Eastern Washington
Stormwater Effectiveness Studies

Quality Assurance Project Plan (QAPP)

Non-Vegetated Bioretention TAPE Project

Study Classification:

☑ Structural BMP ☐ Operational BMP ☐ Education & Outreach

Study Objective(s):

☐ Evaluate Effectiveness
☐ Compare Effectiveness
☐ Develop Modified BMP
☑ Develop Modified BMP

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Proposal and QAPP Publication Information

The Detailed Study Design Proposal (Proposal) and Quality Assurance Project Plan (QAPP) will be stored and accessible to the public on the following websites:

- City of Spokane: https://my.spokanecity.org/publicworks/stormwater/
- City of Spokane Valley: spokanevalley.org/stormwater
- Spokane County: https://www.spokanecounty.org/918/Stormwater-Utility

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Executive Summary

Bioretention is a common stormwater best management practice (BMP) in urban areas. The Washington State Department of Ecology (Ecology) has approved the use of vegetated bioretention BMPs for providing water quality treatment. This project is being conducted due to the challenges that vegetated bioretention best management practices (BMPs) create for Washington locations with hot and dry summers. Bioretention cells require an irrigation system to keep the vegetation from going dormant between storm events during summers, which adds to the overall lifecycle cost of the BMP and consumes water. The goal of this project is to evaluate the treatment performance of non-vegetated bioretention BMPs using the Ecology 60% sand and 40% compost bioretention soil mix (60:40 BSM) and the Type 2 High Performance Bioretention Soil Mix (HPBSM). The evaluation of the non-vegetated bioretention BMPs will be based upon:

- The pollutant removal efficiency of the non-vegetated installations of the 60:40 BSM and HPBSM.
- The change in the infiltration rate and saturated hydraulic conductivity of each BSM over the duration of the project.
- Comparison to treatment performance goals for basic (TSS) and dissolved metals (Cu and Zn) treatment for both BSMs as well as phosphorus treatment goals for the HPBSM.

The study will conduct field testing of the two non-vegetated bioretention installations. The field testing will involve using automated equipment to collect data at a test site located on the Gonzaga University campus in Spokane, Washington. The data to be collected includes precipitation, flow rate (influent and effluent), and pollutant concentrations from flow-weighted composite water quality samples (influent and effluent). Data will be collected from a minimum of 15 qualifying storm events over two wet seasons starting in summer 2024, If the evaluation objectives can be met, the results from this study will be used to justify the approval of non-vegetated bioretention for general use. The results will also include maintenance guidance based on observation collected during the study.

1.0 Introduction and Background

This section describes the Structural BMP that is the focus of this study, the reasons why the study is being conducted, results from prior studies, and the regulatory requirements that the study addresses.

1.1 Introduction to the Structural BMP

Bioretention swales or cells are common structural stormwater best management practices (BMPs) in Washington State. These BMPs are characterized as shallow landscaped depressions, which are designed to capture stormwater runoff from small basin areas and provide treatment as stormwater infiltrates through engineered soils referred to as bioretention soil media (BSM). Treated stormwater then percolates into the existing native soils beneath the bioretention area or is collected in an underdrain and conveyed to a storm drain network. **Figure 1-1** shows the test site which includes two existing bioretention cells that will be modified for this project.

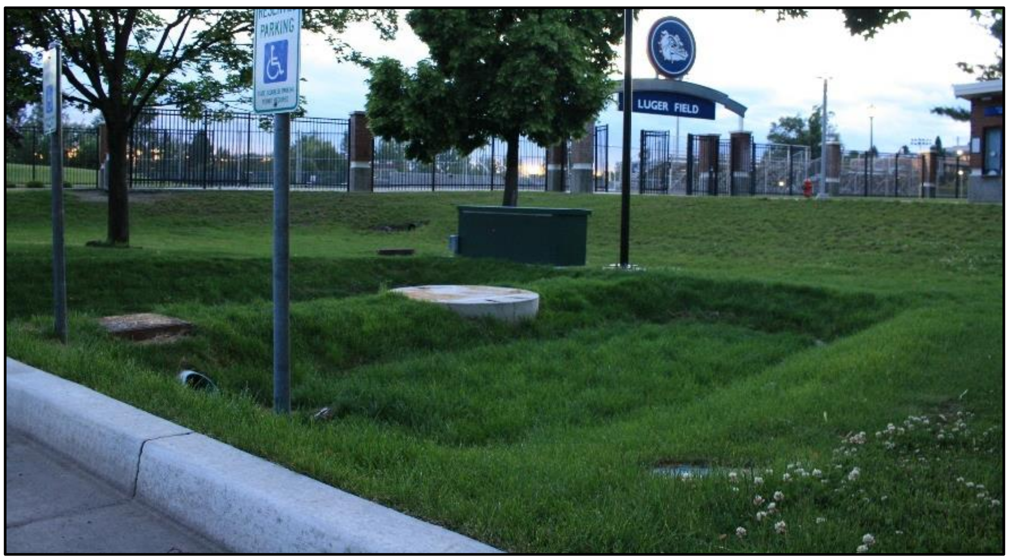

Figure 1-1. Test Site on the Campus of Gonzaga University

The 60:40 BSM and the Type 2 High Performance BSM, as detailed in the Stormwater Management Manual for Eastern Washington (SWMMEW) (Ecology, 2024), and Guidance on Using New High Performance Bioretention Soil Mixes (Howie D. , 2024), respectively, are both approved by the Washington State Department of Ecology (Ecology) for general use to provide treatment. Additional details about each media are described in the subsequent paragraphs in this section.

The 60:40 BSM as detailed in the SWMMEW is composed of 60-65% mineral aggregate, 35-40% compost by volume, 5-8% organic matter content by weight, and cation exchange capacity of greater than 5 meq/100g dry soil. The 60:40 BSM is approved by Ecology to provide runoff treatment for total suspended solids (TSS), dissolved metals (i.e., Cu and Zn), and oils to the levels specified by the TAPE treatment performance goals (Washington State Department of Ecology, 2018). The primary treatment mechanisms of the 60:40 BSM include sedimentation, filtration, and sorption, where sedimentation settles out particles on the surface of the BMP and filtration traps particulates in the pore spaces of the BSM. Sorption removes pollutants by adsorption processes that occur on the surfaces of organic matter and soil clay that are present in the BSM material. **Figure 1-2** illustrates a general facility design that incorporates the 60:40 BSM as a 18-inch-thick layer. The saturated hydraulic conductivity (Ksat) of the 60:40 BSM was measured at approximately 175 inches/hour in a recent column study (Herrera Environmental Consultants, Inc., 2020). Ksat field rates are typically lower than the Ksat measured in columns and typically decline over time. During the last bioretention study at the Gonzaga University test site, the Ksat was measured at 28.5 inches/hour before the study started and 6.3 inches/hour five years later (Navickis-Brasch, Hoffman-Ballard, & Chen, 2021). The SWMMEW bioretention design guidance takes into account that infiltration rates decline over time and set the maximum rate for sizing bioretention BMPs at 12 inches/hour plus correction factors (Ecology, 2024). Operations and Maintenance requirements for the 60:40 BSM can be found in **Section 6.1.9** and the specifications are located in **Appendix D**. *Specifications*.

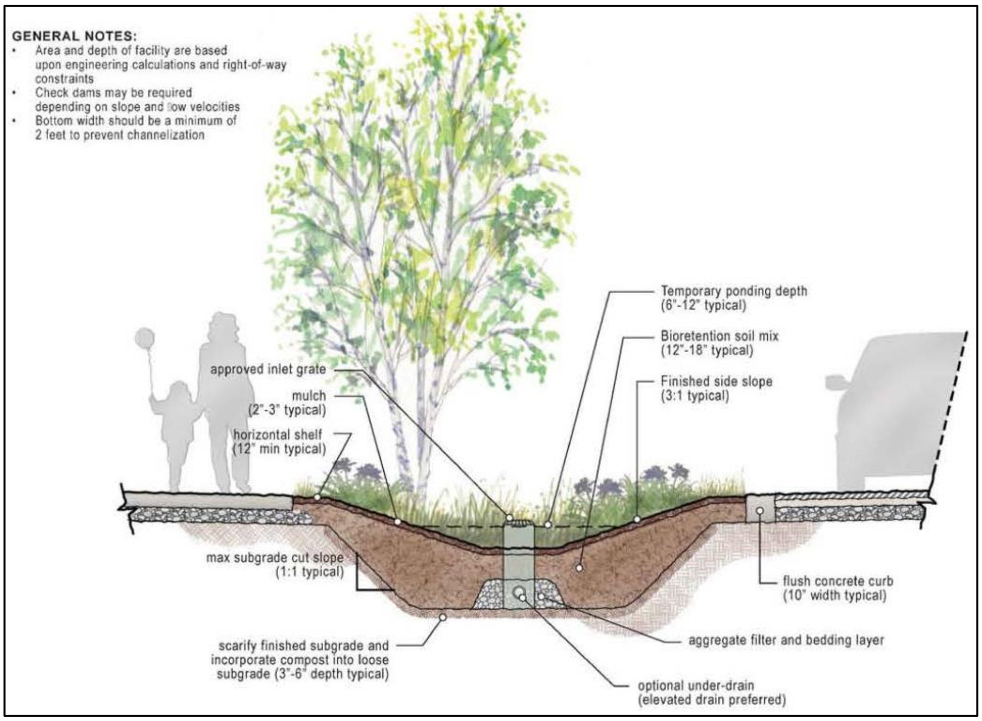

Figure 1-2. Typical Bioretention Swale Design (Ecology, 2019)

The HPBSM is approved by Ecology to provide runoff treatment for TSS, dissolved Cu and Zn, and phosphorus to the levels specified by the TAPE treatment performance goals (Washington State Department of Ecology, 2018). The HPBSM Type 2 includes 18-inch-thick primary layer composed of 70% sand, 20% coir fiber, and 10% high carbon wood ash (biochar), with a 12-inch-thick polishing layer composed of 90% sand, 7.5% activated alumina, and 2.5% iron aggregate. Similar to the 60:40 BSM, the pollutant removal mechanisms for typical stormwater pollutants in the primary layer include sedimentation, filtration, and sorption. In addition, the polishing layer provides adsorption of phosphorus. **Figure 1-3** shows a bioretention swale cross-section detailing the primary treatment, polishing, and optional layers of the HPBSM. The Ksat measured during column testing for the HPBSM was approximately 175 inches/hour. However, field rate measurements have been two to three times lower than column Ksat measurements at approximately 40–50 in/hr (Herrera Environmental Consultants, Inc., 2020). The maximum design rate for the HPBSM is the same as the 60:40 BSM: 12

inches/hour (Ecology, 2024; Howie D. , 2024). The HPBSM specification is located in **Appendix D**. *Specifications*.

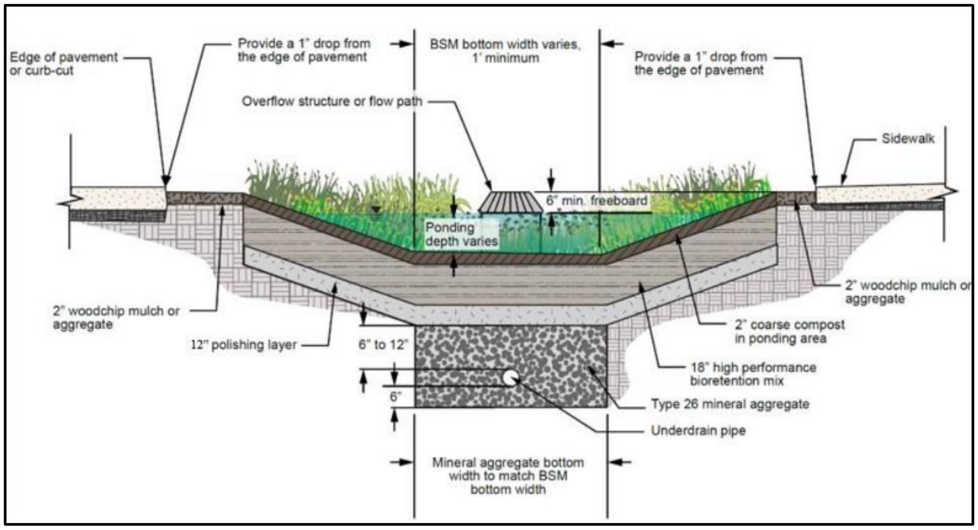

Figure 1-3. Typical Cross-Section of HPBSM with Primary, Polishing, and Optional Layers (Howie D. , 2024)

1.2 Problem Description

The existing specifications for bioretention Best Management Practices (BMPs) require the incorporation of vegetation, posing a challenge for Washington sites experiencing hot and arid summers. Maintaining the health of the vegetation in bioretention cells necessitates irrigation between storm events. The installation and operation of an irrigation system contributes to the overall life cycle cost of stormwater BMPs and consumes water that could have a higher beneficial use. This issue becomes more pronounced during years with drought when restrictions on irrigation are imposed. Furthermore, in certain locations in Washington, extended periods of cold climate last for several months each year, causing plant life to become dormant and less effective in facilitating treatment mechanisms (Ecology, 2024).

Based on lab tests of the 60:40 BSM and HPBSM as well as relevant literature, it appears that these BMPs without vegetation will be capable of providing sufficient treatment to meet TAPE treatment performance criteria. Additional details about these studies are included in **Section 1.3**.

1.3 Results of Prior Studies

Prior stormwater research has been conducted on both the 60:40 BSM and the HPBSM. The 60:40 BSM was developed in 2009 and has been tested in flow through columns as well as in the field. The HPBSM was developed in 2020 and at the time this document was written only published results from column testing was located. A summary of results from studies for both BSMs is included in this section along with general research related to the role and performance of vegetation in the treatment of stormwater pollutants.

1.3.1 Performance of the 60:40 BSM

1.3.1.1 60:40 BSM Development and Initial Field Testing

The development of the 60:40 BSM was based on literature that evaluated different soil/media properties, such as infiltration rate, CEC, organic matter content, and percent fines with regard to water quality treatment performance. (Hinman, Shannon, Wilson, & MacDonald, 2009). The performance of the media was evaluated in the field at three sites located in the City of Redmond, City of Tacoma, and WSU Puyallup over several years (Ecology, 2013; Ecology, 2016). The results of the monitoring indicated the 60:40 BSM met TAPE treatment performance goals for TSS and dissolved zinc, however phosphorus leached significantly for an extended time from the media. Additionally, dissolved copper was higher in the effluent than the concentrations in the influent for some of the BSM installations for many months following installation. That said, toxicity testing of the copper in the effluent indicated the copper was in a less toxic form and was not negatively affecting juvenile coho salmon survival at the concentrations of copper and dissolved organic matter present in the experiment. The observation is limited to the test species, life stage, and other conditions of the specific experiment (McIntyre, et al., 2015). The monitoring prompted Ecology to publish recommendations to avoid using bioretention within one-quarter mile of phosphorus sensitive water bodies if underlying native soils do not meet soil suitability criteria defined in the SWMMEW, and to avoid installing an underdrain if the flow from the underdrain is routed to a phosphorus-sensitive water body.

1.3.1.2 60:40 Field Testing at Gonzaga University Test Site

The 60:40 BSM was tested from September 2018 to January 2021 at the Gonzaga test site planned for this project (Navickis-Brasch, Hoffman-Ballard, & Chen, 2021). The performance of 18-inches of 60:40 BSM is summarized in **Table 1-1**:

Table 1-1. Summary of 60:40 Removal Efficiencies During Field Testing[1]

Total Suspended Solids Removal Efficiency	Dissolved Copper Removal Efficiency	Dissolved Zinc Removal Efficiency	Total Phosphorus Removal Efficiency
71.1%	-93.4%	34.9%	-381%

[1] The average influent concentrations were: TSS = 45 mg/L, Dissolved Zinc = 0.037 mg/L, Dissolved Copper = 0.008 mg/L, and Total Phosphorus = 0.663 mg/L.

The physiochemical properties of the BSM were measured when the cells were constructed and approximately five years after installation. A comparison of the data indicates that copper was not being retained in the BSM, while zinc was retained. The media measurements support the findings that dissolved copper is leaching from the BSM while dissolved zinc is removed by the BSM.

1.3.1.3 60:40 BSM Column Testing

A study further described in **Section 1.3.2** evaluated the performance of 60:40 BSM in non-vegetated columns in the laboratory (Herrera Environmental Consultants, Inc., 2020). The columns were subjected to two simulated storms using stormwater obtained from the field. The performance from those two tests is reported in **Table 1-2**:

Table 1-2. Summary of 60:40 Removal Efficiencies During Column Testing[1]

Total Suspended Solids Removal Efficiency	Dissolved Copper Removal Efficiency	Dissolved Zinc Removal Efficiency	Total Phosphorus Removal Efficiency
38.6%	11.7%	83.7%	-382%

[1] The average or median influent concentrations were as follows: TSS = 104 mg/L, Dissolved Copper = 28 μg/L, Dissolved Zinc = 130.5 μg/L, and Total Phosphorus = 0.14 mg/L

The study also flushed the column containing 60:40 BSM with deionized water. The media continued to export total phosphorus, ortho-phosphate, nitrates and nitrites, and total and dissolved Copper after flushing for one water year.

1.3.2 Performance of the HPBSM

1.3.2.1 HPBSM Development

Guidance and Ecology approval related to the use of the HPBSM was added to the SWMMEW in 2021 (Howie & Lubliner, 2021) and updated in 2024 (Howie D. , 2024). The guidance was based on a report summarizing the performance of several different types of alternative media (Herrera Environmental Consultants, Inc., 2020). The report also summarized the development of the media through column testing. The testing indicated that HPBSM would meet Basic, Enhanced, and Phosphorus treatment goals, as shown in **Table 1-3**. It is important to note that the column was not vegetated and able to achieve the TAPE treatment performance goals. Field testing of media in vegetated bioretention installations is ongoing.

Table 1-3. Summary of HPBSM Removal Efficiencies During Study[1]

Total Suspended Solids Removal Efficiency[2]	TSS Effluent Concentration[2]	Dissolved Copper Removal Efficiency	Dissolved Zinc Removal Efficiency	Total Phosphorus Removal Efficiency
88.5%	<20 mg/L	94.6%	96%	71.3%

[1] The median influent concentrations were as follows: TSS = 104 mg/L, Dissolved Copper = 28.4μg/L, Dissolved Zinc = 130.5μg/L, and Total Phosphorus = 0.14 mg/L
[2] Two events had an influent TSS concentration >100 mg/L and the remaining events had influent concentrations <100 mg/L.

1.3.3 Performance of Non-Vegetated BMPs

A literature search was conducted to understand the role vegetation plays in the treatment of stormwater pollutants. Plants reportedly improve the aesthetics of bioretention systems and improve hydraulic conductivity by creating preferential flow paths through the media (McIntyre, Davis, & Knappenberger, 2020). Several studies reported that the primary bioretention treatment mechanisms for TSS and dissolved metal removal are a function of the BSM physiochemical properties as opposed to the vegetation (Davis & Hsieh, 2005; Hunt, 2003; Hunt & Lord). Further, studies indicate that the vegetation uptake of dissolved metals is negligible (Barrett, Limouzin, & L. D. F., 2012; LeFevre, et al., 2014; Davis, Shokouhian, Sharma, & Minami, 2006). While plants are known to enhance nutrient pollutant removal (Kadlec & Wallace, 2009; Minton, 2012), in temperate climates, nutrients tend to return to the soil as the plants become dormant in the winter, particularly if the vegetation is not cut back and removed during the non-growing season (Schwartz & Amasino, 2013). These few studies suggest that vegetation may play only a small role in pollutant removal under some circumstances; as such, BSM without vegetation may still meet treatment performance goals.

The majority of the bioretention literature located focused on pollutant retention related to bioretention cells with vegetation. No research was located on non-vegetated bioretention cells; as such, no research was found regarding the lifecycle or maintenance frequency of non-vegetated bioretention. This project will attempt to estimate the lifecycle related to treatment performance, infiltration, and needed maintenance. The project will measure hydraulic conductivity twice, once after the test site has been constructed and again after data collection is completed, to understand how infiltration may change for non-vegetated bioretention cells in the field. Additionally, the project will regularly inspect and collect data on the operation and maintenance of bioretention cells, as described in **Section 6.1.9**.

1.4 Regulatory Requirements

This project is not being performed to meet a requirement in the EWA NPDES Phase II Municipal Stormwater permit. The project is funded by an Ecology Water Quality Grant and is seeking approval for non-vegetated BMPs through TAPE. As such, the project is subject to the requirements of the Water Quality Grant and the 2018 TAPE Guidance Manual.

2.0 Project Overview

2.1 Study Goal

The goal of this project is to evaluate whether non-vegetated bioretention using 60:40 BSM and HPBSM meet the TAPE treatment performance goals. The non-vegetated bioretention will be evaluated against the performance goals for which they are approved as vegetated BMPs. The results of this project will be used to support approval of non-vegetated bioretention BMPs.

2.2 Study Description and Objectives:

The goal of this project will be accomplished through field monitoring and sampling at a test site following the requirements/guidelines in the 2018 TAPE Guidance Manual (Ecology, 2018). The test site is located on Gonzaga University's campus and was used for a similar study that ended in 2021. The test site contains dual cells and will be reconstructed to install the 60:40 BSM and HPBSM. The dual cells will allow the project to compare the performance of two media to the TAPE treatment performance goals under the same environmental conditions. An automated monitoring system is installed at the test site which collects flow-weighted samples, rainfall depth, flow rate (influent and effluent), and temperature. The primary work associated with field monitoring and sampling will include: daily monitoring of the weather forecast to identify when qualifying rainfall events are likely to occur; operating and maintaining the equipment; collecting three composite flow-weighted water quality samples for each rainfall event identified as qualifying (one influent and two effluent) as well as field duplicates for 10% of the samples; delivering the samples to the lab for analysis; and downloading data from the data logger (precipitation depth and runoff flow rate). Prior to installing the BSM, the properties of the BSM selected for this study will be confirmed to meet the BSM properties defined in the 2024 SWMMEW bioretention specification. Following the study, samples of each BSM will be collected and submitted to a laboratory for analysis to assess changes in the media properties. In addition, properties that indicate treatment capacity will be tested before and after data collection to assess changes the media life cycle (**Section 5.9**). Water quality sampling is expected to occur over two wet seasons. A detailed description of the project experimental design is provided in **Section 5.0**.

The goals of this study will be achieved by meeting the following objectives:

- Determine the pollutant removal efficiency of the non-vegetated installations of the 60:40 BSM and HPBSM
- Determine the change in infiltration rate of each cell over the duration of the project.
- Determine whether the treatment performance goals were achieved for basic (TSS) and dissolved metals (Cu and Zn) treatment for both installations. Determine whether the treatment performance goals were achieved for phosphorus treatment for the non-vegetated HPBSM.
- Develop design and maintenance guidance for the study and refine the guidance using the study results.
- Summarize the study results into a final report and submit the report to Ecology. If either of the non-vegetated bioretention cells meet TAPE treatment performance goals, submit the final report to justify approval of the modified BMPs.

2.3 Study Location

The test site is within the City of Spokane municipal boundary, located on the Gonzaga University campus, directly south of the Martin Center and east of Luger Field. The site is a grassy area adjacent to buildings, walkways, and a parking area. Approximately 0.61 acres of impervious surfaces contribute stormwater to the study's bioretention cells which include an asphalt parking lot, asphalt walkways, and a small area of sidewalk concrete. The asphalt parking area is approximately 0.53 acres in size, and the remaining 0.08 acres is comprised of asphalt pavement access road and sidewalks with a small section of concrete. The parking area drains to the bioretention cells with an approximate slope of 0.009 - 0.015 ft/ft. The parking area is full during the academic year and during sporting events. Additionally, the parking area is expected to have a high turnover of vehicles as students come and go to classes. Aerial photographs of the site are shown in **Figure 2-1** and **Figure 2-2**.

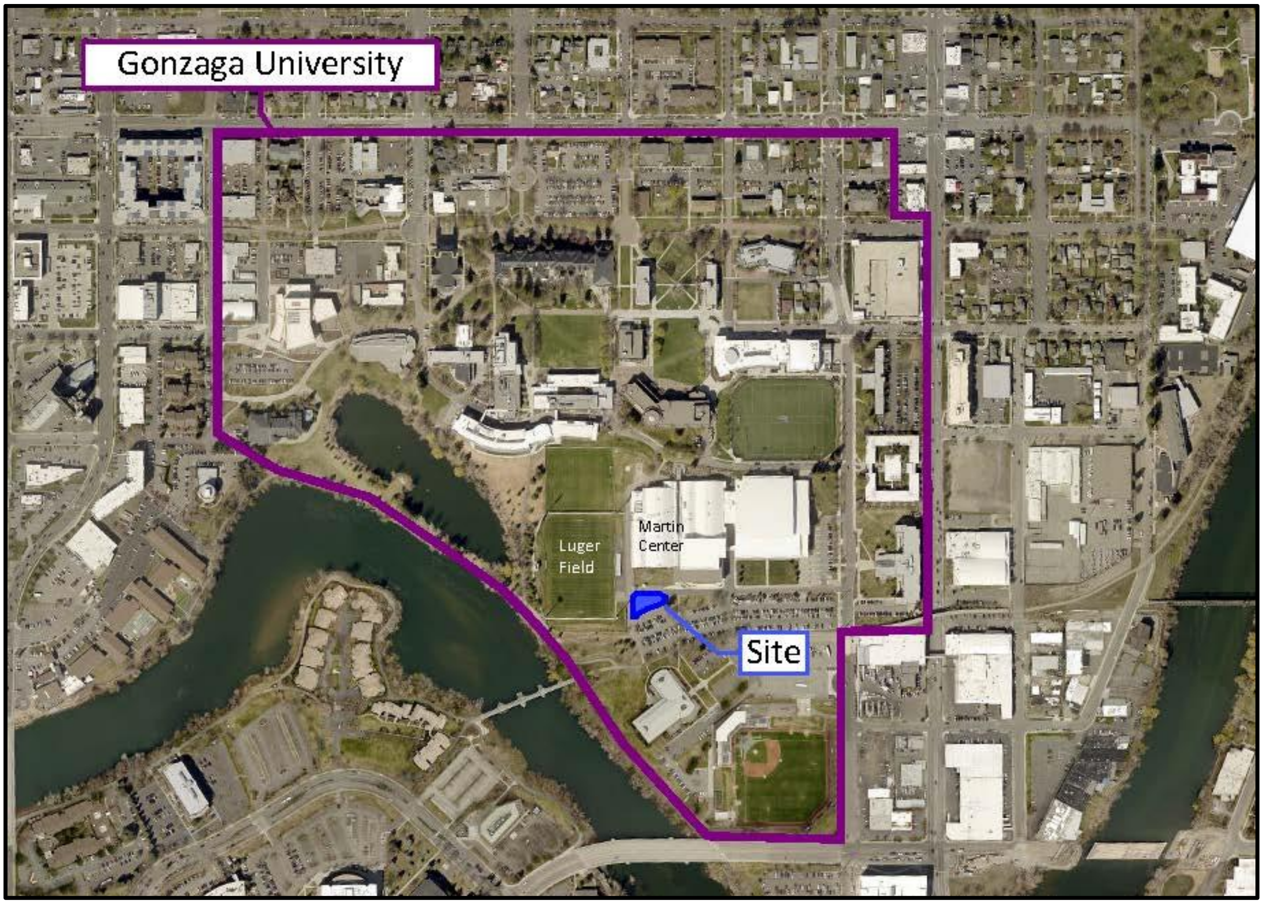

Figure 2-1. Aerial View of Test Site

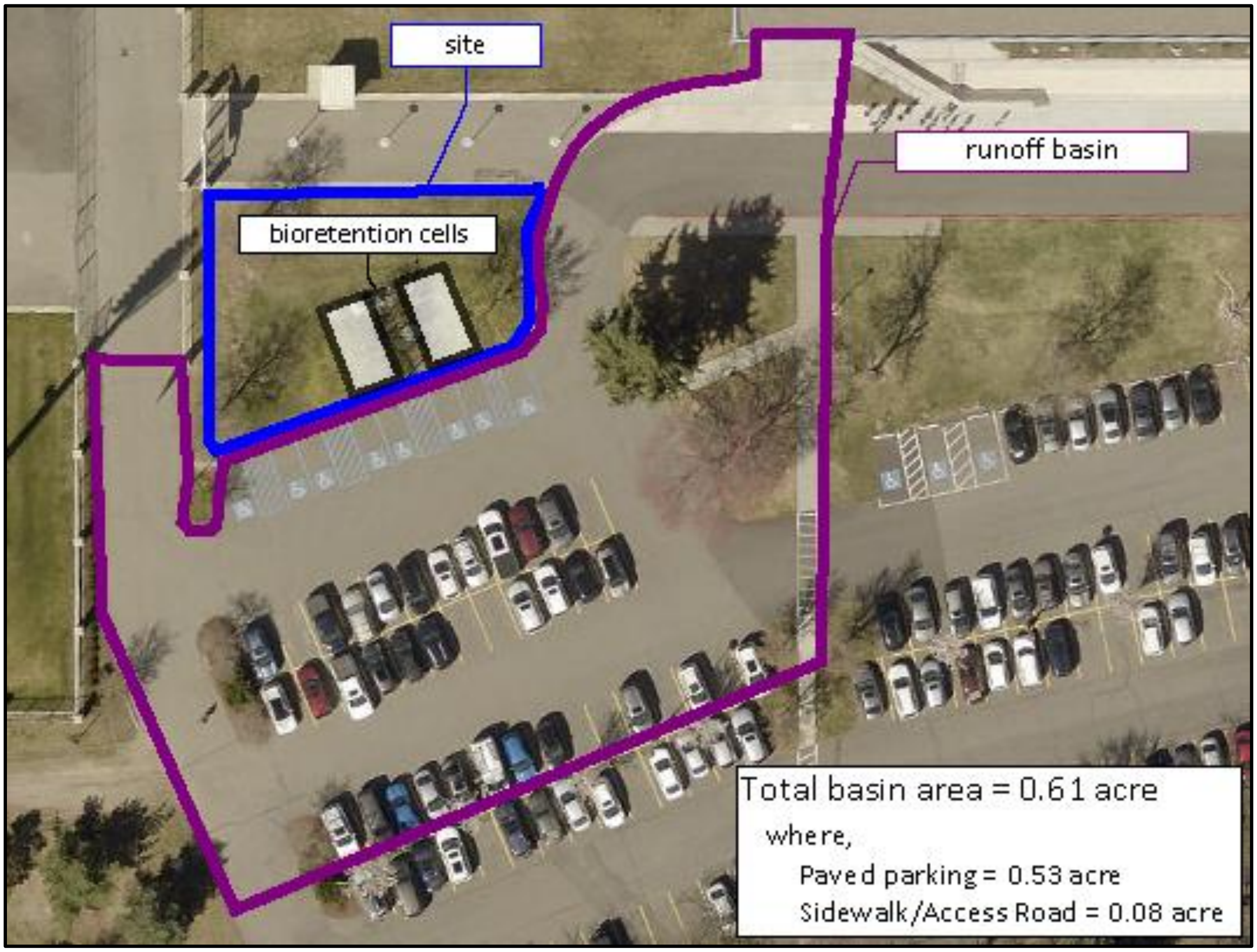

Figure 2-2. Contributing Basin Area

2.4 Data Needed to Meet Objectives

The data needed to complete this study is summarized in **Table 2-1**. The water quality parameters to be tested to demonstrate that the BMP meets performance goals are summarized in **Table 2-2**.

Table 2-1. Data Needed to Meet Objectives

Data Type	How Data Will Be Collected	Purpose
60:40 BSM and HPBSM media physiochemical properties	The properties of the BSM provided by the supplier will be compared and confirmed to meet the **Appendix D** specifications prior to construction; in addition, properties that indicate treatment capacity will be tested before and after data collection to assess changes in the media life cycle (**Section 5.9**)	Confirm the physiochemical properties of the media meet the specifications and estimate the media lifecycle
Precipitation	A rain gauge connected to the data logger at the test site	Determine whether a particular event meets TAPE guidelines for qualifying storm events
Flow (influent, effluent)	Measured continuously using a control weir and pressure transducer upstream of the weir	Calculate influent and effluent flow rates; determine when sampling should begin (if storm meets TAPE criteria)
Composite water quality samples (see **Table 5-5**)	Auto-samplers collect composite flow weighted samples when triggered by the data logger	Quantify parameters' influent & effluent concentrations; assess treatment performance
Sediment PSD from influent	Collect composite flow weighted samples from influent	Characterize the size of the sediment that enters the BMP
pH and Temperature Measurements	pH measured during sample collection and processing; temperature measured by pressure transducer and reported to data logger	Quantify influent & effluent pH; quantify temperature of influent and effluent
Saturated hydraulic conductivity	Falling head test (See **Section 6.1.8** for SOP)	Calculate BSM saturated hydraulic conductivity and infiltration rate

Table 2-2. Summary of Water Quality Testing (per TAPE requirements)

Performance Goal	Required Parameters	Required Screening Parameters
Basic	TSS	PSD, pH, TP, orthophosphate, TKN, nitrate-nitrite, hardness, total and dissolved Cu and Zn, fecal coliform, E. coli
Dissolved metals	TSS, hardness, total and dissolved Cu and Zn	PSD, pH, TP, orthophosphate, TKN, nitrate-nitrite, fecal coliform, E. coli

Phosphorus[1]	TSS, TP, orthophosphate	PSD, pH, TKN, nitrate-nitrite, hardness, total and dissolved Cu and Zn, fecal coliform, E. coli

[1] Parameters to assess the phosphorus performance goal will only be sampled from the bioretention cell containing HPBSM.

