log data to your smartphone and download results in a Universal Data File.
- Simplify instrument setup, reduce errors and improve data use with Log Setup Assistant and Panoramic Live Data.
- Connect a cabled logger to a telemetry system, radio, controller, or a SCADA/PLC system via Modbus/RS485 or SDI-12 (with the Rugged TROLL 200 and Rugged BaroTROLL).
- Integrate with VuLink® Telemetry and HydroVu® Data Services for real-time feedback on your remote monitoring sites.

EXTENDED SHELF LIFE

- The battery indicator on Rugged TROLL 100 and 200 instruments is controlled by an algorithm so that it will not count down until your unit is deployed and has taken at least 1,000 readings or is more than 9 months past its manufacturing date.

Applications:

- **COASTAL WETLAND AND ESTUARY RESEARCH**
- **CREST STAGE GAGING AND STREAM GAGING**
- **DRILLING AND WELL DEVELOPMENT**
- **FLOOD AND STORM SURGE MONITORING**
- **LANDFILL LEACHATE MONITORING**

Rugged TROLL® 100 and 200 Data Loggers

GENERAL	RUGGED TROLL 100 & 200	RUGGED BAROTROLL
TEMPERATURE RANGES[1]	Operational: 0-50° C (32-122° F) Storage: -40-80° C (-40-176° F) Calibrated: 0-50° C (32-122° F)	Operational: 0-50° C (32-122° F) Storage: -40-80° C (-40-176° F) Calibrated: 0-50° C (32-122° F)
DIAMETER	2.62 cm (1.03 in.)	2.62 cm (1.03 in.)
LENGTH	14.43 cm (5.68 in.)	14.43 cm (5.68 in.)
WEIGHT	137 g (0.30 lb)	137 g (0.30 lb)
MATERIALS	Titanium, Acetal, FKM Fluoroelastomer, Ceramic	Titanium, Acetal, FKM Fluoroelastomer, Ceramic
OUTPUT OPTIONS	Rugged TROLL 100: USB via docking station; Wireless Rugged TROLL Com Rugged TROLL 200: USB via docking station; Wireless Rugged TROLL Com; Modbus/RS485 or SDI-12 via Rugged TROLL 200 Cable	USB or RS232 via docking station; Modbus/RS485 or SDI-12 via Rugged TROLL 200 Cable; Wireless Rugged TROLL Com Device
BATTERY TYPE & LIFE[2]	3.6V lithium; 10 years or 2M readings	3.6V lithium; 10 years or 2M readings
EXTERNAL POWER	Rugged TROLL 100: NA Rugged TROLL 200: 8-36 VDC	8-36 VDC
MEMORY Data records[3] Data logs	2.0 MB 120,000 Rugged TROLL 100: 1 log Rugged TROLL 200: 2 logs	2.0 MB 120,000 1 log
FASTEST LOGGING RATE	1 per second	1 per minute
FASTEST OUTPUT RATE	Rugged TROLL 200 only Modbus & SDI-12: 1 per second	Modbus & SDI-12: 1 per second
LOG TYPES	Linear, Fast Linear, and Event	Linear
SENSOR TYPE/ MATERIAL	**PIEZORESISTIVE; CERAMIC**	**PIEZORESISTIVE; CERAMIC**
RANGE	9 m (30 ft) (Burst: 18 m; 60 ft) 30 m (100 ft) (Burst: 40 m; 134 ft) 76 m (250 ft) (Burst: 112 m; 368 ft)	7 to 30 psi; 0.5 to 2 bar
ACCURACY	±0.05% FS from 0 to 50 °C	±0.05% FS from 0 to 50 °C
RESOLUTION	±0.01% FS or better	±0.01% FS or better
UNITS OF MEASURE	Pressure: psi, kPa, bar, mbar, mmHg Level: in., ft, mm, cm, m	Pressure: psi, kPa, bar, mbar, mmHg, inHg
TEMPERATURE SENSOR	**SILICON**	**SILICON**
ACCURACY	±0.3° C	±0.3° C
RESOLUTION	0.01° C or better	0.01° C or better
UNITS OF MEASURE	Celsius or Fahrenheit	Celsius or Fahrenheit
WARRANTY	**2 YEARS**	**2 YEARS**

NOTES: 1 Temperature range for non-freezing liquids. 2 Typical battery life when used within the factory-calibrated temperature range. 3 1 data record = date/time plus 2 parameters logged for a total of 360,000 data points, no wrapping. Delrin is a registered trademark of E.I. du Pont de Nemours & Co. Specifications are subject to change without notice. Android is a trademark of Google Inc.

VUSITU MOBILE APP FOR WIRELESS CONNECTION

Use the VuSitu Mobile App to view results instantly from your Android™ or iOS™ smartphone or tablet when connected to the Wireless Rugged TROLL Com or the Wireless Rugged TROLL Com. Consolidate all site information and tag data with site photos and GPS coordinates. Log data to your smartphone and download results in a standard .csv file format.

RUGGED TROLL® 200 CABLE

Use the Rugged TROLL Direct-Read Cable to connect your Rugged TROLL 200 Data Logger or Rugged BaroTROLL Data Logger directly to a controller or logger. The cable comes in 2 communication modes:

- Direct Read Cable for SDI-12 (always Stripped and Tinned)
- Direct Read Cable for RS485
  - Twist-lock connector for connection to VuLink or Wireless TROLL Com
  - Top of Well connector for connection to Wireless Rugged TROLL Com or Rugged TROLL Com
  - Stripped and Tinned for connection to third-party telemetry/ data loggers

JACKET OPTIONS	TPU (thermoplastic polyurethane)
CONDUCTORS	4 conductors, 24 AWG, polypropylene insulation
DIAMETER	Cable: 5.1 mm (0.200 in.) Connector: 26.1 mm (1.03 in.)
CABLE LENGTHS	Modbus/RS485: Customizable up to 300 m (1,000 ft) SDI-12: Standard lengths up to 60 m (200 ft)
MINIMUM BEND RADIUS	5X cable diameter
BREAK STRENGTH	68 kg (150 lbs)

WIRELESS RUGGED TROLL® COM COMMUNICATION DEVICE

Use the Wireless Rugged TROLL Com Device for communication between a cabled Rugged TROLL 100/200 or a cabled Rugged BaroTROLL and a VuSitu Mobile App or a laptop/PC.

OPERATING TEMP. RANGE	-5-50° C (23-122° F), 95% relative humidity, non-condensing
STORAGE TEMP. RANGE	-20-50° C (-4-122° F), 95% relative humidity, non-condensing*
MATERIALS	PC/ABS blend, Silicon, Urethane, Stainless Steel, Brass, Santoprene, Poron, Polyethylene, Versapor, Titanium, PEEK, Viton
ENVIRONMENTAL RATING	IP67
DIMENSIONS (LXWXH) WEIGHT (WITH BATTERIES)	6.3 x 1.710 x 1.210 in. 165 g
COMMUNICATION PROTOCOL	Android: SPP; Windows: SPP or USB
OUTPUT CONNECTION	Bluetooth and USB communication
BATTERY TYPE	1 3.7V 8600mWHr Lithium Rechargable cell (UBBL19-FL)
CHARGING REQUIREMENTS	5VDC USB charger (1A or 500 mA)
CERTIFICATIONS	CE, FCC (SSSBC127-X), WEEE
WARRANTY	1 year

Copyright © 2023 In-Situ Inc. All rights reserved. July 2023

CR350-Series Specifications

Data Logger

Electrical specifications are valid over a -40 to +70 °C, non-condensing environment, unless otherwise specified. Recalibration is recommended every three years. Critical specifications and system configuration should be confirmed with Campbell Scientific before purchase.

System specifications

Processor: ARM Cortex M4 running at 120 MHz

Memory:

- CPU Drive: 50 MB serial flash
- Data Storage: 50 MB serial flash
- Operating System: 2 MB flash
- Settings, Calibration, TLS Certificates and Key, System Information: 3 MB serial flash
- Background Tasks and Table Information, Buffers, System Memory, Program Variables: 7 MB RAM

Program Execution Period: 100 ms to 1 day

Real-Time Clock:

- Battery backed while external power is disconnected
- **Resolution**: 1 ms
- **Accuracy**: ±3 min. per year

Wiring Panel Temperature: Measured using a sensor, located on the processor board.

Physical specifications

Dimensions (additional clearance required for cables, wires and antennas):

- **CR350**: 16.3 x 8.4 x 5.6 cm (6.4 x 3.3 x 2.2 in)

Weight/Mass:

- **CR350**: 288 g (0.64 lb)
- **CR350-WIFI/RF407/RF412/RF422**: 306 g (0.68 lb)

Case Material: High-impact-resistant polycarbonate, recycle code 7

Power requirements

Power specifications for a communications option are shown within the specifications section for that option.

Protection: Power inputs are protected against surge, over-voltage, over-current, and reverse power. IEC 61000-4 Class 4 level.

Charge Terminal Characteristics (CHG+ and CHG-):

- Input from power converter or solar panel, typical
- Voltage input 16 to 32 VDC
- Current limit at 1.1 A

Battery Terminal Characteristics (BAT+ and BAT-):

- Input from external battery 12 VDC, 7 Ah lead-acid, typical
- Voltage input 10 to 18 VDC
- Current limit at 3.7 A

Internal Lithium Battery: 3 V coin cell CR2025 for battery-backed clock. 6-year life with no external power source.

Average Current Drain:

Assumes 12 VDC on BAT terminals — add 2 mA if using CHG terminals.

- **Idle**: 0.5 mA
- **Active 1 Hz scan w/ one analog measurement**: 1.5 mA
- **Active** (Processor always on): 8 mA
- **Serial** (RS-232): Active + 5 mA

Copyright © 2023
Campbell Scientific, Inc.

USB Power: Functions that will be active with USB 5 VDC include sending programs, adjusting data logger settings, and making some measurements. If USB is the only power source, then the VX1 and VX2 ranges are reduced to 150 to 2500 mV. The SW1, SW2, and 12V terminals will not be operational. For the control terminals (C1, C2), voltage output is limited to 4.75 V.

Cellular Average Additional Current Contribution at 12 VDC:

- **Idle**: Connected to network, no data transfer.
  - -CELL205 average = 14 mA
  - -CELL210 average = 28 mA
  - -CELL215 average = 14 mA
  - -CELL220 average = 14 mA
  - -CELL225 average = 14 mA
- **Transfer/Receive**:
  - -CELL205 average = 75 mA
  - -CELL210 average = 90 mA
  - -CELL215 average = 75 mA
  - -CELL220 average = 75 mA
  - -CELL225 average = 75 mA

Wi-Fi Additional Current Contribution at 12 VDC:

- **Client mode communicating**: 70 mA typical
- **Client mode idle**: 7 mA typical
- **Access point mode communicating**: 70 mA
- **Access point mode idle**: 62 mA typical
- **Idle**: <0.1 mA

RF Average Additional Current Contribution at 12 VDC

	-RF407, -RF412, -RF427	-RF422
Transmit	< 80 mA	20 mA
Idle On	12 mA	9.5 mA
Idle 0.5 s Power Mode	4 mA	3.5 mA
Idle 1 s Power Mode	3 mA	2 mA
Idle 4 s Power Mode	1.5 mA	1.5 mA

Power output specifications

System power out limits (when powered with 12 VDC):

Temperature (°C)	Current Limit[1] (A)
–40°	5.8
20°	3.7
70°	2.0
[1] Limited by self-resetting thermal fuse	

12V: Provide unregulated 12 VDC power with voltage equal to BAT+ input voltage. Disabled when operating on USB power only. Current output limited by thermal fuses. Two 12V terminals share one thermal fuse up to 2.5 A @ 20 °C.

- **Terminals**:
  - **12V**: two terminals, always on
  - **SW1 and SW2**: switched under program control, current limit at 2.1 A each

VX: Two independently configurable voltage terminals (VX1-VX2). VX outputs are produced by a 12-bit DAC[1]. VX terminals can also be used to supply a switched, regulated 5 VDC power source to power digital sensors and toggle control lines.

- **Range**: 150 to 5000 mV
- **Resolution**: 1.6 mV
- **Maximum Source Current**: 50 mA total, concurrently or independently.

Analog measurement specifications

4 single-ended (SE) or 2 differential (DIFF) terminals individually configurable for voltage, thermocouple, current loop, ratiometric, and period average measurements, using a 24-bit ADC. One channel at a time is measured.

Voltage measurements

Terminals:

- **Differential Configuration**: DIFF 1H/1L – 2H/2L
- **Single-Ended Configuration**: SE1 – SE4

Input Resistance:

- 5 GΩ typical (f_{N1} = 50/60 Hz)
- 300 MΩ typical (f_{N1} = 4000 Hz)

Input Voltage Limits: -100 to +2500 mV

Sustained Input Voltage without Damage:

- SE1-SE2: –6 V, +9 V
- SE3-SE4: ±17 V

DC Common Mode Rejection:

- >120 dB with input reversal
- ≥90 dB without input reversal

Normal Mode Rejection:

- >71 dB at 50 Hz
- >74 dB at 60 Hz

Input Current @ 25 °C:

- ±.08 nA typical (f_{N1} = 50/60 Hz)
- ±13 nA typical (f_{N1} = 4000 Hz)

Filter First Notch Frequency (f_{N1}) Range: 50/60, 400, 4000 Hz (user specified)

[1]Digital to analog conversion. The process that translates digital voltage levels to analog values.

Analog Range and Resolution:

		Differential with input reversal		Single-ended and differential without input reversal	
Notch frequency (f_{N1}) (Hz)	Range[1] (mV)	RMS (µV)	Bits[2]	RMS (µV)	Bits[2]
4000	–100 to +2500 –34 to +34	23 3.0	16.8 14.5	33 4.2	16.3 14.0
400	–100 to +2500 –34 to +34	3.8 0.58	19.4 16.8	5.4 0.82	18.9 16.3
50/60[3]	–100 to +2500 –34 to +34	1.6 0.23	20.6 18.2	2.3 0.33	20.1 17.7

[1] Range overhead of ~10% on all ranges guarantees that full-scale values will not cause over range

[2] Typical effective resolution (ER) in bits; computed from ratio of full-scale range to RMS resolution.

[3] 50/60 corresponds to rejection of 50 and 60 Hz ac power mains noise.

Accuracy (does not include sensor or measurement noise):

- 0 to 40 °C: ±(0.04% of measurement + offset)
- –40 to 70 °C: ±(0.1% of measurement+ offset)

Voltage Measurement Accuracy Offsets:

	Typical offset (µV RMS)		
Range (mV)	Differential with input reversal	Differential without input reversal	Single-ended
–100 to +2500	±20	±40	±60
–34 to +34	±6	±14	±20

Measurement Settling Time: 10 µs to 50 ms; 500 µs default

Multiplexed Measurement Time:

Measurement time = (multiplexed measurement time + settling time) • reps +0.8 ms

	Differential with input reversal	Single-ended or differential without input reversal
Example fN1[1] (Hz)	Time[2] (ms)	Time[2] (ms)
4000	2.9	1.4
400	14.6	7.3
50/60	103	51.5

[1] Notch frequency (1/integration time).

[2] Default settling time of 500 µs used.

Resistance measurement specifications

The data logger makes ratiometric-resistance measurements for four- and six-wire full-bridge circuits and two-, three-, and four-wire half-bridge circuits using voltage excitation.

Accuracy:

Assumes input reversal for differential measurements `RevDiff`. Does not include bridge resistor errors or sensor and measurement noise.

- **0 to 40 °C**: ±(0.05% of voltage measurement + offset)
- **–40 to 70 °C**: ±(0.06% of voltage measurement + offset)

Current-loop measurement specifications

Two analog inputs terminals may be configured as independent, non-isolated 0-20 mA or 4-to-20 mA current-loop inputs referenced to ground. One channel at a time is measured. Current is measured using a 24-bit ADC[1].

Terminals: SE1-SE2

Range: 0 to 25 mA

Accuracy:

- **0 to 40 °C**: ±0.14% of reading
- **–40 to 70 °C**: ±0.26% of reading

Pulse measurement specifications

Terminals are individually configurable for switch closure, high-frequency pulse, or low-level AC measurements.

Switch-closure input

Terminals:

- P_SW
- C1-C2 (Requires an external 100 kΩ resistor connected from the terminal to VX1 or VX2.)
- SE1-SE4 (Requires an external 100 kΩ resistor connected from the terminal to VX1 or VX2.)

Maximum Input Frequency: 150 Hz

Minimum Switch Closed Time: 3 ms

Minimum Switch Open Time: 3 ms

Maximum Bounce Time: 1 ms open without being counted

[1]Analog to digital conversion. The process that translates analog voltage levels to digital values.

High-frequency input

Terminals:

- SE1-SE4
- P_LL
- P_SW
- C1-C2

Maximum Input Frequency:

- SE1-SE4: 35 kHz
- P_LL: 20 kHz
- P_SW: 35 kHz
- C1-C2: 35 kHz

Low-level AC input

Terminals: P_LL

Maximum Input Voltage: ±20 VDC

DC-offset Rejection: Internal AC coupling eliminates DC-offset voltages up to ±0.05 VDC

Input Hysteresis: 12 mV at 1 Hz

Low-Level AC Pulse Input Ranges:

Sine wave (mV RMS)	Range (Hz)
20	1.0 to 20
200	0.5 to 200
2000	0.3 to 10,000
5000	0.3 to 20,000

Quadrature input

Terminals: SE1 and SE2, SE3 and SE4, or C1 and C2 can be configured as digital terminal pairs to monitor the two sensing channels of an encoder.

Maximum Frequency: 2.5 kHz

Period-averaging measurement specifications

Terminals:

- SE1-SE4
- C1-C2

Accuracy: ±(0.01% of measurement + resolution), where resolution is 0.13 µs divided by the number of cycles to be measured

Voltage Range: 0 to 3.3 V

Minimum Pulse Width: 33 ns

Voltage Threshold: Counts cycles on transition from <0.9 VDC to >2.1 VDC

Digital input/output specifications

Up to seven terminals may be configured for digital input or output (I/O).

Terminals:

- SE1-SE4
- P_SW
- C1-C2

Digital I/O Voltage Levels:

Terminal	High State	Low State	Current Source	Maximum Input Voltage
C1 C2	5.0 V output 3.3V input	0 V	10 mA at 3.5 V	–10 V, +15 V
SE1 SE2	3.3 V	0 V	100 µA at 3.0 V	–6 V, +9 V
SE3 SE4 P_SW	3.3 V	0 V	100 µA at 3.0 V	±17 V

Pulse-width modulation

Terminals:

- SE1-SE4
- C1

Period Maximum: 2047 ms

Resolution

- 0 – 5 ms: 83.33 ns or 12 MHz
- 5 – 325 ms: 5.00 µs or 200 kHz
- > 325 ms: 31.25 µs or 32 kHz

Communications specifications

Internet Protocols: Ethernet, PPP, RNDIS, ICMP/Ping, Auto-IP (APIPA), IPv4, IPv6, UDP, TCP, TLS (v1.2), DNS, DHCP, SLAAC, Telnet, HTTP(S), FTP(S), POP3/TLS, NTP, SMTP/TLS, MQTT

Additional Protocols: PakBus, PakBus Encryption, SDI-12, Modbus RTU / ASCII / TCP, DNP3, custom user definable over serial

USB: Type C 2.0. Full speed: 12 Mbps. Operates as:

- Device for computer communications
- Host for mass storage devices

SDI-12 (C1, C2): Two independent SDI-12 compliant terminals are individually configured and meet SDI-12 Standard v 1.4.