2.5 Tasks Required to Conduct Study

Tasks required to conduct the study include:

- **Quality Assurance Project Plan (QAPP)**
  - Develop QAPP (this document)
  - Submit QAPP to Ecology and advisory panel for review; respond to comments
- **Modify Test Site:**
  - As part of QAPP, develop construction plans and specifications for test site modification
  - Confirm BSM meets 2024 SWMMEW bioretention specifications
  - Construct the test site and provide oversight during construction
- **Prepare for Data Collection:**
  - Program and install monitoring equipment
  - Develop and provide monitoring equipment training for the sampling staff
  - Maintain bioretention cells as defined in the QAPP SOPs
- **Data Collection and Analysis:**
  - Track and select storms (daily) for sample collection
  - Maintain storm monitoring equipment (monthly)
  - Prepare stormwater monitoring equipment for storm sampling and calibrate equipment (immediately prior to sampling event)
  - Collect stormwater influent and effluent samples from a minimum of 15 rainfall events; submit samples to lab and test for required and screening parameters (immediately following qualifying rainfall events)
  - Following each monitoring event: download data (i.e., precipitation, temperature, influent, and effluent flow rate) and analyze data
  - Develop and manage a database that contains all the collected data
  - Collect samples of each BSM after all water quality samples have been collected and confirm the physical and chemical properties and treatment capacity
  - Conduct falling head twice; once before data collection begins and once after all water quality samples have been collected
- **Develop Technical Reports:**
  - Develop technical evaluation report (TER)
  - Develop study fact sheet
  - Upload study data to the International BMP Database

  - Submit TER to Ecology and advisory panel for review; request appropriate designation based on the results

2.6 Potential Constraints

Potential constraints are conditions that may impact the project schedule, budget, or scope. The potential constraints identified in **Table 2-3**, along with the steps that will be taken to reduce the impact of these conditions (mitigation approach), are based on the information that was available at the time the QAPP was written.

Table 2-3. Summary of Potential Constraints and Mitigation Approaches

Potential Constraint	Mitigation Approach
Spills: oil or other chemicals	Spills could impact the BMP treatment performance, so visually inspect the cell following each rainfall event; if a spill occurs, conduct appropriate maintenance and note the incident in the data collection log
Uneven delivery of influent flows to each cell	Periodically measure flow and compare flows; balance flow rates at cell inlets, as needed, as described in **Section 6.1.3**
Insufficient qualifying rainfall events	Extend monitoring period or collect data from lower depth (<0.1-inches) rainfall events (see **Section 5.5**)
Campus facilities using fertilizer or pesticides adjacent to test-site	Educate campus facilities about the study and if needed adjust their maintenance practices
Campus facilities placing landscaping waste near the test-site	Educate campus facilities staff about the study and request that they adjust their maintenance practices
Monitoring equipment malfunctions	Inspect equipment according to the SOPs (**Section 6.1.2**) and review system output variables after each storm for any anomalies. Fix equipment promptly if problems are encountered
Instruments are out of calibration	The instruments will be calibrated regularly over the course of the study as described in **Section 6.1.2**

3.0 Organization and Schedule

The purpose of this section is to describe the responsibilities of project team members, when project tasks will be completed, and how the study will be funded, as shown in **Table 3-1**.

3.1 Key Project Team Members: Roles and Responsibilities

Table 3-1. Key Project Team Members: Roles and Responsibilities

Name & Organization	Role	Contact Information
Trey George, City of Spokane	Lead Entity Project Manager[1]	(509) 625-7908 jgeorge@spokanecity.org
Chad Phillips, City of Spokane Valley	Financial Support[2]	(509) 720-5013 cphillips@spokanevalley.org
Bill Galle, Spokane County	Financial Support[2]	(509) 477-7261 BGalle@spokanecounty.org
Chris Dudenhoeffer, Department of Ecology	Ecology Reviewer[3]	(360) 870-8409 Chris.dudenhoeffer@ecy.wa.gov
Jefferson Davis, Department of Ecology	Ecology Reviewer[3]	(509) 385-9280 Jefferson.Davis@ecy.wa.gov
Adriane Borgia, Department of Ecology	Ecology Reviewer[3]	(509) 329-3515 Adriane.borgias@ecy.wa.gov
Doug Howie, Department of Ecology	TAC Member[4]	(360) 870-0983 douglas.howie@ecy.wa.gov
Curtis Hinman, Curtis Hinman and Associates	TAC Member[4]	(253) 330-9878 curtis@curtishinmanassociates.com
David Batts, King County	TAC Member[4]	(206) 477-4636 David.batts@kingcounty.gov
Aimee Navickis-Brasch, Evergreen StormH2O	Principal Investigator[5]	(509) 995-0557 aimee@evergreenstormh2o.com
Mikala Lindgren, Evergreen StormH2O	Field Lead[6]	(509) 216-2758 mikala@evergreenstormh2o.com
Mark Maurer, Evergreen StormH2O	QA/QC Lead[7]	(360) 790-6421 mark@evergreenstormh2o.com
Kathy Sattler, Anatek	Laboratory Manager[8]	(509) 838-3999 kathy@anateklabs.com
Kyle Bair, SoilTest	Laboratory Manager[8]	(509) 765-1622 kyle@soiltestlab.com
Greg Conrad, Environmental Technical Services	Laboratory Manager[8]	(360) 534.9777 Medhanie.tecle@mtc-inc.net

[1] Lead Entity Project Manager – Responsible for ensuring the study is conducted as described in this QAPP. The Lead Entity Project Manager is the primary point of contact for the lead entity.
[2] Financial Support – Responsible for splitting the cost of the study with the lead entity.
[3] Ecology Reviewer – Responsible for reviewing and approving the study documents: the Proposal and QAPP.

[4] Technical Advisory Committee (TAC) Member - Goal of the TAC is to provide insight, suggestions, and professional opinions to the Principal Investigator throughout the study. The primary responsibilities of TAC members include attending project meetings (by webinar or in person) and participating in the meeting discussion; review and provide comment on research materials (i.e., QAPP, data collected, data analyzed, final report, etc.) prior to the lead entity submitting the documents to Ecology. Members of the TAC may also serve as an auditor to verify the study conforms to the plan and procedures as defined in the QAPP and/or a data verifier who reviews the analyzed data and verifies the analysis is correct and that the data being analyzed matches the data collected.

[5] Principal Investigator – Responsible for developing an Ecology approved Proposal and QAPP. Serves as the primary point of contact for the laboratory manager, the lead entity project manager, and sampling staff. Responsible for conducting the study as defined in the Ecology-approved QAPP. Responsible for submitting the study documents to Ecology including the Proposal and QAPP. Responsible for management of all study documents, scheduling audits, verifying and assessing the usability of data, and executing corrective actions. Responsible for developing the final report including data analysis, interpretation of results, and summarizing the study findings. Responsible for ensuring that staff working on this project are trained and have adequate experience to complete their assigned tasks. Responsible for maintaining and operating the monitoring equipment.

[6] Field Lead - Responsible for monitoring storms, assisting the Principal Investigator with maintaining and operating the equipment, collecting and processing samples (water quality or sediment) following the standard operating procedures in this QAPP including delivering the samples to the lab, assisting with the falling head test, assisting with transferring data from the lab and field forms to spreadsheets, and assisting with the data analysis.

Sampling staff - *Each year a team of senior civil engineering students will be selected to work on this project to meet their requirements for senior design. Each year the students will be trained to perform the tasks defined for the sampling staff.*

[7] QA/QC Lead – Responsible for performing quality assurance and quality control (QA/QC) reviews, which are described in the study QAPP.

[8] Laboratory Manager – Responsible for supervision of laboratory personnel involved in conducting analytical testing for this study and ensuring that laboratory personnel are properly trained in conducting the testing methods defined for this study. Also responsible for: providing sample containers and other sampling supplies (i.e., labels); analyzing samples using the standard methods selected for this study; carrying out lab quality control (QC) procedures to confirm that the related MPCs have been met (**Section 8.0**); reporting results for samples and QC procedures; and reviewing data and verifying results before the results are sent to the principal investigator and the lead entity.

3.2 Project Schedule

A task timeline based on quarterly activities is shown below.

Task Name	2024										2025				2026				2027					
	J	F	M	A	M	J	J	A	S	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	J	F	M	A	M	J
Task 1 Project Grant Administration																								
Task 2.1.1 TAPE Project Grant Administration																								
1.1 Quarterly Reports																								
1.2 Recipient Closeout Report																								
Task 2.0 Consultant Project Management & Coordination																								
Task 2.2.1 TAPE Project Management & Coordination																								
2.1 Final Project Schedule																								
2.2 TAC Member List																								
2.3 Cultural Resource Review Form																								
2.4 Inadvertent Discovery Plan																								
2.5 TAC Meeting Agenda & Notes; Comment Responses																								
2.6 Consultant Project Management & Coordination																								
Task 3.0 Study Preparation																								
Task 3.2.1 TAPE Project Preparation																								
3.1 TAPE Application																								
3.2 Quality Assurance Project Plan (QAPP)																								
3.3 BSM Supplier Inventory																								
3.4 BSM Testing Results																								
3.5 Test Site Plan Sheets								Modify Test Site																
Task 4.0 Data Collection & Analysis																								
Task 4.2.1 TAPE Project Data Collection & Analysis						Equipment Maintenance/Installation																		
4.1 Sample Water Quality Testing Results																								
4.2 Tables of Data Analysis Results																								
4.3 Audit Summary and Results																								
Task 5.0 Reporting																								
Task 5.2.1 TAPE Project Reporting																								
5.1 Technical Evaluation Report; Comment Responses																								
5.2 Fact Sheet																								
5.3 Complied Data Ready for EIM/BMP Database																								
5.4 Upload Data to EIM/BMP Database																								
Task 6.0 Project Closeout																								
6.1 Close Out Report																								
6.2 Outcome Summary																								

Notes & Color Coding City, County, Valley Review Period Ecology Review Period

3.3 Budget and Funding Sources

The TAPE project is funded by an Ecology Water Quality Grant. The grant is managed by the City of Spokane. The fees associated with the project are shown in **Table 3-2**.

Table 3-2. Study Budget

Task Number & Name	Fees
Task 1.2.1 TAPE Project Grant Administration	$15,525
Task 2.2.1 TAPE Project Management & Coordination	$60,278
Task 3.2.1 TAPE Study Preparation	$110,924
Task 4.2.1 TAPE Data Collection and Analysis	$171,588
Task 5.2.1 TAPE Project Reporting	$41,685
TAPE Project Total	**$400,000**

4.0 Quality Objectives

4.1 Data Quality Indicators

This section of the QAPP provides a roadmap of the QA/QC plan that will be implemented in the experimental design and employed throughout the project. The purpose of a QAPP is to ensure that the data collected during the project is scientifically and legally defensible (Ecology, 2011). The QAPP documents how quality assurance (QA) and quality control (QC) will be applied to a research project to assure that the results obtained are of the type and quality needed and expected. The QA/QC plan for this project is embedded throughout the QAPP and emphasizes how the data quality indicators (DQIs) and respective measurement performance criteria (MPCs) are addressed. DQIs are qualitative and quantitative measures that characterize the aspects of quality data (EPA, 2006). DQIs are goals for data quality that are specific to each research project. DQIs are intended to minimize error and improve the accuracy of the data. DQIs guide the development of the experimental design as well as the process of creating and analyzing data. The six principle DQIs for Structural BMP studies are as follows (Lombard, 2004):

- Precision
- Bias
- Representativeness
- Completeness
- Comparability
- Sensitivity

Each DQI listed above is defined in detail below. **Table 4-1** contains the approach for addressing each DQI and the respective MPC for this study. The DQIs provide the basis for the MPCs which are the acceptance criteria for the DQIs that specifies how good the data must be to meet the project objectives.

Reference **Section 11.0** for details regarding the process that will be employed to evaluate the quality and usability of the data for meeting the project objectives which is based primarily on whether the MPCs were met for the applicable DQIs.

4.1.1 Precision

Precision is a measure of agreement among repeated measurements of the same property taken under identical or substantially similar conditions (EPA, 2006; EPA, 2002; Erickson, 2013). Data is considered precise when the measured values are consistently the same and imprecise when the measured values are consistently different (Erickson, 2013). Random error is a common cause of imprecise data and is always present because of normal variability in the many factors that affect measurement results. For example, variability in sampling or data collection procedures and/or variations of the actual concentrations in the media being sampled (Ecology, 2011)

4.1.2 Bias

Bias is a systematic error that results in sample values that are consistently distorted in one particular direction from the "true" or known value (EPA, 2006; Erickson, 2013). Bias can result from improper data collection, poorly calibrated analytical or sampling equipment, or limitations or errors in analytical methods and techniques (Ecology, 2011).

4.1.3 Representativeness

Representativeness is a qualitative term that expresses the degree to which the data accurately and precisely represents the conditions being evaluated (EPA, 2002). Common variables considered when determining the degree of representativeness include the selected sampling locations, sampling frequency and duration, and sampling methods (Ecology, 2011).

4.1.4 Completeness

Completeness is the amount of valid data needed to be obtained during the study to meet the project objectives (Lombard, 2004).

4.1.5 Comparability

Comparability is a qualitative term that expresses the measure of confidence that one dataset can be compared to another and can be combined or contrasted for the decision(s) to be made. Data is comparable if sample collection techniques, measurement procedures, analytical methods, and reporting are equivalent for samples within a sample set and meet acceptance criteria between sample sets.

4.1.6 Sensitivity

Sensitivity is the capability of a method or instrument to discriminate between measurement responses representing different levels of the variable of interest (EPA, 2002).

Table 4-1. Summary of the Data Quality Indicators (DQI) and Measurement Performance Criteria (MPC)

	Data Quality Indicators (DQIs)	Measurement Performance Criteria (MPCs)
Precision	Develop and consistently following SOPs for collecting samples and measuring data will reduce the potential of collecting imprecise data.	Audits (Section 10.0) will be conducted to verify that sampling staff are following the SOPs. Data will be considered acceptable if the sampling staff are consistently following the SOPs.
	Duplicate analytical testing will be performed for the water quality parameters shown in Table 4-2.	If the results of the duplicate sampling meet the respective relative percent difference (RPD) for the parameters listed in Table 4-2, the results of the analytical testing will be considered acceptable.
	Rain gauge and flow measurements will also be assessed.	If the flow measurements and rain gauge data meet the RPD defined in Section 4.1.1, that data will be considered acceptable.
Bias	Calibration of instruments, including the pH meter, pressure transducers and ISCO, will occur according to manufacturer's specifications. Buffer solutions will be used to calibrate the pH meter to reduce the potential for bias.	To reduce the potential for biased measurements, the instruments requiring calibration will be calibrated according to the procedures and frequency outlined in Section 6.0, per manufacturer's specifications. Audits (Section 10.0) will be conducted to verify sampling staff are following the SOPs.
	Lack of maintenance at the site can be a source of bias in sample values or measurements. For example, if the PTs are not calibrated monthly, drift in measurements can result in skewed flow readings. For that reason, manufacturer's recommendations for maintenance frequency and procedures will be followed to reduce the potential for bias.	Audits (Section 10.0) will be conducted to verify that sampling staff are following the SOPs outlined in Section 6.0 (written to match manufacturer's specifications).
	SOPs defined in Section 6.0 will be followed when collecting samples and measuring data to limit bias.	Audits (Section 10.0) will be conducted to verify that sampling staff are following the SOPs outlined in Section 6.0.
	Method blanks, rinsate blanks, matrix spikes, and field duplicates will be analyzed to check for bias.	Sample results will be accepted if results of the method blanks, rinsate blanks, matrix spikes, and/or field duplicates are below the limits shown in Table 4-2.

Representativeness	The location selected for this study is at the downstream end of a parking lot with an expected high number of trip returns.	These conditions reflect the characteristics of a location where a bioretention cell are installed: an area where higher loading of TSS and metals are expected.
	Hydrologic conditions at the site should be representative of a range of weather patterns and conditions.	Local stormwater hydrologic conditions are represented by conducting the project over two and a half wet seasons and collecting data from a minimum of 15 qualifying storm events.
	Rainfall data, flow data, and water quality samples should be representative of the site.	Equipment will be set up to achieve representative rainfall, flow, and water quality data as follows: • The rain gauge will be installed within the drainage basin of the bioretention cells and in a location where no buildings, trees, or other objects obstruct or divert rainfall from entering the rain gage • Pressure transducers will be installed upstream of weirs in influent and effluent pipes, which will mimic typical bioretention cell construction • Water quality samples will be collected as composite samples. pH measurements will also be taken from the composite samples. The composite samples will capture at least 10 aliquots and 75% of the qualifying rainfall event hydrograph to be representative of water quality during the storm
	Equipment at the site will be installed per manufacturer specifications.	Data will be considered acceptable if equipment at the site will be installed per manufacturer specifications.
Completeness	A minimum of 15 qualifying rainfall events (**Section 5.0**) are required to be sampled during the project, per TAPE. Additionally, at least 10 aliquots and 75% of the hydrograph must be sampled during each qualifying rainfall event.	The number of rainfall events sampled will be compared to the minimum amount at the end of the project, and additional rainfall events will be sampled as needed. Samples which represent less than 75% of the hydrograph will not be accepted. If samples only consist of 7-9 aliquots, the samples may be accepted if rationale is provided in the TER as to why the sample was used (per TAPE).
	A minimum of 95% of the samples analyzed by the lab must be considered valid prior to the end of the project.	95% of the samples must be accompanied by method blanks, rinsate blanks, matrix spikes, lab control spikes, and field duplicate results which are valid. Additionally, the samples must be received and analyzed within the appropriate temperatures and holding times. Temperature will be verified on the data results reported from the lab.

	Define procedures for handling missing data, use appropriate coding for missing data, and report missing data with the results	Procedures for handling missing data and coding missing data are defined in **Section 9.0**. The Final Technical Report for this study will include consideration for how missing data could limit the comparability of the data set.
	Conduct routine maintenance for equipment at the site, in accordance with sampling procedures outlined in **Section 6.0**, to limit the possibility of missing or invalid data.	Audits (**Section 10.0**) will be conducted to verify that sampling staff are following the sampling procedures outlined in **Section 6.0** (written to match manufacturer's specifications).
	An equipment checklist and Chain of Custody forms will be used to prevent loss of data resulting from missing containers, inoperable delivery and collection apparatus or sample delivery.	Equipment checklists are located in **Section 6.0** and the Chain of Custody is located in Error! Not a valid result for table. of this document.
Comparability	The test site is located downstream of a parking area on the Gonzaga University campus with an expected high trip end count.	The process for selecting the project area is defined in **Section 5.2**; the process focused on having a test site that is representative of locations where a bioretention cell would be installed.
	Define and consistently follow sampling procedures for sample collection and field measurements	SOPs were developed and will be consistently followed during this project.
	All data and sample collection will be conducted in accordance with the SOPs outlined in **Section 6.0**.	Audits (**Section 10.0**) will be conducted to verify that sampling staff are following the SOPs outlined in **Section 6.0**.
	Standard testing methods will be used to analyze samples submitted to the lab.	Anatek, the laboratory proposed for water quality testing during this project, is certified by Ecology and will follow standard methods approved by the US Environmental Protection Agency (EPA) (APHA, AWWA, and WEF, 2012; EPA, 1983). The methods to be used are listed in **Table 5-5**. Deviations from methods will be noted on analytical reports.
Sensitivity	Analytical results for water quality samples will be reported if they are above the reporting limit.	The reporting limits for water quality analytical parameters are shown in **Table 7-1**. Data reported as below the detection limit will be presented using the reporting limit.
	All water quality testing methods selected have detection limits above the expected range of results.	The expected range of results and respective reporting limit were compared in **Table 7-1**.
	Instruments capable of accurately measuring variables at the site will be used during the study.	The sensitivity of instruments at the site is included with the monitoring equipment specifications in **Appendix D**. *Specifications*.

4.1.7 Precision

Water quality samples and measurement precision will be assessed using laboratory and field duplicates. **Table 4-2** shows the limits for acceptable results for these tests. In all cases, the RPD of duplicate samples will be calculated using the following equation:

$$RPD = \frac{|C_1 - C_2|}{\ddot{x}} \ x\ 100$$

Where, RPD = relative percent difference,
C1 = concentration of original sample,
C2 = concentration of duplicate, and
ẍ = mean of samples.

Flow measurement precision will be assessed throughout the project. Precision for flow will be assessed by comparing repeated pressure measurements with a known depth of water over each of the respective pressure transducers. Procedures for calibrating the pressure transducers are included in **Section 6.1.2**.

4.1.8 Bias

Bias will be assessed based on analyses of method blanks, rinsate blanks, matrix spikes, and laboratory control standards. **Table 4-2** shows the limits for acceptable results for these tests. Percent recovery (%R) for matrix spikes will be calculated using the following equation:

$$\%R_m = \frac{(x_s - x_0)}{c_s} \ x\ 100$$

Where, %R = percent recovery,
X_S = spike sample result,
X_O = original sample amount, and
C_S = concentration of spike.

If the analyte is not detected in the un-spiked sample, then a value of zero will be used in the equation. Percent recovery (%R) for control standards will be calculated using the following equation:

$$\%R_c = \frac{M}{T} \ x\ 100$$

Where, %R = percent recovery,
M = measured value, and
T = true value.

4.1.9 Representativeness

Representativeness is the degree that the data accurately describe the conditions being evaluated based on the selected sampling locations, sampling frequency, and sampling methods. The BMP location selected for the project is representative of an area which would use a bioretention cell (see **Section 5.2**, Test-Site(s) Selection Process). Local stormwater hydrologic conditions are represented by conducting the study over two and a half winter seasons and collecting data from a minimum of 15 storm sampling events. Qualifying storm events are described in **Section 5.5**. The rainfall tipping bucket gage will have a measurement resolution of 0.01 inches, which will be adequate to evaluate these qualifying storm criteria. Rainfall measurements will be made every

15 minutes and every 5 minutes during storm events, which will be an adequate resolution to characterize the storm hydrograph. The tipping bucket rain gage will be located on-site within the drainage basin for the facility to accurately represent on-site rainfall characteristics. The rain gage will be installed in a secure, level fashion in a location where no buildings, trees, overpasses, or other objects obstruct or divert rainfall prior to entering the rain gage.

Field and laboratory methods will have measurement ranges and reporting limits adequate to evaluate achievement of TAPE treatment performance goals (Ecology, 2011). Grab samples will be collected during the rising limb of the storm hydrograph, per TAPE guidance. Composite samples will be collected by in-situ flow-weighted composite sampling. These methods will provide samples representative of the storm water quality.

Table 4-2. Measurement Performance Criteria (MPC) for Water Quality and Sediment Data

Matrix	Parameter	Units	Method	Method Blank	Rinsate Blank	LCS Recovery	MS Recovery	MS RPD	Field Duplicate (RPD)[1]	Laboratory Duplicate (RPD)
Water Quality	Total Suspended Solids (TSS)	mg/L	SM 2540D	1/batch	3	80-120%	N/A	NA	10%	1/batch
	Particle Size Distribution (PSD)	%	ASTM D3977-97[2]	NA	NA	NA	NA	NA	10%	1/batch
	pH	std	EPA 150.2	NA	NA	NA	NA	NA	10%	NA
	Dissolved Copper (Cu)	µg/L	EPA 200.8 (ICP/MS)	1/batch	3	70-130%	75-125%	≤20%	10%	1/batch
	Dissolved Zinc (Zn)	µg/L		1/batch	3	70-130%	75-125%	≤20%	10%	1/batch
	Total Copper (Cu)	µg/L		1/batch	3	70-130%	75-125%	≤20%	10%	1/batch
	Total Zinc (Zn)	µg/L		1/batch	3	70-130%	75-125%	≤20%	10%	1/batch
	Hardness as CaCO3	mg/L	SM 2340B (ICP)	1/batch	3	70-130%	75-125%	NA	10%	1/batch
	Ortho-phosphate (OP)	mg/L	SM 4500-P G	1/batch	3	80-120%	75-125%	≤20%	10%	1/batch
	Total Phosphorus (TP)	mg/L	SM 4500-P F	1/batch	3	80-120%	75-125%	≤20%	10%	1/batch
	Nitrate-Nitrite	mg/L	SM 4500-NO3 F	1/batch	NA	80-120%	75-125%	≤20%	10%	1/batch
	TKN	mg/L	SM 4500-Norg D	1/batch	NA	80-120%	75-125%	≤20%	10%	1/batch
	Fecal Coliform	CFU/ml	SM 9222D	1/batch	NA	NA	NA	NA	10%	1/batch
	E. Coli	CFU/ml	SM 9223B	1/batch	NA	NA	NA	NA	10%	1/batch

Notes:

[1] Samples are defined as the total number of influent and effluent samples collected (e.g., 5 storm events result in 10 samples). Duplicates must be analyzed for no fewer than 10% of samples. (e.g., 3 duplicates would be required for 21-30 samples collected)

[2] Modified Suspended Sediment Concentration (SSC) Method according to ASTM Method D3977-97 (ASTM 2002) using wet sieve filtration (Method C) and glass fiber filtration. (Method B)

mg/L = milligrams per liter, µg/L = micrograms per liter, std. units = standard units, RL = Reporting Limit, LCS = Laboratory Control Sample, MS= Matrix Spike, MSD = Matrix Spike Duplicate, RPD = Relative Percent Difference, NA = Not Applicable PSD = Particle Size Distribution, batch = must consist of 20 or fewer samples

5.0 Experimental Design

5.1 Study Design Overview

The intent of this study is to evaluate the treatment performance of two non-vegetated bioretention cells constructed with two different Ecology-approved BSMs. The test site is located on the Gonzaga University campus and includes a dual cell bioretention pond. As part of this study, the cells will be reconstructed with the 60:40 BSM in one cell and the HPBSM in the other cell (see **Appendix D**. *Specifications* for BSM specifications). The top of the cells will be covered with a rock mulch to stabilize the soils and limit weed growth. The test site is set up with automated monitoring system with equipment located in two catch basins, a sump, a manhole, and equipment storage vault. Runoff from a parking lot is collected in the catch basin inlet located at the south end of the cells, which is also where influent samples are collected. Then runoff overflows through a pipe into a covered sump where the influent flow rate is measured. Runoff then discharges into a second covered catch basin located between the cells and then flow is distributed to each cell through pipes located on opposite sides of the catch basin. Runoff infiltrates through the BSM in each cell and is captured by the impermeable liner and conveyed to a manhole through underdrain pipes where the effluent flow rate is measured and the effluent samples are collected. **Figure 5-1** provides an aerial view of the test site highlighting where sample collection and the automated equipment is located.

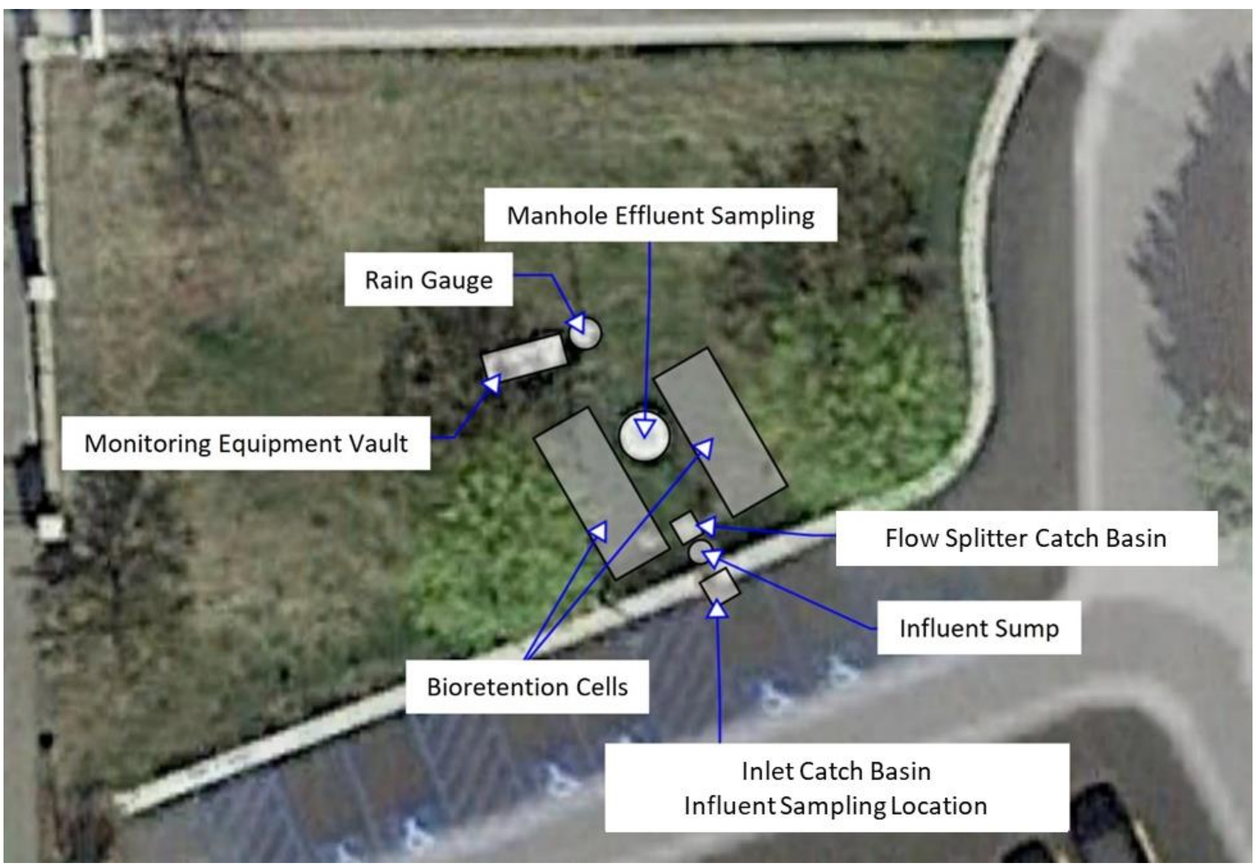

Figure 5-1. Aerial of Site

Figure 5-2. Manhole-effluent sampling (top left), weir (top right), influent sump (bottom left), and monitoring equipment vault with samplers and data logger (bottom right)

Major components of the monitoring system are shown in

Figure 5-2 and generally described below. Details about how the equipment and instrumentation are connected are shown in Figure 5-3 and described in Table 5-1.

- A rain gauge, adjacent to the monitoring vault, measures rainfall depth, which is relayed to the data logger located in the equipment vault. Reference Section 5.5 for more details.
- Pressure transducers continuously measure flow depth upstream of v-notched weirs located in the influent pipe (located in the influent sump) and effluent pipes (located in the manhole). The data is then transmitted to the data logger, which is programed to calculate flow rate using the measured flow depth and an equation developed specifically for the weirs. Reference Section 5.6 for more details.
- A data logger, located in the monitoring vault, triggers the automated samplers to collect samples based on the qualifying rainfall event criteria that is defined and programmed into the data logger before each sampling event. Reference Section 5.7 for more details.
- Three automated samplers stored inside the monitoring vault collect flow-weighted composite samples from the inlet catch basin and from the effluent pipes in the manhole (Figure 5-1). Reference Section 5.7 for more details.

Composite stormwater samples, one from the influent and two from each effluent, will be collected from a minimum of 15 qualifying rainfall events (see Section 5.5 for details on qualifying events). Samples will be tested for the required parameters (each sampling event) and screening parameters (minimum 3 sampling events). The testing results will be used to evaluate whether each BSM can achieve the applicable TAPE treatment performance goals shown in Table 12-1. This will include calculating removal efficiencies of each cell and performing bootstrapping statistical analyses. Data and statistical analysis are described in more detail in **Section 12.0**. Testing is expected to occur over two wet seasons starting in September 2024 and ending in December 2026.

Samples of each type of BSM will be collected prior to construction and after stormwater sampling is complete and submitted to the lab for analysis. These samples will be used to estimate lifecycle of the media. **Section 5.9** provides more details on material testing.

Saturated hydraulic conductivity (Ksat) and infiltration testing will occur twice during the study, as described in **Section 5.8**. Ksat will be tested using a falling head test, which will include using a fire hydrant to fill the cells, and the rate of fall will be measured using yard sticks. Infiltration testing will include measuring the effluent flow rate during the falling head test. The purpose of this testing is to monitor changes in Ksat and infiltration rate over the duration of the study.

After field testing is completed, a technical evaluation report (TER) will be developed that summarizes the results of the study and submitted to Ecology and the BER for review. If the TAPE treatment performance goals are met for either BSM, the TER will request a 'functionally equivalent' designation for non-vegetated bioretention cells. Reporting for the project is described in more detail in **Section 13.0**.