RS-232:

- **COMRS232**: Female RS-232, 9-pin interface, 1200 to 115.2 kbps
- **COM1 (C1,C2)**: TTL or RS-232 logic
- **COM2 - COM3**: Two independent RS-232 Rx/Tx pairs

RS-485 (COM2 - COM3): Two independent RS-485 half duplex or one full duplex

Cellular option specifications

Cell Technology:

Option	Cellular Protocol
-CELL205	4G LTE with automatic 3G fallback
-CELL210	4G LTE CAT-1

Option	Cellular Protocol
-CELL215	4G LTE with automatic 3G fallback
-CELL220	4G LTE with automatic 3G fallback
-CELL225	4G LTE

See https://s.campbellsci.com/documents/us/miscellaneous/Cellular%20Modem%20Frequency%20Bands.pdf for a complete list of supported frequency bands.

Antenna: Two SMA connectors, one for TX/RX, one for diversity RX

SIM Slot: Industry standard 3FF micro-SIM (6 position / contacts) (not externally accessible)

Wi-Fi specifications

WLAN (Wi-Fi)

Maximum Possible Over-the-Air Data Rates: <11 Mbps over 802.11b, <54 Mbps over 802.11g, <72 Mbps over 802.11n

Operating Frequency: 2.4 GHz, 20 MHz bandwidth

Antenna Connector: Reverse Polarity SMA (RPSMA)

Antenna (shipped with data logger): Unity gain (0 dBd), 1/2 wave whip, omnidirectional. Features an articulating knuckle joint that can be oriented vertically or at right angles

Supported Technologies: 802.11 b/g/n, WPA/WPA2-Personal, WPA/WPA2-Enterprise Security, WEP

Client Mode: WPA/WPA2-Personal and Enterprise, WEP

Access Point Mode: WPA2-Personal

Receive Sensitivity: -97 dBm

RF radio option specifications

Antenna Terminal: Reverse Polarity SMA (RPSMA)

Radio Type

- **RF407, RF412**, and **RF427**: Frequency-Hopping Spread-Spectrum (FHSS)
- **RF422**: SRD860 Radio with Listen Before Talk (LBT) and Automatic Frequency Agility (AFA)

Frequency

- **RF407**: 902 to 928 MHz (US, Canada)
- **RF412**: 915 to 928 MHz (Australia, New Zealand)
- **RF422**: 863 to 870 MHz (Europe, Middle East, and Africa)
- **RF427**: 902 to 907.5 MHz/915 to 928 MHz (Brazil)

Transmit Power Output (software selectable)

- **RF407** and **RF412**: 5 to 250 mW
- **RF422**: 2 to 25 mW
- **RF427**: 5 to 250 mW

Channel Capacity

- **RF407**: Eight 25-channel hop sequences sharing 64 available channels.
- **RF412**: Eight 25-channel hop sequences sharing 31 available channels.
- **RF422**: Ten 30-channel hop sequences (default), software configurable to meet local regulations; 10 sequences for reducing interference through channel hop.
- **RF427**: Eight 25-channel hop sequences sharing 43 available channels.

Receive Sensitivity

- **RF407**, **RF412**, and **RF427**: –101 dBm
- **RF422**: –106 dBm

RF Data Rate

- **RF407**, **RF412**, and **RF427**: 200 kbps
- **RF422**: 10 kbps

Maximum nodes in network

- **RF407**, **RF412**, and **RF427**: 50
- **RF422**: 20

Standards compliance specifications

View compliance and conformity documents at www.campbellsci.com/cr350.

Shock and Vibration: ASTM D4169

Protection: IP30

EMI and ESD protection:

- **Immunity**: Meets or exceeds following standards:
  - **ESD**: per IEC 61000-4-2; ±15 kV air, ±8 kV contact discharge
  - **Radiated RF**: per IEC 61000-4-3; 10 V/m, 80-1000 MHz
  - **EFT**: per IEC 61000-4-4; 4 kV power, 4 kV I/O
  - **Surge**: per IEC 61000-4-5; 4 kV power, 4kV I/O
  - **Conducted RF**: per IEC 61000-4-6; 10 V power, 10 V I/O
- Emissions and immunity performance criteria available on request.

RF407 Option

- United States FCC Part 15.247: MCQ-XB900HP
- Industry Canada (IC): 1846A-XB900HP
- Mexico IF: RCPDIXB15-0672-A1

RF412 Option

- ACMA RCM
- United States FCC Part 15.247:
- MCQ-XB900HP
- Industry Canada (IC): 1846A-XB900HP

RF422 Option: View EU Declaration of Conformity at www.campbellsci.com/cr350.

RF427 Option: Brazil ANATEL standards in Resolution No. 506: 08335-17-10644. View the RF427 Brazilian Certificate of Conformity at www.campbellsci.com/cr350.

Wi-Fi

- United States FCC ID: XF6-RS9113SB
- Industry Canada (IC): 8407A-RS9113SB

Cellular Option:

- Industry Canada (IC): 10224A-201611EC21A

> **NOTE:**
> The user is responsible for emissions if changing the antenna type or increasing the gain.

Warranty

Three years against defects in materials and workmanship.

Terminal functions

Analog input terminal functions				
SE	1	2	3	4
DIFF	1 H	1 L	2 H	2 L
Single-Ended Voltage	✓	✓	✓	✓
Differential Voltage	H	L	H	L
Ratiometric/Bridge	✓	✓	✓	✓
Thermocouple	✓	✓	✓	✓
Current Loop	✓	✓		

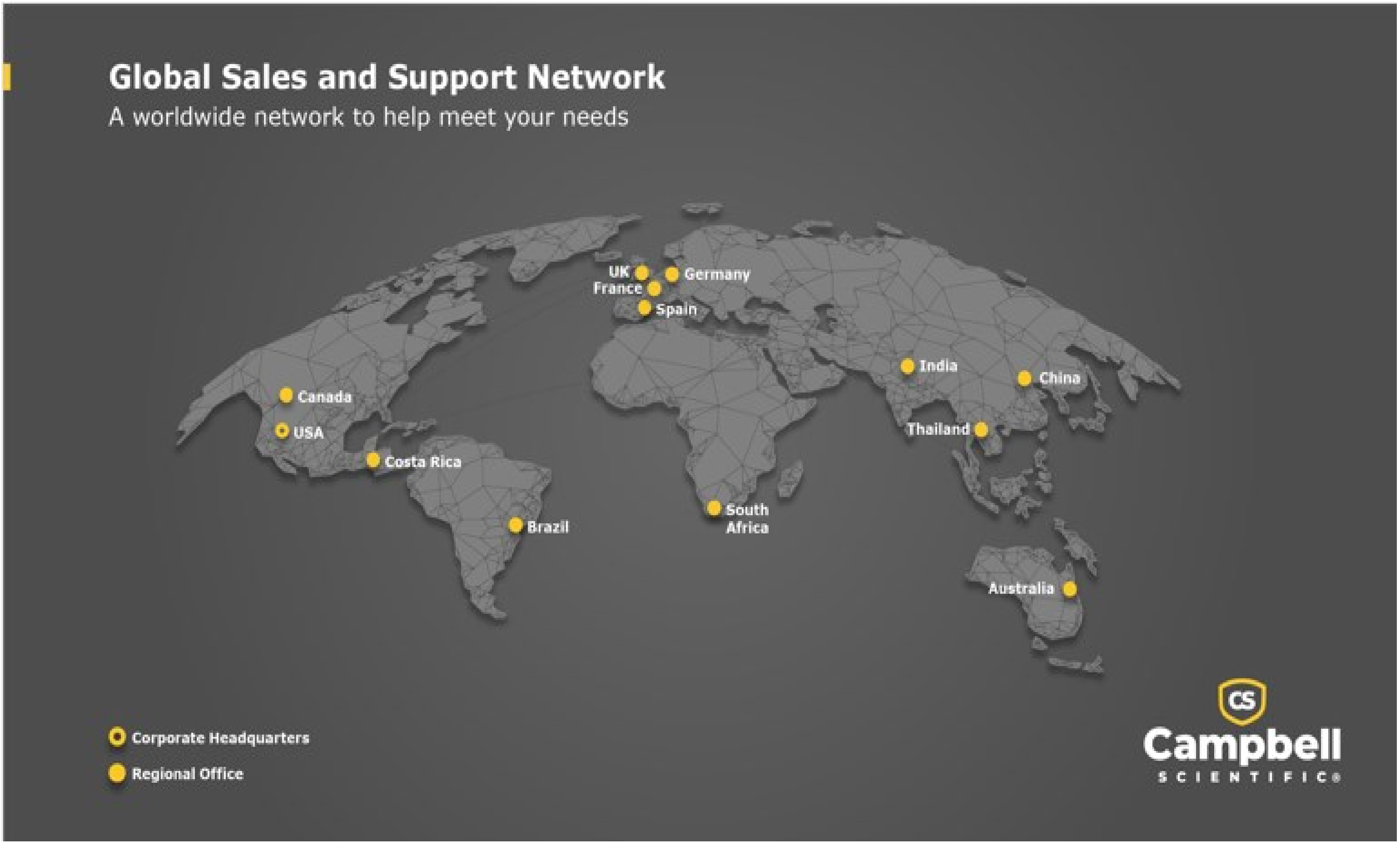
Pulse counting terminal functions	C1	C2	P_SW	P_LL	SE1	SE2	SE3	SE4
Switch-Closure	✓	✓	✓		✓	✓	✓	✓
High Frequency	✓	✓	✓	✓	✓	✓	✓	✓
Low-level AC				✓				
Quadrature	✓	✓			✓	✓	✓	✓
Period Average	✓	✓			✓	✓	✓	✓

Analog output terminal functions	VX1	VX2
Switched Voltage Excitation	✓	✓

Voltage output terminal functions	C1	C2	SE1-4	VX1	VX2	P_SW	12V	SW1 SW2
3.3 VDC			✓	✓	✓	✓		
5 VDC	✓	✓		✓	✓			
BAT +							✓	✓

Communications terminal functions	C1	C2	SE1-3	RS-232	COM2	COM3
SDI-12	✓	✓				
RS-232				✓	✓	✓
RS-232 0-5V	✓	✓				
GPS Time Sync	✓	✓	✓			
GPS NMEA Sentences	Rx	Rx		Rx		
RS-485 Half duplex					✓	✓
RS-485 Full duplex					✓ (COM2–COM3)	
Communications functions also include USB						

Digital I/O terminal functions							
	C1	C2	P_SW	SE1	SE2	SE3	SE4
General I/O	✓	✓	✓	✓	✓	✓	✓
Pulse-Width Modulation Output	✓			✓	✓	✓	✓
Interrupt	✓	✓	✓	✓	✓	✓	✓



Campbell Scientific Regional Offices

Australia

Location: Garbutt, QLD Australia
Phone: 61.7.4401.7700
Email: info@campbellsci.com.au
Website: www.campbellsci.com.au

Brazil

Location: São Paulo, SP Brazil
Phone: 11.3732.3399
Email: vendas@campbellsci.com.br
Website: www.campbellsci.com.br

Canada

Location: Edmonton, AB Canada
Phone: 780.454.2505
Email: dataloggers@campbellsci.ca
Website: www.campbellsci.ca

China

Location: Beijing, P. R. China
Phone: 86.10.6561.0080
Email: info@campbellsci.com.cn
Website: www.campbellsci.com.cn

Costa Rica

Location: San Pedro, Costa Rica
Phone: 506.2280.1564
Email: info@campbellsci.cc
Website: www.campbellsci.cc

France

Location: Montrouge, France
Phone: 0033.0.1.56.45.15.20
Email: info@campbellsci.fr
Website: www.campbellsci.fr

Germany

Location: Bremen, Germany
Phone: 49.0.421.460974.0
Email: info@campbellsci.de
Website: www.campbellsci.de

India

Location: New Delhi, DL India
Phone: 91.11.46500481.482
Email: info@campbellsci.in
Website: www.campbellsci.in

South Africa

Location: Stellenbosch, South Africa
Phone: 27.21.8809960
Email: sales@campbellsci.co.za
Website: www.campbellsci.co.za

Spain

Location: Barcelona, Spain
Phone: 34.93.2323938
Email: info@campbellsci.es
Website: www.campbellsci.es

Thailand

Location: Bangkok, Thailand
Phone: 66.2.719.3399
Email: info@campbellsci.asia
Website: www.campbellsci.asia

UK

Location: Shepshed, Loughborough, UK
Phone: 44.0.1509.601141
Email: sales@campbellsci.co.uk
Website: www.campbellsci.co.uk

USA

Location: Logan, UT USA
Phone: 435.227.9120
Email: info@campbellsci.com
Website: www.campbellsci.com

This page intentionally left blank

6712

Full-size Portable Sampler

The 6700 Series Portable Samplers have set the industry standard, providing the most comprehensive and durable performance available. With the introduction of our 6712, Teledyne ISCO takes another step toward the ultimate by including SDI-12 interface capabilities.

Wide range of bottle configurations, plug-in flow and parameter monitoring

This full-size portable lets you take full advantage of the advanced 6712 Controller, with its powerful pump, versatile programming, and optional plug-in modules for integrated flow measurement. Setup is fast and simple, with online help just a key stroke away.

The environmentally-sealed 6712 controller delivers maximum accuracy and easily handles all of your sampling applications.

In the Standard Programming Mode, the controller walks you through the sampling sequence step-by-step, allowing you to choose all parameters specific to your application. Selecting the Extended Programming Mode lets you enter more complex programs.

Optional land-line and GSM and CDMA cellular telephone modems allow programming changes and data collection to be performed remotely, from a touch-tone phone. They also provide dial-out alarm.

With eleven bottle choices, the 6712 Sampler lets you quickly adapt for simple or intricate sampling routines. Up to 30 pounds (13.5 kg) of ice fits in the insulated base, preserving samples for extended periods, even in extreme conditions. The 6712 with the "Jumbo Base" option holds bottles up to 5.5 gallon (21 liter).

The 6712 Portable Sampler features a vacuum formed ABS plastic shell to withstand exposure and abuse. Its tapered design and trim 20-inch (50.8 cm) diameter result in easy manhole installation and removal. Large, comfortable handles make transporting safe and convenient—even when wearing gloves.

Teledyne ISCO's 6712 Portable Sampler carries a NEMA 4X, 6 (IP67) enclosure rating. Superior capability, rugged construction, and unmatched reliability make the 6712 the ideal choice for portable sampling in just about any application.

Bottle options are available for practically any sequential or composite application.

Applications:

- Wastewater effluent
- Stormwater monitoring
- CSO monitoring
- Permit compliance
- Pretreatment compliance

Standard Features:

- SDI-12 interface provides "plug and play" connection with multi-parameter water-quality sondes and other compatible devices
- Choice of 11 different glass and plastic bottle configurations ranging from 24 x 1 liter to 1 x 5.5 gallon
- NEMA 4X, 6 (IP67) controller enclosure
- Rugged ABS plastic shell
- Foam-insulated base holds up to 30 pounds (13.5 kg) of ice to preserve samples even in extreme conditions
- Sample delivery at the EPA-recommended velocity of 2 ft/sec., even at head heights of 26 feet
- Pump revolution counter and patented liquid detection sensor ensure accurate sample volumes—and tells you when tubing should be replaced

6712 Full-size Portable Sampler

Size (H x Dia):	27 x 20 in (68.6 x 50.7 cm)
Weight:	Dry, less battery–32 lbs (15 kg)
Bottle Configurations:	24 – 1 Liter PP or 350 ml Glass 24 – 1 Liter ProPak Disposable Sample Bags 12 – 1 Liter PE or 950 ml Glass 8 – 2 Liter PE or 1.8 Liter Glass 4 – 3,8 Liter PE or Glass 1 – 9,5 Liter PE or Glass 1 – 5.5 gallon (21 Liter)PE or 5 gallon (19 Liter Glass, (with optional Jumbo Base)
Power Requirements:	12 VDC (Supplied by battery or AC power converter.)

Pump

Suction Tubing:	
-Length:	3 to 99 ft (1 to 30 m)
-Material:	Vinyl or Teflon
-Inside Dimension:	3/8 in (1.0 cm)
Pump Tubing Life:	Typically 1,000,000 pump counts
Maximum Lift:	28 ft (8.5 m)
Typical Repeatability:	± 5 ml or ± 5 of the average volume in a set
Typical Line velocity at Head height of:	@ 3 ft (0.9 m) head height: 3.0 ft/s (0.91m/s) @10 ft (3.1 m) head height: 2.9 ft/s (0.87 m/s) @15 ft (4.6 m) head height: 2.7 ft/s (0.83 m/s)
Liquid Presence Detector:	Non-wetted, nonconductive sensor detects when liquid sample reaches the pump to automatically compensate for changes in head heights.

Controller

Dimensions (HxWxD):	10.3 x 12.5 x 10.0 in (26.1 x 31.7 x 25.4 cm)
Weight (dry):	13 lbs (5.9 kg)
Operating Temperature:	32 to 120 °F (0 to 49 °C)
Enclosure Rating:	NEMA 4X, 6 (IP67)
Program Memory:	Non-volatile ROM
Flow Meter Signal Input:	5 to 15 volt DC pulse or 25 millisecond isolated contact closure
Number of Composite Samples:	Programmable from 1 to 999 samples
Real Time Clock Accuracy:	1 minute per month, typical

Software

Sample Frequency:	1 minute to 99 hours 59 minutes, in 1 minute increments. Non-uniform times in minutes or clock times 1 to 9,999 flow pulses
Sampling Modes:	Uniform time, non-uniform time, flow, event. (Flow mode is controlled by external flow meter pulses.)
Programmable Sample Volumes:	10 to 9,999 ml, in 1 ml increments
Sample Retries:	If no sample is detected, up to 3 attempts; user selectable
Rinse Cycles:	Automatic rinsing of suction line up to 3 rinses for each sample collection
Program Storage:	5 sampling programs
Sampling Stop/Resume:	Up to 24 real time/date sample stop/resume commands
Controller Diagnostics:	Tests for RAM, ROM, pump, display, and distributor

Ordering Information

6712 Portable Sampler, Full-size
Includes controller with 512kB RAM, top cover, center section, base, distributor arm, instruction manual, pocket guide 68-6710-070

6712 Portable Sampler, with Jumbo Base
As described above 68-6710-082

Note: Power source, bottle configuration, suction line, and strainer must be ordered separately. Many options and accessories are available for 6712 Samplers; see separate literature for 700 Series Modules and other components to expand your monitoring capabilities. Contact Teledyne ISCO, or your local representative for pricing and additional information.

The 6712 Controller is also an SDI-12 data logger, and has many optional capabilities. Please contact your Teledyne ISCO distributor for more information.

Teledyne ISCO
P.O. Box 82531, Lincoln, Nebraska, 68501 USA
Toll-free: (800) 228-4373 • Phone: (402) 464-0231 • Fax: (402) 465-3091

teledyneisco.com

TELEDYNE ISCO
Everywhereyoulook™

Teledyne ISCO is continually improving its products and reserves the right to change product specifications, replacement parts, schematics, and instructions without notice.

L-1107 Rev 2.0
9/18

Wireless TROLL Com/Wireless Rugged TROLL Com

Use the Wireless TROLL Com to connect an In-Situ instrument to a Bluetooth-enabled mobile device and the VuSitu mobile app. The Wireless TROLL Com doesn't have internal data storage. It allows data transfer between an instrument and VuSitu (or Win-Situ 5 via a USB cable).

Wireless Rugged TROLL Com

1 USB connection

Plug your Wireless TROLL Com into a PC for charging or setup.

2 Dust cover for USB connection

3 On/Off button

Press the button once to turn the device on or off.

4 Battery charge status indicator

100% - 90%

90% - 75%

75% - 50%

50% - 25%

Less than 25%

5 Cable connector

Attach an instrument to the Wireless TROLL Com with a Rugged Cable *before* connecting to VuSitu. When switching instruments, you may need to turn the Wireless TROLL Com off and on again.

6 Connection status indicator

Flashing red = The Wireless TROLL Com, instrument, and Bluetooth-enabled device are not connected.