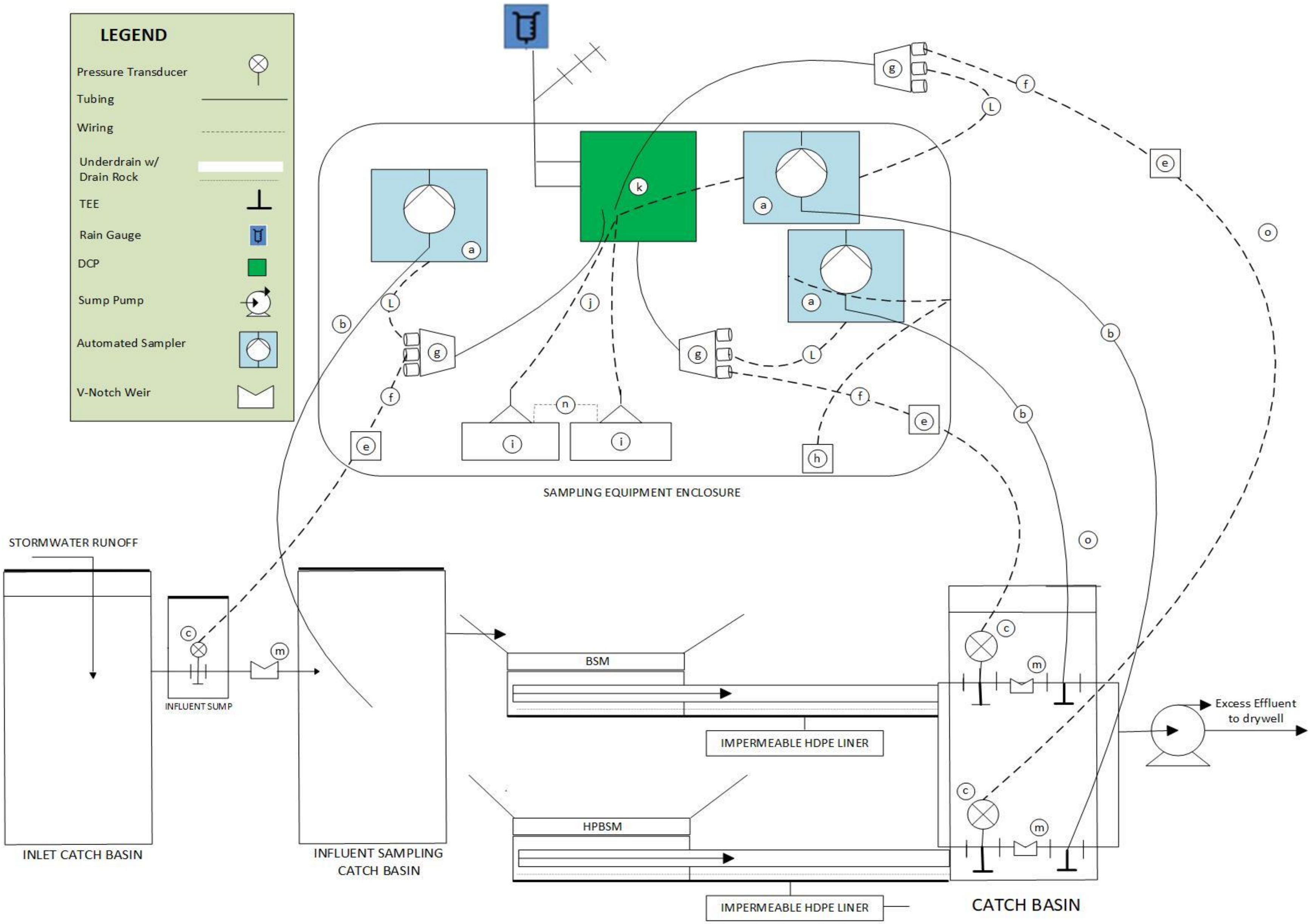

Figure 5-3. Monitoring System Process Diagram

Table 5-1. Monitoring Equipment and Instrumentation

Symbol	Equipment Name and Description	Equipment Function	Quantity
a	ISCO 6712 autosampler	Collects and stores influent and effluent samples	3
b	3/8 inch ID x 25 ft. long vinyl suction line with standard weighted polypropylene strainer. Includes tubing coupler.	Suction tubing conveys sample to the samplers	3
c	Ott Pls Pressure Transducer - aa PLS, Pressure Level SDI12, 0-4M OTT PLS level sensor with 0-4 meter (13.1 ft) range and SDI-12 communication	Measures the depth of water in the pipe which is used along with the thelmar weir to calculate the influent and effluent flow rates	3
d	ISCO 674 Rain Gauge, Tipping bucket, 50 ft Armored Cable	Records rainfall data	1
e	Junction Box - Humidity Absorber Connection Box FAD 5. Humidity absorber connection enclosure for use with OTT PLS level sensor	Houses the desiccant cartridges	2
	Dessicant Cartridge, Replacement OTT Replacement desiccant cartridge for use with OTT FAD 4 and FAD 5 humidity enclosures	Absorbs moisture that could damage the equipment	3
f	Cable, Terminal Strip to SDI Port, 1.5 ft	Extension cable which provides signal to Data Logger. Between junction box and data logger.	2
g	Cable, Terminal Strip to SDI port, 2 ft	Connects PT to the humidity box and Samplers	2
h	Trickle Battery charger (AC to DC Charger)	Continually Charges batteries	1
i	Battery GNB Sunlyte, 100AH, Starved Electrolyte	Battery powers samples and data logger	2
J	Battery Cable, Dual 10A Fuse, F6 & H2, 8.5ft	Connects data logger and samples to battery	1
k	Axiom data logger package (H2)	Records data over time via connected external instruments and sensors	1
l	SDI Interface, 4.5ft Cable Logger to Isco 6712 Samp	Connects PT to humidity box and samplers	2
m	V-Notch Volumetric Weir 6”	Measures influent & effluent flow rates	3
n	Cable, Two Batteries in Parallel	Connects batteries together in parallel	1
o	PLS PROBE CABLE, METERS - Integrated vented cable for use with OTT PLS level sensor - per meter Notes: Each PLS to have 15-meter cable.	Patch cable that provides the signal from the pressure transducer to the datalogger. This cable terminates at the junction box (humidity absorber).	2

5.2 Test-Site(s) Selection Process

In 2014, the test-site was constructed for the purpose of conducting an effectiveness study focused on bioretention soil media. This location was selected because the contributing basin area is a parking lot located near the university soccer field, basketball center, and a recreation facility. During a typical day, the parking stalls are occupied and there is a frequent turnover of vehicles. This type of land use is associated with a buildup of pollutants such as metals and TSS (Minton, 2012). As such, it was anticipated these pollutants will be of measurable quantity in the stormwater runoff and have the potential to meet the TAPE influent concentration range (see **Table 12-1**). The test site was used from 2014 to 2021 to monitor two bioretention cells as part of the Bioretention Soil Media Thickness Effectiveness Study (Navickis-Brasch, Hoffman-Ballard, & Chen, 2021). The testing confirmed that regulated pollutants (TSS, dissolved zinc, and dissolved copper) were present at the test site. Insufficient oils were present in the influent at the test site to evaluate treatment performance of the bioretention cells against TAPE treatment performance goals for oils; as such, oils were not included in this study. The test-site was also selected for this TAPE project to leverage the existing location with infrastructure for monitoring and the existing associated monitoring equipment.

5.3 The Structural BMP System Sizing and Maintenance

5.3.1 BMP Sizing

The bioretention cells were designed following the guidance in the SWMMEW (Ecology, 2024). The following is a summary of the cell design methods, assumptions, and results. A summary of the cell sizing is located in **Table 5-2** and a copy of the BMP sizing calculations are included in **Appendix B**. *Bioretention Sizing Calculations*.

- Both cells have a bottom area of 7 feet by 18 feet and the cells are sized to treat the water quality event (6-month 24-hour storm) and contain the 10-year 24-hour event.
- The cells were sized using the SCS Type IA rainfall distribution in StormShed3G.
- The rainfall depths used 0.97 inches (6-month 24-hour) and 1.8 inches (10-year 24 hour)
- There are two cells at the test site and runoff is assumed to split evenly between the two cells. As such, runoff from half of the contributing basin area (0.61 acres) was routed to the cell modeled in StormShed3G (0.305 acres per cell)
- The BSM infiltration rate was assumed to be 3 inches/hour.

Table 5-2. Summary of Bioretention Cell Sizing

Event	Effluent Peak Flow Rate (cfs)	Maximum Pond Depth (ft)	Volume (cf)	Time to Empty (hr)
6-month 24 hour	0.018	0.89	149.41	0.006

10 year 24 hour	0.121	1.69	433.12	1.879

5.3.2 Operations and Maintenance

An operations and maintenance (OM) plan were developed using recommendations from a non-vegetated swale BMP study conducted by the QAPP authors (Hoffman-Ballard, Navickis-Brasch, Volsky, & Maurer, 2023) as well as maintenance that is typically conducted on bioretention BMPs. An inspection and needed maintenance will be performed monthly as described in **Section 6.1.9** and tracked on a field form (**Appendix E**. *Field Data Collection Forms*). Information from the completed field forms will then be used to develop recommendations for future maintenance.

5.4 Type of Data Being Collected

The sampling process design was developed based on monitoring requirements identified in TAPE (Ecology, 2018). This section addresses the steps and processes taken to develop the monitoring site and sampling strategies and to ensure the data collection and monitoring methods satisfy the requirements of TAPE. **Table 5-3** provides a summary of the types of data that will be collected along with the frequency of data collection, sampling method, and the sampling location.

The study is expected to last two wet seasons. Water quality samples will be collected during a minimum of 15 qualifying rainfall events (see **Table 5-4** for definition of qualifying rainfall events). This will include collecting flow-weighted composite samples from the influent and the effluent. Composite samples will target at least 75% of the storm event hydrograph (by volume). Additionally, sampled storm events will target a minimum of 10 aliquots per storm event. Samples will be tested for the required parameters (15 minimum samples) and screening parameters (three minimum samples) as defined in TAPE to demonstrate the treatment performance (Ecology, 2018).

Table 5-3. Overview of Monitoring Variables

Parameters	Frequency	Monitoring Approach
Rainfall[2]	Continuous,[1] year-round	Rain Gage, on-site
Stage (Discharge)[3]	Continuous,[1] year-round	PT: influent and effluent
Temperature	Continuous,[1] year-round	PT: influent and effluent
Time	Continuous,[1] year-round	Rain gage, PT: influent and effluent
Required Parameters (see **Table 5-5**)	Storm events (min. of 15 events)	Composite[4] with Autosampler, Influent and effluent

Screening Parameters (see **Table 5-5**)	Storm Events (min. 3 events)	Composite[4] with Autosampler Influent and effluent
Saturated Hydraulic Conductivity and Infiltration Rate	Before and after monitoring period	Falling head test
BSM (See **Table 5-5**)	Before and after data collection is complete	Composite Sample; BSM stockpile and cores from bioretention cells

[1] Measured in 5-minute intervals when storms are monitored and 15-minute intervals during all other times.
[2] Rainfall for each storm event will be measured with a tipping bucket rain gage at the test site. Rainfall monitoring is described further in **Section 5.5.2**.
[3] Influent and effluent flow rates will be monitored using pressure transducers (PTs) and in-line weirs. Flow monitoring is described further in **Section 5.6**.
[4] All samples will be composite samples collected with the autosampler, except grab sampling will be used to collect pH, fecal coliform, and E. coli.

5.5 Precipitation Monitoring

Precipitation monitoring consists of two parts: storm event prediction and rainfall measurements. This section describes the methods for both.

5.5.1 Storm Event Prediction

Sampling will be attempted for storms that are predicted to meet the storm event guidelines defined by TAPE (Ecology, 2018). These events are referred to as qualifying rainfall events in this document which have the characteristics defined in **Table 5-4**. The National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS) Spokane forecast office website will be monitored daily for storm forecasts (Hourly Graphical Forecast for 47.66N 117.4W (weather.gov)). This site reports weather forecasts for a station located approximately 0.31 miles south of the test site. These observations will determine if a predicted storm meets is likely, marginal, or unlikely to meet the qualifying event criteria for sample collection as described in **Section 6.1.1**. Monitoring will be attempted for storms that appear likely to meet the criteria, and professional judgement will be used for storms that appear marginal. The SOPs for selecting and tracking a storm are defined in **Section 6.1.1**.

Table 5-4. Storm Event Guidelines for TAPE Monitoring (Ecology, 2018)

Parameter	Definition	Guideline
Minimum storm depth	Total rainfall amount during the storm event	0.15 inches[1]
Storm start (antecedent dry period)	Defines the storm event's beginning as designated by the minimum time interval without significant rainfall	6 hours minimum with less than 0.04 inches of rain

Storm end (post storm dry period)	Defines the storm event's end as designated by minimum time interval without significant rainfall	6 hours minimum with less than 0.04 inches of rain
Minimum storm duration	Shortest acceptable rainfall duration	1 hour
Average storm intensity	Total rainfall amount divided by total rainfall duration (e.g., inches per hours)	Range of rainfall intensities

[1] TAPE identifies 0.15 inches as the minimum rainfall depth. Per discussions with Ecology, this depth was selected to support having a sufficient volume for water quality analysis testing. Because the annual precipitation depth in EWA is lower than WWA, rainfall events predicted with at least 0.10 inches of precipitation will be considered as qualifying events for this study.

5.5.2 Rainfall Measurements

Precipitation monitoring will be conducted for quantify rainfall during storm events and to measure the duration, intensity and distribution of rainfall throughout a discrete storm event. The precipitation monitoring device used for this study is a jeweled bearing tipping bucket rain gage. The tipping bucket rain gage has a data resolution of 0.01 inches (see **Appendix D**. *Specifications* for specification sheet).

The tipping bucket rain gage is located on-site within the drainage basin for the facility to accurately represent on-site rainfall characteristics. The rain gage was installed level in a secure location where no buildings, trees, overpasses, or other objects obstruct or divert rainfall prior to entering the rain gage. The rain gage is mounted approximately 8 feet above the ground. Rain gage placement followed the National Weather Service specifications (https://www.weather.gov/coop/standards) for the site. The rain gage will be calibrated and maintained in accordance with the manufacturers' specifications as described in **Section 6.1.2**.

The data collected from the rain gage will be logged every 15 minutes during typical operating conditions and every 5 minutes during sampling events and can be downloaded via the data logger at the site.

At the end of sampling events, the sampling crew will determine when to deploy for sample collection based on the actual precipitation that has occurred during a storm event using one of two methods:

- Weather Station – If the precipitation data reported on the NOAA website for the weather station (**Section 5.5.1**) indicates the storm has ended, the sampling crew will deploy for sample collection. At the site, the sampling crew will confirm sample collection has stopped by checking the ISCOs and data logger, as described in **Section 6.1.6**.
- Telemetry – Alternatively, the site may be equipped with telemetry, which transmits measurements recorded by the data logger to a remote IT system. Specifically, a Ubicom Transceiver device (see specification sheet in **Appendix D**. *Specifications*) provides telemetry at the test site and allows two-way communication from the data logger on the test site to off-site computers. This allows sampling staff and the field lead to review data logger output from remote offices. For example, they can determine whether a storm has ended or if a storm is qualifying before the samples are picked up, and it can be used to enable the test site to sample from a remote location.

During each monthly monitoring equipment maintenance visit (**Section 6.1.2**), the rain gage will be inspected, cleared of debris, and maintained in accordance with the manufacturers' specifications. Rain gage data will also be downloaded from the logger following sampling events and during scheduled maintenance.

5.6 Flow Monitoring

The discharge flow rate for the influent and effluent are calculated with the data logger using measurements from pressure transducers and a weir equation. There is one influent measurement (before entering each cell), two effluent measurements (after infiltrating through each BSM), and no bypass flow, so all flow into and out of the cells is measured. After the influent flow rate is measured, it splits between the two cells through identical pipes located at the same invert elevation. Flow between the cells is measured and balanced following the procedures in **Section 6.1.3**. Stage values (flow depth) measured in feet by the pressure transducers are combined with weir equations specific to the weir and pipe diameter. V-notch weirs are located downstream of the transducer in the influent pipe and effluent pipes. The weir equation was derived using a regression analysis with flow and corresponding depth data provided by the manufacturer. The equation will be programmed into the data logger logic, which will automatically calculate the discharge flow rate at each time interval using the stage measured by the pressure transducers. Flow over the weirs at the site is calculated from the following equations for 6-inch weirs in the influent and effluent pipes:

$$Q = 5816.563 \times (d_{\mathrm{PT}})^{2.5532}$$

Where,
Q = f low rate (L/min), and
d_{PT} = depth measured at pressure transducer (ft).

The data logger will store data measured on-site by the instrumentation on the internal logger memory. Data will be accessed by downloading to a USB drive at the site. Storm reports will be generated as described in **Section 12.1.1,** which will include creating hydrographs and hyetographs from the collected rain gage and flow rate data to compare and relate the two parameters.

Weirs were selected for this test site because they are preferred over flumes in lower-flow "flashy" systems in order to more accurately characterize small-scale hydrological features (S.E. Rantz, 1982; EPA and ASCE, 2002). However, weirs tend to be more influenced by debris than flumes (Church, Granato, & Owens, 1999) and need to be carefully monitored and maintained. As such, the SOPs defined in **Section 6.1.2** include guidance for checking for and removing debris.

5.7 Water Quality Sampling

Two methods will be used for water quality sampling depending on the parameter that will be analyzed. A description for each sampling method is provided in this section. A summary of the all the parameters that will be sampled for this project is summarized in **Table 5-5**.

5.7.1 Grab Sampling

Grab samples are collected manually in sample containers and/or measured in situ with a probe. Fecal coliform and E. coli will be collected manually from both the influent and effluent as defined in **SOP 6.1.5** and submitted to the lab for analysis. In situ, measurements will be taken for pH from both the influent and effluent by collecting a grab sample of the water volume composited by the autosampler (**Section 5.7.2**) after the storm has ended. In the event that pH is not collected for a qualifying storm event, non-qualifying storm events that did not meet precipitation criteria may be sampled for pH to ensure a robust sample set for statistical analysis. Samples collected from non-qualifying storms will be noted and flagged in the dataset.

5.7.2 Composite Sampling

TAPE specifies that stormwater runoff must be collected by flow-weighted composite sampling, which is described in **Section 6.1.6**. Water temperature, rainfall, discharge, and time will be monitored by the external probes and the data logger to determine if the qualifying storm criteria have been met. When the qualifying storm criteria thresholds have been met for the storm to start, ISCO autosamplers will be triggered to begin collecting aliquots of influent and effluent at a predetermined value (threshold) that will be derived from forecast information specific to the storm. For more details, reference

Appendix *I. Data Logger Threshold Calculations*. The value will be set to collect aliquots across a target of 75 percent of the storm hydrograph. The data logger is programmed to discontinue collecting data when conditions for the storm end occur. If the qualifying storm criteria are not met, samples will not be collected. Reference **Table 5-4** for qualifying event guidelines.

Composite samples are collected in one 2.5-gallon glass jar. The samples are then split into the smaller bottles provided by the lab for analysis, as shown in **Table 6-1**. The procedures for processing and splitting sample follow Ecology's guidelines for Automatic Sampling for Stormwater Monitoring (Washington State Department of Ecology, 2024). Specifically, for volumes less than 5 gallons, manual vigorous agitation is applied to the composite sample jar before samples are transferred to separate bottles.

Table 5-5. Grab and Composite Sampling Analytical Analyses

		Parameter	Analytical Method	Influent	Effluent	60:40 BSM	HPBSM Primary	HPBSM Polishing
Water	Screening	Particle Size Distribution (PSD)	Modified SSC Method (based on ASTM Method D3977-97)	3	-	--	--	--
		Fecal Coliform	SM 9222D	3	3	--	--	--
		E. coli	SM 9223B	3	3	--	--	--
		TKN	SM 4500 Norg-D	3	3	--	--	--
		Nitrate-Nitrite	SM 4500 –NO3 F	3	3	--	--	--
	Required	Total Suspended Solids (TSS)	SM 2540D	15	15	--	--	--
		pH	EPA Method 150.2	15	15	--	--	--
		Total Phosphorous (TP)	SM 4500-P F	15	15	--	--	--
		Orthophosphate (OP)	SM 4500-P G	15	15	--	--	--
		Hardness as CaCO3	SM 2340B (ICP)	15	15	--	--	--
		Total Copper (Cu)	EPA Method 200.8 (ICP/MS)	15	15	--	--	--
		Dissolved Copper (Cu)	EPA Method 200.8 (ICP/MS)	15	15	--	--	--
		Total Zinc (Zn)	EPA Method 200.8 (ICP/MS)	15	15	--	--	--
		Dissolved Zinc (Zn)	EPA Method 200.8 (ICP/MS)	15	15	--	--	--
Soil	BSM Physiochemical Properties	Total Copper (Cu)	EPA Method 6010D_(7/14)	--	--	4	4	4
		Total Zinc (Zn)	EPA Method 6010D_(7/14)	--	--	4	4	4
		Cation Exchange Capacity	EPA Method 9081	--	--	4	4	4
		Organic Matter Content	ASTM D2974 or TMECC 5.07A	--	--	4	4	--
		Phosphorus-Morgan	(Modified) Morgan	--	--	--	--	4

Note: For all water parameters, 3 rinsate blanks will be collected, and field duplicates will be analyzed for at least 10% of samples in accordance with TAPE guidelines.

5.8 Saturated Hydraulic Conductivity and Infiltration Rate Testing

The saturated hydraulic conductivity (Ksat) and infiltration rate of the bioretention ponds will be measured twice during the project. One test will occur prior to the start of the data collection phase and a second test will be conducted after data collection is complete. Ksat will be measured using a falling head test, which includes filling the cells with water using a fire hose, then measuring the rate of fall using yardsticks installed in the cells. The BSM infiltration rate will be calculated using effluent flow rates measured by the data logger during the falling head test. The SOP for conducting this testing is located in **Section 6.1.8,** and the formula for calculating saturated hydraulic conductivity and infiltration rate is included in **Section 12.1.4, and Section 12.1.5** describes how the data will be used to estimate the BMP lifecycle.

5.9 BSM Material Testing

The BSM testing for this study includes the following:

- The supplier of the BSM media will provide third-party testing of media prior to installation. The test will be reviewed prior to the start of data collection to confirm the properties are consistent with the properties shown in **Appendix D.**
- The BSM media will be tested for the properties noted in **Table 5-5** before and after data collection to estimate the lifecycle of the media. Monitoring staff will collect two samples of each media (60:40 BSM and both the primary and polishing layer of the HPBSM) according to the SOP in **Section 6.1.10**. Samples collected from the cells will be submitted to the lab for analysis and analyzed as described in **Section 12.1.5** to estimate the BMP lifecycle.

5.10 Existing Data

The use of existing data is not planned for this project.

6.0 Sampling Procedures

This section defines the field procedures for collecting samples, measuring data, as well as operating, maintaining, and calibrating the monitoring equipment.

6.1 Standard Operating Procedures

Water quality samples will be collected in the field, following sampling procedures outlined in this section. The sampling procedures developed for this study define how to conduct storm selection, sample collection, and equipment maintenance and calibration in detail, including the frequency of the activity. The following list summarizes the sampling procedures included in this section:

- 6.1.1 Procedure for Storm Selection and Tracking
- 6.1.2 Procedure for Storm Monitoring Equipment Maintenance
- 6.1.3 Procedure for Preparing, Measuring, and Balancing Flow Between Cells
- 6.1.4 Procedure for Preparing Stormwater Monitoring Equipment for Storm Sampling
- 6.1.5 Stormwater Grab Sampling
- 6.1.6 Procedure for Composite Stormwater Sample Collection and Processing
- 6.1.7 Procedure for Monitoring Equipment Data Download
- 6.1.8 Procedure to Perform Falling Head Test
- 6.1.9 Operation and Maintenance Observation
- 6.1.10 Procedure for BSM sample collection

6.1.1 Procedure for Storm Selection and Tracking

The purpose of this sampling procedure is to detail how to select and track storm events prior to, and during, stormwater monitoring activities.

Equipment Needed:

- A computer or mobile device with the ability to access weather forecasting websites or applications
- A cellular phone to allow communication between sampling staff and staff tracking the storm event
- A Storm Decision Log (Appendix E. *Field Data Collection Forms*) to record the decision process, weather activity, and outcome of the event

Summary of steps for storm tracking prior to the storm event and storm selection for sampling:

- Step 1: Review weather forecast daily to determine whether upcoming storm events meet the storm event guidelines defined in TAPE (qualifying rainfall event) and described in Section 5.5 of this document. Storm event probability will be tracked via the NOAA National Weather Service Spokane forecast office website at the following link: Hourly Graphical Forecast for 47.66N 117.4W (weather.gov)
- Step 2: The probability of a qualifying rainfall event will be determined based on the weather forecast and the following qualitative classification system:
  - Unlikely: a storm event that is classified as unlikely will produce less than the minimum depth (0.10-inches) for a qualifying rain event and has less than a 50% chance of occurring.
  - Marginal: a storm event that is classified as marginal will produce less than the minimum depth for a qualifying rain event and has a 50% to 75% chance of occurring.

  - Likely: a storm event that is classified as likely will produce greater than the minimum depth for a qualifying rain event and has a greater than 75% probability.

- Step 3: Based on the classification of the predicted rainfall event, the sampling staff will determine whether to prepare to collect samples during the event.
  - If the storm is deemed unlikely, sampling staff will not plan to collect samples during the event.
  - If the storm is deemed marginal, the principal investigator or field lead will determine whether the conditions of the storm look favorable or not using their professional judgment. The judgment will take storm physiology and sampling success to date into account. For storm events with a marginal chance of being a qualifying rainfall event, sampling staff may be informed several days in advance of a possible upcoming event.
  - If the storm is deemed likely, the principal investigator or project manager will inform sampling staff 24 to 48 hours in advance of the anticipated sampling event.
- Step 4: If a storm event is selected for sampling, the equipment will be prepared in accordance with the procedures outlined in **Section 6.1.4**. The current date, the storm event date, qualifying event probability, and the decision to sample will be recorded in the storm decision log. If a storm is not selected for sampling, no information will be recorded in the storm decision log.
- Step 5: Prior to and during a storm event that is selected for sampling, actual precipitation will be monitored remotely as follows:
  - Weather Station – The National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS) Spokane forecast office website will be monitored daily for storm forecasts (Hourly Graphical Forecast for 47.66N 117.4W (weather.gov). These observations will determine if a predicted storm meets the qualifying event criteria for sample collection. This site reports weather forecasts for a station located approximately 0.31 miles south of the test site.
  - Telemetry – Alternatively, the site may be equipped with telemetry that transmits data collected by the data logger to a remote IT system. The sampling crew will then review the data live from the test site to determine when to go to the site to collect samples.

6.1.2 Procedure for Storm Monitoring Equipment Maintenance

The purpose of this sampling procedure is to outline the steps required for maintaining stormwater sampling equipment at the test site. Maintenance of storm monitoring equipment will occur before the first monitoring event and then monthly between monitoring events. Note: If rinsate blanks are collected as outlined in this SOP, the lab will be notified that sampling is expected to occur and that samples will be transported to the lab. An estimate of when each of the samples will be delivered will also be provided to the lab.

Equipment Needed:

- Personal Protective Equipment (PPE), including: eye protection, gloves, high visibility vest, work boots, etc.
- Manhole key and combination to locks for influent sump and monitoring equipment vault
- Periodic Maintenance Checklist Field Form (**Appendix E**. *Field Data Collection Forms*)
- Wet-dry vacuum

- Soft brush
- Cloth rags
- Voltmeter
- USB drive
- pH meter
- Screwdrivers (flathead and Phillips)
- Replacement suction, head, and pump tubing
- Volumetric plastic beaker
- Adjustable wrench
- Camera phone
- Extendable cell phone holder
- Level
- Flashlight
- Replacement battery
- Spare desiccant bags (for ISCO and pressure transducer)
- Nitrile gloves
- Carboy(s) filled with DI water
- Ice to fill ISCOs
- Replacement composite bottles for ISCOs
- Sample bottles for rinsate blanks
- Cooler for rinsate blank sample bottles
- Hard ice packs for cooler
- Clean, powder-free nitrile gloves

Summary of steps for initial inspection of site conditions and monitoring equipment maintenance at the test-site:

- Step 1: Upon arrival at the site, visually inspect the monitoring site and vicinity for any signs of damage or tampering. Note any findings on the Periodic Maintenance Checklist Field Form.
- Step 2: Access the sampling equipment enclosure, influent sump, and catch basins. Visually inspect pipes, cables, wiring, tubing, and monitoring equipment. Note any frayed wires or damaged equipment on the field form. Contact the principal investigator on how to proceed if damage is observed. Note: When accessing the equipment in catch basins, do not disturb pipes or pipe tees.
- Step 3: Inspect pipes, tees and weirs for debris or obstructions. Note and describe any debris on the field form.
    - If debris and/or sediment are observed in pipes, tees, or weirs, clean pipes according to Steps 3 and 4 in **Section 6.1.4**. Then immediately replace the grate inlet or structure lid.
- Step 4: Disconnect power supply to battery. Check voltage of battery using a voltage meter. Battery voltage reading should be above 10.3 volts. Record the voltage reading on the field form and reconnect power to the battery.
    - If battery voltage is not within the specified range, replace battery with the spare, fully charged battery or use the battery charger to recharge the battery

- Step 5: Connect the USB flash drive to the data logger, tap the screen to wake up the data logger, and start a visit report. Note: when the visit report is ended in Step 20, the current conditions data is automatically downloaded to the USB.
- To start a visit report, press service on the main menu. Tap the visit report icon on the next page and fill in the information as applicable for the visit report. Tap the start visit icon and follow the prompts to start the visit report.
- Step 6: Once every year, unplug the rain gage from the data logger. Remove cover from rain gage and check instrument for levelness and cleanliness of internal parts. Clear any debris carefully. The rain gage is factory calibrated, We will compare our rain gage readings to the reading from weather underground noting any significant difference we will remove the rain gage and send it in for calibration. Note any discrepancies and rest level of rain gage platform if needed. Replace the cover on the rain gage and plug rain gage back into the data logger.
- Step 7: Inspect ISCO suction tubing, head tubing and pump tubing for wear. Note and describe condition on the field form. If kinks or bellies are observed in the tubing, replace tubing. Document whether replacement of tubing occurred during the site visit on the Periodic Maintenance Checklist. Clean any ISCO tubing that was not replaced quarterly as follows:
    - Triple rinse the tubing with 10% HNO_3 acid solution, then wash the tubing with liquinox soap solution, and finally triple rinse the tubing with DI water.
- Step 8: Check the Internal Humidity Indicator to the right of the keypad on the ISCO.
    - If all of the indicator is blue, no additional action is needed. Record the indicator color on the field form.
    - If the area of the indicator next to 20% is white or pink, no additional action is needed, though action may be required in the near future. The color change near the 20% indicates that the level of humidity inside the ISCO controls compartment is 20%. Record indicator color on the field form.
    - If the area of the indicator next to 30% or any of the other areas above 30% are white or pink, the desiccant inside the ISCO controls compartment needs to be replaced. Record indicator color and whether the desiccant was replaced on the field form.
    - To replace the desiccant:
        - Pull discharge and pump tube away from bulkhead fitting. Remove the distributor arm by unscrewing the nut that attaches the arm to the distributor shaft. Unscrew the 11 screws securing the cover for the ISCO controls compartment.
        - Remove the desiccant bag from the box inside the controls compartment and replace with a new desiccant bag.
        - Replace the cover for the controls compartment and replace the 11 screws needed to secure the cover. Reattach the distributor arm and discharge and pump tubing.
- Step 9: Check the colored indicator on each of the pressure transducer humidity absorbing systems. Record the observed color on the field form.
    - If the indicator is orange/brown, the desiccant cartridge is dry and does not need to be replaced.
    - If the indicator is white, the desiccant cartridge must be replaced. Note that either the desiccant cartridge needs to be replaced or has been replaced in the field form.

- Step 10: If the ISCO controller keypad is inflated, carefully reach behind the head unit and unscrew one of the bulkhead caps to relieve pressure. Retighten cap after pressure has been relieved to maximize desiccant lifespan.
- Step 11: Check the ISCOs' pump capabilities by manually initiating a grab sample to test purging and pumping capabilities. Do this with the suction tubing disconnected to avoid falsely pumping a sample into clean sampling equipment.
    - Obtain the volumetric plastic beaker.
    - To manually initiate a grab sample, press the return arrow button on the control pad, navigate to "grab sample" and hit the return arrow button again. Follow the prompts to begin the grab sample.
    - Hold the beaker below the pump tubing. Once the sample has been pumped into the beaker, verify that the volume pumped matches what volume was reportedly pumped by the ISCO. If the volumes do not match, perform volumetric verification test as detailed in Step 12.
- Step 12: Once every three months (quarterly), conduct a volumetric verification test to ensure accuracy of ISCO calibration. Do this with the suction tubing disconnected to avoid falsely pumping a sample into clean sampling equipment. Repeat the test as necessary until volumes are accurate.
    - Press the return arrow button and navigate to "calibrate volume." Enter the sample volume desired.
    - Hold a volumetric plastic beaker (large enough to hold sample volume) under the pump tubing and hit the return arrow button when ready.
    - After the sample volume has been delivered, measure the actual volume delivered to the beaker and enter the amount on the ISCO screen as prompted. Press the return arrow button and follow the prompts.
    - The calibration is complete when the display on the ISCO screen returns to the list of manual functions.
- Step 13: Reconnect suction tubing to pump tubing.
- Step 14: Use a level to check position of weirs and pipe tees. Adjust to a level position as needed and note if weirs or tees were not level on the field form.
- Step 15: Inspect pressure transducers and mounts. If PTs and/or mounts are dirty, remove pressure transducer and gently scrub to remove material with a soft brush. Once PTs and mounts are clean, reinstall PTs in original position within the mounts.
- Step 16: Fill the control tee with clean water until water runs over the v-notch of the weir (This may take a few gallons of water to achieve). Once the water stops flowing over the weir (point of zero flow), use the data logger to get a current pressure transducer reading. The pressure transducer reading may take a few minutes to update.
- Step 17: Once the pressure transducer reading updates, verify using the data logger that the pressure transducer reading value is zero. Take another water surface elevation reading using the electronic water level indicator to verify the pressure transducer and data logger reading.
    - If the values do not match zero or the elevation of water at zero flow, record the observed value on the field form and reset the stage reading for the pressure transducer to zero in the data logger. Notify the principal investigator of the drift as soon as possible.

- Step 18: Inspect and maintain pH meter using the following steps.
    - Step a: Inspect the electrode for cracks in the electrode stem or bulb. If scratches or cracks are present, the electrode must be replaced.
    - Step b: Inspect the cable connecting the electrode to the meter. The cable must be intact with no points of broken insulation on the cable. If breaks are observed, the cable and probe may need to be sent in to the manufacturer. End maintenance of pH meter and refer to the manual for the pH meter for further instructions.
    - Step c: Inspect the electrode for oil, calcium, or sediment build-up on the electrode stem or bulb. If present, remove the protective cap and clean the probe using DI water. Replace the protective cap once cleaning is complete.
    - Step d: Inspect connectors and ensure they are clean and dry. Rinse off any deposits with deionized water.
    - Step e: Inspect the protective cap and replace or refill the storage solution as needed to keep the glass bulb and junction of the pH meter submerged.
    - Step f: Clean the probe by soaking the probe in cleaning solution for at least one-half hour. Once the probe has been cleaned, replace the protective cap with storage solution and discard the cleaning solution

Summary of steps for collecting rinsate blanks.

- Step 19: Rinsate blanks will be collected during the following instances:
    - Once during initial equipment startup after decontaminating the equipment
    - Once after the first or second storm event, following the initial equipment startup (to "contaminate" the equipment)
    - Once at the end of the monitoring program.

  The following steps describe how to prepare rinsate blanks. Note: Before handling any sample bottles, staff will ensure the use of clean gloves. The staff member will wear two pairs of gloves during sample handling: after obtaining samples from cooler and opening the bag containing the sample bottles, the outer set of gloves will be removed to handle the clean sample bottles inside the bag.

    - Step a: Put on a new pair of clean nitrile gloves and obtain the sample bottles provided for the rinsate blank.
    - Step b: Access the influent autosampler. Place the end of the clean suction tubing for that autosampler in a carboy containing DI water and place the end of the clean pump tubing over one bottle provided by the laboratory for the rinsate blank. Set the ISCO to "Pump Forward" and fill the bottle so that no airspace is remaining when the cap is replaced.
    - Step c: Replace the cap on the sample bottle, taking care to not touch the inside of the cap.
    - Step d: Repeat Steps 8-9 for the 60-40 and HPBSM effluent autosamplers and associated rinsate blank bottles.
    - Step e: Once the rinsate bottles have been filled, place bottles in the cooler and fill out the Chain of Custody form for the rinsate samples, then deliver the samples to the lab.

- Step 20: Once all maintenance, cleaning, and calibration has been completed, end the visit report on the data logger, close the monitoring equipment vault, manhole, sump, and catch basins, and secure as needed before leaving the site.

- o To end the visit report, press service on the main menu. Tap the visit report icon on the next page and tap the end visit icon near the bottom of the page. Follow the prompts as necessary and remove the USB drive.

6.1.3 Procedure for Measuring and Balancing Flows Between Cells

The purpose of this sampling procedure is to outline the steps required to use flow meters to measure and balance the amount of flow splitting between cells. Additionally, this section will provide installation and calibration instructions for the flow meter.

Equipment Needed:

- Tools necessary to access fire hydrant and hose
- Fire hydrant flow meter
- Personal Protective Equipment (PPE), including, but not limited to: high-visibility vest, gloves, work boots, etc.
- Two MantaRay flow monitoring devices
- Two sensors with cables to connect to flow monitoring device
- Two sensor mounting pipe band for 6-inch pipe
- USB-A flash drive
- Laptop
- Watch
- Measuring and Balancing Flows Between Cells Field Form (**Appendix E**. *Field Data Collection Forms*)

Summary of steps for calibrating flow meter for on-site specifics:

- Step 1: Open the MantaRay and press any button to illuminate screen showing Main Menu.
- Step 2: Press > button to move cursor over calibration to access the menu.
- Step 3: Look through calibration menu to identify fields that need editing.
- Step 3: Use up and down arrows to move cursor and the > to select the parameter for editing.
- Step 4: When editing parameters, use the up and down arrows to select between available options. Press ✓ to save your selection or < to cancel. Some parameters include numerical entries. When editing these parameters, use the up and down arrows to increase and decrease the value of the selected digit. Use the right and left arrow to move cursor position to another value. Press ✓ to save your selection or < to cancel.
- Step 5: Verify the following parameters match site-specific details. For more information on each of the following calibration parameters, refer to instruction manual in the calibration section. The calibration parameters include level max, level min, level 20mA, level 4mA, level offset, LOW time, LOE behavior, level damping mode, level damping precent, level damping window, velocity 20mA, velocity 4mA, velocity signal cutoff, LOS time, velocity damping mode, velocity damping precent, velocity damping window, flow min, flow 20mA, and flow 4mA.

Summary of steps for flow meter channel setup for on-site specifics:

- Step 1: From Main Menu, press > button while the cursor is on Channel Setup to access this menu.
- Step 2: Repeat Steps 2 and 3 from steps for calibrating the flow meter for on-site specifics.
- Step 3: Using step 3 from the previous calibration section, select "Round" channel shape and save the selection. Based on this selection, additional parameters options may appear.

Summary of steps for running test to measure split flow between cells on-site:

- Step 1: Contact Gonzaga University Plant Services and make arrangements for them to turn on the fire hose located just north of the test- site.
- Step 2: Arrive on-site and access sampling equipment enclosure and catch basins.
- Step 3: Install flow monitor sensors in west-facing 6-inch pipe in second solid catch basin.
- Step 4: Using pipe mounting band, insert sensor into clip at base of the band. Run cord along face of band in designated holding clips from bottom around to the top of band and out the top of the catch basin.
- Step 5: Attach sensor cable to flow meter and hold the ON button.
- Step 6: Repeat steps 3–5 on second flow meter installing in east-facing pipe in same catch basin.
- Step 7: Starting with the flow meter attached to the west-facing pipe, verify data logging parameters.
- Step 8: Hold the ON button until the Main Menu display screen illuminates. Press the > button while the cursor is on data logging to access this menu.
- Step 9: Verify all the following parameters are entered correctly. For more information on each of the following calibration parameters, refer to the data logging instruction manual.
    - Log site ID: 01 (west-facing) 02 (east-facing)
    - Mode: LVT
    - Log mode: Sleep btn
    - File format: .csv
    - Date: current date
    - Time: current time
    - Interval: 2 min
- Step 10: Repeat Steps 7–9 on the flow meter attached to the east-facing pipe.
- Step 11: Connect the fire hose flow meter to the fire hydrant and the fire hose to the flow meter, turn on the hydrant, and direct flow to inlet of catch basin.
- Step 12: Adjust the flow rate so the flow into the cells fills the inlet pipe about 1.5 to 2 inches. Then allow water to flow at a constant rate into the cells for 15 minutes, and turn off the hydrant.
- Step 13: After the flow has been shut off, allow water to finish flowing through pipes.
- Step 14: Starting with the flow meter from the west-facing pipe, unscrew water proofing cap and insert USB into output port on the side of the meter.
    - Note: No water can come into contact with the USB port. Ensure hands, flow meter, and USB are dry before inserting.
- Step 15: The main display will show the data download icon until the full file has been transferred to the USB, at which point it will show a completed ✓ Icon.
    - Note: Download FILENAMES will appear in this format: MRAY_0A.LG2, Where the “0” will automatically change to match the log site ID from the data logging menu, “A” will increment to “B” and so on with each subsequent log. “.LG2” or “.CSV” is for file format.
- Step 16: Insert USB with flow meter data from west-facing pipe into computer and upload file for analysis.
- Step 17: Repeat Step 19 for flow meter data from east-facing pipe.

- Step 18: Analyze flow data from each pipe. If there is a ±10% difference in the flow rate to each cell, adjustments will be made as described in the next set of steps in this section.

Summary of steps for balancing flow between the cells:

- Step 1: If the flow between the cells is greater than ±10%, adjustments will be made to increase the invert elevation of the pipe with the higher flows using a semi-permanent material that does not impact water quality testing results.
- Step 2: Repeat the steps to measure split flow between cells.
- Step 3: Repeat steps 1 & 2 until there is less than ±10% difference between the flows to each cell.
    - Summary of steps for removing the flow meters and sensors:

- Step 1: Unplug sensor cord from flow meter attached to the west-facing pipe in the solid lid catch basin and reseal all open ports on the meter and sensor cable.
- Step 2: Repeat Step 1 on the east-facing pipe.
- Step 3: Remove both meters from wet area and place on dry surface.
- Step 4: Starting with west-facing pipe, unclip sensor from pipe mounting band and unstring sensor cord. Wrap neatly and place with flow meters.
- Step 5: Remove pipe mounting band from pipe.
- Step 6: Repeat Steps 4 & 5 on east-facing pipe.
- Step 7: Once all equipment is removed from pipes, close solid lid catch basin and lock up the sample equipment enclosure.
- Step 8: Pack flow meters back in storage box and return to storage.

6.1.4 Procedure for Preparing Stormwater Monitoring Equipment for Storm Sampling

The purpose of this sampling procedure is to outline the steps required for cleaning and calibrating stormwater sampling equipment and the pH probe prior to monitoring and sampling storms, preferably on the day of the storm event. Additional, general steps to prepare for stormwater sampling and processing are covered in this sampling procedures. Note: prior to performing the steps outlined in this SOP, the lab will be notified that sampling is expected to occur, and that samples will be transported to the lab. An estimate of when each the samples will be delivered will also be provided to the lab.

Equipment Needed:

- Manhole key and combination to locks for the influent sump and monitoring equipment vault
- Extendable cell phone holder
- Adjustable wrench
- Screwdrivers (flathead and Phillips)
- Level
- Voltmeter
- Flashlight
- Wet-dry vacuum
- Soft brush
- Cloth rags
- Water source or 5-gallon bucket (with lid) filled with tap water
- Cleaning solutions for tubing (10% HNO_3 acid solution, liquinox soap solution) in 5-gallon buckets (one for each solution) with lids

- Trash bag (for any large debris)
- pH meter
- pH probe storage solution
- pH probe cleaning solution
- Buffer solutions for pH meter
- Two small plastic beakers
- Personal Protective Equipment (PPE), including eye protection, gloves, high visibility vest, work boots, etc.
- Cellular phone
- Pre-Storm Event Maintenance Checklist (**Appendix E**. *Field Data Collection Forms*), Chain of Custody Form (Summary of steps to prepare monitoring equipment at the test site for storm sampling:
- Step 1: Upon arrival at the site, visually inspect the monitoring site and vicinity for any signs of damage or tampering, or unsafe conditions. Note any findings on the Pre-Storm Event Maintenance Checklist.
- Step 2: Access the sampling equipment enclosure, influent sump, and catch basins. Start a visit report on the data logger according to Step 5 in **Section 6.1.2**. Note: Before handling any sample bottles staff will ensure the use of clean gloves. The staff member will wear two pairs of gloves during sample handling: after obtaining samples from cooler and opening the bag containing the sample bottles, the outer set of gloves will be removed to handle the clean sample bottles inside the bag.
- Step 3: Inspect pipes, tees, weirs, and pipe connections. If debris or sediment are observed, put on gloves and eye protection, as needed. Check for sharp or potentially hazardous materials before beginning to clean. Note: When accessing the equipment in the sampling equipment enclosure and catch basins, do not disturb pipes or pipe tees.
- Step 4: Use the vacuum to remove sediment or debris from pipe, pipe tees, pipe connections, and weirs. Drain or vacuum any remaining liquid or sediment within the sampling and control tees. Then immediately replace the grate inlet or structure lids.
- Step 5: Inspect the pump, suction, and head tubing for the ISCO. If kinks or bellies are observed in the tubing, replace the tubing.
- Step 6: Access the sample bottles inside the ISCO and check bottle configuration. Remove bottles and pack ice in the bottom of the ISCO. If a new bottle is needed before a storm, install using clean hands/dirty hands procedures, as defined in Step 2 of this Section.
- Step 11: Add ice to the around the sample bottles after they are replaced to ensure the samples remain cold prior to pick up.
- Step 12: Make sure all tubing is connected properly, bulkhead caps are secured and that cables are properly attached.
- Step 13: Before leaving the site, set the data logger and ISCO autosampler mode to sample if the criteria for qualifying rainfall event (see **Section 5.5**) are met at the site during the forecasted storm.
    - On the ISCO, navigate to the main menu and set the ISCO to sample. The display should read, "Bottle 1 After 1 Pulses".
    - On the data logger display, tap the processes icon on the screen, then the set sampl_enabl icon. Set the data logger to zero. This will set the data logger to sample if the criteria are met.

- Step 14: Set the threshold on the data logger to tell the system when to trigger influent and effluent sampling.
    - The threshold is determined following the instructions and using the threshold calculator in ***Appendix I****. Data Logger Threshold Calculations*.
    - The threshold values are set in the data logger by tapping the processes icon on the home screen, and then by tapping either of the threshold icons on the next page. The threshold values are then entered for both the influent and effluent thresholds. Record the threshold values entered on the Pre-Storm Event Maintenance Checklist.
- Step 15: Once all maintenance, cleaning, and calibration has been completed, end the visit report on the data logger (according to Step 20 in **Section 6.1.2**), close the sampling equipment enclouser, influent sump, and catch basins, and secure as needed before leaving the site.

Summary of steps to calibrate the pH probe for storm sampling:

- Step 16: Upon returning to the Evergreen StormH2O lab, obtain the pH meter and turn on the meter. Put on nitrile gloves and eye protection.
- Step 17: Pour a small amount of each buffer solution into a clean beaker, so the probe will be immersed at least 1 ½ inches. Begin a new calibration on the pH meter.
- Step 18: Remove the protective cap on the probe and rinse the electrode with some of the buffer solution to be used for the first calibration point. Place the probe in the first buffer and stir gently.
- Step 19: The screen should show the first expected buffer value; change the expected buffer to a different value if needed. Wait for the measured pH value to stabilize.
- Step 20: Once the pH value is stable, confirm the reading and record on the Pre-Storm Event Maintenance Checklist.
- Step 21: Remove the probe from the buffer solution, rinse the probe with the second buffer solution, and place the probe in the beaker with the second buffer solution. Adjust the expected buffer value on the meter screen as needed.
- Step 22: Stir the probe gently in the buffer solution and wait for the reading to stabilize. Once the reading is stable, confirm the reading and record on the Pre-Storm Event Maintenance Checklist.
- Step 23: Navigate back to the measurement mode and turn off the pH meter; the meter will save the calibration data. Replace the protective cap on the probe and refill with storage solution as needed. Discard the used buffer solutions.

6.1.5 Stormwater Grab Sampling

The purpose of this SOP is to outline the steps required to collect grab samples for oils, fecal coliform, and E. coli. Grab samples will be collected during monitoring events, specifically during the rising limb of the event hydrograph. The rising limb is expected to occur within the first hour or two of the monitoring events. Reference **Table 5-5** for how often samples are collected for each parameter.

Equipment Needed:

- Tools necessary to access vaults
- Electronic water level indicator (tape down tool)
- Cellular phone to enable communication between field staff and the principal investigator or project manager
- Flashlight

- Personal Protective Equipment (PPE), including eye protection, high-visibility vest, work boots, etc.
- Clean nitrile gloves
- Sample bottles
- Cooler for sample bottles
- Hard ice pack for cooler
- pH probe
- Grab Sample – Water Quality Collection Field Form (**Appendix E**)
- Falling Head Test Form from the most recent infiltration test
- Chain of Custody form (**Appendix F**) and sample tag

Summary of procedures to obtain grab samples:

- Step 1: At least one hour prior to departing for the site, place sample bottles in the refrigerator to keep the bottles cool.
- Step 2: Upon arrival at the site, visually inspect the monitoring site and vicinity for any signs of damage or tampering. Note any findings on the field form.
- Step 3: Open the sampling equipment enclosure, influent sump and catch basins. Start a visit report on the data logger according to Step 5 in Section 6.1.2. Note: Before handling any sample, bottle staff will ensure the use of clean gloves. The staff members will wear two pairs of gloves during sample handling: after obtaining samples from cooler and opening the bag containing the sample bottles, the outer set of gloves will be removed to handle the clean sample bottles inside the bag.
- Step 4: Put on clean nitrile gloves and obtain the bacteria bottles for the influent fecal coliform and E. coli samples.
- Step 5: Carefully remove the lid of the sample bottle without touching the inside of the lid. Place the bottle below the opening of the influent pipe in the catch basin. Fill the bottle.
- Step 6: Once the bottle is full, place the cap on the bottle and transfer bottle to the plastic bag in the cooler.
- Step 7: Put on new, clean nitrile gloves and obtain the bottles for the effluent sample.
    - The collection of the effluent sample will be delayed a certain amount of time after the influent sample to ensure effluent conditions reflect the conditions in the influent sample. The delay time will be equivalent to the estimated infiltration rate through the BSM by reviewing the effluent flow rates from prior sample collection events.
- Step 8: Attach the bacteria bottle securely to the end of a sampling extension pole. Carefully remove the lid of the first fecal coliform sample bottle without touching the inside of the lid. Place the bottle at the end of the pipe and collect a sample from flow discharging the pipe until the bottle fills up to the bottom of the bottle neck. Samples will be collected from the pipe downstream of the weir located in the flow splitter catch basin for influent and in the manhole for effluent (Figure 5-1).
- Step 9: Once the bottle is full, place the cap on the bottle and transfer the bottle to the plastic bag in the cooler.
- Step 10: Repeat Steps 8 & 9 for the remaining fecal coliform and E. coli sample bottles.
- Step 11: Fill out the Chain of Custody form for the grab samples according to the procedures outlined in Section 6.5. Measure the temperature in the cooler using the pH meter and record the temperature on the Chain of Custody form.
- Step 12: When ready to leave the site, end the visit report on the data logger (according to Step 14 in Section 6.1.2), and close the monitoring vault.

- Step 13: Transport samples to Anatek Laboratory in Spokane.
    - If samples have been collected after laboratory hours, keep samples below 10°C in a cooler or refrigerator until the laboratory reopens.

6.1.6 Procedure for Composite Stormwater Sample Collection and Processing

The purpose of this sampling procedure is to outline the steps required for collecting and processing composite samples as well as collecting sample pH measurements.

Equipment Needed:

- Manhole key and combination to locks for the influent sump and monitoring equipment vault
- Screwdrivers (flathead and Phillips)
- USB flash drive
- Electronic water level indicator (tape down tool)
- Cellular phone
- Flashlight
- Voltmeter
- Level
- Small, clean plastic beaker
- Personal Protective Equipment (PPE) including eye protection, gloves high visibility vest, work boots, etc.
- Clean, powder-free, nitrile gloves
- Sample bottles
- Gallon plastic bags
- Cooler for sample bottles
- Hard ice pack for cooler
- Syringe
- 0.45 µm filter
- pH probe
- Chain of Custody form (**Appendix F**. Chain of Custody Forms), sample tag, Composite Sample – Water Quality Collection Field Form (**Appendix E**. Field Data Collection Forms)

Summary of steps for collecting sample jars from the test site:

- Step 1: At least one hour prior to departing for the site, place sample bottles in the plastic bag in the refrigerator to keep the bottles cool.
- Step 2: Upon arrival at the site, visually inspect the monitoring site and vicinity for any signs of damage or tampering. Note any findings on the field form.
- Step 3: Access the sampling equipment enclosure, influent sump, and catch basins. Start a visit report on the data logger according to Step 5 in **Section 6.1.2**.
    - Note: Before handling any sample bottles staff will ensure the use of clean gloves. staff member will wear two pairs of gloves during sample handling: after obtaining samples from cooler and opening the bag containing the sample bottles, the outer set of gloves will be removed to handle the clean sample bottles inside the bag.

- Step 4: Check the ISCO and data logger to verify that the ISCO has completed its sampling a that the data logger has disabled sampling. If neither scenario has happened, wait until sampling is complete before collecting the sample.
  - The ISCO will show that sampling is complete on the display if it says, "sample X after 1 pulses".
  - The data logger will show that sampling is complete if the data logger sampl_enabl value (tap processes, then sampl_enabl icon) is set to 1.
- Step 5: Open the ISCO and put on clean, nitrile gloves. Visually check that the amount of water in the composite jar roughly correlates to the number of aliquots reported to have been collected by the ISCO (e.g., if the number of aliquots reported is 20, and very little to no water is present, there has been a malfunction).
- Step 6: Replace the lid on the composite jar with a lab-cleaned, solid lid.
- Step 7: Remove jar from the ISCO and place the composite sample into the cooler for transport to the Evergreen StormH2O lab.
- Step 8: Download storm data from the data logger following the procedures in **Section 6.1.7**.
- Step 9: End the visit report (according to Step 20 in **Section 6.1.2**) after all samples have been collected and the ISCO indicates that the program has been reset.
- Step 10: When ready to leave the site, close the sampling equipment enclosure, influent sump, manhole, and catch basins, and secure as needed before leaving the site.

Summary of steps for splitting samples and preparing samples for the lab:

- Step 11: Return to the Evergreen StormH2O lab. Samples are transported to the Evergreen StormH2O lab prior to Anatek to transfer composite samples in ISCO bottles to the laboratory-specified bottles listed in **Table 7-1** and to filter samples for dissolved metals and ortho-phosphate analysis.
  - Add sample will be pulled from ISCO and vigorously agitated before splitting the composite sample into individual lab bottles.
  - To filter the samples for dissolved metals and ortho-phosphate analysis, obtain the syringe and place a 0.45 µm filter on the end of the syringe. Fill the syringe with 50 mL of sample and use the plunger on the syringe to filter the sample into a 125 mL bottle that has been preserved with trace metals grade nitric acid. Repeat the process to get 100 mL of filtered sample in the bottle.
- Step 12: Fill out the Chain of Custody form for the samples according to the procedures outlined in **Section 6.5**. Measure the temperature in the cooler using the thermometer and record the temperature on the Chain of Custody form.
- Step 13: Place the filled laboratory bottles in the plastic bags provided by the lab and place the plastic bag(s) in the ice bath within the cooler to keep samples at or below 6°C.
- Step 14: Confirm the storm met qualifying conditions prior to delivering samples to the lab. If storm did not meet qualifying conditions, the sampling crew will consult with the principal investigator to determine if the samples should be tested or dumped.
- Step 15: Transport the samples to Anatek. If samples have been collected after laboratory hours, keep samples below 6°C in a cooler or refrigerator until the laboratory reopens.

- Step 16: PSD will be shipped to Environmental Technical Services, following their shipping instructions.

Summary of steps for collecting pH measurements:

- Step 17: Pour some of the composite sample into a small beaker to a depth of at least 1 ½ inches and place the pH probe in the beaker. Stir the liquid with the probe and proceed with Steps 8–9 while waiting for the reading to stabilize. If it has, record the pH reading on the field form. If not, wait for the reading to stabilize before recording pH on the form. Remove the pH probe from the beaker, add the pH storage solution to the protective cap, replace the protective cap on the probe, and discard the small amount of sample.

6.1.7 Procedure for Monitoring Equipment Data Download

The purpose of this sampling procedure is to outline the steps required to collect data from the data logger following the sampling event.

Equipment Needed:

- Manhole key and combination to locks for the influent sump and monitoring equipment vault
- USB flash drive
- Cellular phone to enable communication between staff and principal investigator
- Flashlight
- Personal Protective Equipment (PPE) including but not limited to: high visibility vest, gloves, work boots, etc.
- Monitoring Equipment Data Download Field Form (**Appendix E**. *Field Data Collection Forms*)

Procedures for downloading data from the data logger:

- Step 1: Upon arrival at the site, visually inspect the monitoring site and vicinity for any signs of damage or tampering. Note any findings on the field form.
- Step 2: Open the monitoring equipment vault.
- Step 3: Insert USB flash drive into the data logger and download the data. Remove the USB flash drive when the download is complete.
    - To download the data, tap data on the main screen, then tap the download (downward arrow) icon on the bottom of the screen. Select the desired range of data and press the checkmark.
- Step 4: Close and lock the monitoring equipment vault lid.

6.1.8 Procedure to Perform Falling Head Test

The purpose of this sampling procedure is to outline the steps required to perform a falling head test on the BSM in the bioretention cell and measure Ksat and the infiltration rate. A falling head test will be performed before the study starts and after the study has been completed.

Equipment Needed:

- Tools necessary to access the fire hydrant and hose
- Fire hydrant flow meter

- Personal Protective Equipment (PPE) including but not limited to high visibility vest, gloves, work boots, etc.
- At least 4 yardsticks
- Timer
- Falling Head Test Field Form (**Appendix E**. *Field Data Collection Forms*)
- Fire hose

Summary of steps for the falling head test:

- Step 1: Contact Gonzaga University Plant Services and make arrangements for them to turn on the fire hose located just north of the test-site.
- Step 2: Install two-yard sticks in each cell, located in the middle of the 7-foot-wide cell, with 1/3 at each end of the 18-foot length. The yard sticks should be inserted level into the BSM far enough into the media that they will not move during testing.
- Step 3: Connect the fire hose to the fire hydrant, turn on the hydrant, and spray the parking lot contributing basin area around the inlet. Runoff will flow into the grate inlet and be conveyed to the ponds. Fill the bioretention cells with water until the water has ponded 12 inches above the cell surface (yardsticks will be used to verify that 12 inches has been reached). Allow time for the media to become saturated. To determine whether the media is saturated, record the effluent flow rates from the data logger readings every 5 minutes. Assume the media is saturated if the flow rates are within 10% of each other. If needed, use the fire hose to fill the water level in the cells back up to just above 12 inches, and continue measuring to verify the difference between the effluent flow rates from each cell is 10%.
- Step 4: Use the fire hose to fill the pond up to just above the 12-inch depth. Once the water level reaches 12 inches, start the timer.
- Step 5: Record the time for water to drop 1 inch on the Falling Head Field Test Form. Continue recording time until Ksat is stable, which is defined as when the value does not change more than 10% for 3 intervals.
- Step 6: Remove the yard sticks and download the data measured by the system during the falling head test from the data logger according to procedures in **Section 6.1.7**.
- Step 7: Close and secure the monitoring vault and manhole before leaving the site.
- Step 8: Follow the data analysis procedures in **Section 12.1.4** to calculate Ksat and the infiltration rate.

6.1.9 BMP Inspection and Maintenance

Monthly an inspection and needed maintenance will be performed and tracked on a field form (**Appendix E.** *Field Data Collection Forms*).

The field form documents the following information:

- Date and time
- Field staff names
- Climate
- Date of last maintenance visit maintenance
- Visual observation of site
- Photos of before maintenance
- Removal of trash and debris

- Removal of weeds
- Inspection of creep rock
- Inlet Inspection
- Sediment removal
- Photos of complete maintenance

Equipment Needed:

- Field form
- Writing utensil
- Camera for Photos
- Computer access for weather reporting
- Tape Measure
- Rake
- Shovel
- Gloves
- Replacement Materials (when needed)
- Contractor Bags
- Operations and Maintenance Inspection field form (**Appendix E**. *Field Data Collection Forms*)

Summary of steps to complete an inspection, needed maintenance, and report findings:

- Step 1: Arrive on site with Operation and Maintenance Inspection Field Form and necessary maintenance tools.
- Step 2: Complete visual inspection following steps on the Operations and Maintenance Inspection Field Form
- Step 3: Begin with documenting the visual inspection conditions on the Operation and Maintenance Inspection Field Form.
- Step 4: Note details on the last inspection performed.
- Step 5: Document precipitation at the site in the last 48 hrs.
- Step 6: Inspect the four inlet pipes noted below. Note the material, severity of blockage (partial, complete, not applicable), and capture photo evidence. Note any maintenance suggestions and when that maintenance is recommended.

    - Inlet #1 – Pipe discharging runoff from parking lot catch basin
    - Inlet #2 – Pipe discharging runoff into the flow splitter catch basin
    - Inlet #3 – Pipe discharging into the HPBSM pond
    - Inlet #4 - Pipe discharging into the 60:40 BSM pond

  Maintenance is required if any obstruction has accumulated to 1” of inlet pipe openings.

    - Using hands and hand tools, clear all debris, vegetation, and sediment from the inlet pipe. Bag excess material and remove from site.

- Step 7: Inspect the rock mulch in each cell for sediment accumulation or vegetation growth. Note the size of the sediment accumulation and capture photo evidence. Note the amount and type of vegetation growth. Note any maintenance suggestions and when that maintenance is recommended.

- Maintenance is required if sediment accumulation is observed on top of the rock mulch or ponded water is observed in either cell more than 72 hours after the storm has ended.
    - Using a rake and shovel remove any sediment accumulated on top of the rock mulch. If necessary, remove or move rock mulch to determine the reason for any ponding. Replace rock mulch.
- Maintenance is required if vegetation is growing in the bioretention cell.
    - Hand pull any vegetation in cell and replace with clean rock to match original depth. Do not spray herbicides.

- Step 8: Inspect for standing water, capture photo evidence. Note any maintenance suggestions and when that maintenance is recommended.
    - Maintenance is required when water stands in the bioretention cell between storms and does not drain freely.
        - Using hands and hand tools remove any debris from outlet pipe. Bag material and remove from site.
        - If necessary, remove or move rock mulch to determine the reason for ponding. Run a falling head test to determine whether the media is draining freely. Replace rock mulch.
- Step 9: Inspect for trash and debris accumulation of any kind. Note material, quantity, and capture photo evidence. Note any maintenance suggestions and when that maintenance is recommended.
    - Maintenance is required when any trash or debris has accumulated in the pipes, on bottom of cell, or in any of the structures.
        - Use hands or tools to remove trash. Bag and dispose of trash appropriately.
- Step 10: Inspect for erosion or scouring of any kind. Note the location, severity, and capture photo evidence. Note any maintenance suggestions and when that maintenance is recommended. If consistent maintenance is needed, consider increasing size of cobbles or developing other solutions to help decrease scouring.
    - Maintenance is required when ruts are <12” wide.
        - Repair the damaged area by replacing it with rock gradation.
    - Maintenance required when ruts are >12” wide.
        - The cell should be graded in the area that the erosion and scouring took place.
- Step 11: Summarize any recommended maintenance determined for steps 6–11.
- Step 12: Record the maintenance recommendation and estimate the time for completing maintenance.
- Step 13: Record completed maintenance and time duration on field form.
- Step 14: Finalize the Operation and Maintenance Inspection Field Form and upload to the project directory.

- Step 15: If maintenance was completed during a separate site visit, note the completed maintenance on the current field form with date and time duration of maintenance.

The completed field forms will be reviewed by the QAQC Lead. The frequency and procedures for maintenance actions will be determined and summarized in the final report as recommendations for maintenance.

6.1.10 Procedure for BSM Sample Collection

The purpose of these sampling procedures is to outline the steps required to collect samples from the BSM in each cell and submit the samples to the lab.

Equipment Needed:

- Cellular phone to enable communication between staff and principal investigator or project manager
- Personal Protective Equipment (PPE) including but not limited to: high visibility vest, gloves, work boots, etc.
- Clean, powder-free, nitrile gloves
- Sample containers
- Soil sampler probe
- Chain of Custody form (***Appendix F***. *Chain of Custody Forms*), sample tag, Sample Collection Field Form (**Appendix E**. *Field Data Collection Forms*)

Summary of steps for collection of BSM samples:

- Step 1: Upon arrival at the site, visually inspect the monitoring site and vicinity for any signs of damage or tampering. Note any findings on the field form.
- Step 2: Two samples will be collected from each media from the center of the 7-foot width (3.5 feet from the sides of the pond bottom) and one third of the 18-foot length on each end (6 feet from end of the pond bottom). Measure each cell to locate the sample locations and remove the rock mulch. Record the sample locations on the field form.
- Step 3: Inset the soil probe 18 inches deep in 60-40 media mix cell. Take care to ensure that the probe is inserted vertically into the soil and not tilted to the side. Remove the probe and transfer the entire soil core from the probe to the container. Each sample will be placed in a separate container for analysis.
- Step 4: Repeat Step 3 for the HPBSM primary layer. Before transferring the sample to the container, visually examine the portion of the sample that was pulled from the bottom of the media. If a portion of the polishing layer was collected, remove it before transferring the sample to the container.
- Step 5: Insert soil probe into the same holes where the HPBSM primary layer was extracted until the probe is 3 feet deep. Take care to ensure that the probe is inserted vertically into the soil and not tilted to the side. Remove the probe and transfer the entire soil core from the probe to the container. Each sample will be placed in a separate container for analysis.
- Step 6: Fill out the Chain of Custody for the samples according to the procedures outlined in **Section 6.5**. Measure the temperature in the cooler using the thermometer and record the temperature on the Chain of Custody form.
- Step 7: Fill the holes where the cores were pulled with sand and replace the rock mulch.

- Step 8: Place the filled laboratory bottles in the plastic bags provided by the lab and place the plastic bag(s) in the ice bath within cooler, ensure samples do not exceed the QA/QC limits for sample temperature.
- Step 9: Ship the samples to the Soiltest lab in Moses Lake before the hold times expire.

6.2 Containers, Preservation Methods, Holding Times

Clean sample bottles and associated preservatives will be provided by Anatek Laboratory and Environmental Technical Services (PSD only) in Petaluma, CA according to **Table 6-1**. Sample containers and preparation will follow Code of Federal Regulations [40 CFR 136] guidelines. Spare sample bottles will be carried by the sampling staff conducting the testing in case of breakage or possible contamination.