Continuous red = The Wireless TROLL Com is connected to an instrument, but not connected to a Bluetooth-enabled mobile device.

Flashing green = The Wireless TROLL Com is connected to the Bluetooth-enabled device, but is not connected to an instrument.

Continuous green = The Wireless TROLL Com, instrument, and Bluetooth-enabled device are connected.

Information subject to change without notice. In-Situ, In-Situ logo, "Water Simplified", VuLink, RDO, RuggedCable, TROLL, BaroTROLL, HydroVu, VuSitu, Baro Merge, and Win-Situ are trademarks or registered trademarks of In-Situ Inc. ©2023. All rights reserved. This product may be covered by patents identified at www.in-situ.com/patents

2023-03-20 | 0031242

Charging the Wireless TROLL Com

Open the dust cover at the top of the Wireless TROLL Com.

Connect the USB cable to the device.

Plug the USB cable into the wall charger or a powered USB port from a computer. Make sure the computer is plugged in.

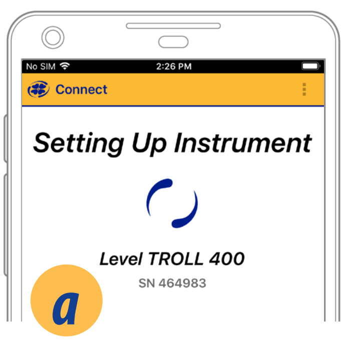
The device lights will turn on and blink according to charge level.

A fully-charged communication device will run for up to 40-50 continuous hours. Avoid full discharges and charge the battery each use. Do not store the Wireless TROLL Com in temperatures above 122 F/50 C.

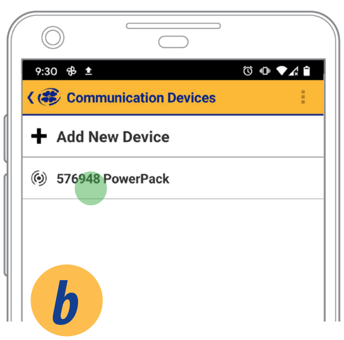
Connecting to VuSitu with a Wireless TROLL Com

You must have the VuSitu mobile app to use the instrument with a mobile device. Download VuSitu from the Google Play Store or the Apple App Store.

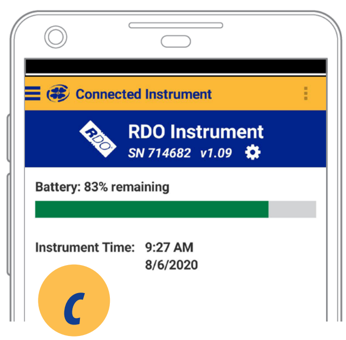
Connecting to VuSitu



Attach an instrument and turn on the Wireless Rugged TROLL Com. Launch VuSitu. The app will automatically connect.



To connect to another instrument, press **Disconnect**. VuSitu displays a list of available connections.



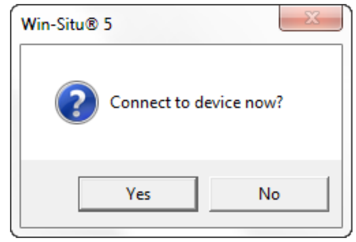
VuSitu displays the Connected Instrument screen when pairing is complete.

Connecting to Win-Situ 5

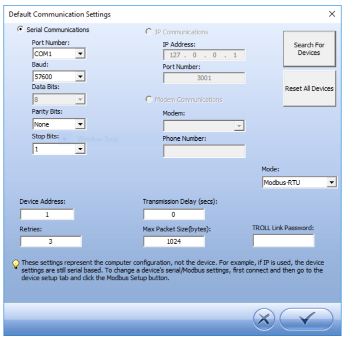
Attach an instrument to the Wireless TROLL Com with a Rugged Cable.

Connect the USB cable to the port at the top of the Wireless TROLL Com.

Plug the other end of the cable into your PC's USB port.

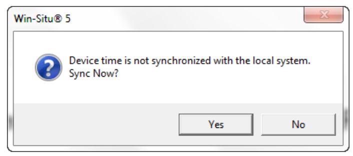


Open Win-Situ. Select No when asked "Connect to device now?"



Choose Preferences > Com Settings from menu bar. Select Serial Communications radio button and then choose the correct Com Port. Click check mark button.

Click yellow connect button at bottom right of screen.



Click **Yes** if prompted to sync device time with local system, or if prompted to update firmware.

Default communication settings

The following default communication settings are most common for In-Situ instruments:

- Baud: 19200
- Data bits: 8
- Parity bits: Even
- Stop Bits: 1
- Device Address: 1
- Mode: Modbus-RTU

Rebooting the Wireless TROLL Com

Follow the steps below if your Wireless TROLL Com doesn't respond while connected to a computer.

Disconnect the Wireless TROLL Com from a power/charging source.

Turn on the Wireless TROLL Com.

Hold the Power button down until the bottom LEDs flash back and forth and then turn off.

Turn the Wireless TROLL Com back on and attempt to use.

Wireless TROLL Com Accessories

The Wireless TROLL Com may be used with the following accessories:

USB Cable or Charging cable

Twist-Lock cable (Wireless TROLL Com only)

or

Rugged TROLL cable (Wireless Rugged TROLL Com only)

Cleaning the Wireless TROLL Com

Clean the surface of the Wireless TROLL Com with a damp cloth and mild soap.

Do not clean the charging port.

Clean dirty or corroded connector pins with alcohol.

Make sure all parts are fully dry before use.

Safety

Read the safety information on this page before using your Wireless TROLL Com. If you have questions, contact In-Situ Technical Support for assistance.

- Do not use the Wireless TROLL Com in any manner not specified by the manufacturer. If the device is used in a manner not specified in this manual, the protection provided by the equipment may be impaired.
- Do not submerge the Wireless TROLL Com or your mobile device in liquid.
- Do not use the Wireless TROLL Com in temperatures beyond those specified in this document.
- The Wireless TROLL Com should only be charged indoors.
- The Wireless TROLL Com is not serviceable. Do not attempt to service or disassemble the uni.
- The Wireless TROLL Com is safe to use above 2000 m.

Specifications

Operating temperature	-5 to 50° C (23 to 122° F); 95% relative humidity, non-condensing
Storage temperature	-20 to 50° C (-4 to 122° F); 95% relative humidity, non-condensing
Dimensions	16 x 4.3 x 3 cm (6.3 x 1.7 x 1.2 in.)
Weight	165 g (0.36 lb)
Materials	Polycarbonate / Acrylonitrile Butadiene Styrene blend, Silicon, Urethane, Stainless steel, Brass, Thermoplastic Vulcanizate, Polyurethane, Polyethylene, Acrylic Copolymer, Titanium, Polyetheretherketone, FKM Fluoroelastomer
Environmental rating	IP67
Output options	Bluetooth®, USB
Communication protocol	Android®: SPP Windows®: SPP or USB
Battery type	3.6 V 2.9AH Lithium rechargeable cell (UBBL39-FL)
Charging requirements	5 VDC USB charger (1 A or 500 mA)
Warranty	1 year
Certifications	CE, FCC (SSSBC127-X), WEEE, UKCA

Sensor	**Temperature**	**Barometric pressure**
Accuracy	±2° C max	±3 mbar max
Range	-20 to 70° C (-4 to 158° F)	300 to 1100 mbar
Resolution	0.1° C	0.01 mbar
Sensor type	Fixed	Fixed
Response time	< 30 seconds	Instantaneous in thermal equilibrium
Units of measure	Celsius or Fahrenheit	psi, kPa, bar, mbar, mmHg, inHg, Torr, atm
Method	EPA 170.1	Piezoresistive

Manufacturer Information

In-Situ Inc.
221 East Lincoln Ave
Fort Collins, CO 80524, USA

This page intentionally left blank

APPENDIX D

Field and Quality Assurance Forms

HERRERA
Science + Planning + Design

This page intentionally left blank

Data Entry Review Worksheet

Project Name/No./Client: Geneva Bioretention Pilot Project/ 21-07565-001/ Whatcom County Public Works

Page ____ of ____

Data entered by: ____________________ Data reviewed by: ____________________

Laboratories: ____________________ Date reviewed: ____________________

Event ID ____________ Sample Date ____________________

Monitoring Stations: ____

Parameters: ____

____

Percentage of Data Reviewed:

Data Source (i.e., Lab or Field)	Monitoring Station	Parameter	Incorrect Value	Correct Value	Corrective Action

Notes:

Data Quality Assurance Worksheet

By ____________________

Project Name/No./Client: Geneva Bioretention Pilot Project/ 21-07565-001/ Whatcom County Public Works

Date ____________ Page ____ of ____

Laboratory/Parameters: Exact Scientific Services/Water Analysis: TSS, pH, hardness, Dissolved Cu & Zn, Total Cu & Zn, fecal coliform bacteria, *E. coli* bacteria

Checked: initials ____________

Sample Date/Sample ID: ____________________

date ____________

Parameter	Completeness/ Methodology	Pre-preservation Holding Times (days)		Total Holding Times (days)		Method Blanks Reporting Limit	Matrix Spikes/ Surrogate Recovery (%)		Lab Control Samples Recovery (%)		Lab Duplicates RPD (%)		Field Duplicates RPD (%)		Instrument Calibration/ Performance	ACTION
		Reported	Goal	Reported	Goal		Reported	Goal	Reported	Goal	Reported	Goal[a]	Reported	Goal[a]		
TSS			**NA**		≤7	**≤0.5** **1.0**		**≤10% or ±2 x RL**		**80–108**		**≤15**		**≤15**		
Hardness			**NA**		≤28	**≤1.0** **1.0**		**≤20% or ±2 x RL**		**90–110**		**≤10**		**≤10**		

[a] If the sample or duplicate value is less than five times the reporting limit, the difference is calculated rather than the relative percent difference (RPD). The QA goal is a difference <2 times the detection limit instead of the number indicated in the goal column.

NA – not applicable or not available; NC – not calculable due to one or more values below the detection limit; NS – field duplicate not sampled.

Data Quality Assurance Worksheet

By	____________________
Date	________ Page ____ of ____
Checked:	initials ____________
	date ____________

Project Name/No./Client: POST System TAPE Performance Monitoring/16-06417-000/City of Bellingham

Laboratory/Parameters: Exact Scientific Services/Water Analysis: TSS, TP, orthophosphorus, hardness, Dissolved Cu & Zn, Total Cu & Zn, fecal coliform bacteria

Sample Date/Sample ID: ____________________

Parameter	Completeness/ Methodology	Pre-preservation Holding Times (days)		Total Holding Times (days)		Method Blanks / Reporting Limit	Matrix Spikes/ Surrogate Recovery (%)		Lab Control Samples Recovery (%)		Lab Duplicates RPD (%)		Field Duplicates RPD (%)		Instrument Calibration/ Performance	ACTION
		Reported	Goal	Reported	Goal		Reported	Goal	Reported	Goal	Reported	Goal[a]	Reported	Goal[a]		
Copper, dissolved			≤1		≤180	≤0.0001 0.0001		**≤20% or ±2 x RL**		**90–110%**		**≤10**		**≤10**		
Copper, total			**NA**		≤180	≤0.0001 0.0001		**≤20% or ±2 x RL**		**90–110%**		**≤10**		**≤10**		
Zinc, dissolved			≤1		≤180	≤0.001 **0.001**		**≤20% or ±2 x RL**		**90–110%**		**≤10**		**≤10**		
Zinc, total			**NA**		≤180	≤0.005 **0.005**		**≤20% or ±2 x RL**		**90–110%**		**≤10**		**≤10**		
Fecal Coliform Bacteria			**NA**		≤1	**NA** **NA**		**≤35% lab; ≤50% field**		**NA**		≤25		≤25		
E. coli Bacteria			**NA**		≤1	**NA** **NA**		**≤35% lab; ≤50% field**		**NA**		≤25		≤25		

[a] If the sample or duplicate value is less than five times the reporting limit, the difference is calculated rather than the relative percent difference (RPD). The QA goal is a difference <2 times the detection limit instead of the number indicated in the goal column.

NA – not applicable or not available; NC – not calculable due to one or more values below the detection limit; NS – field duplicate not sampled.

Data Quality Assurance Worksheet

HERRERA

By ____________________

Project Name/No./Client: Geneva Bioretention Pilot Project/ 21-07565-001/ Whatcom County Public Works

Date ____________ Page ____ of ____

Laboratory/Parameters: Environmental Technical Services, Inc. /Particle Size Distribution (PSD)

Checked: initials ____________

Sample Date/Sample ID: ____________________

date ____________

Parameter	Completeness/ Methodology	Holding Times (days)		Blanks/ Detection Limit	Matrix Spikes/ Surrogate Recovery (%)		Lab Control Samples Recovery (%)		Lab Duplicates RPD (%)		Field Duplicates RPD (%)		Instrument Calibration/ Performance	ACTION
		Reported	Goal		Reported	Goal	Reported	Goal	Reported	Goal[a]	Reported	Goal[a]		
PSD			**≤7**	NA	NA	**NA**	NA	**NA**		**≤10%**		**≤10%**		

[a] If duplicate values are less then 5 times the detection limit then the RPD goal is <2 times the detection limit instead of the number indicated in the goal column.

NA – not applicable or not available, NC – not calculable due to one or more values below the detection limit, NS – field duplicate not sampled.

Data Quality Assurance Worksheet

Project Name/No./Client: Geneva Bioretention Pilot Project/ 21-07565-001/ Whatcom County Public Works

Laboratory/Parameters: Analytical Resources, Inc./Water Analysis: TP, orthophosphorus

Sample Date/Sample ID: ______

By ______

Date ______ Page ____ of ____

Checked: initials ______

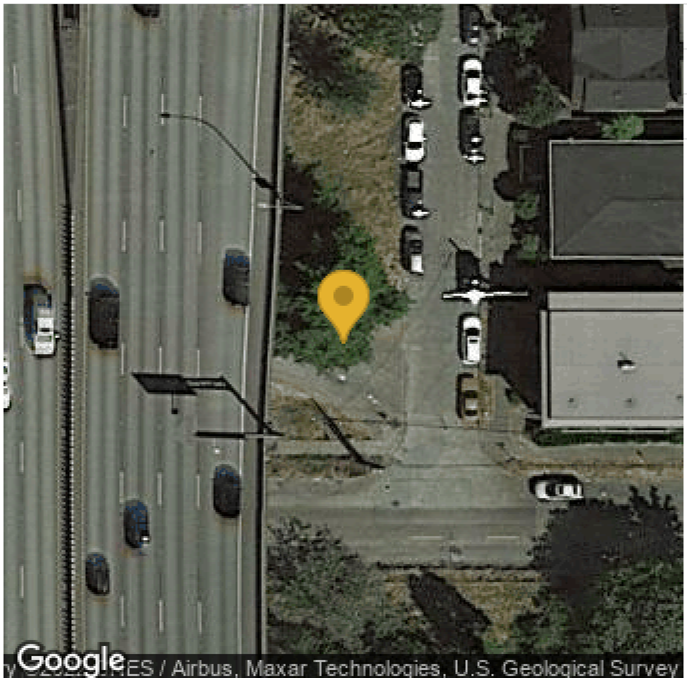
date ______

Parameter	Completeness/ Methodology	Pre-preservation Holding Times (days)		Total Holding Times (days)		Method Blanks Reporting Limit	Matrix Spikes/ Surrogate Recovery (%)		Lab Control Samples Recovery (%)		Lab Duplicates RPD (%)		Field Duplicates RPD (%)		Instrument Calibration/ Performance	ACTION
		Reported	Goal	Reported	Goal		Reported	Goal	Reported	Goal	Reported	Goal[a]	Reported	Goal[a]		
Total Phosphorus			**NA**		≤28	**≤0.005** **0.005**		**≤20% or ±2 x RL**		**90–110%**		**≤10%**		**≤10%**		
Ortho-phosphorus			**≤.0.5**		≤28	**≤0.003** 0.003		**≤20% or ±2 x RL**		**90–110%**		**≤10%**		**≤10%**		

[a] If the sample or duplicate value is less than five times the reporting limit, the difference is calculated rather than the relative percent difference (RPD). The QA goal is a difference <2 times the detection limit instead of the number indicated in the goal column.

MWS-3 TAPE Project 3.2

Coordinates	47.65608569,-122.32203517



Latitude	47.65608569
Longitude	-122.32203517
Accuracy	23.68 m

Visit Type	Pre-Storm, Post-Storm, Maintenance

PRE-STORM VISIT

Personnel	NH
Arrival Date	05/11/2022
Arrival Time:	08:59 AM
Weather	Sunny
Flow Conditions:	Baseflow

Inlet Station - Pre-Storm

Pre-Storm Checklist:	Clean Bottle Installed, Ice Added, Intake Checked, Sample Line Rinsed, Tubing Connected, 6" Valve Cleared, Modem Online, Sampler Ready to Sample
Inlet Photos - Pre-Storm	

EXAMPLE

Outlet Station - Pre-Storm	
Pre-Storm Checklist:	Clean Bottle Installed, Ice Added, Intake Checked, Sample Line Rinsed, Tubing Connected, Sampler Ready to Sample, Outlet Pipe Vacuumed
Outlet Depth Calibrated?	Yes
Depth Before Calibration (ft):	-0.036
Depth after Calibration (ft):	0.00
True Depth (ft):	1.52

Outlet Photos - Pre-Storm

EXAMPLE

before

after

Bypass Station - Pre-Storm	
Bypass Depth Calibrated?	Yes
Depth Before Calibration (ft):	-0.19
Depth after Calibration (ft):	0.00
True Depth (ft):	1.80

EXAMPLE

Bypass Photos - Pre-Storm

Pre-Storm Observations:	
Tasks for next visit?	No
POST-STORM VISIT	
Personnel	M. O'Connor Lenth
Arrival Date	05/13/2022
Arrival Time:	09:42 AM
Weather	Cloudy
Flow Conditions:	No Flow
Inlet Station - Post-Storm	
Date End	05/12/2022
Time End	07:00 PM
Sample Count	58
Estimated Volume (L)	13
Visual Condition	Darn brown
Post Storm Checklist	Sent to Lab, Sampled Without Error
Inlet Photos - Post-Storm	

EXAMPLE

sampled without error

Outlet Station - Post-Storm	
Date End	05/12/2022
Time End	06:35 PM
Sample Count	59
Estimated Volume (L)	11
Visual Condition	Light brown
Post Storm Checklist	Sampled Without Error, Sent to Lab
Outlet Photos - Post-Storm	

EXAMPLE

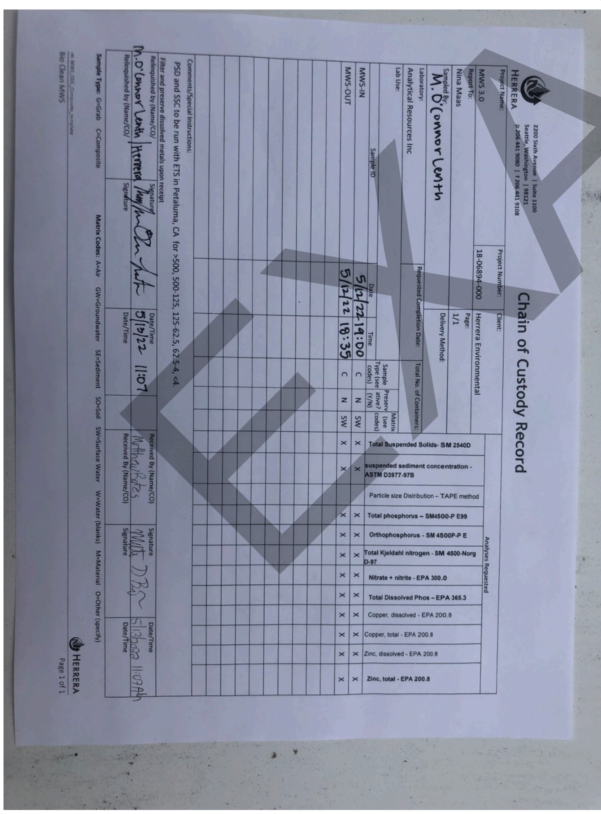
sampled without error

"out" bottle on the left, "in" on the right

Post-Storm Observations:

Tasks for next visit?	No

COC Photo



HERRERA
2200 Sixth Avenue | Suite 1100
Seattle, Washington | 98121
p 206 441 9080 | f 206 441 9108

Chain of Custody Record

Project Name: MWS 3.0
Project Number: 18-06894-000
Client: Herrera Environmental
Report To: Nina Maas
Page: 1/1
Sampled By: M. O'Connor Lenth
Delivery Method:
Laboratory: Analytical Resources Inc
Requested Completion Date:
Total No. of Containers:
Lab Use:

Sample ID	Date	Time	Sample Type (see codes)	Preservative? (Y/N)	Matrix (see codes)	Total Suspended Solids- SM 2540D	suspended sediment concentration - ASTM D3977-97B	Particle size Distribution – TAPE method	Total phosphorus – SM4500-P E99	Orthophosphorus - SM 4500P-P E	Total Kjeldahl nitrogen - SM 4500-Norg D-97	Nitrate + nitrite - EPA 300.0	Total Dissolved Phos – EPA 365.3	Copper, dissolved - EPA 200.8	Copper, total - EPA 200.8	Zinc, dissolved - EPA 200.8	Zinc, total - EPA 200.8
MWS-IN	5/12/22	19:00	C	N	SW	x	x		x	x	x	x	x	x	x	x	x
MWS-OUT	5/12/22	18:35	C	N	SW	x	x		x	x	x	x	x	x	x	x	x

Comments/Special Instructions:
PSD and SSC to be run with ETS in Petaluma, CA for >500, 500-125, 125-62.5, 62.5-4, <4.
Filter and preserve dissolved metals upon receipt

Relinquished by (Name/CO)	Signature	Date/Time	Received By (Name/CO)	Signature	Date/Time
M. O'Connor Lenth / Herrera	[signature]	5/13/22 11:07	Matthew Bates	[signature]	5/13/2022 11:07AM
Relinquished by (Name/CO)	Signature	Date/Time	Received By (Name/CO)	Signature	Date/Time

Sample Type: G=Grab C=Composite
Matrix Codes: A=Air GW=Groundwater SE=Sediment SO=Soil SW=Surface Water W=Water (blanks) M=Material O=Other (specify)
Bio Clean MWS
HERRERA
Page 1 of 1

MAINTENANCE VISIT

Personnel	NH

SAMPLE

Arrival Date	05/11/2022
Arrival Time:	08:59 AM
Weather	Sunny
Flow Conditions:	Baseflow
Maintenance Activities	
Maintenance Checklist:	Intakes Checked, Modem online, Outlet pipe vacuumed
Outlet Depth Calibrated?	
Bypass Depth Calibrated?	
Maintenance Observations:	Vacuumed outflow. Attempted to put in mixer for primary chamber but the mixer was causing breakers to flip Influent intake was outside of inflow chamber but was rinsed, inside and out, and zip tied back into the bottom of the outlet pipe of the inflow chamber
Tasks for next visit?	No

EXAMPLE

Vegetation Monitoring – Example Field Data

Project Name/No./Client: Geneva Bioretention Pilot Project/ 21-07565-001/ Whatcom County Public Works

Data Field	Options
Bioretention Cell Identification	Develop coding system
Cell Section	Bottom, side slope, top slope
Dominant Species	List of planted species
Health	Stressed, normal growth, vigorous growth
Plant Species Notes	Open fill in
Percent Cover of Planted	0–10%, 11–30%, 31–50%, 51–75%, 76–100%
Percent Cover of Weeds	0–10%, 11–30%, 31–50%, 51–75%, 76–100%
Percent Bare Ground	0–10%, 11–30%, 31–50%, 51–75%, 76–100%
Non-Native/Weedy Plant Species Present	Most common three to five
Noxious Weeds Present	Most common three to five
Signs of Pests/Disease	Yes/no
If signs of pests/disease are present, please describe.	Open fill in
Signs of Browse/Herbivory	Yes/no
Is there health stem and leaf growth?	Yes/no
Are there signs of healthy bud and flower production?	Yes/no
If signs of browse/herbivory are present, please describe.	Open fill in
General Notes	Open fill in

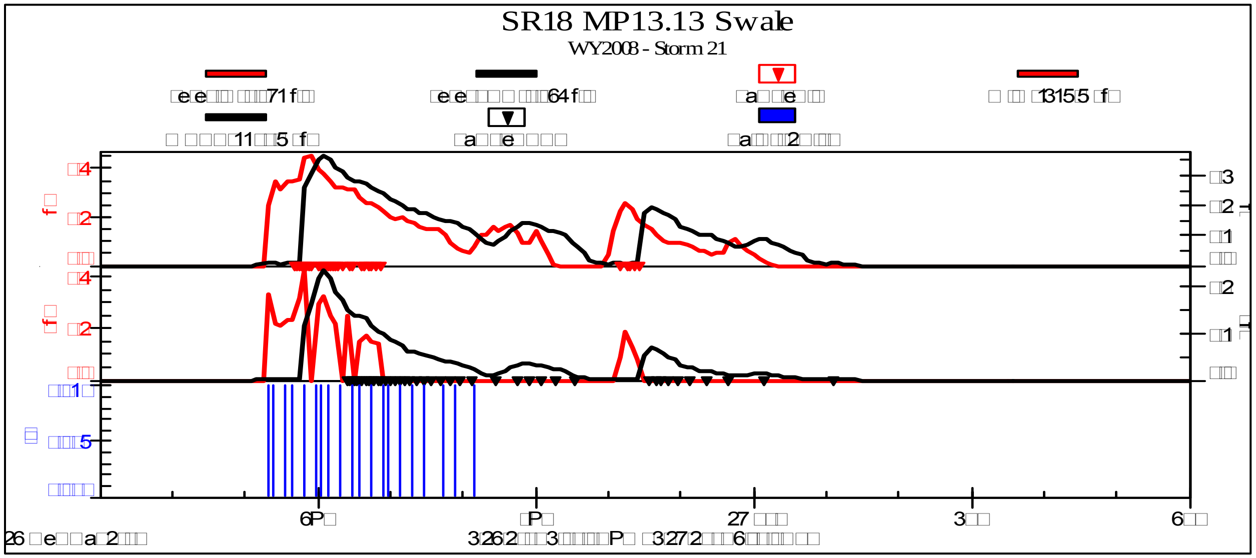
This page intentionally left blank

APPENDIX E

Example
Individual Storm Report

HERRERA
Science + Planning + Design

Individual Storm Report



Site Information		
Site Name		
WA Bioswale at SR18 MP 13.13		
BMP Type		
Bioswale		
BMP Location	IN	OUT
zone (UTM)	10	10
N (UTM)	5047951	5047924
E (UTM)	541539	541674
Drainage Area		
Total (ac):	3.47	
Percent Impervious:	16.7	
AADT		
# vehicles:	2,400	

Storm Information - Storm WY2008-21

	Goal	IN	QA	OUT	QA	notes
Precipitation Total (in):	≥0.15	0.20		0.20		
Precipitation Duration (hr):	NA	2.8		2.8		
Mean Precip. Intensity (in/hr):	NA	0.071		0.071		
Storm Volume (cf):	NA	1548.6		1198.5		
Maximum Discharge (cfs):	NA	0.420		0.234		
Flow Duration (hr):	NA	5.3		7.7		
Antecedent Dry Period (hr):	≥6	10.0		10.0		

Sampling Information

	Goal	IN	QA	OUT	QA	notes
Number of Aliquots:	≥7	34		42		
% Storm Sampled:	≥75	100.0		100.0		
Sampling Duration (hr):	≤48	4.8		6.7		

QA Narrative: 5% of influent hydrograph edited due to gauge errors (see blue sections of hydrograph).

Analytical Information

	EMC Concentration (mg/L or CFU/100mL)						Load (grams or millions of CFU)					% Conc. Reduction	% Volume Reduction	% Load Reduction
	IN	QA	OUT	QA	MDL	notes	IN	QA	OUT	QA	notes			
Hardness	9.4		10.7		2.0		NA		NA			NA	22.6	NA
TSS	83.0		16.0		0.5		3640		543			80.7	22.6	85.1
TP	0.119		0.042		0.002		5.2		1.4			64.7	22.6	72.7
Total Cu	0.0097		0.0036		0.001		0.425		0.122			62.9	22.6	71.3
Dissolved Cu	0.0019		0.0016		0.001		0.083		0.054			15.8	22.6	34.8
Total Zn	0.060		0.024		0.005		2.63		0.81			60.0	22.6	69.0
Dissolved Zn	0.015		0.014		0.005		0.66		0.48			6.7	22.6	27.8
TPH-diesel					0.05		NA		NA			NA	22.6	NA
TPH-oil					0.1		NA		NA			NA	22.6	NA
Fecal Coliform					2		NA		NA			NA	22.6	NA

notes: j = conditional use (storm/sampling criteria); J = conditional use (chemical analysis criteria); r = rejected (storm/sampling criteria)
R = rejected (chemical analysis criteria); U = at or below detection limit; G = value greater than max. detection limit; NA = not applicable

This page intentionally left blank

November 4, 2024

Quality Assurance Project Plan Addendum

Geneva Bioretention Pilot Project Contaminants of Emerging Concern Whatcom County, Washington

Prepared for
King County Water and Land Resources Division
201 South Jackson Street
Seattle, Washington 98104
and
Whatcom County Public Works Department
322 North Commercial Street, Suite 224
Bellingham, Washington 98225

Prepared by
Herrera Environmental Consultants, Inc.
2200 Sixth Avenue, Suite 1100
Seattle, Washington 98121
Telephone: 206-441-9080

HERRERA
Science + Planning + Design

This page intentionally left blank

Signature Page

Approved by: Date

______________________________ ____________

Sam Nilsson, Project Manager, Herrera Environmental Consultants, Inc.

______________________________ ____________

Dylan Ahearn, Principal Investigator, Herrera Environmental Consultants, Inc.

______________________________ ____________

Cody Swan, Project Manager, Whatcom County Public Works

______________________________ ____________

Chelsea Mitchell, Project Manager, King County Water and Land Resources Division

______________________________ ____________

Chelsea Morris, Project Manager, Washington State Department of Ecology

______________________________ ____________

Chris Dudenhoeffer, QA Coordinator, Washington State Department of Ecology

______________________________ ____________

Fionna Bestwick, Laboratory Manager, Exact Science

______________________________ ____________

Meghan Elkey, Laboratory Project Manager, King County Environmental Laboratory

______________________________ ____________

David Alltucker, Laboratory Project Manager, Eurofins. Inc.

Distribution List

Name	Affiliation	Title	Phone	Address/E-Mail
Sam Nilsson	Herrera Environmental Consultants, Inc.	Herrera Project Manager	971-200-8871	Herrera Environmental Consultants, Inc. 2200 Sixth Avenue, Suite 1100 Seattle, WA 98121 cwebb@herrerainc.com
Dylan Ahearn	Herrera Environmental Consultants, Inc.	Herrera Principal Investigator	206-441-9080	Herrera Environmental Consultants, Inc. 2200 Sixth Avenue, Suite 1100 Seattle, WA 98121 dahearn@herrerainc.com
Cody Swan	Whatcom County Public Works	Project Manager	360-778-6265	322 North Commercial Street, Suite 224 Bellingham, Washington cswan@co.whatcom.wa.us
Chelsea Mitchell	King County Water and Land Resources Division	Project Manager	206-786-1238	King County DNPR 201 South Jackson Street, Room 5700 Seattle, Washington 98104-3855 Chemitchell@kingcounty.gov
Chelsea Morris	Washington State Department of Ecology	Project Manager	564-999-3052	P.O. Box 47600 Olympia, Washington 98504-7600 morr461@ecy.wa.gov
Fiona Bestwick	Exact Scientific Services	Laboratory Manager	360-733-1205	1355 Pacific Place, Suite 101 Ferndale, WA 98248 info@exactscientific.com
Meghan Elkey	King County Environmental Laboratory	Laboratory Project Manager	206-477-7154	King County Environmental Laboratory 322 West Ewing Street Seattle, Washington 98119 Meghan.elkey@kingcounty.gov
David Alltucker	Eurofins, Inc.	Laboratory Project Manager	916-374-4383	Eurofins, Inc Sacramento 880 Riverside Parkway West Sacramento, California 95605 David.Alltucker@et.eurofinsus.com

Contents

Appendices

Appendix A Data Verification and Validation Checklist

Tables

This page intentionally left blank

Introduction

Lake Whatcom, the drinking water source for over 100,000 Whatcom County residents, was added to the Clean Water Act's 303(d) list in 1998 due to inadequate dissolved oxygen levels and is currently listed with a Total Maximum Daily Load (TMDL) for phosphorus and bacteria. Whatcom County is part of a multi-jurisdictional effort to restore the Lake Whatcom watershed and has been implementing projects aimed at reducing phosphorus loads in stormwater runoff including retrofitting existing stormwater infrastructure to maximize nutrient-removal opportunities. The Geneva Bioretention Pilot Project is intended to improve the water quality of runoff flowing into Lake Whatcom by reconstructing a series of underutilized bioretention swale cells located on the southern shore of the lake's western end.

As part of this retrofit project, the "Austin South" bioretention swale cells were reconstructed with a liner, swale cell weirs, underdrain, and High Performance Bioretention Soil Media (HPBSM) with an additional polishing media layer (HPBSM Type 2 – Ecology 2024a). In addition, an inflow dosing system was constructed that regulates inflow rates and allows the HPBSM to intermittently dry. In 2023, a Quality Assurance Project Plan (QAPP) was produced for Whatcom County Public Works to guide a performance verification monitoring program at the facility (Herrera 2023). Performance verification monitoring includes hydrologic and water quality monitoring intended to determine whether the retrofitted facility's pollutant removal performance is consistent with previous laboratory investigations. This ongoing performance verification monitoring is being conducted in accordance with a Washington Department of Ecology (Ecology) approved QAPP following Technology Assessment Protocol – Ecology (TAPE) guidelines (Ecology 2018); however, the results will not be submitted for TAPE review.

In 2023, King County Water and Land Resources Division contracted with the Stormwater Action Monitoring (SAM) program for the additional work described under this QAPP addendum. This document describes expanded water quality monitoring (Addendum monitoring) for toxics and contaminants of emerging concern (CECs). Target contaminants for this monitoring program include 6PPD-quinone (6PPDQ), per- and polyfluoroalkyl substances (PFAS), polycyclic aromatic hydrocarbons (PAHs), dissolved organic carbon (DOC), aquatic toxicity, and total and dissolved metals. The Addendum monitoring described herein is intended to occur concurrently with the final period of performance verification monitoring under the original QAPP. In addition to sampling procedures and experimental design, the QAPP and QAPP Addendum document are produced to ensure that all results obtained from this monitoring program are scientifically and legally defensible.

Facility Description

The Austin South facility is an aboveground stormwater filtration system that consists of three swale "Cascades" (a Cascade consists of six or seven level bioretention cells), which are described in detail in the QAPP (Herrera 2023). The facility is designed to treat 92.1 percent of the average annual inflowing runoff volume before Cascade weirs are overtopped and runoff discharges via the bioretention swale overflow. For inflowing runoff not treated by the facility (i.e., overflowing the swale), an existing bioretention swale ("Austin North" Swale) and filter cartridge vault are located downstream to provide additional runoff treatment.

Pretreatment Device

A pretreatment device with a General Use Level Designation (GULD) (Contech Vortechs) is included in the design to reduce the sediment load on the swale media and therefore reduce its maintenance frequency. Sediment and debris maintenance will occur primarily in the pretreatment device and dosing vault (discussed below), which will be relatively easy locations in which to perform sediment removal. The dosing siphon located downstream of the dosing vault can also capture some TSS that is not retained in the pretreatment device or dosing vault.

Bioretention Swale Cascades

The reconstructed bioretention swale will incorporate HPBSM, which is composed of a primary media layer (18-inch depth) and polishing media layer (12-inch depth) to maximize phosphorus treatment performance. The HPBSM with polishing media was approved by Ecology for phosphorus-sensitive receiving waters in 2021 (Ecology 2021). A 6-inch ponding depth, compared to the existing as-designed depth of 2 inches, will increase the total ponded volume and therefore increase the total runoff volume receiving treatment.

The reconstructed bioretention swale will be lined with an impermeable liner to prevent infiltration to native soils due to local basement flooding concerns. An underdrain will collect treated runoff and route it to an existing pipe for treated runoff under the "Austin North" swale.

The Project consists of three bioretention swale Cascades. Cascade 1 is the southernmost and receives the first 28 percent of runoff; flow is then split to Cascade 2 (37.4 percent of runoff) and, finally, Cascade 3 (34.6 percent of runoff). Cascade 1 has six level bioretention cells separated by weirs, Cascades 2 and 3 have seven and six cells, respectively. Sampling described herein is intended to evaluate the performance of Cascade 1 with the assumption that the performance of other Cascades will be similar.

Project Description

The primary goal of this Addendum monitoring is to collect data through field testing to quantify the performance of the "Austin South" bioretention swale with regard to CECs, and through aquatic toxicity testing to understand whether the HPBSM is effective at removing these contaminants from stormwater. The following objectives have been defined for the field testing:

- Evaluate influent and effluent pollutant concentrations for the Project using flow-weighted composite sampling.
- Evaluate influent and effluent pollutant concentrations and aquatic toxicity for the Project using grab sampling.

To meet these objectives, the experimental design for the field testing involves the monitoring of water chemistry at the following locations:

- At the inlet of the "Austin South" bioretention swale (downstream of the pretreatment vault, dosing vault, and dosing siphon) for characterizing influent pollutant concentrations entering the bioretention swale.
- At the approximate midpoint of the "Austin South" bioretention swale underdrain to estimate pollutant concentrations in the treated effluent of the bioretention swale.

The number of representative influent and effluent water samples to be collected over the duration of the field testing period is provided in Table 4 in the Quality Control section of this report. The field testing is scheduled to begin in October 2024 and continue for 7 months or until the targeted number of events have been sampled.

Project Organization and Schedule

This section describes how the Addendum monitoring is organized, key personnel, and the project schedule. Personnel and schedules for the performance verification monitoring will remain consistent with the QAPP (Herrera 2023).

Organization and Key Personnel

Herrera Environmental Consulting, Inc. (Herrera) is responsible for developing this QAPP Addendum with oversight from King County and Ecology and implementing the sample collection and coordination component. Required laboratory services for this project will be provided by Exact Scientific Services, King County Environmental Laboratory (KCEL), and Eurofins, Inc. Key personnel that will be involved in this effort are identified below with their respective roles.

King County Water and Land Resources Division 201 South Jackson Street, Room 5700 Seattle, Washington 98104-3855 206-786-1238 Chelsea Mitchell, Project Manager	Exact Scientific Services 1355 Pacific Place, Suite 101 Ferndale, Washington 98248 360-733-1205 Fiona Bestwick, Laboratory Manager
Herrera Environmental Consultants, Inc. 2200 Sixth Avenue, Suite 1100 Seattle, Washington 98121 206-441-9080 Sam Nilsson, Herrera Project Manager Dylan Ahearn, Principal Investigator	King County Environmental Laboratory 322 West Ewing Street Seattle, Washington 98119 206-477-7200 Meghan Elkey, Laboratory Project Manager Francis Sweeney, Aquatic Toxicology Unit Supervisor
Washington State Department of Ecology Headquarters Office P.O. Box 47600 Olympia, Washington 98504-7600 564-999-3052 Chelsea Morris, Project Manager	Eurofins Inc. Sacramento 880 Riverside Parkway West Sacramento, California 95605 916-373-5600 David Alltucker, Laboratory Project Manager

Laboratory services for this project may be provided by Manchester Environmental Laboratory (MEL) if KCEL does not receive accreditation for 6PPDQ in time to process samples. Key personnel that may be involved in this effort if analysis at MEL is necessary are identified below.