Table 6-1. Sample Containers, Preservative, and Holding Times

Matrix	Parameter	Method	Sample Container[3]	Preservative	Pre-filtration Holding Time	Total Holding Time
Water Quality	pH	EPA Method 150.2	NA	NA	NA	NA
	PSD, influent	ASTM D3977-97[2]	P; 1000 mL	Cool, ≤6°C	NA	NA
	Total Suspended Solids (TSS)	SM 2540D	P, FP, G; 1000 mL	Cool, ≤ 6°C	NA	7 days
	Dissolved Metals (Cu, Zn)	EPA 200.8 (ICP/MS)	P, FP, G; 125 mL	Cool, ≤ 6°C; filtration, 0.45 µm; HNO3 to pH < 2	12 hours[b]	6 months
	Total Metals (Cu, Zn)		P, FP, G; 125 mL	Cool, ≤ 6°C; HNO3 to pH < 2	NA	6 months
	Hardness as CaCO3	SM 2340B (ICP)	P, FP, G; 125 mL	HNO3 pH < 2	NA	6 months
	Ortho-phosphate (OP)	SM 4500-P G	P, FP, G; 44 mL	Cool, ≤6°C; filtration, 0.45 µm	12 hours[b]	48 hours
	Total Phosphorus (TP)	SM 4500-P F	P, FP, G; 44 mL	Cool, ≤ 6°C; $H2SO_4$ to pH < 2	NA	28 days
	Total Kjeldahl nitrogen (TKN)	SM 4500 Norg-D	P, FP, G;125 mL	Cool,≤6°C; H_2SO_4 to pH < 2	NA	28 days
	Nitrate-Nitrite	SM 4500-NO3 F	P, FP, G; 125 mL	Cool,≤6°C; H_2SO_4 to pH < 2	NA	28 days
	Fecal Coliform	SM 9222D	G; 125mL	Cool, 10°C, 0.0008% $Na_2S_2O_3$	NA	8 hours [1]
	E.coli	SM 9223B	G; 125mL	Cool, 10°C, 0.0008% $Na_2S_2O_3$	NA	8 hours [1]
Bioretention Soil Media	Cation Exchange Capacity	EPA Method 9081	P; 2 grams	Cool, ≤ 6°C	NA	NA
	Total Elements (Zn, Cu)	EPA Method 6010D_(7/14)	P; 20 grams	Cool, ≤ 6°C	NA	NA
	Organic Matter Content	ASTM D2974 or TMECC 5.07A	P; 50 grams	Cool, ≤ 6°C	NA	NA
	Phosphorus	(Modified) Morgan	Sample Bag; 2 cups	Cool, ≤ 6°C	NA	NA

[1] Sample analysis should begin immediately, preferably within 2 hours of collection. The maximum transport time to the laboratory is 6 hours, and samples should be processed within 2 hours of receipt at the laboratory.

[2] Modified Suspended Sediment Concentration (SSC) Method according to ASTM Method D3977-97 (ASTM 2002) using wet sieve filtration (Method C) and glass fiber filtration (Method B)

[3] Sample Container Abbreviations: P-polyethylene, G-Glass, FP-Fluoropolymer

[b] Pre-filtration holding times of 15 minutes for dissolved metals and orthophosphate are recommended in U.S. EPA (1983) and required in 40 CFR 136.3, Table II; however, these holding times cannot be realistically met with flow proportional automated sampling techniques. Consequently, a surrogate holding time of 12 hours from the time that the last aliquot was collected can be used for this monitoring. Ecology will accept data qualified as an estimate (J) if filtration (at the laboratory or in the field) occurred between 15 minutes and 12 hours after the last aliquot was collected.

6.3 Equipment Decontamination

Equipment decontamination will follow procedures in **Sections 6.1.2** and **6.1.4**. The pH meter and ISCO sample bottles will be decontaminated between sample events. The pressure transducers will be cleaned monthly and the ISCO sample tubing will be decontaminated quarterly.

6.4 Sample Identification

All sample containers will be labeled with the following information, using waterproof labels and indelible ink and placed on dry sample container lids:

- Sample Identification
- Date of sample collection (month/day/year)
- Time of sample collection (military format)
- Sampler initials
- Parameters (pre-printed and provided by laboratory)

6.5 Chain of Custody

After samples have been obtained and the collection procedures properly documented, a written record of the chain-of-custody of each sample will be completed by field personnel to ensure that samples have not been tampered with or compromised in any way and to track the requested analysis for the analytical laboratory.

Information that will be provided on the chain-of-custody form includes:

- Date and time of sample collection
- Location of sample collection
- Printed names and signatures of field personnel and laboratory personnel handling the samples
- Laboratory analysis requested and control information (e.g., duplicate or spiked samples) and any special instructions (e.g., time-sensitive analyses)

After collection, water quality samples (except PSD) will be immediately delivered to Anatek in Spokane, WA; BSM samples will be delivered to SoilTest in Moses Lake, WA; and PSD samples will be delivered to Environmental Technical Services in Petaluma, CA. Sample custody will be tracked in the field and laboratory through the entire sample collection process, and the signed Chain of Custody forms and analytical results returned to the Evergreen StormH2O principal investigator. The sampling staff will record the date and time of sample deliveries for the project file. Example Chain of Custody forms from each laboratory are **Appendix F. Chain of Custody Forms**.

6.6 Field Log Requirements

Field observations and measurements associated with a monitoring event will be recorded on the field forms (**Appendix E**. *Field Data Collection Forms*). The field form will document all activities completed, measurements taken, and samples collected during the field event.

The field form documents the following information:

- Date and time

- Field staff names
- Climate conditions
- Sampling description and label information
- Sampling equipment condition
- Samples collected (checklist)
- QC samples collected (checklist)
- Water temperature and pH
- Instrument calibration results
- Measurement of sediment accumulation
- Comments on activities or issues that may influence the quality of the data

7.0 Measurement Procedures

This section of the QAPP focuses on identifying the methods required to measure the data collected during the study including the equipment and instruments that will be used.

7.1 Procedures for Collecting Field Measurements

Field measurements will be made for precipitation, discharge (influent and effluent flow rate), water quality (stormwater influent and effluent), pH, and stormwater temperature.

- Precipitation, temperature and discharge measurements will be collected during data download from the data logger as described in **Section 6.1.7**.
- Grab and Composite samples will be collected and processed according to the procedures in **Section 6.1.5** and **6.1.6**.
- The pH measurements will be instantaneous measurements collected with a calibrated pH meter, as described in **Section 6.1.5**.

Field measurement quality will be evaluated in terms of bias and precision as described in **Section 4.0**. Measurement bias will be measured and corrected by checking the depth measurements of the pressure transducers during each maintenance cycle, calibrating the pH meter prior to sampling events, and calibrating the ISCO quarterly. Detailed calibration procedures are in **Sections 6.1.2** and **4**. Measurement precision will be evaluated through duplicate samples and will be evaluated for pH by collecting duplicate measurements for at least 10% of all measurements. Additionally, the rain gauge measurements will be checked for bias before the start of the study as the rain gauge is factory calibrated. If the rain gage is not measuring the correct amount when it is checked, it will be sent to the manufacturer for maintenance.

7.2 Sample Preparation Methods

Ortho-phosphorus, dissolved copper, and dissolved zinc require filtration and preservation prior to analysis. Nitrate-Nitrite, Fecal Coliform, and E. coli require a preservative. The labs will provide prepared sample bottles with preservatives (if needed) as described in **Table 6-1**. The field lead will filter and preserve the samples which will be analyzed by the respective lab according to the methods outlined **Table 7-1**.

7.3 Laboratory Procedures

Laboratory analytical procedures for water quality analysis will follow methods approved by the US Environmental Protection Agency (EPA) (EPA, 1983) or Standard Methods (APHA, AWWA, and WEF, 2012). The BSM testing for this study is being tested to estimate the media life cycle and TAPE does not require this testing. The BSM testing will follow standard and commonly accepted methods for analyzing samples. The water quality methods provide reporting limits that are below the TAPE criteria or guidelines and will allow direct comparison of the analytical results with these criteria. Preservation methods, analytical methods, reporting limits, and sample holding times are presented in **Table 6-1** and **Table** 7-1. Evergreen StormH2O will filter for parameters requiring filtration (i.e., ortho-phosphate, dissolved copper, and dissolved zinc) and preserve the samples within four hours of their collection. The samples will be stored at the temperature noted in **Table 6-1** and delivered to the laboratory during their business hours (Monday-Friday, 8:00am to 5:00pm). Anatek, the laboratory identified for the water quality samples for this project. SoilTest Farm Consultants, Inc. Laboratory (SoilTest) is the lab identified for soil analytical samples. PSD sample analysis will be performed by Environmental Technical Services. Samples will be mailed to these labs following their procedures.

The laboratories will report the analytical results within 30 days of receipt of the samples and will include a case narrative summarizing any problems encountered in the analyses. The laboratories will provide sample and quality control data in standardized reports suitable for evaluating the project data.

7.4 Lab(s) Accredited for Methods

The following labs are accredited and able to assist with this study:

- Anatek Labs, Inc. is accredited by Ecology for the stormwater water quality parameters collected for this study. The exception is PSD which will be sent to Environmental Technical Services for analysis and orthophosphate however the method Anatek uses is equivalent to the methods defined in TAPE. Stormwater monitoring samples will be sent to Anatek for analysis.
- Soiltest Farm Consultants, Inc. is accredited by Ecology for total elements (zinc and copper) in soil. Soiltest is not accredited for the other media testing; however, the testing they are doing is not required by TAPE. BSM samples collected for this study will be sent to SoilTest for analysis.
- Environmental Technical Services is accredited by Ecology for PSD water samples collected for this study. PSD samples will be sent to Petaluma, Ca for analysis.

Table 7-1. Laboratory measurement methods

Matrix	Parameter	Units	Method	Reporting Limit Target[a,b]	Expected Range of Results
Water Quality Stormwater	pH	units	EPA 150.2	0.2	6.5 - 8.0
	PSD, influent	%	ASTM D3977-971[1]	NA	N/A
	Total Suspended Solids (TSS)	mg/L	SM 2540D	1.0	20 - 500
	Dissolved Copper (Cu)	µg/L	EPA 200.8 (ICP/MS)	0.1	0.1 - 20
	Dissolved Zinc (Zn)	µg/L		1.0	5 - 300
	Total Copper (Cu)	µg/L		0.1	0.1 - 40
	Total Zinc (Zn)	µg/L		5.0	5 - 600
	Hardness as CaCO3	mg/L	SM 2340B (ICP)	1.0	1 - 100
	Ortho-phosphate (OP)	mg/L	SM 4500-P G	0.01	0.01 - 0.5
	Total Kjeldahl Nitrogen (TKN)	mg/L	SM 4500- Norg D	0.5	
	Nitrate-Nitrate	mg/L	SM 4500- NO3 F	0.01	
	Total Phosphorus (TP)	mg/L	SM 4500-P F	0.01	0.01 - 0.5
	Fecal Coliform	CFU/ml	SM 9222D	1/100	1 - 100
	E. coli	CFU/ml	SM 9223B	1/100	1 - 100
Bioretention Soil Media	Cation Exchange Capacity	meq/100g	EPA Method 9081	NA	Expected to meet specification
	Total Elements (Zn, Cu)	mg/kg	EPA 6010D_(7/14)	5.0 (Zn); 0.1 (Cu)	
	Organic Matter Content	Percent	ASTM D2974 or TMECC 5.07A	0.01	
	Phosphorus	mg/kg	(Modified) Morgan	0.01	

Notes:

[1] Modified Suspended Sediment Concentration (SSC) Method according to ASTM Method D3977-97 (ASTM 2002) using wet sieve filtration (Method C) and glass fiber filtration (Method B)

[a] Reporting limit targets established as per the Phase I Municipal Stormwater Permit (Ecology 2012b). To the extent possible, reporting limits for the laboratory selected by the proponent should be the same or below those given in the table.

[b] All results below reporting limits should also be reported and identified as such. These results may be used in the statistical evaluations.

8.0 Quality Control

This section includes information on field quality assurance/quality control (QA/QC) and laboratory quality control.

8.1 Field QC Required

Field quality control will be maintained by personnel training, sampling procedures development, equipment maintenance and calibration, and quality control samples.

At least two field staff will be trained in all field activities. Field staff will be trained to consistently follow field sampling procedures and measurement procedures. Field staff will become familiar with all associated sampling procedures which cover all field activities. Training will include conducting all procedures in the field at least one time under the supervision of the principal investigator. Completion of each element of training will be verified and documented by the principal investigator in a training completion log (**Appendix E**. *Field Data Collection Forms*).

Equipment maintenance and calibration will ensure that the BMP, the sampling equipment, and the water quality meters are working properly. Equipment maintenance will occur prior to the first monitoring event and monthly between monitoring events. Calibration of the ISCO pumps will occur once every three months following the manufacturers specifications. Details of equipment maintenance and calibration are provided in **Section 6.1.2** (with exception of calibration of the pH meter, see **Section 6.1.4**) and will consist of the following activities:

- Inspection of all equipment for damage.
- Cleaning and/or repair of all equipment, connections, tubing, and influent/effluent pipes.
- Calibration of the pressure transducer and ISCO pump.

Maintenance and calibration will be documented with either the Periodic Maintenance Checklist Field Form or the Pre-Storm Checklist Field Form (**Appendix E**. *Field Data Collection Forms*). Recordkeeping processes will be consistently followed.

Field quality control samples will consist of rinsate blank and field duplicate samples. Rinsate blanks are samples of analyte free water poured over or through decontaminated field sampling equipment prior to the collection of environmental samples. The purpose of collecting rinsate blanks is to assess the adequacy of the decontamination process. Rinsate blanks will be collected for all water quality parameters collected by flow-weighted composite sampling (i.e., the collected in the autosamplers). They will be collected immediately after decontamination of each respective autosampler. After decontamination, the autosamplers will be filled with distilled deionized water and then dispensed through the autosampler to fill sample containers. Rinsate blanks will be collected three times throughout the study for TSS, total phosphorus, orthophosphate, hardness, and total and dissolved copper and zinc. The parameter concentrations in the rinsate blanks are expected to be less than two times the reporting limit concentrations. Reporting limits are presented in **Table 7-1**.

A field duplicate is a second independent sample collected at the same time and location as the original sample. Field duplicates are primarily used to assess the variation attributable to sample collection procedure and sample matrix effects. Field duplicates will be collected for all water quality parameters and must meet the associated relative percent difference (RPD) MPCs in **Table 4-2**.

8.2 Laboratory QC Required

Laboratory quality control will be maintained for the water quality samples by running method blanks and laboratory control standards, matrix spikes, and matrix spike duplicates, and laboratory duplicates. MPCs associated with the quality control samples are in **Table 4-2**. Method blanks and laboratory control standards will evaluate bias, in terms of overall method accuracy. Matrix spike and matrix spike duplicates will evaluate bias in terms of method interferences. Laboratory duplicates will evaluate the precision of laboratory measurements. Each of these quality control samples will be run in the laboratory one time for each respective laboratory batch. The analytical lab will perform its own quality control checks on the analyses of each of the parameters and provide that information with the analytical report.

8.3 Corrective Action

Technical system audits will be performed to ensure that procedures are being followed appropriately, as discussed in **Section 10.1**. The auditor will notify the principal investigator in writing (via email) within 2 business days if corrective actions are needed based on the audit findings. The principal investigator is responsible for developing and implementing a written corrective action plan within 30 days of being notified by the auditor. A record of the corrective action plan will be kept throughout the study (see example table in ***Appendix G**. Corrective Action Plan Table*) and included in the final report.

9.0 Data Management Plan Procedures

This section defines the data management plans. It specifically describes how the data and other important project documents will be managed, stored, and archived during the study. These plans are developed to reduce the potential for errors during the data collection and analysis phases of the project.

9.1 Data Recording & Reporting Requirements

Field data will be recorded on standard field forms (**Appendix E**. *Field Data Collection Forms*).

- The field forms include information such as the date and time, data collectors name(s), field measurements, field observations, a checklist of samples collected for laboratory analysis, and comment field.
- All completed field forms will be scanned and uploaded to the project files as described in **Section 9.2**. Measurements collected from sampling events will be manually entered into the project database, also within 24 hours of collecting or receiving the data (from the lab).
- Evergreen StormH2O's QA/QC Lead will perform an independent review to ensure that the data 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. Evergreen StormH2O's QA/QC Lead will qualify or reject field measurements based on field DQIs and associated MPCs.
- All files will be archived for the duration of the study on an Evergreen StormH2O server and transferred to the City of Spokane, Spokane County, and the City of Spokane Valley after completion of the study.

Laboratory results from Anatek Labs, Soiltest Farm Consultants, and Environmental Technical Services will report any results within 30 days of receipt of the samples.

- The laboratories will provide sample and quality control data in standardized Electronic Data Deliverable (EDD) spreadsheets and reports that are suitable for evaluating the project data. These EDDs and reports will include 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.
- Evergreen StormH2O's QA/QC Lead for the project will perform an independent data verification to ensure laboratory consistency with this QAPP, add additional qualifiers, or reject data based on field DQIs and associated MPCs (**Section 4.0**).
- A new qualifier column will be created in each EDD that represents Evergreen StormH2O's independent data verification and will include both field and laboratory qualifiers. Evergreen StormH2O's QA/QC Lead for the project will perform an independent review to ensure that the data were uploaded 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.

- The information contained in the EDD and independent data verification will be stored in a database such as Microsoft Excel by Evergreen StormH2O up to one year following approval of the Technical Evaluation Report.

9.2 Electronic Transfer Requirements

All field and calibration forms will be scanned and electronically filed on the Evergreen StormH2O server. The laboratory reports, original laboratory EDDs and verified laboratory EDDs will be electronically filed in Evergreen StormH2Os server. Verified EDDs will be uploaded into the project database for all subsequent data management and archiving tasks.

9.3 Laboratory Data Package Requirements

Anatek Labs and Material Testing and Consulting, Inc. will provide Level II data packages, corresponding to Stage 2A verification and validation checks (EPA, 2009). These data packages will provide the following documentation:

- Sample submittal and receipt
- Analytical methods, sampling dates and times, data and time of laboratory receipt, sample conditions upon receipt at the laboratory, and sample analysis dates and times
- Evaluation of sample holding times
- Analyte results, units, detection limits, reporting limits, and laboratory data qualifiers
- Sample-related QC data and QC acceptance criteria
- Frequency of QC samples
- Sample results are evaluated and qualified based on meeting holding times and sample-related QC results

Soiltest Labs will provide the following documentation:

- Sample submittal and receipt
- Analytical methods, date of laboratory receipt, date of sample analysis/reporting
- Analyte results, units, detection limits, and laboratory data qualifiers

9.4 Procedures for Missing Data

Missing data will be qualified as missing and will have a qualifier code (e.g., “M”) that is unique from a rejected value. In addition, a note will be added to the spreadsheet explaining the reasons why the data is missing (if known). Missing data will be reported with the results and discussed in the “Data Summaries and Analysis” section of the TER along with a description of how the data set was analyzed without the missing data. All missing data contributes to the completeness of DQI and MPC of 95% valid data collection.

9.5 Acceptance Criteria for Existing Data

No existing data will be used for this study.

9.6 Data Upload Procedures

Per section S8.B-9 of the MS4 permit, City of Spokane, Spokane County, and City of Spokane Valley will enter applicable data collected into Ecology's Environmental Information Management (EIM) database and the end of the study. Per the Ecology Grant requirements, Evergreen StormH2O will upload the data into the International BMP database at the end of the study. Additionally, Evergreen StormH2O will include copies of all data collected during the study in the final report.

10.0 Audits

This section describes the types of audits that will be conducted, the audit process and procedures, number of audits, frequency, and who is responsible for conducting the audits.

10.1 Technical System Audits

Technical system audits performed for field data collection will occur during the first monitoring event, and at one additional event, at the discretion of the principal investigator. The technical system audits will be performed by a third party and will verify that field staff are following the sampling procedures for sample collection, all field data are being recorded, and equipment and instruments are being maintained and calibrated per manufacturer's requirements. The auditor will notify the lead entity and principal investigator in writing (via email) within two business days if corrective action is needed based on the audit findings, as described in **Section 8.3**. Results from these audits will be documented in field audit worksheets (**Appendix E**. *Field Data Collection Forms*) that will be prepared for each batch of samples.

Technical system audits performed for laboratory data will occur within seven business days of receiving results from the 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 and raw data will also be examined to determine if the DQIs for the project have been met. Results from these audits will be documented in QA worksheets (**Appendix E**. *Field Data Collection Forms*) that will be prepared for each batch of samples.

In the event that a potential QA issue is identified through these audits, Evergreen StormH2O's data quality assurance lead 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 or advising the laboratory that methodologies or QA/QC procedures need to be improved.

10.2 Proficiency Testing

Proficiency testing is a quantitative determination of an analyte in a blind standard to evaluate the proficiency of the analyst or laboratory. No proficiency testing will be conducted as part of this study.

11.0 Data Verification & Usability Assessment

This section outlines the process the study will employ to evaluate the quality and usability of the data for meeting the project objectives. The following list includes the data that will be verified:

- Water quality data
- BSM data
- Flow measurements
- Rainfall data

11.1 Data Verification

Data verification will be performed for water quality and BSM data received from the laboratory. Water quality results will first be reviewed at the laboratory for errors or omissions. Laboratory quality control results will be reviewed by the laboratory to verify compliance with acceptance criteria. The laboratory will also validate the results by examining the completeness of the data package to determine whether method procedures and laboratory quality assurance procedures were followed. The review, verification, and validation by the laboratory will be documented in a case narrative that accompanies the analytical results. The data received from the laboratory will be reviewed by Evergreen StormH2O staff and validated within 7 days of receiving the results from the 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 include the following:

- Reviewing all the data records to ensure they are consistent, correct, and complete, with no errors or omissions.
- Review data records to verify the entries are consistent, correct, and complete.
- Review the results from the QC section.

Results from these data verification reviews will be summarized in quality assurance worksheets (**Appendix E**. *Field Data Collection Forms*) that are prepared for each sample batch. The principal investigator will be responsible for identifying and initiating corrective action. 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 with an “R”. Estimated values may be used for evaluation purposes, but rejected values will not be used.

11.2 Data Usability Assessment

The data usability assessment will incorporate the results of the water quality and BSM data verification reviews as well as an evaluation of whether all monitoring data collected met MPCs and DQIs identified in this QAPP. First, the Evergreen StormH2O QA/QC Lead will provide an independent review of the water quality and BSM QC data from each sampling event by determining whether or not MPCs for each DQI identified in this QAPP have been met. The data usability assessment of the water quality data will be presented along with the data verification results in an appendix to the TER. The data usability assessment of the water quality data and remaining monitoring data will summarize quality control results, identify when data quality objectives were not met, and discuss any resulting limitations 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 (***Appendix H****. Deviations from QAPP*)
- Results of field and laboratory data verification
- Results of technical system audits
- Identification of 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

12.0 Data Analysis Methods

This section defines the process and methods the project will use to analyze the data and address the study goals outlined in **Section 2.1** as well as describe how the data will be presented in the final report.

12.1 Data Analysis Methods

12.1.1 Storm Reports

Storm, hydrologic, and pollutant data will be compiled for each sampling event that occurred during the data collection and summarized in tables. The storm-specific report will include:

- Monitoring site name
- Site location (UTM or latitude/longitude)
- Storm name or number
- Storm event date
- Total storm precipitation depth
- Storm duration
- Storm average and peak precipitation intensity
- Storm antecedent dry period
- Total influent, effluent, and bypass runoff volume
- Influent and effluent peak and average flow rates
- Bypass peak flow rate
- Influent and effluent flow duration
- Number of influent and effluent aliquots
- Percentage of influent and effluent storm volume sampled
- Parameters monitored
- Pollutant removal efficiency
- Lab detection limits
- Data flags for identified QA issues

This information will be used to develop individual storm reports for each sampling event. The information will also be used to demonstrate that the data collected meets the requirements defined in TAPE (i.e., qualifying storm events, treatment performance goals, etc.) and define flow characteristics through the two BSMs over a range of influent flow rates (i.e., infiltration rate). In addition, the individual storm reports may also provide justification for why data has been included that does not meet TAPE requirements.

12.1.2 Calculation and Evaluation of Pollutant Reduction Efficiencies

The effectiveness of the non-vegetated bioretention BMPs will be evaluated based on the average removal efficiency and mean concentration for each parameter over 15 qualifying rainfall events. This will include calculating the removal efficiency of each BSM for each pollutant from each individual rainfall event using **Equation 12-1**. Then the bootstrapping method will be used to compute the confidence intervals around the mean effluent concentration (for TSS influent concentrations between

20-100 mg/L) or pollutant removal efficiency (for influent TSS concentrations greater than 100 mg/L, dissolved metals, and phosphorus). The boot strapping method is a distribution-free method for computing confidence intervals around a measure of central tendency (Efron & Tibshirani, 1993) and is method recommended in TAPE (Ecology, 2018). If analytical results provided by the lab include effluent values that are non-detectable, the reporting limit for the respective pollutant will be used, as defined by the standard testing method, to calculate the pollutant reduction. Alternatively, if the analytical results provided by the lab include influent values that exceed the upper influent range shown in **Table 12-1**, the upper concentration limit will be used to calculate the pollutant reduction.

Equation 12-1

$$\Delta C = 100x\frac{c_{in-}\,c_{out}}{c_{in}}$$

Where:

C_{in} = influent concentration (mg/L)
C_{eff} = effluent concentration (mg/L)

Table 12-1. TAPE Treatment Performance Goals (Ecology, 2018)

Performance Goal	Influent Range	Criteria
Basic Treatment	20-100 mg/L TSS	Effluent goal < 20 mg/L TSS
	100-200 mg/L TSS	≥ 80% TSS removal
Dissolved Metals Treatment[1]	Dissolved copper 0.005-0.02 mg/L	≥ 30% dissolved copper removal
	Dissolved zinc 0.02-0.03 mg/L	≥ 60% dissolved zinc removal
Phosphorus Treatment[1]	Total phosphorus (TP) 0.1-0.5 mg/L	≥ 50% TP removal

12.1.3 Water Quality Treatment Performance

The water quality data will be evaluated against the Ecology performance goals for basic, dissolved metals (Zn and Cu), and phosphorus. This includes comparing the lower one-sided 95 percent confidence interval around the mean removal efficiency or the upper one-sided 95 percent confidence interval around the mean effluent concentration (TSS concentrations less than 100 mg/L) to the performance goals identified in **Table 12-1**. If the removal efficiency is equal to or greater than the treatment performance criteria, the conclusion will be made that the BSM met the treatment performance criteria for the pollutant of concern.

12.1.4 Saturated Hydraulic Conductivity (Ksat) and Infiltration Rate Measurements

The change in saturated conductivity will be evaluated using the results from the falling head tests described in **Sections 5.8** and **6.1.8**. The K_{sat} will be calculated using **Equation 12-2**.

Equation 12-2

$$K_{sat} = \frac{A_1}{A_{\,2}}X\frac{L}{\Delta Time}ln\frac{H_1}{H_2}$$

Where:

H_1 = initial ponded water depth above the surface of the cell (in)

H_2 = final ponded water depth above the top of the cell for time interval (in)

$\Delta Time$ = time interval for water to fall from H_1 to H_2 (sec)

L = depth of BSM (in)

A_1 = cell surface area at H_1 (ft2)

A_2 = cell surface area at H_2 (ft2)

L = depth of BSM (in)

The infiltration rate of the media will be calculated using effluent flow rate data recorded by the data logger during the falling head tests as described in **Sections 5.8** and **6.1.8**. The infiltration rate will be determined using **Equation 12-3**.

Equation 12-3

$$Infiltration = \frac{Q_{out}}{A_{average}}$$

Where:

Q_{out} = Average effluent flow rate recorded by the data logger over the duration of the test: from initial ponded depth to when water has completely infiltrated into the BSM or 0-inches of ponded water (cft/hr)

$A_{average}$ = Bioretention cell average surface area: average of surface area at initial ponded depth and surface area at 0-inches of ponded water (sqft)

12.1.5 BSM Analysis

12.1.5.1 Media Testing Analysis

The BSM properties listed in **Table 5-5** along with Ksat and infiltration rate will be tested before and after the study to assess how these properties change over the study. This includes averaging the values measured from the samples collected in each cell and using Equation 12-1 to determine the percent change. The metals (Cu and Zn) and phosphorus (HPBSM only) results will be used to assess the portion of the pollutants retained in the soil. The remaining parameters will be used to assess the BSM lifecycle as described in **12.1.5.2**.

12.1.5.2 Lifecycle Estimate

The BSM lifecycle will be evaluated to approximate when the BSM will need to be replaced. This will include using the results from **Section 12.1.5.1** for infiltration rate and CEC. Then dividing by the number of months testing occurred to determine the monthly rate of change. The rate of change will be used along with the properties before testing started to determine how long it will take for infiltration rate to reach 3 inches/hour and the CEC to reach zero. The 3 inches/hour was selected because this is the design value used in SWMMEW, and if the infiltration rate drops below this value, the pond will be undersized for the contributing basin area.

12.2 Data Presentation

The data will be presented (i.e., tables, charts, and/or graphs) in the final reports to illustrate trends, relationships, and anomalies. Examples of how the data may be presented is briefly described below:

- A table summarizing all the values/parameters measured for each testing event (i.e., water quality results, storm data, hydrologic data, K_{sat}, etc.).
- A hydrograph for each storm during a sampling event that includes precipitation, influent and effluent flow rate, and influent and effluent aliquots.
- Box and Whisker Plots display the distribution of data collected during the study. This will include the average and range of influent and effluent concentrations and any outliers. When applicable, the concentration representing the Ecology treatment performance goal will be graphed (using a red dashed line or similar) to illustrate the relationship to the influent and effluent average concentrations.
- Log-Normal Graphs are line graphs of the pollutant reduction ratio (C_{eff}/C_{in}) for each sampling event. These graphs illustrate the trend in the treatment performance over the duration of the study.

13.0 Reporting

The purpose of this section is to describe how the study findings will be reported and disseminated.

13.1 Final Reporting

The following provides a summary of the reports that will be produced for this study as well as the party responsible for preparing the reports.

- Technical Evaluation Report (TER) – the TER will summarize the results of the study and recommend future actions based on the study findings. **Table 13-1** provides an outline of the anticipated TER content. Since the study goal includes developing a modified BMP, the TER will be developed to meet the requirements specified in the TAPE Guidance Document section Preparing a Technical Evaluation Report (TER), (Ecology, 2018).
- A Fact Sheet – a 2 page document that summarizes the key points and findings of the study.

Table 13-1. Proposed Technical Evaluation Report Content

Final Report Sections		Develop Modified BMP
0.0	Cover Letter	✓
1.0	Executive Summary	✓
2.0	Introduction	See Note 1
3.0	Technology Description	See Note 1
4.0	Sampling Procedures	See Note 1
5.0	Data Summaries and Analysis	✓
6.0	Operation and Maintenance (O&M) Information	See Note 2
7.0	Discussion	✓
8.0	Conclusions	✓
9.0	Future Action Recommendations	✓
10.0	Appendices	✓
11.0	Third-Party Review	See Note 3

1. Reference the approved QAPP for these sections. Indicate changes made since the QAPP was approved.
2. Provide a summary of the original BMPs O&M information as defined in the applicable stormwater manual (and reference the manual) and describe any differences in the O&M information for the modified BMP.
3. Through the TAPE applications process, Board of External Reviewers (BER) shall provide a peer review of the study documents including the QAPP and TER.

13.2 Dissemination of Project Documents

The Final Technical Report will be shared with the participating agencies and will be posted to the City of Spokane, City of Spokane Valley, and Spokane County webpages along with a video fact sheet about the study and study findings. Links to respective webpages are included on page i under Proposal and QAPP Publication Information.