Manchester Environmental Laboratory

7411 Beach Drive East
Port Orchard, Washington 98366
360-871-8700

Nancy Rosenbower, Laboratory Manager

Schedule

Field testing under this QAPP Addendum is scheduled to begin in October 2024 and continue through April 2025 in line with the projected end of the preexisting performance verification sampling. However, the field sampling period may be extended if necessary to reach the target number of samples. The following project milestones have been identified:

- **September 2024**: QAPP Addendum submitted to King County and Ecology
- **October 2024:** Addendum monitoring (sampling and lab analysis) begins
- **January 2025**: Semi-annual progress report number 1 submitted to Ecology
- **April 2025:** Addendum monitoring ends
- **July 2025:** Semi-annual progress report number 2 submitted to Ecology
- **January 2026:** Semi-annual progress report number 3 submitted to Ecology
- **April 2026:** Draft report submitted to Ecology
- **June 2026:** Final report submitted to Ecology
- **June 2026:** Data formatted for International Stormwater BMP database submitted to Ecology
- **November 2026:** Findings presented to Stormwater Work Group and at local conference
- **November 2026:** Draft SAM fact sheet submitted to Ecology

Quality Objectives

The goal of this QAPP Addendum is to ensure that the data collected for this study are scientifically accurate, useful for the intended analysis, and legally defensible. To achieve this goal, the collected data will be evaluated relative to the following indicators of quality assurance:

- **Precision:** A measure of the variability in the results of replicate measurements due to random error.
- **Bias:** The systematic or persistent distortion of a measurement process that causes errors in one direction (i.e., the measured mean is different from the true value).
- **Representativeness:** The degree to which the data accurately describe the conditions being evaluated based on the selected sampling locations, sampling frequency and duration, and sampling methods.
- **Completeness:** The amount of data obtained from the measurement system.
- **Comparability:** The ability to compare data from the current study to data from other similar studies, regulatory requirements, and historical data.

Measurement quality objectives (MQOs) are performance or acceptance criteria that are established for each of these quality assurance indicators. MQOs for hydrologic data and performance verification monitoring data are described in the QAPP (Herrera 2023). The specific MQOs that have been identified for this project are based on standard method quality control criteria described below and summarized for water quality data in Table 1. Note that the term “reporting limit” in this document refers to the practical quantification limit established by the laboratory, not the method detection limit.

Precision

Analytical precision will be assessed by laboratory splits of samples, matrix spikes, and laboratory control samples (see below, under Bias). These will be assessed using relative percent difference (*RPD*).

$$RPD = \left(\frac{\left| C_1 - C_2 \right|}{C_1 + C_2} \right) \times 200\%$$

Where: *RPD* = Relative percent difference
C_1 and C_2 = Concentration values
For metals and DOC, RPD ≤20%
For PFAS, RPD ≤30%
For PAHs, RPD ≤40%
For 6PPDQ, RPD ≤40% except MS/MSD pairs (RPD ≤45%)

If split sample concentrations are both within 5 times the reporting limit, the RPD goal for all parameters is <2 times the reporting limit. If either of the split samples is at or below the reporting limit, the MQO cannot be calculated. *RPD* values exceeding those described herein and in Table 1 will trigger an assessment as to whether there are any problems with laboratory methodology, which might warrant remediation.

Table 1. Measurement Quality Objectives for Water Quality Data.					
Parameter	**Laboratory Method or Field Blank[a]**	**Equipment Rinsate Blank[a]**	**Control Standard Recovery**	**Matrix Spike Recovery[b]**	**Laboratory and Field Duplicate *RPD*[c]**
Aquatic Toxicity	NA	NA	>90% Survival	NA	NA
Dissolved Organic Carbon	≤RL	≤RL	85–115%	75–125%	20
Arsenic, dissolved	≤RL	≤RL	85–115%	75–125%	20
Arsenic, total	≤RL	≤RL	85–115%	75–125%	20
Cadmium, dissolved	≤RL	≤RL	85–115%	75–125%	20
Cadmium, total	≤RL	≤RL	85–115%	75–125%	20
Chromium, dissolved	≤RL	≤RL	85–115%	75–125%	20
Chromium, total	≤RL	≤RL	85–115%	75–125%	20
Copper, dissolved	≤RL	≤RL	85–115%	75–125%	20
Copper, total	≤RL	≤RL	85–115%	75–125%	20
Lead, dissolved	≤RL	≤RL	85–115%	75–125%	20
Lead, total	≤RL	≤RL	85–115%	75–125%	20
Nickel, dissolved	≤RL	≤RL	85–115%	75–125%	20
Nickel, total	≤RL	≤RL	85–115%	75–125%	20
Selenium, dissolved	≤RL	≤RL	85–115%	75–125%	20
Selenium, total	≤RL	≤RL	85–115%	75–125%	20
Zinc, dissolved	≤RL	≤RL	85–115%	75–125%	20
Zinc, total	≤RL	≤RL	85–115%	75–125%	20
6PPD-quinone	<RL	<RL	50–150%	50–150%	40, (LD) 45 (MSD)
Acenaphthene	≤RL	≤RL	53–114%	49–118%	40
Acenaphthylene	≤RL	≤RL	61–115%	59–118%	40
Anthracene	≤RL	≤RL	63–129%	58–132%	40
Benz(a)anthracene	≤RL	≤RL	62–148%	53–150%	40
Benzo(a)pyrene	≤RL	≤RL	75–120%	74–120%	40

Table 1 (continued). Measurement Quality Objectives for Water Quality Data.					
Parameter	Laboratory Method or Field Blank[a]	Equipment Rinsate Blank[a]	Control Standard Recovery	Matrix Spike Recovery[b]	Laboratory and Field Duplicate *RPD*[c]
Benzo(b,j,k)fluoranthene[d]	≤RL	≤RL	66–142%	63–143%	40
Benzo(g,h,i)perylene	≤RL	≤RL	55–150%	36–150%	40
Chrysene	≤RL	≤RL	62–133%	52–141%	40
Dibenz(a,h)anthracene	≤RL	≤RL	66–142%	48–150%	40
Fluoranthene	≤RL	≤RL	67–136%	54–146%	40
Fluorene	≤RL	≤RL	53–118%	49–115%	40
Indeno(1,2,3-cd)pyrene	≤RL	≤RL	67–146%	51–150%	40
1-Methylnaphthalene	≤RL	≤RL	31–116%	28–124%	40
2-Methylnaphthalene	≤RL	≤RL	31–116%	28–124%	40
Naphthalene	≤RL	≤RL	50–110%	44–113%	40
Phenanthrene	≤RL	≤RL	61–125%	55–130%	40
Pyrene	≤RL	≤RL	58–150%	56–150%	40
Perfluorobutanoic acid (PFBA)	≤RL	≤RL	70–140%	70–140%	30
Perfluoropentanoic acid (PFPeA)	≤RL	≤RL	65–135%	65–135%	30
Perfluorohexanoic acid (PFHxA)	≤RL	≤RL	70–145%	70–145%	30
Perfluoroheptanoic acid (PFHpA)	≤RL	≤RL	70–150%	70–150%	30
Perfluorooctanoic acid (PFOA)	≤RL	≤RL	70–150%	70–150%	30
Perfluorononanoic acid (PFNA)	≤RL	≤RL	70–150%	70–150%	30
Perfluorodecanoic acid (PFDA)	≤RL	≤RL	70–140%	70–140%	30
Perfluoroundecanoic acid (PFUnA)	≤RL	≤RL	70–145%	70–145%	30
Perfluorododecanoic acid (PFDoA)	≤RL	≤RL	70–140%	70–140%	30
Perfluorotridecanoic acid (PFTrDA)	≤RL	≤RL	65–140%	65–140%	30
Perfluorotetradecanoic acid (PFTeDA)	≤RL	≤RL	60–140%	60–140%	30
Perfluorobutanesulfonic acid (PFBS)	≤RL	≤RL	60–145%	60–145%	30

Table 1 (continued). Measurement Quality Objectives for Water Quality Data.					
Parameter	**Laboratory Method or Field Blank[a]**	**Equipment Rinsate Blank[a]**	**Control Standard Recovery**	**Matrix Spike Recovery[b]**	**Laboratory and Field Duplicate *RPD*[c]**
Perfluoropentanesulfonic acid (PFPeS)	≤RL	≤RL	65–140%	65–140%	30
Perfluorohexanesulfonic acid (PFHxS)	≤RL	≤RL	65–145%	65–145%	30
Perfluoroheptanesulfonic acid (PFHpS)	≤RL	≤RL	70–150%	70–150%	30
Perfluorooctanesulfonic acid (PFOS)	≤RL	≤RL	55–150%	55–150%	30
Perfluorononanesulfonic acid (PFNS)	≤RL	≤RL	65–145%	65–145%	30
Perfluorodecanesulfonic acid (PFDS)	≤RL	≤RL	60–145%	60–145%	30
Perfluorododecanesulfonic acid (PFDoS)	≤RL	≤RL	50–145%	50–145%	30
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2 FTS)	≤RL	≤RL	70–145%	70–145%	30
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2 FTS)	≤RL	≤RL	65–155%	65–155%	30
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2 FTS)	≤RL	≤RL	60–150%	60–150%	30
Perfluorooctanesulfonamide (PFOSA)	≤RL	≤RL	70–145%	70–145%	30
N-methylperfluorooctane sulfonamide (NMeFOSA)	≤RL	≤RL	60–150%	60–150%	30
N-ethylperfluorooctane sulfonamide (NEtFOSA)	≤RL	≤RL	65–145%	65–145%	30
N-methylperfluorooctanesulfonamidoacetic acid (NMeFOSAA)	≤RL	≤RL	50–140%	50–140%	30
N-ethylperfluorooctanesulfonamidoacetic acid (NEtFOSAA)	≤RL	≤RL	70–145%	70–145%	30
N-methylperfluorooctane sulfonamidoethanol (NMeFOSE)	≤RL	≤RL	70–145%	70–145%	30
N-ethylperfluorooctane sulfonamidoethanol (NEtFOSE)	≤RL	≤RL	70–135%	70–135%	30
Hexafluoropropylene Oxide Dimer Acid (HFPO-DA)	≤RL	≤RL	70–140%	70–140%	30
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	≤RL	≤RL	65–145%	65–145%	30
Perfluoro-3-methoxypropanoic acid (PFMPA)	≤RL	≤RL	55–140%	55–140%	30
Perfluoro-4-methoxybutanoic acid (PFMBA)	≤RL	≤RL	60–150%	60–150%	30
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	≤RL	≤RL	50–150%	50–150%	30
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9Cl-PF3ONS)	≤RL	≤RL	70–155%	70–155%	30

Table 1 (continued). Measurement Quality Objectives for Water Quality Data.					
Parameter	**Laboratory Method or Field Blank[a]**	**Equipment Rinsate Blank[a]**	**Control Standard Recovery**	**Matrix Spike Recovery[b]**	**Laboratory and Field Duplicate *RPD*[c]**
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	≤RL	≤RL	55–160%	55–160%	30
Perfluoro (2-ethoxyethane) sulfonic acid (PFEESA)	≤RL	≤RL	70–140%	70–140%	30
3-Perfluoropropylpropanoic acid (3:3 FTCA)	≤RL	≤RL	65–130%	65–130%	30
3-Perfluoropentylpropanoic acid (5:3 FTCA)	≤RL	≤RL	70–135%	70–135%	30
3-Perfluoroheptylpropanoic acid (7:3 FTCA)	≤RL	≤RL	50–145%	50–145%	30

[a] If criterion is not met, associated blank concentration is defined as the new reporting limit, and project sample data within 5 times this de facto reporting limit are flagged with a *U*.

[b] For inorganics, the CLP Functional Guidelines state that the spike recovery limits do not apply when the sample concentration exceeds the spike concentration by a factor of 4 or more (Ecology 2005).

[c] The relative percent difference must be less than or equal to the indicated percentage for values greater than 5 times the reporting limit. *Difference* must be within ±2 times the reporting limit for values less than or equal to 5 times the reporting limit.

[d] PAH benzo(b,j,k)fluoranthene will be reported as combined results for benzo(b)fluoranthene, benzo(j)fluoranthene, and benzo(k)fluoranthene.

Bias

Bias will be assessed based on analyses of method blanks, equipment rinsate blanks, field blanks, matrix spikes, and laboratory control samples (LCS).

Field Sample Bias

If a blank sample is greater than the RL, and the associated sample results within 5 times the blank quantity, that sample will be flagged with a "U" during data validation. The method detection limit (MDL) reported for that "U" -qualified sample will be equal to the concentration measured in that sample. This approach allows us to acknowledge the blank was contaminated and that associated sample results could be biased by that contamination.

Laboratory Bias

The values for method blanks will not exceed the reporting limit. The percent recovery of matrix spikes and LCS are listed in Table 1. Percent recovery for matrix spikes will be calculated using the following equation:

$$\%R = \frac{(S - U)}{C_{sa}} \times 100\%$$

Where:	%R	=	Percent recovery
	S	=	Measured concentration in spike sample
	U	=	Measured concentration in unspiked sample
	C_{sa}	=	Actual concentration of spike added

If the analyte is not detected in the unspiked sample, then a value of zero will be used in the equation.

Percent recovery for LCS will be calculated using the following equation:

$$\%R = \frac{M}{T} \times 100\%$$

Where:	%R	=	Percent recovery
	M	=	Measured value
	T	=	True value

Representativeness

The sampling design will provide samples that represent a wide range of water quality conditions during storm flow conditions. Sample representativeness will be ensured by adequate sample size over a sufficient time span, and by employing consistent and standard sampling procedures.

One of the goals of this project is to collect flow-weighted composite samples that are representative of event-mean concentrations (EMCs). For a composite sample to be representative of an EMC, certain sampling criteria are recommended. The sampling criteria for this project as defined by the TAPE guidance manual (Ecology 2018) are as follows:

- At least **7 to 10 flow-weighted sub-samples** (or aliquots) must be collected during the duration of the event.
- Samples shall be collected for at least **75 percent of the storm event hydrograph** as measured by volume for the first 24 hours of the event.
- Maximum sample duration will be **36 hours** from the time of the collection of the first aliquot to the last.

Storm sampling events will be selected as described in the QAPP based on TAPE guidelines (Herrera 2023, Ecology 2018). Up to three of the nine total sampling events may be base-flow monitoring events and will be selected based on the following criteria:

- Less than 0.04 inch of rain in the previous 24 hours prior to start of sampling.
- No forecast precipitation during the target base-flow sampling period.

This will result in 5 of the 20 total sampling events identified in the QAPP being base-flow samples with the remaining 15 being storm flow samples.

Completeness

Completeness will be calculated by dividing the number of valid values by the total number of values. Valid sample data consists of unflagged data and estimated data that has been assigned a *J* qualifier. A qualitative assessment will be made as to which *J* flagged data may need to be excluded from this calculation before the production of the final report. If less than 95 percent of the samples submitted to the laboratory are judged to be valid, then additional samples will be collected until at least 95 percent are judged to be valid.

Comparability

Standard sampling procedures, analytical methods, units of measurement, and reporting limits will be applied in this study to meet the goal of data comparability.

Experimental Design

This section describes the experimental design that will be used for the Addendum sampling at the Geneva "Austin South" study site.

Hydrologic Monitoring Process Design

Hydrologic monitoring will be conducted as described in the QAPP, and no additional hydrologic monitoring is proposed. However, bypass flow monitoring described in the performance verification monitoring QAPP will be abandoned due to equipment malfunction and site constraints. Instead, visual indicators of bypass will be noted on field forms during grab sample events when the dosing siphon is discharging. If the bypass weirs are being overtopped during siphon discharge field staff will document this with photographs and field notes.

Water Quality Sampling Process Design

An automated sampler (ISCO 6712) is currently installed at the inlet pipe to Flow Splitter 1 which conveys water into Cascade 1 of the Austin South facility (AS-IN) and represents untreated stormwater from the contributing basins. A second automated sampler intake is installed inside the underdrain pipe of Cascade 1 (AS-OUT) and represents the treated flows from the southern section of the Austin South bioretention swale (Cascade 1). These samplers will collect flow-weighted composite samples of the facility in accordance with the QAPP (Herrera 2023). These automated samplers will be used to collect paired samples during up to nine discrete events to obtain 18 samples (9 events × 2 samples per event = 18 samples). At least six of these sampling events will be storm events and up to three will be base-flow events. These composite samples may be collected in the same composite carboys as the performance verification samples. Sample volume will be split from the carboys and analyzed for the following suite of parameters: DOC, PAHs, 6PPDQ, and total and dissolved metals (arsenic, cadmium, chromium, copper, lead, nickel, selenium, and zinc). Flow-weighted composite sampling will follow the Automatic Sampling for Stormwater Monitoring SOP (Ecology 2024b) and is described in detail in the QAPP (Herrera 2023). Grab samples will also be collected at AS-IN and AS-OUT stations during individual events and analyzed for aquatic toxicity (four discrete events) and PFAS (six discrete events). All grab samples will be collected during qualifying storm events, not during baseflow events.

Additional samples will also be collected throughout the course of the monitoring program for quality assurance purposes (e.g., field duplicates, equipment rinsate blanks, and field blanks) and analyzed for a subset of these parameters, as appropriate. As described in the QAPP, each target composite sampling event will require a pre-event trip to deploy ice and check level sensor calibration and a post-event trip to pick up the composite samples. Each target grab sampling event, which may coincide with a composite sampling event, will require a during-event sampling trip to collect grab samples (PFAS and aquatic toxicity). See Table 4 in the Quality Control section for details on the anticipated number of water samples for each parameter.

Campbell Scientific CR350 dataloggers will control the ISCO 6712 automated samplers and will be programmed to trigger their respective automated samplers based on a predefined pacing volume. Once triggered, both automated samplers will collect a 200 mL sub-sample for compositing into separate 20-liter HDPE bottles. Samplers will be programmed to collect a sample at initiation to account for the volume of water that passed the monitoring stations before initiation. Pumped sub-sample volume will be calibrated at installation and then approximately once per month. Equipment inspection and calibration procedures and documentation are described in the performance validation monitoring QAPP.

The chemistry data from samples collected at the AS-IN station will be used to characterize pollutant concentrations from the basin runoff after pretreatment and solids settling. The chemistry data from the AS-OUT station will be used to evaluate the water quality treatment performance of Cascade 1 of the Project (see QAPP Figures 3 and 4).

Sampling Procedures

The specific field safety and sample collection procedures that will be used in connections with this study are described in the following subsections.

Field Safety Procedures

Herrera's Safety Policy is that health and safety of the staff is of paramount importance. Activities performed under potentially hazardous conditions shall be acknowledged and planned to mitigate personal injury. Herrera's Safety Policy shall apply during company-approved field work only.

- Prior to working on site, a general inspection of hazards will be made by the project manager.
- Onsite field personnel must have a communication device (i.e., cell phone, satellite phone) capable of connecting to an emergency contact (i.e., Herrera office, local emergency service).
- Designate at least one vehicle for emergency use.
- Roof-mounted flasher will be present on vehicles.
- Care will be taken when parking on the Austin Street shoulder. There is parallel street parking to the south of the Project along Austin Street. However, there is not a designated crosswalk to cross Cable Street.
- Field staff must visually and audibly confirm there is no traffic coming from either direction of Cable Street before crossing. Both low-traffic streets are straight, so sightlines are not limited in the vicinity.
- At a minimum, field personnel will follow the general requirements for personal protective equipment (PPE) by dressing appropriately for close proximity to vehicular traffic (WAC 296-155-200).
    - Protective footwear
    - High-visibility safety vest

All installation and monitoring work will be conducted in accordance with WSDOT safety protocols (WSDOT 2006). At least two field personnel will always be present when confined-space entry occurs at the site. All personnel entering maintenance holes for equipment installations, maintenance, and repairs will have confined-space entry training in accordance with Occupational Safety and Health Administration requirements (WAC 296-809).

Table 2 provides potential hazards and control measures identified for this work site.

Table 2. Potential Site Hazards and Control Measures.	
Hazards	**Hazard Control Measures**
Motor Vehicle Driving	• Drive defensively. • If you need to place or receive a phone call, pull off the road to a safe location and stop the vehicle before using your cell phone. Allow voicemail to handle your calls. • Be aware of weather and road conditions when driving (i.e., heavy rain, snow; large puddles in roadway, black ice). • Driver and passengers must wear seatbelts.
Weather Extremes	• Establish site-specific contingencies for severe weather situations. • Provide for frequent weather broadcasts. • Weatherize safety gear, as necessary. Note that certain weatherproofing chemicals may introduce PFAS contamination. • Identify special PPE needs. • Discontinue work during severe weather.
Heat Stress	• Provide cool break area and adequate breaks. • Promote heat stress awareness. • Use active cooling devices (e.g., cooling vests) where specified.
Sunburn	• Apply sunscreen. Select sunscreen that has been verified to be PFAS-free if needed during PFAS grab sampling. • Wear hats/caps and long-sleeved shirts.
Cold Exposure	• Provide warm break area and adequate breaks. • Provide warm, non-caffeinated beverages. • Promote cold stress awareness.
Slips, Trips, Falls	• Be aware of obstacles, such as cords, tools, and other equipment that may be present on the ground in the work area. • Identify and mark areas that are potentially slippery (e.g., wet or oily surfaces) with spray paint or flagging and walk around them. • Use handholds. • Wear boots with good traction.
Traffic Hazards	• Establish and follow a traffic control plan for equipment removal. • Wear bright orange reflective vests, when working within or alongside traffic.

Training

All field workers have received health and safety training required by OSHA (29 CFR 1910.120) and Washington State Division of Occupational Safety and Health (Chapter 296-843-200 WAC), including some or all of the following:

- First Aid and CPR training
- Annual Medical Clearance

Field Sampling Procedures

Field stormwater sampling procedures are described in the following sections.

Composite Stormwater Sampling Procedures

As described above, this project involves the collection of flow-weighted composite samples during at least six discrete storms and up to three base-flow events. Antecedent conditions and storm predictions will be monitored via the Internet, and a determination will be made as to whether to target an approaching storm. Before each targeted event, field staff will conduct site visits to set up the automated samplers at the AS-IN and AS-OUT stations. During these pre-event site visits, field staff will perform the following activities:

- Remove any blockages in the rain gauge and weirs.
- Calibrate the AS-IN and AS-OUT velocity sensors, as needed.
- Backflush the sample lines with deionized water.
- Check the state of the desiccant associated with the equipment.
- Place a clean sample bottle in the samplers.
- Pack ice around the sample bottles within each sampler.

Ice is estimated to keep the interior of the samplers cool for 48 hours; therefore, ice will be added to the samplers not more than 24 hours before a targeted event.

Sample pacing for the automated samplers will be determined based on rainfall versus runoff relationships that are developed using linear regressions of data that were collected during previous storm events. These regressions will be continually updated throughout the year to reflect changing hydrologic conditions. The rainfall versus runoff regressions are used to convert forecast rainfall totals into runoff volumes. The resultant runoff volume (gallons) is then divided by 50 (the median number of 200 mL aliquots that a 20-liter bottle will hold) to estimate the sample pacing (cubic feet) volume necessary to collect an adequate number (greater than 10) of aliquots across at least 75 percent of the storm hydrograph. Sample pacing for the automated samplers during base-flow events will be determined based on recent base-flow rates and sampler programming will ensure that sample aliquots are collected during dosing periods of the bioretention cell.

When the first aliquot is collected during a targeted event, the datalogger described above in the Water Quality Sampling Process Design section will send an alarm via text message to alert field personnel that stormwater is now flowing into Flow Splitter #1 (AS-IN monitoring location).

Flow-weighted composite sampling criteria will be assessed before post-event sample retrieval by accessing sampling data with a remote cellular link (Campbell CR350-CELL210 digital cellular modem). If sampling criteria are not met, the samples will be retrieved before the next event but not submitted for analysis. If sampling criteria are met, field personnel will return to the site and make visual and operational checks of the system and collect detailed field notes using standardized field forms (see Field

Quality Control Procedures). Field personnel will then remove the 20-liter HDPE bottles from each automated sampler, label each HDPE bottle with station ID, date, and time of last sample, then transport them on ice to the laboratory within the allowable limits for sample holding times (see Table 3). Additional samples will also be collected through the course of the Addendum sampling for quality assurance purposes (e.g., field duplicates and equipment rinsate blanks).

The laboratory will be given prior notice of a pending sampling event to ensure that adequate laboratory staff will be available to process the incoming samples. Once in the laboratory, water from the 20-liter HDPE bottles will be split and used to fill decontaminated, preserved (where appropriate) sample bottles for the required performance verification and Addendum sampling analyses. Sample bottles for the Addendum sampling will be shipped to Herrera's Bellingham office by KCEL prior to the targeted event and delivered to Exact Scientific with the composite sample volume. The samples will be analyzed for the suite of parameters that is identified in the Water Quality Sampling Process Design section.

Aquatic Toxicity Sampling Procedures

Grab samples for aquatic toxicity analysis will be collected in accordance with the U.S. EPA's methods for measuring the acute toxicity of effluents and receiving water to freshwater and marine organisms (U.S. EPA 2002) and Ecology's Laboratory guidance and whole effluent toxicity test review criteria (Ecology 2016). Water samples will be collected by hand from each of the two monitoring locations and filled into a 20-liter FLPE sample carboy provided by the laboratory. The Field Sampler will use aseptic techniques for collecting water samples. Because the carboy is too large to collect samples directly from the source, a laboratory-provided seasoned 2-liter Pyrex beaker that is clean and safe for toxicity sampling will be used to repeatedly collect grab samples until the carboy is full. Pyrex beakers will be attached to a sample pole with swivel to aid sample collection.

The collected water samples will be immediately stored in a cooler with ice at a temperature less than 6°C (Celsius). Grab samples for aquatic toxicity will be driven directly from the project site to KCEL for analysis within the recommended 36-hour (up to 72 hours if necessary due to logistics) holding time

Table 3. Water Quality Analysis Methods and Detection Limits.

Parameter	Analytical Method	Method Number[a]	Method Detection Limit	Reporting Limit/ Resolution	Units	Field Sample Container[b]	Pre-Filtration Holding Time	Total Holding Time	Field Preservation	Laboratory Container	Laboratory Preservation
Aquatic Toxicity	Whole Effluent Toxicity	EPA 2019, EPA 2021	NA	NA	NA	20-liter FLPE bottle	NA	36–72 hours	Cool ≤4°C	NA	Maintain ≤4°C, dark
Dissolved Organic Carbon	Persulfate UV	SM 5310B	0.5	2	mg/L	20-liter HDPE bottle	24 hours[b]	28 days	Cool ≤6°C	125-mL Amber HDPE	Maintain ≤4°C, HCl to pH <2 after filtration[f]
Arsenic, dissolved	ICP-MS	EPA 200.8	0.05	0.25	µg/L		24 hours[b,c]	180 days		500-mL HDPE	Maintain ≤4°C, HNO_3 to pH <2 after filtration[f]
Cadmium, dissolved			0.05	0.25							
Chromium, dissolved			0.2	1							
Copper, dissolved			0.3	2							
Lead, dissolved			0.1	0.5							
Nickel, dissolved			0.1	0.5							
Selenium, dissolved			0.5	1							
Zinc, dissolved			0.5	2.5							
Arsenic, total			0.05	0.25			NA			500-mL HDPE	Maintain ≤4°C, HNO_3 to pH <2
Cadmium, total			0.05	0.25							
Chromium, total			0.2	1							
Copper, total			0.3	2							
Lead, total			0.1	0.5							
Nickel, total			0.1	0.5							
Selenium, total			0.5	1							
Zinc, total			0.5	2.5							
6PPD-quinone[d]	LC-MS/MS	EPA 1634 Draft	2	10	ng/L		NA	14 days		250-mL Amber HDPE	Maintain ≤6°C
Acenaphthene	GC-MS	EPA 8270E	0.2	0.4	µg/L		NA	14 days		1-liter Amber glass	Maintain ≤6°C
Acenaphthylene			0.25	0.5							
Anthracene			0.25	0.5							
Benz(a)anthracene			0.25	0.5							
Benzo(a)pyrene			0.5	1							
Benzo(b,j,k)fluoranthene[e]			0.75	1.5							
Benzo(g,h,i)perylene			0.5	1							
Chrysene			0.25	0.5							
Dibenz(a,h)anthracene			0.75	1.5							
Fluoranthene			0.3	0.6							
Fluorene			0.25	0.5							
Indeno(1,2,3-cd)pyrene			0.5	1							
Fluoranthene			0.75	1.5							

Table 3 (continued). Water Quality Analysis Methods and Detection Limits.											
Parameter	Analytical Method	Method Number[a]	Method Detection Limit	Reporting Limit/ Resolution	Units	Field Sample Container[b]	Pre-Filtration Holding Time	Total Holding Time	Field Preservation	Laboratory Container	Laboratory Preservation
2-Methylnaphthalene	GC-MS	EPA 8270E	0.75	1.5	µg/L	20-liter HDPE bottle	NA	14 Days	Cool ≤6°C	1-liter Amber glass	Maintain ≤6°C
Naphthalene			0.25	0.5							
Phenanthrene			0.25	0.5							
Pyrene			0.25	0.5							
PFBA	LC-MS/MS	EPA 1633	1.00	4.00	ng/L	3x 125 mL HDPE bottles	NA	28 days preparation; 90 days analytical	Cool ≤6°C	NA	Cool ≤6°C
PFPeA			0.500	2.00							
PFHxA			0.500	2.00							
PFHpA			0.500	2.00							
PFOA			0.500	2.00							
PFNA			0.500	2.00							
PFDA			0.500	2.00							
PFUnA			0.500	2.00							
PFDoA			0.550	2.00							
PFTrDA			0.580	2.00							
PFTeDA			0.810	2.00							
PFBS			0.500	2.00							
PFPeS			0.500	2.00							
PFHxS			0.500	2.00							
PFHpS			0.500	2.00							
PFOS			0.500	2.00							
PFNS			0.500	2.00							
PFDS			0.500	2.00							
PFDoS			0.530	2.00							
4:2 FTS			1.00	4.00							
6:2 FTS			1.00	4.00							
8:2 FTS			1.00	4.00							
PFOSA			0.500	2.00							
NMeFOSA			0.500	2.00							
NEtFOSA			0.500	2.00							
NMeFOSAA			0.500	2.00							
NEtFOSAA			0.500	2.00							
NMeFOSE			2.50	10.0							
NEtFOSE			2.50	10.0							
HFPO-DA			0.390	1.50							
ADONA			0.500	2.00							
PFMPA			0.500	2.00							

Table 3 (continued). Water Quality Analysis Methods and Detection Limits.

Parameter	Analytical Method	Method Number[a]	Method Detection Limit	Reporting Limit/ Resolution	Units	Field Sample Container[b]	Pre-Filtration Holding Time	Total Holding Time	Field Preservation	Laboratory Container	Laboratory Preservation
PFMBA			0.500	2.00							
NFDHA			0.720	2.00							
9Cl-PF3ONS	LC-MS/MS	EPA 1633	0.580	2.00	ng/L	3x 125 mL HDPE bottles	NA	28 days preparation; 90 days analytical	Cool ≤6°C	NA	Cool ≤6°C
11Cl-PF3OUdS			0.500	2.00							
PFEESA			0.500	2.00							
3:3 FTCA			1.00	4.00							
5:3 FTCA			2.50	10.0							
7:3 FTCA			2.50	10.0							

[a] SM method numbers are from APHA et al. (1998); EPA method numbers are from the U.S. Environmental Protection Agency (U.S. EPA 1983, 1984, 2002, 2023, 2024). The 18th edition of *Standard Methods for the Examination of Water and Wastewater* (APHA et al. 1992) is the current legally adopted version in the *Code of Federal Regulations*.

[b] A 0.45 µm fiber nylon filter will be used for dissolved organic carbon filtration. A 0.45 µm cellulose filter will be used for dissolved metals filtration.

[c] U.S. EPA requires filtering for dissolved metals within 15 minutes of the collection of the last aliquot. This goal is exceedingly difficult to meet when conducting flow-weighted sampling. A more practical proxy goal for this study is 24 hours. Both goals will be reported with the data.

[d] 6PPD-quinone analysis will be conducted by KCEL unless Ecology accreditation is not received in time to process samples associated with this project (currently anticipated early October, 2024). In this case, samples would be submitted to Manchester Environmental Laboratory and will have a reporting limit of 1 ng/L.

[e] Benzo(b,j,k)fluoranthene is reported with combined results for benzo(b)fluoranthene, benzo(j)fluoranthene, and benzo(k)fluoranthene.

[f] A 0.45 µm cellulose filter will be used for dissolved metals filtration.

C = Celsius

GC-MS = gas chromatography mass spectroscopy

HDPE = High-Density Polyethylene

ICP-MS = inductively coupled plasma/mass spectrometry

mg/L = milligrams per liter

mL = milliliter

ng/L = nanograms per liter

FLPE = Fluorinated high density polyethylene

HCl = Hydrochloric acid mg/L = milligrams per liter

HNO_3 = Nitric acid

LC-MS/MS = Liquid chromatography/tandem mass spectrometry

µg/L = micrograms per liter

NA = Not applicable

PFAS Grab Sampling Procedures

Procedures for collecting grab stormwater samples for PFAS analysis are generally consistent with typical stormwater grab sampling procedures described in Ecology's Standard Operating Procedures for Collecting Grab Samples from Stormwater Discharges (Ecology 2024c) with additional considerations to avoid cross contamination due to the widespread use of PFAS in manufacturing and low water quality criteria. These additional procedures and considerations are presented in the subsections below.

PFAS Cross-Contamination

All equipment and materials used in the vicinity of the sample collection should be screened as sources of PFAS contamination prior to sample collection. PFAS screening will be approached in two stages: (1) sampling equipment that will come in direct contact with the sample volume including sample dippers and containers and (2) materials and equipment that will be in the vicinity of the samples including sampler clothing, sample coolers, and labels. Stage 1 materials should be thoroughly reviewed and free of known sources of PFAS, whereas Stage 2 materials should avoid known or suspected sources of PFAS unless it impacts field safety. Typical materials used in sampling equipment that may contain PFAS include:

- Polytetrafluoroethylene (PTFE)
- Fluorinated ethylene-propylene (FEP)
- Low-density polyethylene (LDPE)
- Pipe thread tapes and compounds

Typical Stage 2 materials and substances that may contain PFAS include:

- Certain personal care products including sunscreen, insect repellant, deodorant, or moisturizers
- Clothing or PPE treated with certain waterproofing or stain resistant chemicals
- Tyvek®
- Latex gloves
- Food containers or wrappers

Refer to the Michigan Department of Environment, Great Lakes, and Energy's General PFAS Sampling Guidance for a more comprehensive list of known PFAS containing materials and allowable PFAS-free alternatives (EGLE 2024).

In general, field staff will wear well laundered (washed at least six times without fabric softener) clothing made from synthetic and natural fibers and wear boots that do not contain GoreTex or Tyvek and have not been recently treated with waterproofing chemicals. On the day of sampling, field staff will avoid use of certain personal care products including deodorant, floss, moisturizer, and makeup. Sunscreen and insect repellants prescreened to be PFAS free may be used if necessary. Immediately prior to sample collection, field staff will avoid handling food packaged in containers or wrappers and ensure the sampling area is clear of potential contaminant sources including chemical ice packs, felt tip pens, sticky notes, and plastic binders or clipboards. Only powder-free nitrile gloves will be worn by the field staff during sampling area preparation and sample collection.

HDPE sample containers will be provided by the analytical laboratory, Eurofins Inc., and will be verified to be PFAS-free. Samples will be collected using a stainless-steel dipper that has been decontaminated as described below and rinsed using laboratory-provided PFAS-free water. An equipment blank will be collected using laboratory-provided PFAS-free water to verify that the equipment is free of contamination.

Field Decontamination

Field decontamination procedures will generally follow those outlined in the QAPP with the following considerations:

- Only use scrub brushes with polyethylene or PVC bristles.
- Use PFAS-free detergent such as Alconox®, Liquinox®, or Citranox®.
- Use laboratory-provided PFAS-free deionized water during all decontamination steps or triple rinse with laboratory-provided PFAS-free if standard deionized water was used during earlier decontamination steps.
- Decontaminated equipment may be stored in clean Ziploc® bags for short periods of time prior to use.

Sample Collection and Handling

Upon arrival at the project site, field staff will establish a sample staging area and a decontamination area. The staging area will be free from potential or known sources of PFAS contamination. The decontamination area may include potential sources of PFAS contamination including sampling equipment or rinse water but will otherwise be free of potential sources. Field sampling equipment will be decontaminated as described above and moved to the staging area. Field staff will change to fresh powder-free nitrile gloves after decontaminating equipment, when re-entering the staging area, and as needed to prevent contamination.

A field blank will be collected in the sample staging area prior to field sample collection by pouring laboratory-provided PFAS-free water into the laboratory-provided sample container. An equipment blank will be collected from the stainless-steel dipper by pouring laboratory-provided PFAS-free water into the decontaminated dipper and then into the laboratory-provided sample container after all field samples have been collected during the monitoring day. Field samples will then be collected starting at the influent station (AS-IN) and ending at the effluent station (AS-OUT) during dosing of the facility. The stainless-steel dipper will be decontaminated prior to collection of each field sample. The lag time between the start of dosing at the influent station and the end of the corresponding flow at the effluent station is expected to be approximately 30 minutes, which will allow field decontamination and collection of samples from the same dose. PFAS sampling is generally recommended to take place from lowest to highest expected concentrations however, while lower concentrations may be expected at AS-OUT, the concentrations are expected to be within the same order of magnitude. Sampling AS-IN and AS-OUT during the same dose will facilitate interpretation of the facility's PFAS treatment effectiveness.

Samples will be stored together in a plastic bag inside of a sample cooler. Wet ice will be bagged and used to keep the sample cool until delivery to the analytical laboratory. PFAS grab samples will not be stored with other samples.

Measurement Procedures

Laboratory analytical procedures for this project will follow U.S. Environmental Protection Agency (U.S. EPA)-approved methods (Table 3). Aquatic toxicity tests will be conducted with coho salmon (*Oncorhynchus kisutch*) and water flea (*Daphnia pulex*). However, if coho salmon are unavailable or show signs of poor health at the time of testing, it will instead be performed with rainbow trout (*Oncorhynchus mykiss*). The preservation methods, analytical methods, reporting limits, and sample holding times are presented in Table 3. Samples for the parameters requiring filtration (e.g., dissolved metals and DOC) will be delivered to the laboratory (Exact Scientific Services) within 24 hours of their collection. Upon their receipt, laboratory personnel will immediately filter and preserve these samples in containers provided by KCEL.