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15.0 Appendices

Appendix A. Ecology QAPP Approval Letter, Comments, and Responses to Comments

Comment #	Commenter Name	Document Section, Table, or Figure #	Comment	Comment Resolution	Comment Resolved?
1	David	0 Executive Summary	Also makes a WQ treatment facility potentially subject to introduction of chlorine, inasmuch as potable water is often chlorinated. This may result in formation of halogenated organic compounds within bioretention, and subsequent environmental release.	Comment noted	Y
2	David	0 Executive Summary	From a TAPE point of view, this qualifies as a 'does/doesn't' meet TAPE criteria exercise. From a science point of view, it would be best to do a paired study involving four cells: BSM and HPBSM each with and without plants. That presents paired studies, which largely factors out unaccounted variables that may affect plants vs no plants performance.	Comment noted	Y
3	Carla	0 General Comment	Multiple places in the document where the references need to be updated. Currently reference Table X or “PSD samples will be delivered to X in X” as a placeholder-	These references have been updated.	Y
4	Carla	0 Signature Page	The lab they will be using for PSD isn’t specified.	The PSD lab has been added.	Y
5	David	1.1 Introduction to the structural BMP	bioretention soil mix(s) (BSM)	BSM is now spelled out before the acronym BSM.	Y
6	Curtis	1.1 Introduction to the structural BMP	We've since found that these measurements are a significant over estimate. Suggest citing Ecology's numbers (12 in/hr initial) or better yet delete this sentence.	Added text to clarify based on Curtis comment.	Y
7	Curtis	1.1 Introduction to the structural BMP	As above, we've since found these measurements to be significant over estimates. suggest deleting.	Added text to clarify based on Curtis comment.	Y
8	David	1.2 Problem Description	Reiterating prior note: Also makes a WQ treatment facility potentially subject to introduction of chlorinated (potable) water with potential for creation and release of halogenated organic compounds.	Comment noted	Y
9	David	1.3.1 Performance of the 60:40 BSM	juvenile coho	added	Y
10	David	1.3.1 Performance of the 60:40 BSM	Recommend adding, "at the concentrations of copper and dissoved organic matter present in the experiment". The observation is limited to the test species, life stage, and other conditions of the specific experiment. Literature review indicates there is a body of evidence that while increased dissolved organic carbon (DOC) has an ameliorating or mitigating effect to one degree or another with respect to dCu toxicity to a number of species, degree of mitigation depends on species and biological effect; it does not appear to be absolute at typical DOC discharge concentrations.	Added Text	Y
11	David	1.3.1 Performance of the 60:40 BSM	Additionally, McIntyre (2016) & McIntyre, Davis, and Knappenberger (2020) testing for arsenic found that the compost-based bioretention media was also a net discharger of arsenic at concentrations substantially higher than the WA state groundwater quality standard and the surface water human health standard (see internal white paper (attached)	Comment noted	Y

12	David	1.3.3 Performance of Non-vegetated BMPs	Suggest review of McIntyre, Jenifer, Jay Davis, and Thorsten Knappenberger. 2020. Plant and Fungi Amendments to Bioretention for Pollutant Reduction over Time. Final Report to Washington State Department of Ecology Stormwater Action Monitoring [Program] U. S. Fish and Wildlife Service.	Add text from report regarding role of plants in bioretention for treatment.	Y
13	David	1.3.3 Performance of Non-vegetated BMPs	Citation is specific to constructed wetlands; no mention of bioretention. Sending in email, more detailed comments including citations from Minton (2009) and Davis et al. (2006).	Added additional citations.	Y
14	David	1.3.3 Performance of Non-Vegetated BMPs	This is a repeat of the prior sentence, w/ minor variation. After deleting one, IMO replace the other with, "These few studies suggest that vegetation may play only a small role in pollutant removal under some circumstances; as such, BSM without vegetation may still meet treatment performance goals".	Added suggestion.	Y
15	Curtis	1.3.3 Performance of Non-Vegetated BMPs	This is partially correct and ok for the QAPP. If we want to be a bit more precise, add a sentence or two explaining the soil building properties (structural and biological) of plants that enhance and maintain treatment properties.	Added some additional text about soils earlier in the paragraph related to treatment properties.	Y
16	Curtis	2.2 Study Description and Objectives	Influent and effluent for each cell or one influent measurement site? I ask because flow splitting is notoriously challenging.	One influent sample is being collected. Added SOP in section 6 for evaluating and balancing flow splitting.	Y
17	David	2.2 Study Description and Objectives	Influent should be sampled independently for each of the two cells, so 4 compostite flow weighted samples rather than 3. Agreeing w/ CH that flow splitting is fraught & likely to result in different pollutant profiles at the two cell inlets. Even if flows can be partitioned equally, while truly momentarily dissolved pollutants should likewise partition equally, TSS may not; and that can affect 'hitchhiker' pollutants including some ostensibly dissolved (to one degree or another) ones.	It is not possible to change the site design to include two influent samples. We are adding SOPs to evaluate and balance the flow split between cells.	Y
18	Curtis	2.2 Study Description and Objectives	Fix line spacing	fixed	Y
19	David	Table 2-1 Data Needed to Meet Objectives	In as much detail as possible. Not only necessary for the stated purpose, but also because results will be specific to the media used.	Comment noted	Y
20	Curtis	Table 2-1 Data Needed to Meet Objectives	Hmm...pressure transducer or sonde. Pressure transducer usually for water depth (many include temp and some pH capability).	Reviesed text to clarify how pH and temperature are measured.	Y
21	David	Table 2-2 Summary of Water Quality Testing (per TAPE requirements)	Need to add ***Supplementary Analytes*** , perhaps as another Table; and under that add total arsenic. And ideally consider adding 6PPD-quinone and PFAS (discuss later which of the PFAS). While there is no treatment goal for these, gaining an understanding of removal through any treatment facility ought to be a goal for Ecology, which IMO should be willing to fund the analytical costs. And the only 60:40 BSM studies that included arsenic as an analyte indicated net discharge, so that should be added as an analyte for bioretention studies as well. These should all really be added universally as TAPE screening parameters.	Since adding analytes will add to the cost and is not required per TAPE, not additional analytes were added. 6PPD is being added through an amendment.	Y
22	David	Table 2-3 Summary of Potential Constraints and Mitigation Approaches	Here or elsewhere describe instrument calibration (e.g., flow, rain gauge, etc.), corrective action, and mitigation should instrumentation be found to be out of calibration over the course of the monitoring period.	Added reference to SOPs.	Y

23	David	Table 2-3 Summary of Potential Constraints and Mitigation Approaches	'Large' is a relative term. Degree of potential harm depends on toxicity of what's spilled. Suggest simply deleting as indicated.	edited as suggested	Y
24	Curtis	Table 2-3 Summary of Potential Constraints and Mitigation Approaches	Great. Interested in more detail for doing this.	Added reference to SOP where more information is located.	Y
25	Curtis	Table 2-3 Summary of Potential Constraints and Mitigation Approaches	Signage?	Gonzaga will not allow signage. I added “staff” to the text to clarify who we are talking with.	Y
26	David	4.1.9 Representativeness	How and how frequently will it be calibrated? (raingage)	Reference SOPs for information about equipment maintenance and calibration.	Y
27	David	4.1.9 Representativeness	How and How frequently will it be calibrated?	Reference SOPs for information about equipment maintenance and calibration.	Y
28	David	Table 4-2 Measurement Performance Criteria (MPC) for Water Quality and	I may have missed it somewhere -- need to define batch.	Definition of batch per TAPE has been added below the table.	Y
29	David	5.1 Study Design Overview	Unsure re: CH's what comment, "better than representative results" means. My view: to any degree a catch basin modifies the runoff before it reaches a bioretention cell, the CB becomes part of the treatment. That needs to be considered in results, conclusions about design, and post-hoc design specifications.	Moved influent sample location to the first catch basin.	Y
30	Curtis	5.1 Study Design Overview	Media components or blends?	Added "samples of each BSM blend"	Y
31	Carla	5.6 Flow Monitoring	There is no mention of bypass. Will the cells have internal or external bypass structures? If so, how will they be monitoring bypass? (they only mention flow monitoring at the influent and effluent)	Note added to explicitly state that there is no bypass.	Y
32	Carla	5.7.1 Grab sampling	They state the only grab samples they'll be doing are in situ measurements for pH. They should also be collecting grab samples for fecal coliform and e. coli as well as for TPH if they are trying to show performance for oils (as stated in Section 12.1.3).	Updated to include fecal coliform and e.coli. SOPs will also be updated to include collecting grab samples for fecal and e. coli. TPH is not being tested as part of this study.	Y
33	David	5.9 BSM Material Testing	For both BSM and HPBSM, not only do media need to be tested; they need to be characterized in as great detail as possible. E.g., but not limited to: for any media: specific source (vendor and their product name and ideally batch number); for compost, specific feedstocks and Ecology-required content and maturity test results; for coir, processing (composted, and if so in what manner? any chemical wash? rinsing to remove tannins? residual tannin measurement in leachate? etc.); for HCWA, specific feedstock(s), processing (temperature, pressure, duration, % oxygen, any parameter cyclig/timng, etc.); for sand, geolgic and geographic source, predominant mineral (e.g., silica-based), ... etc.	The text was updated to clarify the testing that would be done. Specifically: we are using the supplier specs to confirm the media meets the specs. Then testing for properties that indicate treatment performance capaicty related to lifecyle.	Y
34	Curtis	5.9 BSM Material Testing	Hmm...there is no spec criteria for HPBSM blends.	The text was updated to clarify the testing that would be done. Specifically: we are using the supplier specs to confirm the media meets the specs. Then testing for properties that indicate treatment performance capaicty related to lifecyle.	Y

35	Curtis	6.1.1 Procedures for Storm Selection and Tracking	Highly recommend using your gauge and setting up telemetry.	Comment noted. If telemetry can be used, it will be.	Y
36	Carla	Figure 5-2 sample equipement	There is one influent sampling and flow monitoring point for both cells (and then flows are split to the two cells). Have they confirmed an even distribution of flows between the cells? The single influent sampling point is in a catch basin but the document doesn't specify where within the catch basin. We should confirm that the sampling point is downstream of any sump or other structure that may provide treatment.	Added text to clarify the flow monitoring location. Flow distribution between the cells is not measured. The pipes the discharge the Type 1 catch basin are located at the same invert elevation and slope to the ponds. Procedures were added in SOP 6.1.3 to measure and balance flows to each cell.	Y
37	Carla	Table 13-1 Purposed Technical Evaluation Report Content	I want to confirm that the O&M information they reference in Table 13-1 is O&M data and information they'll be collecting as part of this evaluation (not just reiterating the typical O&M requirements that are outlined in the manual).	Section 6.1.9 provides SOPs for O&M and an inspection checklist was added to the appendix that will be used during the study. Section 5.3 provides details about the maintenance plan, how it was developed, and explains that information collected on the field forms will be used to develop the final recommendations for maintenance.	Y
38	Curtis	Appendix D	This spec is incorrect. Suggest inserting May 2024 version which is still incorrect, but somewhat better than 2021.	The spec was updated to include the revisions in the 2024 document	Y

Appendix B. Bioretention Sizing Calculations

Appended on: Monday, March 11, 2024 6:16:34 AM

LPOOLCOMPUTE [cellsetup] SUMMARY using Puls, 24 hr Storm Event

Start of live storage:100 ft

Event	Match Q (cfs)	Peak Q (cfs)	Max Depth (ft)	Vol (cf)	Vol (acft)	Time to Empty (hr)
6-month 24 hr	0.0593	0.0177	0.8173	149.4097	0.0034	0.0059
10 yr 24hr	0.121	0.03	1.6934	433.1198	0.0099	1.8788

Summary Report of all Detention Pond Data

Project Precips

Event	Precip (in)
6-month 24 hr	0.966
10 yr 24hr	1.80

BASLIST2

BasinID	Event	Peak Q (cfs)	Peak T (hrs)	Peak Vol (ac-cf)	Area (ac)	Method/Loss	Raintype
existing	6-month 24 hr	0.0593	8.01	0.0193	0.305	SCS	TYPE1a.rac
existing	6-month 24 hr	0.0593	8.01	0.0193	0.305	SCS	TYPE1a.rac
existing	10 yr 24hr	0.121	8.01	0.0401	0.305	SCS	TYPE1a.rac
existing	10 yr 24hr	0.121	8.01	0.0401	0.305	SCS	TYPE1a.rac

Record Id: existing

Design Method	SCS	**Rainfall type**	TYPE1a.rac
Hyd Intv	10.00 min	**Peaking Factor**	484.00
Storm Duration	24.00 hrs	**Abstraction Coeff**	0.20
Pervious Area	0.00 ac	**DCIA**	0.305 ac
Pervious CN	0.00	**DC CN**	98.00
Pervious TC	0.00 min	**DC TC**	5.00 min

DCI - CN Calc

Description	SubArea	Sub cn
Impervious surfaces (pavements, roofs, etc)	0.305 ac	98.00
DC Composited CN (AMC 2)		98.00

DCI - TC Calc						
Type	**Description**	**Length**	**Slope**	**Coeff**	**Misc**	**TT**
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

HydID	Peak Q (cfs)	Peak T (hrs)	Peak Vol (ac-ft)	Cont Area (ac)
6-month 24 hr out	0.0177	9.09	0.0192	0.305
10 year out	0.03	9.58	0.0397	0.305

STORLIST
[cell]
LSTEND

Record Id: cell

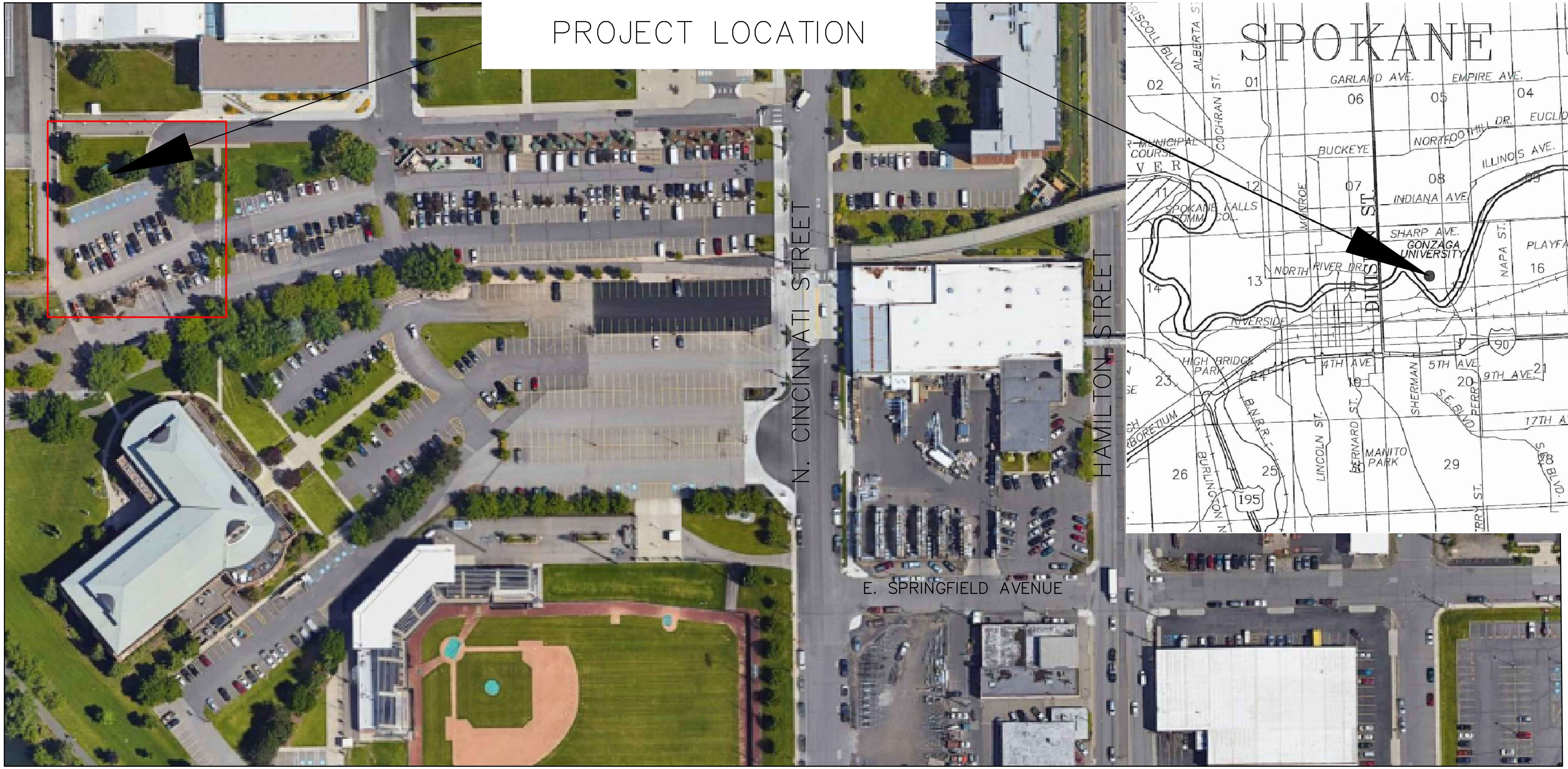
Descrip:	Prototype Record	Increment	0.10 ft
Start El.	100.00 ft	Max El.	108.00 ft
Void Ratio	100.00		
Length	18.00 ft	Width	7.00 ft
Length ss1	3.00v:1h	Length ss2	2.00v:1h
Width ss1	3.00v:1h	Width ss2	2.00v:1h
Consider wetted surface for infiltration			
Trap Type Node			

DISCHLIST
[infiltration]
LSTEND

Record Id: infiltration

Infiltration			
Descrip:	Prototype Structure	**Increment**	0.10 ft
Start El.	100.00 ft	**Max El.**	108.00 ft
Infiltration rate	3.00 in/hr	**WP Multiplier**	1.00

Appendix C. Test-Site Construction Plans



NOT TO SCALE		
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DESIGNED BY	NAVICKIS-BRASCH	MAY 2024
CHECKED BY	MAURER	MAY 2024

EVERGREEN STORMH2O

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PO BOX 18912,
SPOKANE, WA 99228
www.evergreenstormh2o.com

APPROVED:
STORMWATER ENGINEER

Date:

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Development of Non-Vegetated BMPs

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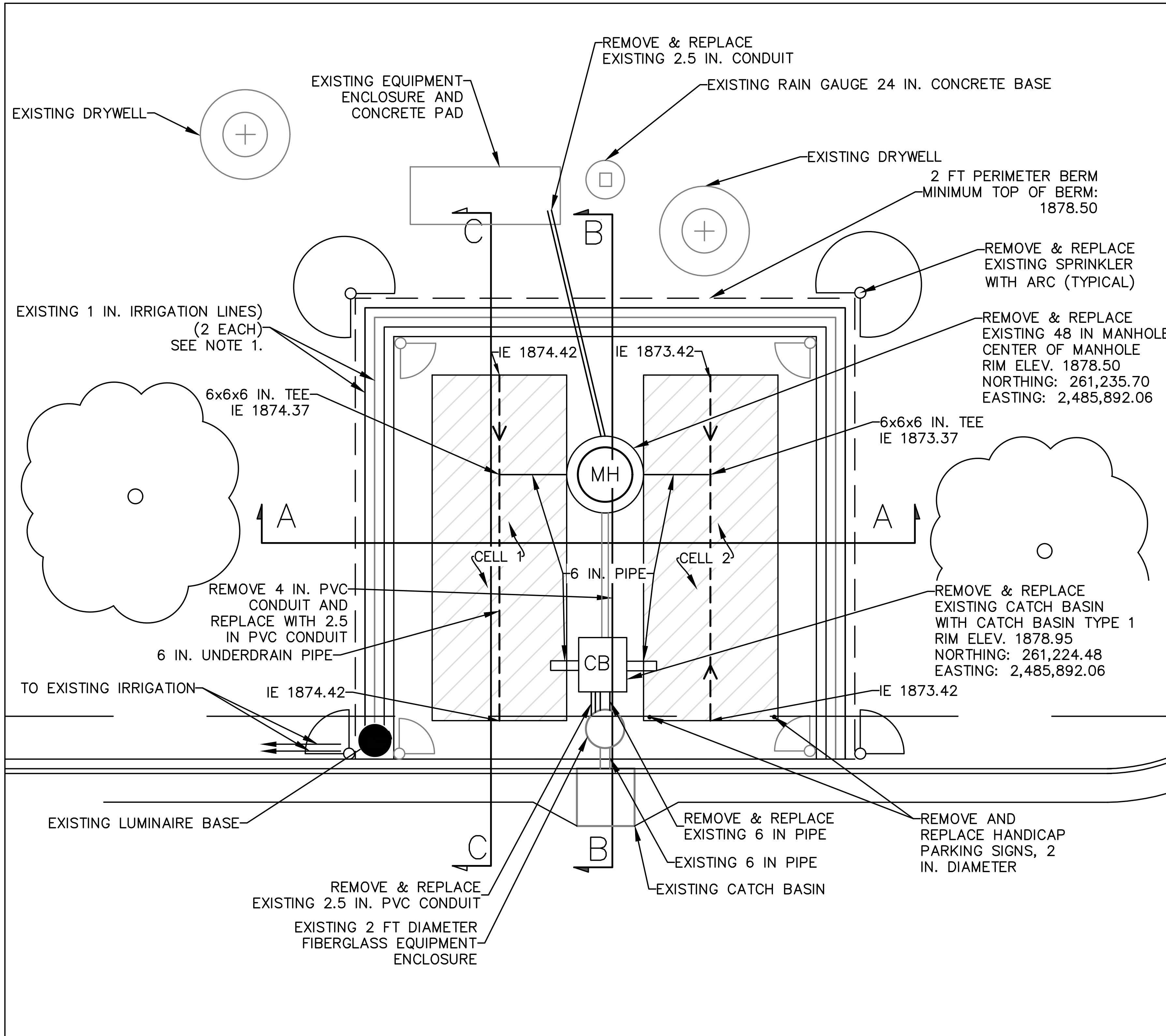

NOTES:

1. REMOVE EXISTING IRRIGATION LINES AND SPRINKLERS BEFORE CONSTRUCTION. AFTER CONSTRUCTION REPLACE IRRIGATION LINE AND SPRINKLER HEADS FOR WATERING OUTSIDE THE POND AREA.
2. UNLESS OTHERWISE NOTED, EXISTING ITEMS TO REMAIN IN PLACE.

Item Number	Item Description	Item Units	Item Quantity
1	MOBILIZATION	LS	
2	EXCAVATION INCL. HAUL	CY	38
3	PERFORATED UNDERDRAIN PIPE, 6 IN. SDR 35	LF	36
4	SOLID WALL STORM SEWER PIPE, 6 IN. SDR 35	LF	20
5	6X6X6 SEWER TEE, SOLVENT WELD SDR 35	EA	6
6	6 IN. CAP S PVC SDR 35	EA	4
7	11.5 DEGREE COUPLINGS FOR 6 IN. SDR 35 PIPE	EA	2
8	2.5 IN. PVC CONDUIT, SCHEDULE 40	LF	10
9	FLEXIBLE PVC PIPE, COUPLING AND FITTINGS, 2.5 IN. SCHEDULE 40	LF	20
10	1-1/4 IN. PVC DISCHARGE PIPE SCHEDULE 40	LF	20
11	1-1/2 IN. FLEXIBLE PVC (SPRINKLER PIPE) SCHEDULE 40	LF	20
12	MANHOLE TYPE 1 - 48 IN. WITH 4 FT BASE	EA	1
13	2 FT RISER FOR 48 IN. MANHOLE TYPE 1	EA	1
14	CUSTOM CORE HOLES IN MANHOLE BY VENDOR	EA	5
15	PRECAST CATCH BASIN, TYPE 1	EA	1
18	SEEDING, FERTILIZING, AND MULCHING	AC	0.01
19	GRAVEL BACKFILL FOR DRAINS	CY	4
20	CHOKE STONE #8 OR #89 WASHED (PEA GRAVEL)	CY	8
21	3/4 IN. CRUSHED BASALT CHIPS (ROCK MULCH)	CY	4
22	HIGH PERFORMANCE BIORETENTION MIX	CY	18
23	POLISHING LAYER	CY	12
24	60:40 BIORETENTION MIX	CY	18
25	30 ML HDPE GEOMEMBRANE LINER	SF	1575 (45 FT BY 35 FT)
26	SUMP PUMP	EA	2
27	PIPE SUPPORTS	EA	4
28	1 IN IRRIGATION PIPE AND FITTINGS	LF	140
29	SPRINKLER	EA	4
30	6 IN. THEL-MAR WEIRS	EA	3
31	EROSION AND SEDIMENT CONTROL	LS	1

0 4 8 Feet

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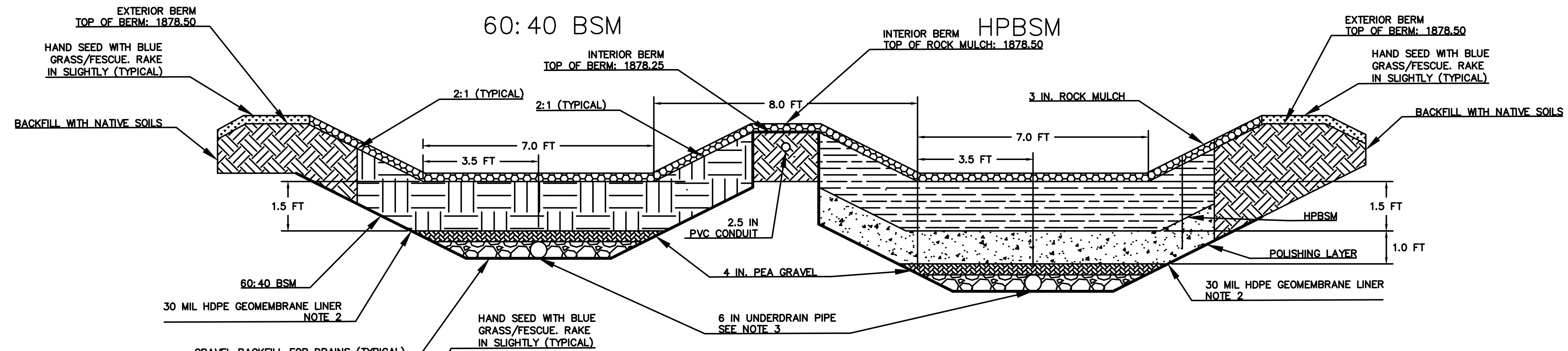
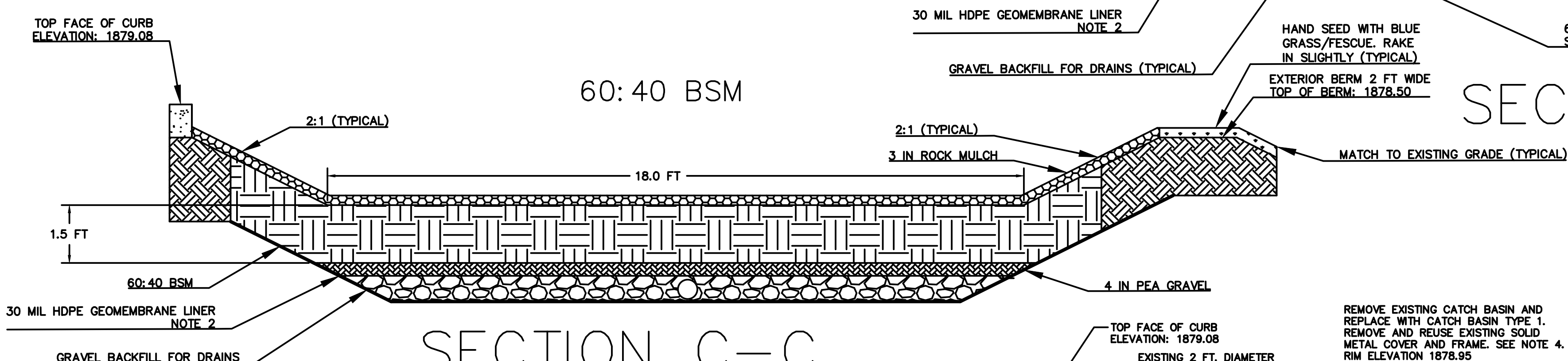
NOTES:

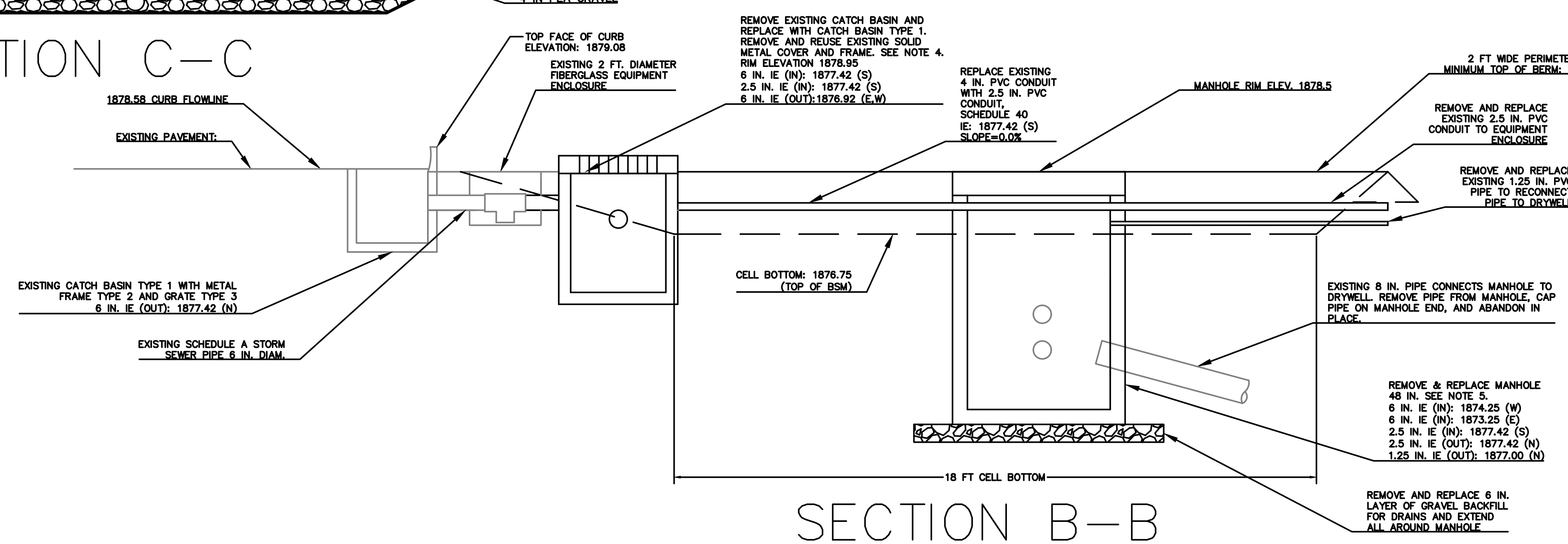
1. COMPACT THE BSM TO A RELATIVE COMPACTION OF 85% OF MODIFIED MAXIMUM DRY DENSITY (ASTM D1557–12). COMPACTION CAN BE ACHIEVED BY BOOT PACKING (SIMPLY WALKING OVER ALL AREAS OF EACH LIFT) AND THEN APPLY 0.2 INCHES OF WATER PER 1 INCH OF BSM DEPTH. WATER FOR SETTLING SHOULD BE APPLIED BY SPRAYING OR SPRINKLING.
2. LOCATE GEOMEMBRANE LINER ALONG THE ENTIRE POND SIDE SLOPES AND BOTTOM AND OVER THE TOP OF THE BERM. SEAL STRUCTURE AND PIPE PENETRATIONS AND SEAMS PER MANUFACTURERS RECOMMENDATIONS.
3. 6 IN UNDERDRAIN PIPE WITH SLOTS CUT PERPENDICULAR TO THE LONG AXIS OF THE PIPE, MEASURE 0.04 TO 0.069 INCHES BY 1 INCH, AND BE SPACED 0.25 INCHES APART (SPACED LONGITUDINALLY). SLOTS SHOULD BE ARRANGED IN TWO ROWS SPACED ON 45–DEGREE CENTERS AND COVER ONE–HALF THE CIRCUMFERENCE OF THE PIPE. PIPE SHALL BE INSTALLED WITH SLOTS ORIENTED ON TOP OF THE PIPE.
4. INSTALL PIPE THROUGH KNOCKOUTS AT THE ELEVATIONS SHOWN. PROVIDE A 1.5 IN. MINIMUM GAP BETWEEN THE KNOCKOUT WALL AND THE OUTSIDE OF THE PIPE. AFTER THE PIPES ARE INSTALLED, FILL THE GAP WITH JOINT MORTAR IN ACCORDANCE WITH WSDOT STANDARD SPECIFICATION SECTION 9–04.3.
5. REMOVE EXISTING 48 IN. TOP SLAB AND HALLIDAY ACCESS DOOR AND REINSTALL AFTER NEW MANHOLE IS INSTALLED. REMOVE EXISTING MANHOLE AND REPLACE WITH MANHOLE 48 IN WITH 5 FT BASE AND 1 FT RISER.



SECTION A–A



SECTION C–C



SECTION B–B

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CHECKED BY	MAURER	MAY 2024

0 4 8 Feet

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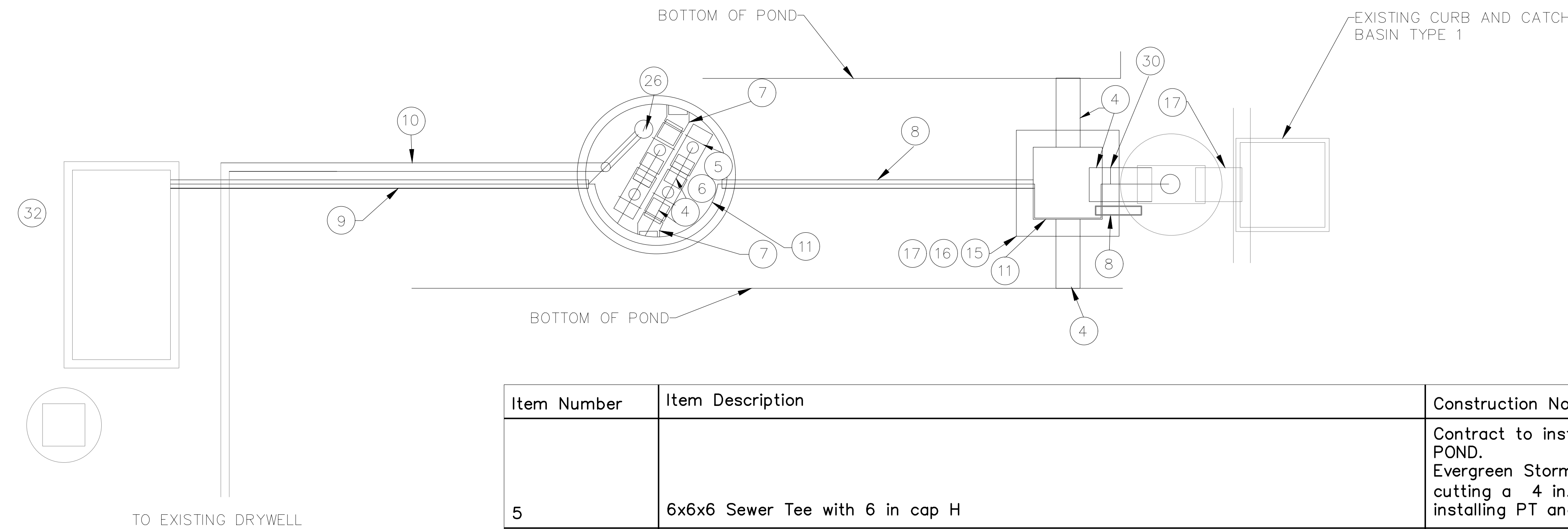
3 of 4



Item Number	Item Description	Construction Notes
5	6x6x6 Sewer Tee with 6 in cap H	Contract to install Tee to underdrain and 6 IN. DISCHARGE TO MANHOLE FROM EACH POND. Evergreen StormH2O staff will install Tees inside manhole after construction including cutting a 4 in. x 5 in. opening into top of Tee (PT access and maintenance) and installing PT and weirs in Tees.
6	6 in cap H; for SDR35 pipe	Evergreen StormH2O staff will install to bottom of each Tee in the manhole after construction.
7	11.5 degree couplings for 6 in. SDR pipe	Replace existing coupling with new coupling and connect to new 6" effluent discharge pipe from each pond.
8	4 in. PVC conduit	Remove existing 4 in. conduit and replace with 4 in. conduit at the elevations shown on page 3. fter construction, Evergreen StormH2O to locate sample tube and PT cord inside of pipe to item 15.
9	Flexible PVC Pipe, Coupling And Fittings, 2.5 in.	Replace existing 2-1/2 in. pipe with new 2-1/2 in. pipe. Pipe will connect to manhole and existing fiberglass enclosure. After construction, Evergreen StormH2O to locate sample tube, PT cord, and power cord for the sump pump, inside of pipe from the manhole to the fiberglass enclosure.
10	1-1/4 in. PVC discharge pipe	Replace existing 2 in pipe from manhole to elbow. This pipe discharges effluent from the sump pump to the existing drywell.
11	1-1/2 in. flexible PVC (sprinkler pipe)	Evergreen StormH2O to install after construction and locate sample tube and PT cord inside flexible tubing to existing pipe supports along inside of manhole and catch basin.
26	Install Sump pumps with float valve	Evergreen StormH2O to replace existing sump pumps with new sump pumps. Both will be located in bottom of manhole and connected to power at the equipment enclosure. Power connections will be routed through the 2-1/2 in. conduit. Discharge from pumps will be routed to existing 2 in pipe to the existing drywell shown.
27	Pipe supports (construction from Hayden)	Evergreen StormH2O will construct 4 pipe supports using channels and install into base of existing manhole. Secure 2 supports to each effluent discharge sample/flow monitoring collection setup using 6" strut clamps (2 per side)
30	Install 6 in. Thel-Mar Weirs	Evergreen StormH2O staff will install weirs after construction.
32	Install/connect monitoring equipment	Evergreen StormH2O will install trickle charger to batteries to ISCO equipment and data logger inside equipment enclosure. Installation will occur after construction.

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Appendix D. Specifications

BSM Specifications

60:40 Bioretention Soil Media (BSM) Specifications

Reference: Ecology Stormwater Management for Eastern Washington, BMP T5.31: Bioretention

The 60:40 BSM should consist of 18 inches of a blend of the Table 1 components and ratios.

Table 1. 60:40 BSM Composition

Component	Ratio (by volume)
Sand	60-65%
Compost	35-40%

The 60:40 BSM mix shall have the following properties.

- 5-8 percent organic matter content before and after saturated hydraulic conductivity test per ASTM D2974.
- Cation exchange capacity (CEC) of greater than or equal to 5 milliequivalents/100 g dry soil per US EPA Method 9081
- pH between 5.5 and 7.0 per US EPA Method 150.1
- Measured (initial) saturated hydraulic conductivity of less than 12 in/hr using ASTM D 2434 at 85% compaction per ASTM D 1557.
- 2-5 percent fines passing the 200 sieves per TMECC 04.11-A.

Sand (Mineral Aggregate) Specification

The aggregate portion should be well graded. According to ASTM D2487-11, well graded sand for BSM should have the following gradation coefficients.

- Coefficient of uniformity $(C_u = D60/D10) \geq 4$
- Coefficient of curvature $\left(C_c = \frac{D30^2}{D60} * D10\right) \geq 1 \text{ and } \leq 3$

Where:

- Coefficient of Uniformity: The ratio of D60 to D20
  - Value larger than 6 classifies soil as well graded
  - Value smaller than 4 is classified as poorly graded
- Coefficient of Curvature: The shape of the particle distribution curve
  - Well graded soil ranges between 1 and 3

The mineral aggregate gradation is provided in Table 2 and testing following ASTM D422-63.

Table 2. Mineral Aggregate Gradation

Sieve Size:	Percentage Passing:
3/8 inch	100
No. 4	95 to 100
No. 10	75 to 90
No. 40	25 to 40
No. 100	4 to 10
No. 200	2 to 5

Compost

The compost for the 60:40 BSM shall meet the following standards:

- Meets the definition of "composted material" as defined in WAC 173-350-100[i].
- Complies with testing parameters and standards outlined in WAC 173-350-220
- Produced at approved compost facility from following list: https://ecology.wa.gov/waste-toxics/reducing-recycling-waste/waste-reduction-programs/organic-materials/managing-organics-compost
- Compost must originate from a minimum of 65 percent by volume recycled plant comprised of yard debris, crop residues, and bulking agents as defined by defined by WAC 173-350-100. A maximum of 35 percent by volume of post-consumer food waste as defined by WAC 173-350-100 (not including biosolids) may be substituted for recycled plant waste.
- Moisture content range: no visible free water or dust produced when handling the material.
- Fine Compost Shall Follow the Table 3 Gradation by Dry Weight. This value is confirmed using TMECC Test Method 02.02-B.

Table 3. Compost Gradation by Dry Weight

Sieve Size	Percent Passing
2″	100%
1″	99%
5/8″	90%
¼″	75%

- pH between 6.0 and 8.5. This value is confirmed using US EPA Method 150.1.
- Minimum organic matter content of 40% per TMECC 05.07-A "Loss on Ignition".
- Soluble salt content less then 4.0 dS/m (mmhos/cm) per TMECC 04.10-A "Electrical Conductivity, 1:5 Slurry Method, Mass Basis").
- Physical contaminants (as defined by WAC 173-350-100) content less than 1% by weight total, not to exceed 0.25 percent film plastic by dry weight. This value is confirmed using TMECC 03.08-A.
- Carbon to nitrogen ratio of less than 25:1 per TMECC 05.02A "Carbon to Nitrogen Ratio".

---

[i] WAC 173-350-100 Definition: means organic solid waste that has undergone biological degradation and transformation under controlled conditions designed to promote aerobic decomposition at a solid waste facility in compliance with the requirements of this chapter. Composting is a form of organic material recycling. Natural decay of organic solid waste under uncontrolled conditions does not result in composted material.

High Performing Bioretention Soil Media (HPBSM) Specifications

Reference: Guidance on Using New High Performance Bioretention Soil Mixes
Ecology Publication 21-10-023

The HPBSM consists of an 18-inch primary layer that overlays a 12-inch polishing layer. The primary layer consists of 70% sand, 20% coir, and 10% high carbon wood ash (biochar). The polishing layer consists of 90% sand, 7.5% activated alumina, and 2.5% iron aggregate. The specifications for each layer are included in the subsequent sections.

HPBSM Primary Layer

The primary layer should consist of 18 inches of a blend of the Table 1 components and ratios. Tables 2-5 summarize the specified physicochemical properties for each component.

Table 1. HPBSM Primary Layer Composition

Component	Ratio (by volume)
Filter Sand	70% (+/-3%)
Coconut Coir Fiber	20% (+/-2%)
High Carbon Wood Ash	10% (+/-1%)

Primary Layer Coconut Coir Fiber

The Coconut Coir Fiber should be double rinsed and buffered and meet the criteria in Table 2

Table 2. Coconut Coir Fiber Criteria

Test/Method[1]	Criterion	Requirement
Synthetic Precipitation Leaching Protocol (EPA Method 1312) and EPA Method 353.2	NO_3+NO_2	0.15 mg/L (Max.)
Synthetic Precipitation Leaching Protocol (EPA Method 1312) and NEMI Method SM 4500-P E-99	Ortho-phosphorus	0.80 mg/L (Max.)
Synthetic Precipitation Leaching Protocol (EPA Method 1312) and EPA Method 200.8 UCT-KED	Dissolved Copper	10 µg/L (Max.)
Test Methods for the Examination of Compost and Composting (TMECC) Method 04.10-A	Electrical Conductivity	1.0 mmhos/cm (Max.)

[1] The synthetic Precipitation Leaching Protocol testing referenced above shall be modified to use Deionized Water as the Extraction Fluid in lieu of the diluted acid described in EPA Method 1312.

Primary and Polishing Layer Filtered Sand

The aggregate shall be sand meeting the gradation in Table 3 and the requirements of Section 9-03.1(2)B (Class 1) of the Washington State Department of Transportation (WSDOT)

Standard Specifications and shall have a Coefficient of Uniformity of four (minimum). The filter sand gradation tolerances herein apply to the aggregate in the HPBSM Primary Layer media as well as the HPBSM Polishing Layer media.

Table 3. Filtered Sand Gradation[2]

Sieve Size	Percent Passing Min.	Percent Passing Max.
3/8"	99	100
No. 4	95	100
No. 8	68	86
No. 16	47	65
No. 30	27	42
No. 50	9	20
No. 100	0	7
No. 200	0	2.5

The filter sand shall be thoroughly cleaned and free of dirt, clay, silt, asphalt, organic material, or other foreign matter and all aggregate passing the No. 200 sieve size shall be non-plastic. The filter sand shall meet the Table 4 requirements for quality.

Table 4. Fine Sand Quality Requirements

Test/Method[1]	Criterion	Requirement
Synthetic Precipitation Leaching Protocol (EPA Method 1312) and EPA Method 353.2	NO_3+NO_2	0.15 mg/L (Max.)
Synthetic Precipitation Leaching Protocol (EPA Method 1312 and NEMI Method SM 4500-P E.-99	Ortho-Phosphorus	0.15 mg/L (Max.)
Synthetic Precipitation Leaching Protocol (EPA Method 1312) and EPA Method 200.8 UCT-KED	Copper	10 µg/L (Max.)

[1] The synthetic Precipitation Leaching Protocol testing referenced above shall be modified to use Deionized Water as the Extraction Fluid in lieu of the diluted acid described in EPA Method 1312.

Primary Layer High Carbon Wood Ash (Biochar)

The High Carbon Wood Ash (HCWA) should consist of screened and processed organic and inorganic residue remaining after the thermal processing of biomass in an oxygen-controlled environment. The biomass feedstocks should be limited to clean cellulosic material from the 1) woody by-products of pacific northwest forestry operations (including cut residues left after a timber harvest, cut trees that are not marketable as lumber), 2) chipped trees and brush from biomass reduction operations (i.e. commercial tree trimming), and 3) agricultural residues such as nut shells, straw, orchard pruning, seeds, hulls, and pits. The biomass feedstocks should not include any post-consumer or post-industrial sourced woody biomass (i.e., construction or demolition waste, wood contaminated with paints or sealers, metal, plastic, or other deleterious materials).

The HCWA should be classified as a "Class 1" Biochar following the International Biochar Initiative (IBI) guidelines (IBI 2015).

The HCWA should be sourced from a producer with at least 5-years of experience producing HCWA for soil amendments and/or water filtration and meet the Table 5 requirements for quality and grading.

Table 5. High Carbon Wood Ash Requirements

Test/Method[1]	Criterion	Requirement
Synthetic Precipitation Leaching Protocol (EPA Method 1312) and EPA Method 353.2	NO_3+NO_2	0.15 mg/L (Max.)
Synthetic Precipitation Leaching Protocol (EPA Method 1312) and NEMI Method SM 4500-P E.-99	Ortho-Phosphorus	0.80 mg/L (Max.)
Synthetic Precipitation Leaching Protocol (EPA Method 1312) and EPA Method 200.8 UCT-KED	Dissolved Copper	10 µg/L (Max.)
Total C and H analysis by dry combustion-elemental analyzer (EPA Method 440.0). Inorganic C analysis by determination of CO2-C content with 1N HCl, as outlined in ASTM D4373 Standard Test Method for Rapid Determination of Carbonate Content of Soils. Organic C calculated as Total C – Inorganic C.	Organic Carbon (C_{org})	60% (Min.)
	H: C_{org}	0.7 (Max.)
Proximate Analysis (ASTM D1762)	Volatile matter	20% (Max.)
	Ash	40% (Max.)
Metals (EPA Method 6020)	Arsenic	20 ppm (Max.)
	Cadmium	10 ppm (Max.)
	Lead	150 ppm (Max.)
	Mercury	8 ppm (Max.)
	Molybdenum	9 ppm (Max.)
	Nickel	210 ppm (Max.)
	Selenium	18 ppm (Max.)
	Zinc	1400 ppm (Max.)
Cation Exchange Capacity (USEPA Method 9081)	Milliequivalents CEC/100g dry soil	Report
Gradation (ASTM D422)	# 6	100% Passing
	# 100	10% Passing (Max.)

[1] The synthetic Precipitation Leaching Protocol testing referenced above shall be modified to use Deionized Water as the Extraction Fluid in lieu of the diluted acid described in EPA Method 1312.

HPBSM Polishing Layer

The polishing layer should consist of 12 inches of a blend of the Table 1 components and ratios. Tables 6-8 summarize the specified physicochemical properties for each component.

Table 6. HPBSM Polishing Layer Composition

Component	Ration (by volume)
Filter Sand	91% (+/-1%)
Activated Alumina	6.5% (+1%/ - 0%)
Iron Aggregate	2.5% (+0%/-0.25%)

The HPBSM Polishing Layer media should be mechanically blended to produce a homogenous mix by a blending vendor/contractor with at least 5-years of soil blending experience.

Polishing Layer Activated Alumina

The Activated Alumina should meet the Table 7 requirements for quality and grading.

Table 7. Activated Alumina Requirements

<table>
<tr><th>Test/Method[1]</th><th>Criterion</th><th>Requirement</th></tr>
<tr><td>Synthetic Precipitation Leaching Protocol (EPA Method 1312) and EPA Method 200.8 UCT-KED</td><td>Dissolved Copper</td><td>1 µg/L (Max.)</td></tr>
<tr><td rowspan="3">Producer Analysis</td><td>Alumina (Al_2O_3) content</td><td>90% (Min.)</td></tr>
<tr><td>Bulk density</td><td>760 Kg/m^3 (Min.)</td></tr>
<tr><td>Surface area</td><td>300 m^2/g (Min.)</td></tr>
<tr><td rowspan="2">Gradation (ASTM D422)</td><td>#16 US Standard Sieve (#14 Tyler)</td><td>100% Passing</td></tr>
<tr><td>#30 US Standard Sieve (#28 Tyler)</td><td>0% Passing</td></tr>
</table>

[1] The synthetic Precipitation Leaching Protocol testing referenced above shall be modified to use Deionized Water as the Extraction Fluid in lieu of the diluted acid described in EPA Method 1312.

Polishing Layer Iron Aggregate

The Iron Aggregate should be ground Iron meeting the Table 8 requirements for quality and grading.

Table 8. Iron Aggregate Requirements

Test/Method[1]	Criterion	Requirement
Synthetic Precipitation Leaching Protocol (EPA Method 1312) and EPA Method 353.2	NO_3+NO_2	0.15 mg/L (Max.)
Synthetic Precipitation Leaching Protocol (EPA Method 1312 and NEMI Method SM 4500-P E.-99	Ortho-Phosphorus	0.15 mg/L (Max.)
Synthetic Precipitation Leaching Protocol (EPA Method 1312) and EPA Method 200.8 UCT-KED	Copper	10 µg/L (Max.)
Producer Analysis	Iron Content by Weight	80%-97%
Gradation (ASTM D422) or Producer Analysis	#4	100% Passing
	#8	95-100% Passing
	#16	75-90% Passing
	#30	25-45% Passing
	#50	0-10% Passing
	#100	0-5% Passing
	#200	0-2.5% Passing

[1] The synthetic Precipitation Leaching Protocol testing referenced above shall be modified to use Deionized Water as the Extraction Fluid in lieu of the diluted acid described in EPA Method 1312.

Monitoring Equipment Specifications

EXTREME ENVIRONMENTS
EXTREMELY RELIABLE

AXIOM H1 / H2
DATALOGGER / DCP

Tough on the outside.
Clever on the inside.

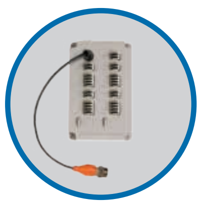
The Axiom Datalogger / DCP offers uncompromising reliability (borne out of our experience meeting the strict reliability demands of the North American fire weather market for over 35 years), extreme rugged construction and integrated waterproof touchscreen. These unique innovations result in lower post-purchase costs through reduced replacement from damage, higher data reliability and elimination of damage to (and even purchase of) laptops.

The Axiom Datalogger

Flexibility and expandability.

- Install new programs, firmware and operating system updates easily via any standard USB flash memory stick.
- Large internal memory capacity can store upwards of 10 years of data (assuming 8 sensors sampling once per hour).
- A virtually unlimited library of configurations can be stored, uploaded, downloaded and selected via the touchscreen, ideal for large network operators maintaining an inventory of spare equipment.
- Allows virtually unlimited expandability—up to 62 digital sensors. Calibration coefficients are not required.
- Can also be expanded with multiple analog sensors via optional SDI-AM analog interface module.

Transfer data or firmware updates via standard USB memory sticks



The SDI analog module provides analog sensor expansion

Integrated, preconfigured GOES, and optional 2-way cellular/Iridium.

The industry-leading G6 GOES transmitter—the same equipment that's a standard for all North American fire weather stations—is available as an integrated option in the Axiom. Extremely low power consumption and accurate time keeping enables reliable hourly data for up to 28 days even without a GPS fix.

For added reliability and 2-way remote management of the station, Iridium satellite telemetry can be easily added with Ubicom.

Ubicom
2-way remote management

Reliable connections.

We pioneered the use of military-style bayonet connectors for attaching external devices to our dataloggers. Why?

- The watertight, corrosion-resistant, positive-locking connection becomes incredibly reliable, eliminating the most probable point of failure.
- The color-coded, single-port design makes connecting sensors and other features during installation and maintenance dead simple and fast.
- All FTS sensors include bayonet connectors, and they can be added to any of your current SDI-12 sensors, power sources and rain gauges.

Leave the laptop at the office.

Integrated waterproof, daylight-readable touchscreen.

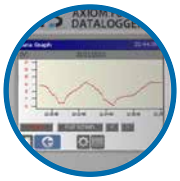
Built like a tank.

Fully watertight. 3 levels of lightning protection. Waterproof military bayonet connectors. IP67 aluminum case.

No laptop required.

The Axiom integrates a waterproof, industrial-grade, daylight-readable, color touch screen. By embedding the software right into the datalogger, we eliminate the need for field laptops and cables.

Create graphs of any parameter from any range of dates, to spot data anomalies.



View and export data in tabular format.

Simple diagnosis.

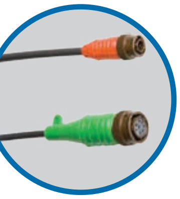
Axiom integrates a power manager and a solar charge regulator (H2 only) which is sealed inside the waterproof case. This reduces the chance of a problem with the power system—a common source of problems—and minimizes your time spent troubleshooting.

- The Axiom is constantly aware of parameters like solar voltage and current, battery voltage and current, battery and internal ambient temperature, and can transmit this information via any telemetry method. This allows the datalogger to provide a complete picture of power conditions for diagnosing power issues remotely, eliminating unnecessary site visits.
- At the site, this information is readily available as a graph on the integrated touchscreen with one click. Find out quickly when the problem occurred by viewing the log of data graphically.
- The integrated power manager adds an additional layer of intelligence to the Axiom by allowing the datalogger to directly talk to and manage the solar panel and battery.

Extreme ruggedness.

Because reliability is paramount and any downtime means lost data and increased liability, the Axiom is engineered for long-term durability in the harshest environments (minimizing site visits is nice too).

- Three levels of lightning protection. We have over 33 years of experience building equipment for the most extreme lightning strike locations, and it's in here.
- The entire unit—the cast aluminum, O-ring sealed case and all ports—is completely impervious to the elements. Even the touchscreen. And not just splashproof: fully watertight.
- Positive-locking, waterproof, color-coded, cadmium-plated, corrosion resistant, military-style bayonet connectors.



Extremely simple.

Clever graphical interface makes configuration and troubleshooting easy. Reduces the chance for things to go wrong.

Embracing SDI-12

The Axiom's waterproof SDI-12 ports are each on a **separate, electrically isolated SDI bus,** and each can supply **up to 500mA to sensors.**

Reduced risk of failure:

If one port becomes disabled because of one of the sensors that's attached to it, the other sensors on the other ports will continue to function. More independent SDI-12 ports means you can reduce the risk of failure by spreading out the sensors among more ports.

More responsive data throughput:

Because each SDI port is independent of the other, the datalogger can drive multiple sets of sensors without having to wait for the first to respond before polling the second, and so on.

Increased reliability for complex systems:

The DCP can issue simultaneous M commands to each port to manage long read-time, high power draw sensors such as side lookers. This allows sensors to collect data concurrently so all the data from the station is from the same time window.

Modular analog expansion:

The SDI-AM analog module permits analog sensor expansion on any of the SDI ports.

H1-R: Rain counter, 2 SDI-12 ports

H1-RS: Rain counter, 2 SDI-12 ports, Integrated solar charge regulator

Axiom H1

Simple hydrology applications where reliability, data integrity and a competitive price are important.

Axiom H2

Simple to complex hydrology or meteorology applications where reliability is paramount and/or the station is very remote.

DCP Comparison Table

ATTRIBUTE	Axiom H1	Axiom H2	Sutron 8310-N w/Satlink2	Sutron Satlink2-V2	Design Analysis H-522+
DISPLAY	Waterproof, daylight-readable, 3.5" color graphical display	Waterproof, daylight-readable, 3.5" color graphical display	40 character (2-line) monochrome LCD	No (optional 40 character monochrome LCD)	20 character monochrome LCD
USER INTERFACE	Graphical touchscreen or PC Software	Graphical touchscreen or PC Software	Basic configuration via 6-button membrane-type key panel; connected laptop for diagnosis, programming and more advanced configuration	None (connected laptop required); optional 6-button key panel	Basic configuration via 7-button key panel; connected laptop for diagnosis, programming, more advanced configuration
FILE TRANSFER (configuration/firmware update, data download)	USB memory stick or PC Software	USB memory stick or PC Software	SD card	Connected laptop	Connected laptop
PROGRAMMING	GUI on integrated touchscreen or GUI on PC	GUI on integrated touchscreen or GUI on PC	BASIC, C++ programming languages	GUI running on connected laptop	GUI running on connected laptop
POWER CONSUMPTION					
STANDBY	7mA	7mA	12mA	8.2mA	10mA
OPERATING - DISPLAY ON	60mA	60mA	73mA	n/a	250mA
OPERATING - DISPLAY OFF	12mA	12mA	up to 33mA	n/a	80mA
TRANSMITTING - 300 BPS	2.6A	2.6A	3.5A	3.1A	2.75A
SENSOR PORT TYPE	Waterproof, military-style bayonet connector	Waterproof, military-style bayonet connector	Unprotected terminal strip	Unprotected terminal strip	Unprotected terminal strip
SDI-12 PORTS					
HOW MANY?	2	4	2	1	1
NUMBER OF SDI-12 BUSES	2	4	1	1	1
ELECTRICALLY ISOLATED?	Yes	Yes	No	No	No
MAX. CURRENT OUTPUT PER PORT	500mA	500mA	100mA max output across all ports	No digital output	1A
ANALOG PORTS	Up to 62 available via modular expansion	1 rain counter, up to 62 available via modular expansion	8	4	6
ENVIRONMENTAL SEALING	NEMA Type 6P (IP67): completely protected against dust and dirt, protected against immersion in water up to 1m.	NEMA Type 6P (IP67): completely protected against dust and dirt, protected against immersion in water up to 1m.	NEMA Type 4 (IP65): Weatherproof (not submersible), must exclude at least 65 GPM of water from 1" nozzle delivered from a distance greater than 10' for 5 min.	None	None
LIGHTNING PROTECTION	3 levels	3 levels	Multistage input protection including spark gaps (analog ports only)	No	No
INTEGRATED SOLAR CHARGE REGULATOR	No (H1-R), Yes (H1-RS)	Yes, sealed in watertight enclosure	Yes	No	No
PC CONNECTION	**RS232 Serial direct connect or BLE wireless**	**RS232 Serial direct connect or BLE wireless**	**RS232 Serial direct connect or BLE wireless**	**RS232 Serial direct connect or BLE wireless**	**RS232 Serial direct connect or BLE wireless**

CANADA 1065 Henry Eng Place | Victoria, BC | V9B 6B2
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**EXTREME ENVIRONMENTS
EXTREMELY RELIABLE**

Management System registered to ISO 9001 QMI-SAI Global

Rev. 2016_10_12_01

Isco 674 Rain Gauge

Connects directly to 6712 and Avalanche™ Samplers, 4200 Flow Meters, and 4100 Flow Loggers

The 674 rain gauge features a precision tipping bucket and 3-point leveling system for easy setup.

The Isco 674 Rain Gauge is a precision instrument that uses a tipping bucket design for rainfall measurement. It has an 8-inch diameter orifice and is factory-calibrated to tip at either 0.01 inch or 0.1 mm of rainfall. With a 674 Rain Gauge connected, an Isco flow meter or sampler will:

- Store rainfall data in internal memory for retrieval and analysis with Isco Flowlink® Software
- Activate sampling based on rainfall
- Plot graphs and print reports of rainfall data on the flow meter's built-in printer

A 674 rain gauge connected to an Isco 6712 or Avalanche sampler is ideal for collecting rainfall data as well as runoff-triggered samples at remote monitoring sites.

Applications

- Stormwater runoff monitoring
- TMDL and Watershed surveys
- Inflow and infiltration studies
- cMOM and CSO/SSO programs (Sewer overflow monitoring and prevention)
- General rainfall measurement

Standard Features

- Three-point leveling and integral bubble level make it easy to align the rain gauge for maximum accuracy.
- Sapphire jewel bearings on the tipping bucket are spring-loaded to prevent damage to the bearings and ensure consistent operation over a wide temperature range.
- Screens cover all openings to prevent leaves, insects, and other debris from clogging the gauge.
- Included 50-foot cable connects directly to compatible Isco flow meters and samplers.

Specifications

Isco 674 Rain Gauge	
Type:	Tipping bucket
Compatible equipment:	Isco 6700, 6712, and Avalanche Samplers, 4200 Series Flow Meters, 4100 Series Flow Loggers
Connect cable:	50 ft. (15.2 m), 2 conductor with 4-pin plug
Bearings:	Spring-loaded sapphire jewel
Orifice Diameter:	8 in. (20 cm)
Sensitivity:	English - 0.01 inch; Metric 0.1 mm
Accuracy:	English - ±1% at 2 in/hour; +3%/-4% up to 5 in/hour Metric - ±1.5% at 5 cm/hour; +3.5%/-9% up to 13 cm/hour
Capacity:	English – 22 inches/hour Metric – 38 cm/hour
Output Signal:	Contact closure of at least 50 millisecond duration
Switch Type:	Hermetically sealed magnetic proximity switch. Normally open, 200V DC, 0.5 A maximum.
Height:	13 in. (33 cm)
Diameter:	9.5 in. (24 cm) (at mounting base)
Weight:	10 lbs. (4.5 kg)
Operating Temperature:	32° to 140°F (0° to 60°C)
Storage Temperature:	-40° to 140°F (-40° to 60°C)

The 674 Rain Gauge connects to any 6700 Series or Avalanche Sampler, 4200 Series Flowmeter, or 4100 Series Flow Logger. Rainfall data logged on the host instrument can be analyzed with Flowlink Software.

Ordering Information

The 674 rain gauge includes a 50 ft (15 m) cable for connection to an Isco 6700, 6712, or Avalanche Sampler, 4200 Series Flow Meter, or 4100 Series Flow Logger. Specify English or Metric version.

Description	Part Number
674 Rain Gauge	
English - Tips every 0.01 inch of rainfall	**60-3284-001**
Metric - Tips every 0.1 mm of rainfall	**68-3280-001**

TELEDYNE ISCO
Everywhereyoulook™

4700 Superior Street
Lincoln NE 68504 USA
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Fax: (402) 465-3022
E-Mail: iscoinfo@teledyne.com
Internet: www.teledyneisco.com

Isco Product Data

Isco 6712 Full-size Portable Sampler

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

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, including:

- Flow-paced sampling with or without wastewater effluent
- stormwater monitoring
- CSO monitoring
- permit compliance
- pretreatment compliance

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.

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

Versatile and Convenient

With eleven bottle choices, Isco's 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).

Tough and Reliable

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.

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.

Specifications

Isco 6712 Full-size Portable Sampler	
Size (Height x Diameter):	27 x 20 inches (50.7 x 68.6 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 V DC (Supplied by battery or AC power converter.)
Pump	
Intake suction tubing: Length Material Inside dimension	 3 to 99 feet (1 to 30 m) Vinyl or Teflon 3/8 inch (1 cm)
Pump tubing life:	Typically 1,000,000 pump counts
Maximum lift:	28 feet (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) 10 ft. (3.1 m) 15 ft. (4.6 m)	 3.0 ft./s (0.91 m/s) 2.9 ft./s (0.87 m/s) 2.7 ft./s (0.83 m/s)
Liquid presence detector:	Non-wetted, non-conductive sensor detects when liquid sample reaches the pump to automatically compensate for changes in head heights.

Controller	
Weight:	13 lbs. (5.9 kg)
Size (HxWxD)	10.3 x 12.5 x 10 inches (26 x 31.7 x 25.4 cm)
Operational 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.
Clock Accuracy:	1 minute per month, typical, for real time clock
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 9,990 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

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 Isco, or your Isco representative for pricing and additional information.*

Description	Part Number
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**

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

TELEDYNE ISCO
Everywhereyoulook™

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Lincoln NE 68504 USA
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USA and Canada: (800) 228-4373
Fax: (402) 465-3022
E-Mail: iscoinfo@teledyne.com
Internet: www.teledyneisco.com

Technical Data

OTT PLS - Pressure Level Sensor

Robust ceramic pressure transducer for water level measurement

- Application
  Surface water, Groundwater
- Measurement technology
  Vented pressure cell
- Parameters measured
  Water level, Pressure, Temperature
- Product Highlights
  Water level and temperature measurement - for use with external data logger
- Measurement range
  0 ... 4, 10, 20, 40, and 100 m
- Accuracy
  ± 0.05% FS
- Internal data logger
  No
- Interface
  SDI-12, RS-485 (using SDI-12), or 4 ... 20 mA

The OTT PLS measures water level, depth to water, or pressure by means of an integrated controller and ceramic pressure-measuring cell. Design features such as multiple communication outputs (SDI-12 or 4 ... 20 mA), stainless steel housing, and a rugged cable make this sensor ideal for monitoring water level in a variety of applications.

Water level measurement	
Measurement range	0 ... 4 m, 10 m, 20 m, 40 m, 100 m

Accuracy	
SDI-12	±0.05 % FS (linearity and hysteresis)
4 ... 20 mA	±0.1 % FS (linearity and hysteresis) 10 ppm/°C at 20 °C
Resolution (SDI-12)	0.001 m; 0.1 cm; 0.01 ft; 0.1 mbar; 0.001 psi
Temperature compensated working range	-5 °C ... +45 °C (ice-free)

Temperature measurement	-25 °C ... +70 °C (ice-free)
Resolution	0.1 °C / 0.1 °F
Accuracy	±0.5 °C / ±0.9 °F

Electrical data	
Available interfaces (use as required)	4 ... 20 mA, SDI-12, RS485 (via SDI-12 protocol)
Supply voltage	+9.6 ... +28 V DC, typically 12/24 V DC

Power consumption (SDI-12)	
Sleep	<600 µA
Active	<3.6 mA

Pressure sensor	(capacitive pressure sensor) ceramic, temperature compensated, overload safe for up to 5 times the measuring range without permanent mechanical damage

Temperature sensor	NTC

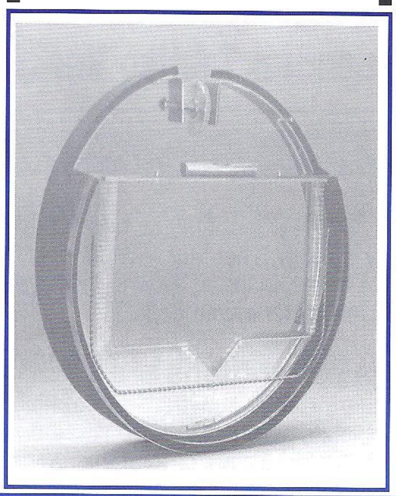
Dimensions	195 mm x 22 mm
Weight	approx. 0.3 kg

Environmental conditions	
Operating temperature	-25 ... +70 °C
Storage temperature	-40 ... +85 °C

Materials	
Housing	stainless steel 1.4539 (904L) resistant to sea water
Seals	Viton
Cable jacket	PUR
Protection type	IP68
Mechanical Strength	meets the mechanical shock tests of IEC 68-2-32

EMC limits	CE conformity; EN 61000-4-2/3/4/5/6 and EN 61000-6-3 Class B are adhered to

Volumetric Weir for Measuring Flows in Manholes and Open End Pipe

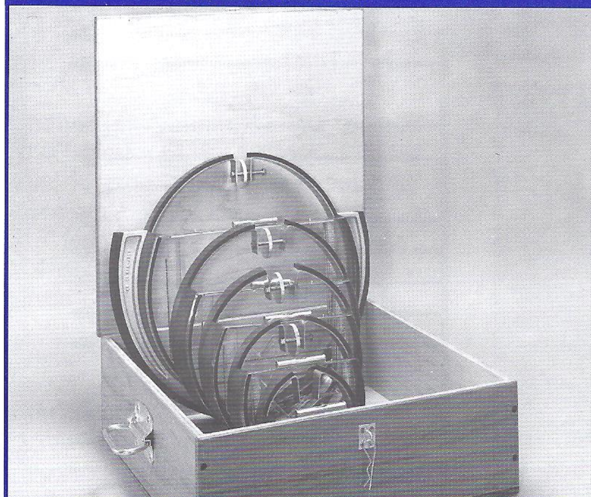


The Most Accurate Portable Flow Measuring Device Available

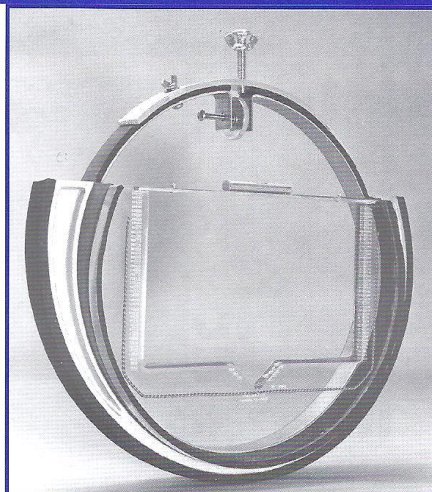
THEL-MAR COMPANY

Post Office Box 1529 • Brevard, North Carolina 28712
(828) 883-8908 • Fax: (828) 883-8908
TOLL FREE 1- 800-322-WEIR (9347)

WEIR SET



15" WEIR WITH 18" ADAPTOR



The Most Practical, Economical Instrument for Testing New Sewer Lines

A volumetric calibrated weir is a portable flow measuring device that is used to determine infiltration in newly installed sewer lines, or measure substantial flows in existing lines.