The laboratories identified for this project (Exact Scientific Services, KCEL, MEL, and Eurofins, Inc.) are certified by Ecology and participate in audits and inter-laboratory studies by Ecology and U.S. EPA. Performance and system audits have verified the adequacy of the laboratories' standard operating procedures, which include preventive maintenance, data reduction, and QA/QC procedures. KCEL is currently not accredited for 6PPDQ analysis via EPA 1634 Draft method, but is anticipating accreditation in early October 2024, prior to collection of the first samples for this program. If KCEL does not receive accreditation in time, 6PPDQ samples will be shipped to MEL for analysis instead. MEL is accredited for the EPA 1634 Draft method.

Exact Scientific Services will be used for sample splitting and filtration; Eurofins, Inc. will be used for PFAS analysis; and KCEL will analyze all other parameters. King County will be responsible for managing the laboratory data from KCEL and Eurofins, Inc.

The laboratories will report the analytical results within 30 days of receipt of the samples. The laboratories will provide all sample and quality control data in standardized reports that are suitable for evaluating the project data. Submittals will include all raw data, including but not limited to:

- All raw values including those below the reporting limit and between the method detection limit and the laboratory reporting limit
- The laboratory method detection limits and reporting limits for all analytes for each batch
- All field duplicate and laboratory split results

The reports will also include a case narrative summarizing any problems encountered in the analyses.

Quality Control

Quality control procedures are identified in separate subsections below for field and laboratory activities. The overall objective of these procedures is to ensure that data collected for this project are of a known and acceptable quality.

Field Quality Control Procedures

Quality control procedures that will be implemented for field activities are consistent with those described in the QAPP except where described in the following subsections. The frequency and type of quality control samples to be collected in the field are also summarized in Table 4.

Equipment Rinsate Blanks

Equipment rinsate blanks will be collected to verify that the automated sampler PTFE tubing is not a source of contamination for flow-weighted composite sampling. To collect the sample, the sample line will be rinsed in the same manner that it is during pre--event site visits. The sample line will then be detached at the point of sample collection and placed in a carboy of reagent grade water. The sampler will be programmed to collect 20 liters of reagent grade water using normal sample collection procedures. Tubing rinsate blanks for the Addendum monitoring program will be collected before the first targeted event and at the end of the study. All tubing rinsate blank samples will be submitted to the laboratory and labeled as separate (blind) samples.

Equipment rinsate blanks will also be collected to verify that the stainless-steel sample dipper is not a source of PFAS contamination for the stormwater grab samples. To collect the sample, laboratory-provided PFAS--free water will be used to fill the decontaminated dipper cup which will then be transferred to laboratory-provided sample containers. One PFAS rinsate blank will be collected during each sampling event once all field PFAS samples have been collected. All PFAS rinsate blank samples will be submitted to the laboratory and labeled as separate (blind) samples.

PFAS Field Blanks

One field blank per sampling event will be collected to verify that samples and laboratory-provided PFAS--free water have not been contaminated due to sampler or laboratory contamination. The sample will be collected by pouring laboratory-provided PFAS free water directly into a sample container in the sample staging area prior to field sample collection. All field blank samples will be submitted to the laboratory and labeled as separate (blind) samples.

Table 4. Quality Assurance Requirements and Anticipated Number of Water Samples for Each Parameter.

Parameter	Project Samples		Field QA Samples			Total Number of Samples Submitted to Laboratory	Laboratory QA Samples			
	Flow-Weighted Composite Samples	Grab Samples	Field Equipment Rinsate Blanks[d]	Field Blanks	Field Duplicates[e]		Laboratory Method Blanks	Laboratory Control Standard	Matrix Spike	Laboratory Duplicates
Aquatic toxicity	0	8	NA	NA	0	8	NA	1 per batch[f]	NA	NA
Total and dissolved metals[a]	18	0	2	0	2	22	1 per batch[f]	1 per batch[f]	1 per batch[f]	1 per batch[f]
Dissolved organic carbon	18	0	2	0	2	22	1 per batch[f]	1 per batch[f]	1 per batch[f]	1 per batch[f]
6PPD-quinone	18	0	2	0	2	22	1 per batch[f]	1 per batch[f]	1 per batch[f]	1 per batch[f]
PAHs[b]	18	0	2	0	2	22	1 per batch[f]	1 per batch[f]	1 per batch[f]	1 per batch[f]
PFAS[c]	NA	12	6	6	2	26	1 per batch[f]	1 per batch[f]	NA	NA

[a] Total and dissolved metals will include arsenic, cadmium, chromium, copper, lead, nickel, selenium, and zinc.

[b] PAHs analysis will include 17 individual PAH compounds. See Amendment to QAPP addendum (2025)

[c] PFAS analysis will include 40 individual PFAS compounds

[d] Tubing rinsate blanks will be collected before the first event and at the end of the study, and PFAS equipment blanks will be collected on during the first, third or fourth, and sixth events immediately prior to sample collection.

[e] Field duplicates will be collected and analyzed for at least 10 percent of the total number of submitted samples.

[f] Laboratory QA samples will be analyzed with each batch of samples submitted to the laboratory for analysis. A laboratory batch will consist of no more than 20 samples.

NA = not applicable; PAHs = Polycyclic aromatic hydrocarbons; PFAS = Per- and polyfluoroalkyl substances

Field Duplicates

Field duplicates will be collected at a sufficient frequency to represent 10 percent of the total number of project samples analyzed. The number of field duplicates to be collected during each year of field testing is listed in Table 4. For water quality samples, field duplicates will be collected from the AS-IN station. All duplicate samples will be submitted to the laboratory and labeled as separate (blind) samples. The resultant data from these samples will then be used to assess variation in the analytical results that is attributable to environmental (natural), sub-sampling, and analytical variability.

Sample Packing and Shipping

Composite samples for DOC, PAHs, and total and dissolved metals analyses will be shipped by Exact Scientific to KCEL in Seattle, Washington. Grab samples for PFAS will be shipped by field sampling staff to Eurofins Inc., in Sacramento, California. Recommended steps for packing and shipping samples include:

- Fold the field-sampling sheets and chain of custody record form and place them in plastic bags to protect the sheets during transport.
- Clearly mark the analyses to be performed for each sample.
- Pack samples to prevent breakage or leakage (samples should already be labeled).
- Securely seal shipping containers and affix identification labels to each shipping container.
- Mark containers "THIS END UP" and number containers in a shipment.

Grab samples for aquatic toxicity will be packed in wet ice and driven directly from the project site to KCEL for analysis.

6PPDQ samples will be shipped to MEL if KCEL has not yet received accreditation for EPA 1634.

Chain-of-Custody Record

A chain-of-custody record will be maintained for each sample batch listing the sampling date and time, sample identification numbers, analytical parameters and methods, persons relinquishing and receiving custody, dates and times of custody transfer, and temperature of sample upon delivery. Samples shipped by field sampling staff will be secured with a signed and dated custody seal.

Laboratory Quality Control Procedures

Quality control procedures that will be implemented in the laboratory are described in the following subsections. The frequency and type of quality control samples to be analyzed by the laboratory are also summarized in Table 4.

Method Blanks

Method blanks consisting of de-ionized and micro-filtered pure water will be analyzed with every laboratory sample batch. A laboratory sample batch will consist of no more than 20 samples and may include samples from other projects. The total number of method blanks anticipated for this study is shown in Table 4 by parameter. Blank values will be presented in each laboratory report.

Control Standards

Control standards for each parameter will be analyzed by the laboratory with every sample batch. A laboratory sample batch will consist of no more than 20 samples and may include samples from other projects. The total number of control standards anticipated for this study is shown in Table 4 by parameter. Raw values and percent recovery (see formula in the Quality Objectives section) for the control standards will be presented in each laboratory report.

Matrix Spikes

For applicable parameters, matrix spikes will be analyzed by the laboratory with every sample batch. A laboratory sample batch will consist of no more than 20 samples and may include samples from other projects. The total number of matrix spikes anticipated for this study is shown in Table 4 by parameter. Raw values and percent recovery (see formula in the Quality Objectives section) for the matrix spikes will be presented in each laboratory report.

Surrogates

For applicable parameters, surrogates will be analyzed by the laboratory with every applicable sample. Raw values and percent recovery (see formula in the Quality Objectives section) for the surrogates will be presented in each laboratory report.

Laboratory Duplicates

Laboratory split-sample duplicates for each parameter will be analyzed with every sample batch. This will represent no less than 5 percent of the project submitted samples. The total number of laboratory duplicates anticipated for this study is shown in Table 4 by parameter. Raw values and relative percent difference (see formula in the Quality Objectives section) of the duplicate results will be presented in each laboratory report.

Data Management Procedures

Hydrologic data will be managed as described in the QAPP, with preliminary hydrologic data provided to King County within 14 days of a target storm event. Complete validated hydrologic data from the performance verification monitoring Report will be provided by Herrera at the conclusion of the monitoring program in spreadsheet (Microsoft Excel) format.

The laboratories will report the analytical chemistry results within 30 days of receipt of the samples. Toxicity test results will be reported within 60 days. The laboratories will provide sample and quality control data in standardized reports that are suitable for evaluating the project data. These reports will include all raw data including raw quality assurance data, and all quality control results associated with the data. The reports will also include a case narrative summarizing any problems encountered in the analyses, corrective actions taken, changes to the referenced method, and an explanation of data qualifiers. Laboratory analytical and QA results will be delivered from the laboratory in electronic form.

Event-based hydrologic data from each storm will be stored in a SQL database and spreadsheet (Microsoft Excel) format. A continuous hydrologic record will also be stored and provided to King County in spreadsheet (Microsoft Excel) format. Chemistry data generated by KCEL will be stored in King County's Laboratory Information Management System (LIMS). Toxicology data generated by KCEL will be stored in King County's Laboratory Information Management System (LIMS) and the lab report file including statistical information will be appended to the project in the LIMS database as a PDF file. PFAS data from Eurofins will be appended to project in King County's LIMS database as a PDF report.

Audits and Reports

Audits will be performed to detect potential deficiencies in the hydrologic and water quality data collected for this project. Hydrologic data audits will be conducted by Herrera as part of the performance verification monitoring program as described in the QAPP (Herrera 2023).

Analytical laboratories (KCEL and Eurofins) participate in performance and system audits as part of their routine procedures. No audits are planned specifically for this project.

Verification and Validation Methods for Water Quality Data

Data will be reviewed and audited by King County within 14 business days of receiving the results from the laboratory as described in the QAPP using MQOs described in Table 1 of this Addendum.

King County will perform the following data validation and verification on chemistry data generated by KCEL and Eurofins:

- Check the analytical data package for completeness and verify that all data requested is present in the data deliverables.
- Check laboratory compliance with QAPP requirements for conditions of samples upon receipt.
- Review all analytical quality assurance and quality control data for acceptance using the MQO criteria described in Table 1.

A complete checklist of data verification and validation steps is included in Appendix A.

Data Quality Assessment

Separate subsections herein describe the procedures that will be used to assess the usability of the data, analyze the data, and report the associated results.

Data Usability Assessment

Consistent with performance verification monitoring procedures outlined in the QAPP, King County will conduct a review of the water quality QC data from each sampling event using the MQOs identified in this QAPP Addendum. King County will add any *U* flags deemed necessary by the MQOs after receipt of the lab data and will document necessary additional flags in the final report.

Unflagged data and estimated data with a *J* flag (data between MDL and RL) will be considered valid and used in the data analyses specified in the following sections. For calculation of removal efficiencies, non-detect ("U"-flagged) data will be statistically imputed according to Table 5 (adapted from Helsel 2012) below if <80 percent of the samples in the statistical group (e.g., influent, effluent) have a "U" flag. This imputed data will then be used in the removal efficiency calculations. If >80 percent of samples are "U"-flagged, imputation and estimation of summary statistics are unreliable, and data will be reported as "% detected" (above MDL). Data that have been "U"-flagged during data validation/verification due to detections in an associated blank sample will be interval-censored (Helsel 2012) with a left-censor equal to the original MDL and a right-censor equal to the reported sample result (see the Field Sample Bias section for blank detection flagging).

Table 5. Approaches for Handling Censored Data ("U" Flagged) in Data Analysis.

Percent Censored at MDL ("U"-flagged)	Data Handling for Analysis
<50% censored observations	Imputation or Kaplan-Meier/Turnbull estimation
50–80% censored observations	Robust Maximum Likelihood Estimation or Robust Regression Order Statistics
>80% censored observations	Report % of data above the MDL

Table is adapted from Helsel (2012) for datasets with less than 50 observations.

Flow data associated with Addendum monitoring events will be assessed as part of the performance verification monitoring program as described in the QAPP.

Data Analysis Procedures

Statistical Comparisons of Influent and Effluent Pollutant Concentrations

Statistical analyses will be performed to assess significance of differences in pollutant concentrations between the influent and effluent stations across individual storm events. The specific null hypothesis (Ho) and alternative hypothesis (Ha) for these analyses are as follows:

H_o: Effluent pollutant concentrations are equal to or higher than influent concentrations.

H_a: Effluent concentrations are lower than influent concentrations.

To evaluate these hypotheses, a Wilcoxon signed rank test (Helsel and Hirsch 2002) will be used to compare performance data from AS-IN and AS-OUT. The Wilcoxon test is a non-parametric analogue to the paired t-test. Statistical significance will be assessed based on an alpha (a) level of 0.05. Values less than or equal to the reporting limit will be set to negative 1 prior to the analysis so that they are ranked below reported values and are set to be equivalent in rank with one another.

Calculation of the Pollutant Removal Efficiency

Pursuant to guidance from Ecology (2018), the reduction (in percent) in pollutant concentration during each individual storm (ΔC) will be calculated as:

$$\Delta C = 100 \times \frac{\left(C_{in} - C_{eff}\right)}{C_{in}}$$

Where:

C_{in} = Flow-weighted influent pollutant concentration
C_{eff} = Flow-weighted effluent pollutant concentration

To isolate the performance of the bioretention swale, this calculation will be performed for AS-IN and AS-OUT.

Reporting Procedures

One report will be prepared to describe the results of this project, consistent with requirements of the SAM agreement. The chemical data gathered as part of this project will be formatted for the International Stormwater Best Management Practices Database (BMPDB) repository at the end of the project term for future upload by Ecology.

References

APHA, AWWA, and WEF. 1992. Standard Methods for the Examination of Water and Wastewater. 18th edition. Edited by A.E. Greenberg, American Public Health Association; A.D. Eaton, American Water Works Association; and L.S. Clesceri, Water Environment Federation.

APHA, AWWA, and WEF. 1998. Standard Methods for the Examination of Water and Wastewater. 20th edition. Edited by A. Greenberg, A.D. Eaton and L. Clesceri. American Public Health Association, American Water Works Association, Water Environment Federation, Washington, DC.

Ecology. 2005. Manchester Environmental Laboratory Lab User's Manual, Eighth Edition. Washington State Department of Ecology, Olympia, Washington.

Ecology. 2016. Whole Effluent Toxicity Testing Guidance and Test Review Criteria. Publication WQ-R-95-80. Washington State Department of Ecology, Water Quality Program, Olympia, Washington. June

Ecology. 2018. Technical Guidance Manual for Evaluating Emerging Stormwater Treatment Technologies: Technology Assessment Protocol – Ecology (TAPE). Water Quality Program, Washington State Department of Ecology, Olympia, Washington.

Ecology. 2021. Guidance on Using New High Performance Bioretention Soil Mixes. Publication 21-10-023. Washington State Department of Ecology, Olympia, Washington.

Ecology. 2024a. Guidance on Using New High Performance Bioretention Soil Mixes. Publication 21-10-023. Water Quality Program, Washington State Department of Ecology, Olympia, Washington.

Ecology. 2024b. Automatic Sampling for Stormwater Monitoring: Standard Operating Procedure Version 1.2. Water Quality Program, Washington State Department of Ecology, Olympia, Washington. March.

Ecology. 2024c. Standard Operating Procedures for Collecting Grab Samples from Stormwater Discharges, version 1.1. Water Quality Program, Washington State Department of Ecology, Olympia, Washington. March.

EGLE. 2024. General PFAS Sampling Guidance. Michigan Department of Environment, Great Lakes, and Energy, Lansing, Michigan. January.

Helsel, D.R., and R.M. Hirsch. 2002. Statistical Methods in Water Resources. Elsevier, Amsterdam.

Helsel, Dennis R. 2012. "Computing Summary Statistics and Totals" *in* Statistics for Censored Environmental Data Using Minitab and R (2012):1–10.

Herrera. 2023. Quality Assurance Project Plan—Geneva Bioretention Pilot Project. Prepared for Whatcom County by Herrera Environmental Consultants, Inc., Seattle, Washington.

U.S. EPA. 1983. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020. U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio.

U.S. EPA. 1984. Guidelines Establishing Test Procedures for the Analysis of Pollutants under the Clean Water Act; Final Rule and Interim Final Rule. CFR Part 136. U.S. Environmental Protection Agency. October 26.

U.S. EPA. 2002. Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms, fifth edition. Publication EPA-821-R-02-012. U.S. Environmental Protection Agency, Office of Water, Washington, DC. October.

USEPA 2009. Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use. EPA 540-R-08-005. Office of Solid Waste and Emergency Response,

Washington D.C. 29 pp. January.

U.S. EPA. 2023. Draft Method 1634 Determination of 6PPD-Quinone in Aqueous Matrices Using Liquid Chromatography with Tandem Mass Spectrometry (LC/MS/MS). Publication EPA-821-D-24-001. U.S. Environmental Protection Agency, Office of Water, Office of Science and Technology, Washington DC. December.

U.S. EPA. 2024. Method 1633 Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Aqueous, Solid, Biosolids, ant Tissue samples by LC-MS/MS. Publication EPA-821-R-24-001. U.S. Environmental Protection Agency, Office of Water, Office of Science and Technology, Washington DC. January.

WSDOT. 2006. Work Zone Traffic Control Guidelines. Publication M 54-44. Washington State Department of Transportation, Olympia, Washington.

Appendix A

Data Verification and Validation Checklist

HERRERA
Science + Planning + Design

Stage 1 Baseline Checklist

Stage 1 validation of the laboratory analytical data package consists of verification and validation checks for the compliance of sample receipt conditions, sample characteristics (e.g., percent moisture), and analytical results (with associated information). The following is a checklist of items for each laboratory analytical data package.

Project QAPP:	
Electronic Data Deliverable filename:	
Laboratory data package ID:	
King County QA Reviewer:	
File path to QA records:	
Comments as appropriate:	

1. **Documentation identifies the laboratory receiving and conducting analyses**. Yes/No
Comments:

2. **Documentation for all samples submitted by the project or requester for analyses**. Yes/No
Comments:

3. **Requested analytical methods were performed and the analysis dates are present**. Yes/No
Comments:

4. **Requested target analyte results are reported along with the original laboratory data qualifiers.** Yes/No
Comments:

5. **Data qualifier definitions are provided for each reported result**. Yes/No
Comments:

6. **The uncertainty of each result and qualifier are clear, with clear indication of the type of uncertainty reported if required (e.g., radiochemical analyses)**. Yes/No.
Comments:

7. **Requested target analyte result units are reported (along with their associated uncertainty units if required, e.g., for radiochemical analyses)**. Yes/No
Comments:

8. **Requested reporting limits for all samples are present**. Yes/No
Comments:

9. **Results at and below the requested (required) reporting limits are clearly identified (including sample detection limits if required)**. Yes/No
Comments:

10. **The following are included in the laboratory data package**:

- Sampling dates (including times if needed). Yes/No
- Date and time of laboratory receipt of samples. Yes/No
- Sample conditions upon receipt at the laboratory (including preservation, pH and temperature). Yes/No

11. **Data Review**: Compare sample conditions upon receipt at the laboratory (e.g., preservation checks) and sample characteristics (e.g., percent moisture) to the requirements and guidelines present in national or regional data validation documents, analytical method(s) or contract. Comments:

Stage 2A Verification and Validation Checklist

Stage 2A validation of the laboratory analytical data package consists of the Stage 1 validation plus the verification and validation checks for the compliance of sample-related QC. To complete Stage 2A, please address the following additional baseline checks using the laboratory analytical data package received for a Stage 2A.

12. **Requested methods (handling, preparation, cleanup, and analytical) were performed**. Yes/No
Comments:

13. **Method dates for handling (e.g., TCLP), preparation, cleanup and analysis are present, as appropriate.** Yes/No
Comments:

14. **The following sample-related QC data and QC acceptance criteria are provided and linked to the reported field samples. "NA" means not applicable according to specifications of the QAPP**:

- Method blanks. Yes/No/NA
- Surrogate recoveries. Yes/No/NA
- Deuterated monitoring compounds (DMC) recoveries. Yes/No/NA
- Laboratory control sample (LCS) recoveries. Yes/No/NA
- Duplicate analyses. Yes/No/NA
- Matrix spike and matrix spike duplicate recoveries. Yes/No/NA
- Serial dilutions. Yes/No/NA
- Post digestion spikes. Yes/No/NA
- Standard reference materials. Yes/No/NA
- Field quality control samples (such as trip and equipment blanks). Yes/No/NA

Comments:

15. **Requested spike analytes or compounds (e.g., surrogate, DMCs, LCS spikes, post digestion spikes) were added, as appropriate to the method or QAPP**. Yes/No
Comments:

16. **Sample holding times (from sampling date to preparation and preparation to analysis) were met.** Yes/No
Comments:

17. **Frequency of QC samples is consistent with QAPP specifications**. Yes/No
Comments:

18. **Data Review:** Compare sample holding times and sample-related QC data to the requirements and guidelines present in national or regional data validation documents, analytical method(s) or contract.

Amendment to Quality Assurance Project Plan Addendum:

Geneva Bioretention Pilot Project Contaminants of Emerging Concern

Prepared by: Chelsea Mitchell, King County Water and Land Resources Division

---

Approved by: Date:

Signature	Date
Chelsea Mitchell, Project Manager, King County Water and Land Resources	2/7/2025
Sam Nilsson, Project Manager, Herrera Environmental Consultants, Inc.	2/11/2025
Dylan Ahearn, Principal Investigator, Herrera Environmental Consultants, Inc.	2/11/2025
Cody Swan, Project Manager, Whatcom County Public Works	2/11/2025
Chelsea Morris, Project Manager, Washington State Department of Ecology	2/11/2025
Chris Dudenhoeffer, QA Coordinator, Washington State Department of Ecology	2/11/2025
Katie Hallaian, Laboratory Manager, Exact Scientific Services	2/11/2025
Meghan Elkey, Laboratory Project Manager, King County Environmental Laboratory	2/11/2025

King County is amending the Geneva Bioretention Pilot Project Contaminants of Emerging Concern QAPP (approved November 2024) to remove PAHs from the sample parameter list due to no detections in the influent (GENEVA_AS_IN) or effluent (GENEVA_AS_OUT) during the first two storm flow sampling events on 12/18/2024 and 01/10/2025 (Table 1). The storm flow events are expected to have higher contaminants concentrations, including PAH analytes, than base flow events for this study, and the lack of detections in storm flow samples so far suggests we are unlikely to detect PAHs in this system using the present method (SW846 3520C*SW846 8270E). It is likely that the detection limits (MDL range 0.189 µg/L – 0.735 µg/L per analyte) are too high to detect PAHs from this residential catchment.

Six samples have been analyzed for PAHs so far (L84792-2, L84792-1, L83717-1, L83719-1, L83717-2, and L83719-2) at a cost of $470/sample. By ceasing to analyze PAHs in the remaining 16 samples for which they were planned to be measured, total project cost savings would be $7,520. These funds could be used to support two additional field sampling events conducted by Herrera after the Whatcom County study ends in April 2026.

PAH data from the first two events of this study will be reported in terms of detection frequency by analyte (0% for all analytes), and no statistical analyses will be conducted.

Table 1. PAH detections for available study data.

Collect Date	Locators (Sample IDs)	Result	Event type
12/11/2024	EQUIPBLANK	All analytes <QL (non-detect)	Equipment rinsate
12/18/2024	GENEVA_AS_IN, GENEVA_AS_OUT	All analytes <QL (non-detect)	Storm flow
01/10/2025	GENEVA_AS_IN, GENEVA_AS_OUT	All analytes <QL (non-detect)	Storm flow

All PAH data are shown in Table 2 of this addendum.

Table 2. All available PAH data from the study so far.

LOCATOR	COLLECTDATE	LABSAMPLENUM	PARMNAME	VALUE	UNITS	QUALIFIER	MDL	RDL
EQUIPBLANK	12/11/2024 12:43	L84792-2	1-Methylnaphthalene	NA	ug/L	<QL	0.708	1.42
EQUIPBLANK	12/11/2024 12:43	L84792-2	2-Methylnaphthalene	NA	ug/L	<QL	0.708	1.42
EQUIPBLANK	12/11/2024 12:43	L84792-2	Acenaphthene	NA	ug/L	<QL	0.189	0.377
EQUIPBLANK	12/11/2024 12:43	L84792-2	Acenaphthylene	NA	ug/L	<QL	0.236	0.472
EQUIPBLANK	12/11/2024 12:43	L84792-2	Anthracene	NA	ug/L	<QL	0.236	0.472
EQUIPBLANK	12/11/2024 12:43	L84792-2	Benzo(a)anthracene	NA	ug/L	<QL	0.236	0.472
EQUIPBLANK	12/11/2024 12:43	L84792-2	Benzo(a)pyrene	NA	ug/L	<QL	0.472	0.943
EQUIPBLANK	12/11/2024 12:43	L84792-2	Benzo(b,j,k)fluoranthene	NA	ug/L	<QL	0.708	1.42
EQUIPBLANK	12/11/2024 12:43	L84792-2	Benzo(g,h,i)perylene	NA	ug/L	<QL	0.472	0.943
EQUIPBLANK	12/11/2024 12:43	L84792-2	Chrysene	NA	ug/L	<QL	0.236	0.472
EQUIPBLANK	12/11/2024 12:43	L84792-2	Dibenzo(a,h)anthracene	NA	ug/L	<QL	0.708	1.42
EQUIPBLANK	12/11/2024 12:43	L84792-2	Fluoranthene	NA	ug/L	<QL	0.283	0.566
EQUIPBLANK	12/11/2024 12:43	L84792-2	Fluorene	NA	ug/L	<QL	0.236	0.472
EQUIPBLANK	12/11/2024 12:43	L84792-2	Indeno(1,2,3-Cd)Pyrene	NA	ug/L	<QL	0.472	0.943
EQUIPBLANK	12/11/2024 12:43	L84792-2	Naphthalene	NA	ug/L	<QL	0.236	0.472
EQUIPBLANK	12/11/2024 12:43	L84792-2	Phenanthrene	NA	ug/L	<QL	0.236	0.472
EQUIPBLANK	12/11/2024 12:43	L84792-2	Pyrene	NA	ug/L	<QL	0.236	0.472
EQUIPBLANK	12/11/2024 12:58	L84792-1	1-Methylnaphthalene	NA	ug/L	<QL	0.708	1.42
EQUIPBLANK	12/11/2024 12:58	L84792-1	2-Methylnaphthalene	NA	ug/L	<QL	0.708	1.42
EQUIPBLANK	12/11/2024 12:58	L84792-1	Acenaphthene	NA	ug/L	<QL	0.189	0.377
EQUIPBLANK	12/11/2024 12:58	L84792-1	Acenaphthylene	NA	ug/L	<QL	0.236	0.472
EQUIPBLANK	12/11/2024 12:58	L84792-1	Anthracene	NA	ug/L	<QL	0.236	0.472
EQUIPBLANK	12/11/2024 12:58	L84792-1	Benzo(a)anthracene	NA	ug/L	<QL	0.236	0.472
EQUIPBLANK	12/11/2024 12:58	L84792-1	Benzo(a)pyrene	NA	ug/L	<QL	0.472	0.943
EQUIPBLANK	12/11/2024 12:58	L84792-1	Benzo(b,j,k)fluoranthene	NA	ug/L	<QL	0.708	1.42
EQUIPBLANK	12/11/2024 12:58	L84792-1	Benzo(g,h,i)perylene	NA	ug/L	<QL	0.472	0.943

LOCATOR	COLLECTDATE	LABSAMPLENUM	PARMNAME	VALUE	UNITS	QUALIFIER	MDL	RDL
EQUIPBLANK	12/11/2024 12:58	L84792-1	Chrysene	NA	ug/L	<QL	0.236	0.472
EQUIPBLANK	12/11/2024 12:58	L84792-1	Dibenzo(a,h)anthracene	NA	ug/L	<QL	0.708	1.42
EQUIPBLANK	12/11/2024 12:58	L84792-1	Fluoranthene	NA	ug/L	<QL	0.283	0.566
EQUIPBLANK	12/11/2024 12:58	L84792-1	Fluorene	NA	ug/L	<QL	0.236	0.472
EQUIPBLANK	12/11/2024 12:58	L84792-1	Indeno(1,2,3-Cd)Pyrene	NA	ug/L	<QL	0.472	0.943
EQUIPBLANK	12/11/2024 12:58	L84792-1	Naphthalene	NA	ug/L	<QL	0.236	0.472
EQUIPBLANK	12/11/2024 12:58	L84792-1	Phenanthrene	NA	ug/L	<QL	0.236	0.472
EQUIPBLANK	12/11/2024 12:58	L84792-1	Pyrene	NA	ug/L	<QL	0.236	0.472
GENEVA_AS_IN	12/18/2024 11:33	L83717-1	1-Methylnaphthalene	NA	ug/L	<QL	0.708	1.42
GENEVA_AS_IN	12/18/2024 11:33	L83717-1	2-Methylnaphthalene	NA	ug/L	<QL	0.708	1.42
GENEVA_AS_IN	12/18/2024 11:33	L83717-1	Acenaphthene	NA	ug/L	<QL	0.189	0.377
GENEVA_AS_IN	12/18/2024 11:33	L83717-1	Acenaphthylene	NA	ug/L	<QL	0.236	0.472
GENEVA_AS_IN	12/18/2024 11:33	L83717-1	Anthracene	NA	ug/L	<QL	0.236	0.472
GENEVA_AS_IN	12/18/2024 11:33	L83717-1	Benzo(a)anthracene	NA	ug/L	<QL	0.236	0.472
GENEVA_AS_IN	12/18/2024 11:33	L83717-1	Benzo(a)pyrene	NA	ug/L	<QL	0.472	0.943
GENEVA_AS_IN	12/18/2024 11:33	L83717-1	Benzo(b,j,k)fluoranthene	NA	ug/L	<QL	0.708	1.42
GENEVA_AS_IN	12/18/2024 11:33	L83717-1	Benzo(g,h,i)perylene	NA	ug/L	<QL	0.472	0.943
GENEVA_AS_IN	12/18/2024 11:33	L83717-1	Chrysene	NA	ug/L	<QL	0.236	0.472
GENEVA_AS_IN	12/18/2024 11:33	L83717-1	Dibenzo(a,h)anthracene	NA	ug/L	<QL	0.708	1.42
GENEVA_AS_IN	12/18/2024 11:33	L83717-1	Fluoranthene	NA	ug/L	<QL	0.283	0.566
GENEVA_AS_IN	12/18/2024 11:33	L83717-1	Fluorene	NA	ug/L	<QL	0.236	0.472
GENEVA_AS_IN	12/18/2024 11:33	L83717-1	Indeno(1,2,3-Cd)Pyrene	NA	ug/L	<QL	0.472	0.943
GENEVA_AS_IN	12/18/2024 11:33	L83717-1	Naphthalene	NA	ug/L	<QL	0.236	0.472
GENEVA_AS_IN	12/18/2024 11:33	L83717-1	Phenanthrene	NA	ug/L	<QL	0.236	0.472
GENEVA_AS_IN	12/18/2024 11:33	L83717-1	Pyrene	NA	ug/L	<QL	0.236	0.472
GENEVA_AS_IN	1/10/2025 15:35	L83719-1	1-Methylnaphthalene	NA	ug/L	<QL	0.735	1.47
GENEVA_AS_IN	1/10/2025 15:35	L83719-1	2-Methylnaphthalene	NA	ug/L	<QL	0.735	1.47

LOCATOR	COLLECTDATE	LABSAMPLENUM	PARMNAME	VALUE	UNITS	QUALIFIER	MDL	RDL
GENEVA_AS_IN	1/10/2025 15:35	L83719-1	Acenaphthene	NA	ug/L	<QL	0.196	0.392
GENEVA_AS_IN	1/10/2025 15:35	L83719-1	Acenaphthylene	NA	ug/L	<QL	0.245	0.49
GENEVA_AS_IN	1/10/2025 15:35	L83719-1	Anthracene	NA	ug/L	<QL	0.245	0.49
GENEVA_AS_IN	1/10/2025 15:35	L83719-1	Benzo(a)anthracene	NA	ug/L	<QL	0.245	0.49
GENEVA_AS_IN	1/10/2025 15:35	L83719-1	Benzo(a)pyrene	NA	ug/L	<QL	0.49	0.98
GENEVA_AS_IN	1/10/2025 15:35	L83719-1	Benzo(b,j,k)fluoranthene	NA	ug/L	<QL	0.735	1.47
GENEVA_AS_IN	1/10/2025 15:35	L83719-1	Benzo(g,h,i)perylene	NA	ug/L	<QL	0.49	0.98
GENEVA_AS_IN	1/10/2025 15:35	L83719-1	Chrysene	NA	ug/L	<QL	0.245	0.49
GENEVA_AS_IN	1/10/2025 15:35	L83719-1	Dibenzo(a,h)anthracene	NA	ug/L	<QL	0.735	1.47
GENEVA_AS_IN	1/10/2025 15:35	L83719-1	Fluoranthene	NA	ug/L	<QL	0.294	0.588
GENEVA_AS_IN	1/10/2025 15:35	L83719-1	Fluorene	NA	ug/L	<QL	0.245	0.49
GENEVA_AS_IN	1/10/2025 15:35	L83719-1	Indeno(1,2,3-Cd)Pyrene	NA	ug/L	<QL	0.49	0.98
GENEVA_AS_IN	1/10/2025 15:35	L83719-1	Naphthalene	NA	ug/L	<QL	0.245	0.49
GENEVA_AS_IN	1/10/2025 15:35	L83719-1	Phenanthrene	NA	ug/L	<QL	0.245	0.49
GENEVA_AS_IN	1/10/2025 15:35	L83719-1	Pyrene	NA	ug/L	<QL	0.245	0.49
GENEVA_AS_OUT	12/18/2024 11:36	L83717-2	1-Methylnaphthalene	NA	ug/L	<QL	0.708	1.42
GENEVA_AS_OUT	12/18/2024 11:36	L83717-2	2-Methylnaphthalene	NA	ug/L	<QL	0.708	1.42
GENEVA_AS_OUT	12/18/2024 11:36	L83717-2	Acenaphthene	NA	ug/L	<QL	0.189	0.377
GENEVA_AS_OUT	12/18/2024 11:36	L83717-2	Acenaphthylene	NA	ug/L	<QL	0.236	0.472
GENEVA_AS_OUT	12/18/2024 11:36	L83717-2	Anthracene	NA	ug/L	<QL	0.236	0.472
GENEVA_AS_OUT	12/18/2024 11:36	L83717-2	Benzo(a)anthracene	NA	ug/L	<QL	0.236	0.472
GENEVA_AS_OUT	12/18/2024 11:36	L83717-2	Benzo(a)pyrene	NA	ug/L	<QL	0.472	0.943
GENEVA_AS_OUT	12/18/2024 11:36	L83717-2	Benzo(b,j,k)fluoranthene	NA	ug/L	<QL	0.708	1.42
GENEVA_AS_OUT	12/18/2024 11:36	L83717-2	Benzo(g,h,i)perylene	NA	ug/L	<QL	0.472	0.943
GENEVA_AS_OUT	12/18/2024 11:36	L83717-2	Chrysene	NA	ug/L	<QL	0.236	0.472
GENEVA_AS_OUT	12/18/2024 11:36	L83717-2	Dibenzo(a,h)anthracene	NA	ug/L	<QL	0.708	1.42
GENEVA_AS_OUT	12/18/2024 11:36	L83717-2	Fluoranthene	NA	ug/L	<QL	0.283	0.566

LOCATOR	COLLECTDATE	LABSAMPLENUM	PARMNAME	VALUE	UNITS	QUALIFIER	MDL	RDL
GENEVA_AS_OUT	12/18/2024 11:36	L83717-2	Fluorene	NA	ug/L	<QL	0.236	0.472
GENEVA_AS_OUT	12/18/2024 11:36	L83717-2	Indeno(1,2,3-Cd)Pyrene	NA	ug/L	<QL	0.472	0.943
GENEVA_AS_OUT	12/18/2024 11:36	L83717-2	Naphthalene	NA	ug/L	<QL	0.236	0.472
GENEVA_AS_OUT	12/18/2024 11:36	L83717-2	Phenanthrene	NA	ug/L	<QL	0.236	0.472
GENEVA_AS_OUT	12/18/2024 11:36	L83717-2	Pyrene	NA	ug/L	<QL	0.236	0.472
GENEVA_AS_OUT	1/10/2025 15:39	L83719-2	1-Methylnaphthalene	NA	ug/L	<QL	0.708	1.42
GENEVA_AS_OUT	1/10/2025 15:39	L83719-2	2-Methylnaphthalene	NA	ug/L	<QL	0.708	1.42
GENEVA_AS_OUT	1/10/2025 15:39	L83719-2	Acenaphthene	NA	ug/L	<QL	0.189	0.377
GENEVA_AS_OUT	1/10/2025 15:39	L83719-2	Acenaphthylene	NA	ug/L	<QL	0.236	0.472
GENEVA_AS_OUT	1/10/2025 15:39	L83719-2	Anthracene	NA	ug/L	<QL	0.236	0.472
GENEVA_AS_OUT	1/10/2025 15:39	L83719-2	Benzo(a)anthracene	NA	ug/L	<QL	0.236	0.472
GENEVA_AS_OUT	1/10/2025 15:39	L83719-2	Benzo(a)pyrene	NA	ug/L	<QL	0.472	0.943
GENEVA_AS_OUT	1/10/2025 15:39	L83719-2	Benzo(b,j,k)fluoranthene	NA	ug/L	<QL	0.708	1.42
GENEVA_AS_OUT	1/10/2025 15:39	L83719-2	Benzo(g,h,i)perylene	NA	ug/L	<QL	0.472	0.943
GENEVA_AS_OUT	1/10/2025 15:39	L83719-2	Chrysene	NA	ug/L	<QL	0.236	0.472
GENEVA_AS_OUT	1/10/2025 15:39	L83719-2	Dibenzo(a,h)anthracene	NA	ug/L	<QL	0.708	1.42
GENEVA_AS_OUT	1/10/2025 15:39	L83719-2	Fluoranthene	NA	ug/L	<QL	0.283	0.566
GENEVA_AS_OUT	1/10/2025 15:39	L83719-2	Fluorene	NA	ug/L	<QL	0.236	0.472
GENEVA_AS_OUT	1/10/2025 15:39	L83719-2	Indeno(1,2,3-Cd)Pyrene	NA	ug/L	<QL	0.472	0.943
GENEVA_AS_OUT	1/10/2025 15:39	L83719-2	Naphthalene	NA	ug/L	<QL	0.236	0.472
GENEVA_AS_OUT	1/10/2025 15:39	L83719-2	Phenanthrene	NA	ug/L	<QL	0.236	0.472
GENEVA_AS_OUT	1/10/2025 15:39	L83719-2	Pyrene	NA	ug/L	<QL	0.236	0.472