The Thel-Mar volumetric weir is basically a compound weir that incorporates the advantage of a 90° v-notch for measuring small infiltration flow where accuracy is of prime importance. The v-notch section measures from 57 gallons to 3700 gallons per 24 hours, which is the range of normal acceptance test requirements. The rectangular section of the weir is capable of measuring in gallons per day up to 35% of pipe capacity.

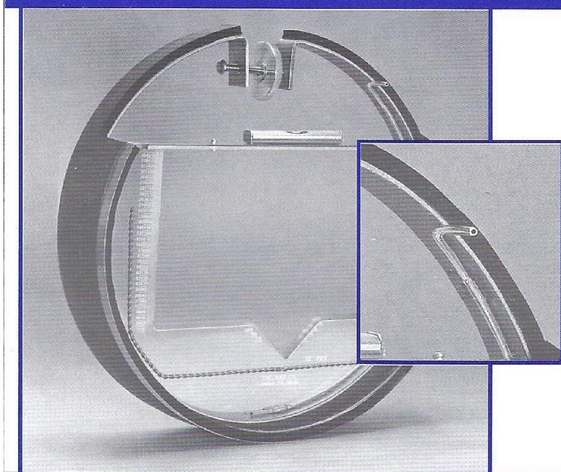
A bubble level is mounted at the top of the weir's face plate for easy visibility. Thel-Mar weirs are calibrated in U.S. gallons per 24 hours in large, easy to read type. Calibration lines are in 2 millimeter increments.

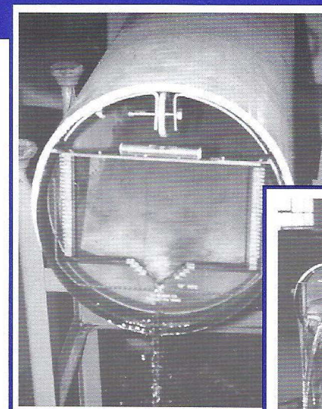
Discharge calibrations for the Volumetric Weir were accurately determined in a hydraulic laboratory where manhole conditions were duplicated. Therefore, there are no induced errors by insufficient drop of the nappe or by contractions, velocity of approach, submergency, or drawdown.

Rugged Construction and noncorroding materials make the Thel-Mar weir extremely reliable. There are no loose parts that require assembly. Installation is quick and positive and the weir requires a minimum of care.

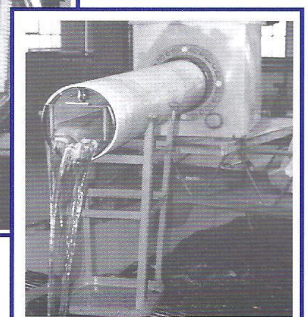
Easy to read flow rate
Simply check water level at the face plate. The figure above the line matching the water level gives you the rate of flow in gallons per 24 hours.

WEIR WITH BUBBLER TUBE





University Tested



Lehigh University Lab Photos

- Night Flow Studies of Existing Lines - Free Flow From Open Pipe.

A compound Weir offers minimum restriction to flow and is relatively free from becoming clogged by debris from sewage. **Thel-Mar Weirs** can be installed for extended periods of time without accumulation of sediment.

Errors in excess of 100% exist in other calibrated V-notch weirs.

Unlike the Thel-Mar weir these were calibrated by the Cone formula.

Bubbler Flow Meters

Especially designed for use with Bubbler Flow meters, all Volumetric Weirs are now available with an attached "Bubbler Tube". These weirs are manufactured with a ⅛-inch O.D. stainless steel tube attached to the right side of the adjustable ring. The bubbler tube protrudes forward approximately two inches from near the top of the ring for easy connection to a line. It runs for there down the inside of the ring to the center bottom approximately 1⅜-inch behind and below the V-notch. This bubbler tube does not in any way affect the function of the Volumetric Weir.

Installation Instructions

Prior to installation, the interior edge of the incoming pipe should be cleaned of sediment and foreign matter to assure seal of the gasket.

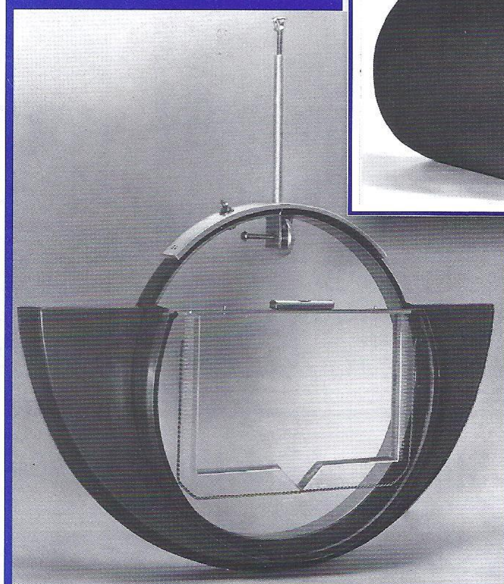
Turn thumb-wheel to extreme right. Place hand through weir opening, with thumb and index finger compress spring. Insert weir into incoming pipe about 1", adjust for leveling, press down and release tension from spring. Secure by turning thumb-wheel to left and finger tighten.

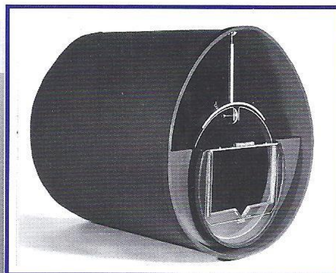
Allow sufficient time for water to back up behind the weir and establish a uniform flow; five to ten minutes for existing flow to an hour for accurate infiltration readings.

15" Weir with adaptor installed in 24" pipe

Individual Volumetric Weirs are available for 6", 8", 10", 12", 14", 15" and 16" pipe. The 14" weir uses a 12" face plate, while the 16" weir uses a 15" face plate. Adaptors for 18", 21", 24", 27", 30", 36", 42" and 48" pipe are used in conjunction with the 15" weir.

Volumetric Weirs are also available in sets.
Set A consists of 6", 8", 10", 12" and 15" weirs with an 18" adaptor **without a storage case.**





Set B is the same as set A, but has Bubbler Tubes Attached to the weirs.

Set C consists of 21" through 48" adaptors **without a storage case.**

Adaptors are available individually or in sets.

WEIR CAPACITIES AND HEAD

Capacities*			Head**
6"	57 to 3700 GPD within V-notch,	rectangular to 46,000 GPD	2.8437
8"	57 to 3700 GPD within V-notch,	rectangular to 124,000 GPD	4.0000
10"	57 to 3700 GPD within V-notch,	rectangular to 234,000 GPD	5.1250
12"	57 to 3700 GPD within V-notch,	rectangular to 361,000 GPD	5.8125
14"	57 to 3700 GPD within V-notch,	rectangular to 361,000 GPD	5.8125
15"	57 to 3700 GPD within V-notch,	rectangular to 620,000 GPD	7.3125
16"	57 to 3700 GPD within V-notch,	rectangular to 620,000 GPD	7.3125

*Calibration lines are in 2 millimeter increments
**In inches from top of rectangular opening to bottom of V-notch

Metric Flow Conversion Charts Available

Telemetry Specifications

PRODUCT OVERVIEW

Ubicom

Rugged, reliable communications anywhere on the globe

For customers who require reliable data access from remote locations, Ubicom delivers bidirectional communications, and gives you the freedom to remotely interact with your Axiom DCP. A choice of integrated communications – Iridium or cellular 4G or both - allows you to transfer the data you want, when you want it and ensures critical information is available anywhere on the globe.

- Rugged, reliable, all-in-one (modem + antenna) IP66 rated product
- Remote by design, brought to you by the people who make the Axiom DCP
- Low power consumption 1/2 that of standard modems

UNIQUE ALL-IN-ONE DESIGN. SIMPLE INSTALLATION. RELIABLE OPERATION.

The transceiver integrates all electronics, antennas and antenna cables into a single device.

INTEGRATED GPS PROVIDES LOCATION AWARENESS.

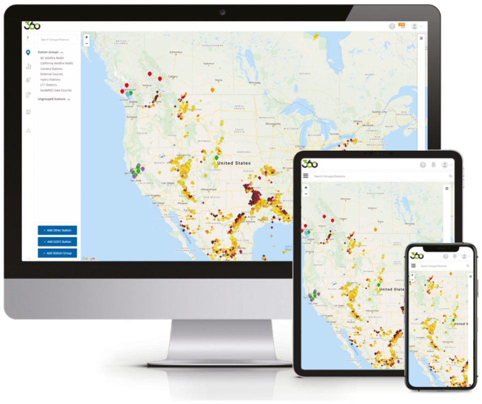
Always know the location of the Axiom DCP (fixed or portable).

CHOICE OF INTEGRATED COMMUNICATIONS.

Iridium OR Cellular 4G OR both. Locally or remotely switch between communication methods.

Detailed Specifications

COMPONENTS	
Height	189 mm (7.45")
Diameter at widest point	90 mm (3.55")
Weight	403 g (0.89 lbs)
Operating temperature range	-30°C to +60°C (-22ºF to 140ºF)
Storage temperature range	-40°C to +85°C (-40ºF to 185ºF)
Humidity	1 - 100% RH
Dust and water ingress	IP66
Input voltage	9 - 16VDC
GPS acquisition time	Hot 1 sec; cold < 35 sec
GPS accuracy	2.5 m (Horizontal CEP)
Certifications	FCC, RCM
Coverage	Global
Telemetry	Iridium Satellite (SBD) Cellular 4G Hybrid Iridium Satellite + Cellular 4G
Avg. power consumption	250 mA (send), 28 mA (receive)
Sleep mode (cannot send/receive)	< 5 mA
What's included	• 5 meter cable • Mounting phlange



FTS360

Powerful and easy-to-use, FTS360 allows you to view, organize and control your stations and sensors from any device.

KEY FEATURES:

- Visualize and download data using our secure cloud-based software
- Provides remote bi-directional communication
- Re-arrange data into internationally accepted formats like METAR

Appendix E. Field Data Collection Forms

Storm Decision Log

Storm Decision Log				
Current Date	**Forecasted Storm Date**	**Qualifying Event Probability**	**Sample? (Y/N)**	**Notes**

Periodic Maintenance Checklist

Periodic Maintenance Checklist	
Field Staff Names:	Date:
	Time:
Apon arrival to site, note any indication of damage/tampering to monitoring site or surrounding area:	
Any indication of damage/tampering during site visit (pipes, cables, wiring, cords, tubing, monitoring equipment):	
Maintenance Activities	**Notes**
Debris/Obstruction removal from piping	
Debris removed? **Y/N**	
Check voltage of battery. Voltage should be above 10.3V. If not, replace battery.	
Measured voltage:	
USB inserted and site visit start on data logger	
Site visit started? **Y/N**	
Rain gage internal part cleanliness and level (annually unless precipitation depth differences are noted at NOAA gage)	
Debris removed? **Y/N** Reset level of gage? **Y/N**	
ISCO head tubing check	
Tubing replaced? **Y/N** Tubing rinsed? **Y/N**	

Periodic Maintenance Checklist	
ISCO pump tubing check	
Tubing replaced? **Y/N** Tubing rinsed? **Y/N**	
ISCO suction tubing check	
Tubing replaced? **Y/N** Tubing rinsed? **Y/N**	
ISCO Internal Humidity Indicator check	
Indicator Color and Percent: Desiccant replaced? **Y/N**	
PT #1 Humidity Indicator Check	
Indicator Color: Desiccant replaced? **Y/N**	
PT #2 Humidity Indicator Check	
Indicator Color: Desiccant replaced? **Y/N**	
PT #3 Humidity Indicator Check	
Indicator Color: Desiccant replaced? **Y/N**	
Deflate ISCO controller pad (as needed)	
ISCO controller pad deflated? **Y/N**	
ISCO pump capabilities	
Tested purging and pumping capabilities? **Y/N**	
ISCO volumetric verification (performed quarterly)	
Service needed? **Y/N**	

Periodic Maintenance Checklist	
Weirs and pipe tees are level	
Weir was unlevel? **Y/N** Pipe tees was unlevel? **Y/N**	
Pressure transducers and mounts cleanliness	
Pressure transducer cleaned? **Y/N** Mount cleaned? **Y/N**	
Pressure transducer is working and recording correctly	
Data logger is reading zero? **Y/N** Water elevation is zero? **Y/N**	
pH meter electrode	
Electrode stem replaced? **Y/N** Electrode blub replaced? **Y/N**	
pH meter cable connecting to electrode	
Breaks present in cable? **Y/N**	
pH meter clean on oil, calcium, or sediment on electrode stem or bulb	
Probe cleaned with DI water? **Y/N** Protective cap replaced? **Y/N**	
pH meter connectors clean and protective cap full of solution	
Connectors clean and dry? **Y/N** Storage solution filled? **Y/N**	
pH meter probe clean	
Soak the probe? **Y/N** Protective cap replaced & solution discard? **Y/N**	
Rinsate blanks prepared (initial setup, following first or second storm event, end of study)	
Rinsate blanks prepared? **Y/N**	

Measuring and Balancing Flows Between Cells

Measuring and Balancing Flows Between Cells						
Flow meter 1			**Flow meter 2**			**Compare Flows**
Date and time	**Flow (ft3/s)**	**Level (in)**	**Date and time**	**Flow (ft3/s)**	**Level (in)**	**%Diff**

Pre-Storm Event Maintenance Checklist

Pre-Storm Maintenance Checklist	
Field Staff Names:	Date:
	Time:
Any indication of damage/tampering during site inspection (surrounding area, pipes, cables, wiring, cords, tubing, monitoring equipment):	

Maintenance Activities	Activity Completed (circle text as appropriate)?			Notes:
Start site visit on data logger	Site visit started? **Y/N**			
Debris/Obstruction removal from piping	Debris removed? **Y/N**			
ISCO head tubing check	Tubing rinsed? **Y/N**		Tubing replaced? **Y/N**	
ISCO pump tubing check	Tubing rinsed? **Y/N**		Tubing replaced? **Y/N**	
ISCO suction tubing check	Tubing rinsed? **Y/N**		Tubing replaced? **Y/N**	
Place sample bottles, ice in ISCOs	Sample bottles and ice placed? **Y/N**			
Data logger set to sample	Data logger set? **Y/N**			
ISCOs set to sample	ISCOs set? **Y/N**			
Set threshold on data logger	Threshold Value:			
End site visit on data logger	Site visit ended? **Y/N**			
Calibrate pH meter	Calibration complete? **Y/N**			
	pH:	7		
		4		
		10		
	Conductivity:			
	Dissolved Oxygen:			

Water Quality Sample Collection Form

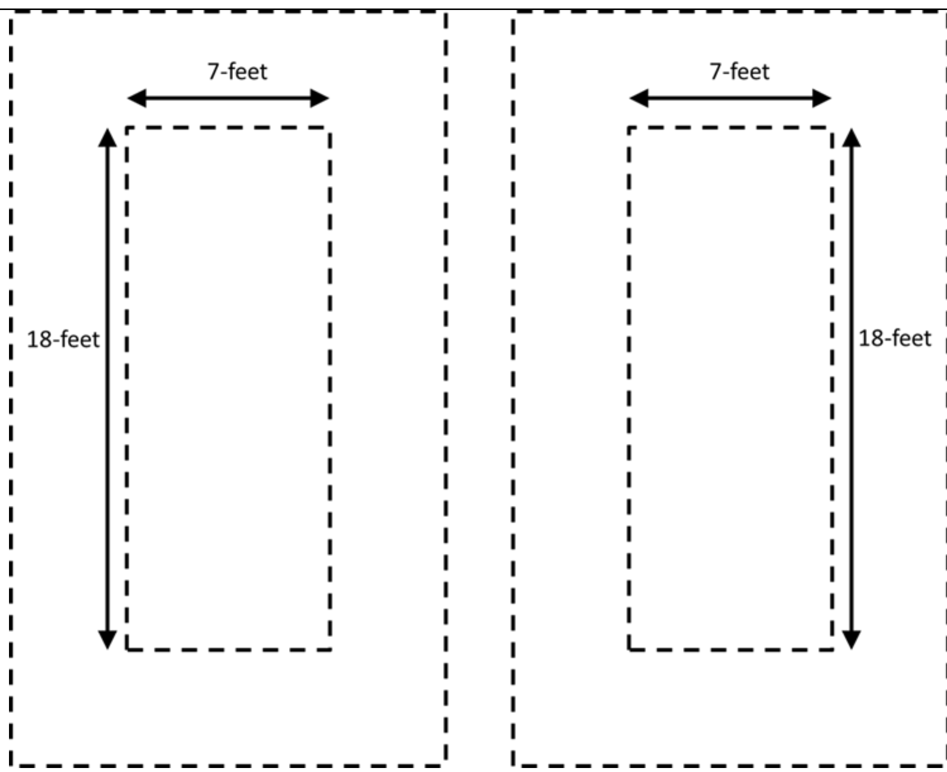
Composite Sample - Water Quality Collection Form		
Field Staff Names:		Date:
		Time:
Sample ID:		Weather Observation:
Qualify Storm event?		Yes No
Sampling Equipment Condition Notes:		
pH:		
Stormwater Samples Collected		
Influent	**Effluent**	**Parameter**
☐	☐	Total Suspended Solids (TSS)
☐	☐	Dissolved & Total Metals (Zn, Cu)
☐	☐	Hardness as CaCO3
☐	☐	Ortho-phosphate (OP)
☐	☐	Total Phosphorus (TP)
☐	☐	Total Kjeldahl Nitrogen (TKN)[1]
☐	☐	Nitrate-Nitrite[1]
☐	☐	Particle Size Distribution (PSD)[1]
QC Samples Collected		
☐		Rinsate Blank
☐		Field Duplicate
Comments:		

[1] *Denotes screening parameters that are only collected three times during the study. All other parameters are collected during each sampling event.*

Grab Sample – Waer Quality Collection Form		
Field Staff Names:	Date:	
	Time:	
Sample ID:	Weather Observation:	
Qualify Storm event? Yes No		
Sampling Equipment Condition Notes:		
Start visit on data logger Yes No		
Grab Samples from Influent		
Influent	**Effluent**	**Parameter**
☐	☐	E.coli
☐	☐	Fecal Coliform
QC Samples Collected		
Influent	**Effluent**	
☐	☐	Rinsate Blank
☐	☐	Field Duplicate
Comments:		

BSM Sample Collection Form

BSM Sample Collection Form	
Field Staff Names:	Date:
	Time:
	Weather Observation:
Qualify Storm event? Yes No	
Sampling Equipment Condition Notes:	
Chain of Custody Sample ID	**BSM Samples Collected**
	1. 60:40 cell southern sample
	2. 60:40 cell northern sample
	3. HPBSM cell primary layer southern sample
	4. HPBSM cell primary layer northern sample
	5. HPBSM cell polishing layer southern sample
	6. HPBSM cell polishing layer northern sample
On the figure below, indicate by number where each sample was collected. Include dimensions from the edge of the pond bottom.	
Comments:	



Monitoring Data Download Checklist

Monitoring Data Download Form	
Field Staff Names:	Date: Time:
Any indication of damage/tampering during site inspection (surrounding area, pipes, cables, wiring, cords, tubing, monitoring equipment):	
Monitoring data covering the entire qualifying storm event and antecedent and post-storm periods was downloaded.	☐
Review data to verify qualifying conditions are met:	☐
Minimum precipitation depth greater than 0.10-inches?	☐
Storm duration exceeded 1 hour?	☐
Composite samples captured from a minimum of 10 aliquots for the influent and both effluent samples?	☐
Aliquots were collected from 75% of the storm hydrograph?	☐

Failing Head Test Field Form

Falling Head Test Form

Field Staff Names:	Date:
	Time:

Any indication of damage/tampering during site inspection (surrounding area, pipes, cables, wiring, cords, tubing, monitoring equipment):
Were two yard sticks installed in each cell, located in the middle of the 7-foot width, with 1/3 at each end of the 18-foot length? Y/N
The yard sticks are level and secure so they will not move during testing? Y/N

Time when fire hose is turned on		Time when water level in pond reaches 12 inches	

Check BSM for saturated conditions – To determine whether the media is saturated, record the effluent flow rates from the data logger readings every 5 minutes. Assume the media is saturated if the flow rates are within 10% of each other. If needed use the fire hose to fill the water level in the cells back up so there is 12 inches of water in the cells.

Trial #	60:40 Flow Rate	HPBSM Flow Rate	60:40 %Diff	HPBSM %Diff	Trial #	60:40 Flow Rate	HPBSM Flow Rate	60:40 %Diff	HPBSM %Diff

Falling Head Test Form									
Time when fire hose is turned on					Time when water level in pond reaches 12 inches				
Trial #	H_1 (inches)	H_2 (inches)	ΔH (inches)	Time (seconds)	ΔTime (seconds)	A_1 (square ft)	A_2 (square ft)	K_Sat (in/hr)	%Diff K_sat

$$K_{sat} = \frac{A_1}{A_2} X \frac{L}{\Delta Time} ln \frac{H_1}{H_2}$$

Where:

- H1 = initial ponded water depth above the top of the cell (inches)
- H2 = final ponded water depth above the top of the cell for time interval (inches)
- Time = cumulative time for water to fall from Ho to Hi (seconds)
- ΔTime = time interval for water to fall from Ho to Hi (seconds)
- L = depth of BSM (inches)
- A1 = cell surface area at H1 (sqft)
- A2 = cell surface area at H2 (sqft)
- L = depth of BSM (inches)

Operations and Maintenance Inspection Checklist

Operations and Maintenance Inspection Checklist

Date:

Field Staff Name:

Field Site Location:

Temperature (F°):

Quantity of last rainfall (in.):

Weather Conditions:

Rainfall measurement location:

Time since last rainfall (hr.):

Based on the visual assessment of the site, answer the following questions and document each section with pictures. Once the visual assessment is done, note in the appropriate table below what maintenance actions were taken. For further instructions, refer to **Section 6.1.9 Operations and Maintenance Observations** in the TAPE QAPP.

1. When was the last inspection performed at this test site? Date:

2. Has it rained within the last 48 hours at this location? □ Yes □ No □ I don't know

3. Inlets:

   a. Are any of the inlet structures clogged (obstruction is covering 1" of inlet openings)? Use the table box to make note of the material and severity of the clogging. (sediment, vegetation, debris, etc.) as well as any maintenance suggestions and when maintenance is recommended.

   b. □ Photo documentation taken.

	Inlet # 1 Parking Lot Catch Basin Pipe	**Inlet # 2 Flow Splitter Catch Basin**	**Inlet # 3 Inlet pipe to HPBSM**	**Inlet # 4 Inlet pipe to 60:40 cell**
Blockage Severity (Partial, Complete, Not Applicable)				
Maintenance Actions Including Frequency				

4. Sediment Accumulation on top of gravel:
    a. Are there indications of any of the following?

        □ Flow above the surface of rock during the water quality or small storm event

        □ Sediment visible on top or in the gravel, i.e., spaces between the gravel

        □ Vegetation growth on top of the gravel

    b. If any boxes are checked above, confirm maintenance recommendation was completed and when in the table below.
    c. □ Photo documentation taken.

Condition when Maintenance is Needed:	**Recommended Maintenance:**	**Notes:**	**Date Completed:**
Flow above the surface of rock during the water quality or small storm event	Remove Sediment and Treatment Rock Layer around the indicator or throughout the bioretention cell as applicable		
Vegetation is growing in the bioretention cell	Remove vegetation, remove and clean rock, and replace rock to match original rock gradations and depth		
Additional maintenance:			

5. Standing Water:
    a. Is water draining freely between storms? □ Yes □ No □ I don't know
    b. If checked no, confirm maintenance recommendation was completed and when in the table below.
    c. □ Photo documentation taken.

Condition when Maintenance is Needed:	Recommended Maintenance:	Notes:	Date Completed:
When water stands in the bioretention cell between storms and does not drain freely	Check the outlet of the bioretention cell of for any debris or blockage		
	Verify the bioretention cell bottom is infiltrating		
Additional maintenance:			

6. Vegetation

    a. Have grass or weeds become visually present in bioretention cells? □ Yes □ No □ I don't know.

    b. If checked yes, confirm maintenance recommendation was completed and when in the table below.

    c. □ Photo documentation taken.

Condition when Maintenance is Needed:	Recommended Maintenance:	Notes:	Date Completed:
When any vegetation becomes visually present	Remove vegetation and sediment		
Check treatment rock layer for sediment build-up below the surface by removing rock down to the pea gravel and/or down to the subsoil	If sediment is found in the rock, remove the affected rock and replace it with the new clean rock to match the original rock gradations depth		
Additional Maintenance:			

7. Trash and Debris Accumulation
    a. Include in the table below:

        □ Where trash or debris was found and if it was blocking a pipe or any part of the monitoring equipment.

        □ Confirm the maintenance recommendation was completed if necessary and note the date the maintenance took place.

    b. □ Photo documentation taken.

    c. Was the blockage in a pipe, near the monitoring equipment, or in a location where it travel through the monitoring equipment?

        □ Circle one: Yes/No/Uncertain

        □ If yes

        - Rate the blockage severity as: completely/partially/not applicable.
        - Describe what equipment might be impacted

Condition when Maintenance is Needed:	**Recommended Maintenance:**	**Notes:**	**Date Completed:**
When Trash and debris accumulated in the pipes, bioretention cell, or structures	Remove trash and debris.		
Additional Maintenance:			

8. Erosion/Scouring

   a. Include in the table below:

      □ Erosion and/or Scouring observed in the bioretention cell.

      □ Confirm the maintenance recommendation was completed if necessary and note the date the maintenance took place.

      □ Photo documentation taken.

Condition when Maintenance is Needed:	Recommended Maintenance:	Notes:	Date Completed:
Eroded or scoured bioretention cell bottom due to flow channelization or higher flows	For ruts <12 inches wide, repair the damaged area by replacing it with the applicable rock gradation. If ruts are large, 12 inches wide, the bioretention cell should be regraded in the area.		
	Consider increasing the size of/adding a layer of 2.5" coarse cobbles at a depth of 2.5 inches on top of the existing rock if erosion or scouring occurred during a flow 25-year or small event.		
Additional Notes:			

Summary of Inspection and Maintenance completed:

Quality Assurance Worksheet

Parameter	Method	Chain-of-Custody Issues?	Completeness/ Methodology	Holding Times (days)				Cooler Temp. (C°)	Rinsate Blanks (mg/L)		Matrix Spikes/Surrogate Recovery (%)		Lab Control Samples Recovery (%)		Lab Duplicates RPD (%)		Influent Field Duplicates RPD (%)		60:40 BSM Effluent Field Duplicate RPD (%)		HPBSM Effluent Field Duplicate RPD (%)		Flagged	Action/ Notes
				Date Collected	Date Analyzed	Reported	Goal		Results	RL	Reported	Goal	Reported	Goal	RPD	RPD limit	Reported	Goal	Reported	Goal	Reported	Goal	Y/N	
pH	EPA Method 150.2						**NA**			0.2 units		NA		NA		NA		≤10%		≤10%		≤10%		
Total Suspended Solids (TSS)	SM 2540D						7 days			1.0 mg/L		NA		80-120		NA		≤20%		≤20%		≤20%		
Dissolved Copper (Cu) & Zinc (Zn)	EPA 200.8 (ICP/Ms)						6 months			0.5 mg/L 5.0 mg/L		75-125		70-130		1/ batch		≤20%		≤20%		≤20%		
Total Copper (Cu) & Zinc (Zn)							6 months			0.5 mg/L 5.0 mg/L		75-125		70-130		1/ batch		≤20%		≤20%		≤20%		
Hardness as CaCO3	SM 2340B (ICP)						6 months			1.0 mg/L		75-125		70-130		1/ batch		≤20%		≤20%		≤20%		
Ortho-phosphate (OP)	SM 4500-P G						2 days			0.01 mg/L		75-125		80-120		1/ batch		≤20%		≤20%		≤20%		
Total Phosphorus (TP)	SM 4500-P F						28 days			0.01 mg/L		75-125		80-120		1/ batch		≤20%		≤20%		≤20%		
Nitrate-Nitrite	SM 4500 -NO3 F						28 days			0.01 mg/L		75-125		80-120		1/ batch		≤20%		≤20%		≤20%		
Total Kjeldahl nitrogen (TKN)	SM 4500 Norg-D						28 days			0.5 mg/L		75-125		80-120		1/ batch		≤20%		≤20%		≤20%		
Fecal Coliform	SM 9222D						8 hours			1 CFU/ 100 ml		NA		NA		1/ batch		≤20%		≤20%		≤20%		
E. Coli	SM 9223B						8 hours			1 CFU/ 100 ml		NA		NA		1/ batch		≤20%		≤20%		≤20%		
PSD, Influent	ASTM D3977						NA			NA		NA		NA		NA		≤20%		≤20%		≤20%		

Parameter	Method	Chain-of-Custody Issues?	Completeness/ Methodology			Holding Times (days)		Cooler Temperature (C◦)	Rinsate Blanks (mg/L)		Matrix Spikes/Surrogate Recovery (%)		Lab Control Samples Recovery (%)		Lab Duplicates RPD (%)		Influent Field Duplicates RPD (%)		Effluent Field Duplicate RPD (%)				Flagged	Action/ Notes
				Date Collected	Date Analyzed	Reported	Goal		Results	Reporting Limit	Reported	Goal	Reported	Goal	Reported	Goal	Reported	Goal	Reported	Goal	Reported	Goal		
Cation Exchange Capacity	S-10.10						NA			NA		NA		NA		NA		NA		NA		NA		
Saturated Hydraulic Conductivity	Modified ASTM D2434 (Ecology 2014a)						NA			NA		NA		NA		NA		NA		NA		NA		
Particle Size Distribution	ASTM D422						NA			NA		NA		NA		NA		NA		NA		NA		
Total Elements (Zn and Cu)	EPA 3050A/6010B						NA			NA		NA		NA		NA		NA		NA		NA		
Organic Matter Content	ASTM D2974 or TMECC 5.07A						NA			NA		NA		NA		NA		NA		NA		NA		

Final Audit Form

Audit Form		
Standard Operating Procedure (SOP)	**Actions Compliant with SOPs?**	**Comments:**
Storm Selection and Tracking	**Overall SOP audit notes:**	
Storm tracked in storm decision log		
Field staff contacted (as applicable)		
Laboratory contacted (as applicable)		
Storm Monitoring Equipment Maintenance	**Overall SOP audit notes:**	
General inspection of site, manhole, catch basin, and vault		
Inspection and/or cleaning of pipes, tees, weirs		
Battery voltage check		
Rain gage check (as applicable)		
Visit report started		
ISCO tubing inspection and/or replacement		
ISCO internal humidity indicator check		
Pressure transducer humidity absorbing system check		
Check whether weirs are level		
Inspection and/or cleaning of pressure transducers, mounts		
ISCO internal pressure check (indicated by keypad inflation)		
ISCO pump capabilities check		
ISCO volumetric verification check		
Visit report ended		
Equipment secured prior to leaving site		
pH meter maintenance		
Preparing Stormwater Monitoring Equipment for Storm Sampling	**Overall SOP audit notes:**	
General inspection of site, manhole, catch basin, and vault		
Visit report started		
Inspection and/or cleaning of pipes, tees, weirs		
ISCO tubing inspection and cleaning (replace if needed)		
Check and/or secure ISCO tubing, caps, and cable connections		
Data logger and ISCO set to sample; threshold set		

Audit Form		
Visit report ended		
Equipment secured prior to leaving site		
pH meter calibration		
Stormwater Sample Collection and Processing	**Overall SOP audit notes:**	
Check whether sampling has been disabled		
Visual verification of aliquots collected		
pH measurement		
Stormwater grab sample collection		
Stormwater composite sample collection		
Filtration for dissolved metals, orthophosphate samples performed as needed		
Sample bottles labeled		
COC filled out		
Monitoring Equipment Download	**Overall SOP audit notes:**	
Data downloaded covers entire event, antecedent dry period, and post-storm dry period		
Confirmed qualifying conditions prior to submitting samples to the lab for analysis		
Falling Head Test	**Overall SOP audit notes:**	
Fill bioretention cells to 12" of water		
Infiltration rate measurements are stable (less than 10% different for 3 intervals)		
Refill bioretention cells to 12" of water		
Time water level to drop 1 inch until Ksat is stable (less than 10% different for 3 intervals)		
Operations and Maintenance Observations	**Overall SOP audit notes:**	
Inspection observations recorded on form		
Maintenance actions recorded on form		
BSM Sample Collection	**Overall SOP audit notes:**	
Samples collected from northern end and southern end of each cell		
Samples collected from the full depth of media		
Each sample is place in separate containers		
Sample containers labeled		
COC filled out		

Training Completion Log

Training Completion Log		
Standard Operating Procedures	**Employee**	**Date**
6.1.1 Procedures for Storm Selection and Tracking		
6.1.2 Procedures for Storm Monitoring Equipment Maintenance		
6.1.3 Procedure for Preparing, Measuring, and Balancing Flow Between Cells		
6.1.4 Procedure for Preparing, Measuring, and Balancing Between Cells		
6.1.5 Stormwater Grab Sampling		
6.1.6 Procedure for Composite Stormwater Sample Collection and Processing		
6.1.7 Procedure for Composite Stormwater Sample Collection and Processing		
6.1.8 Procedure to Preform Falling Head Test		
6.1.9 Operation and Maintenance Observation		
6.1.10 Procedure for BSM sample collection		

Appendix F. Chain of Custody Forms

ANATEK LABS

Chain of Custody Record

Anatek Labs, Inc.
1282 Alturas Drive, Moscow ID 83843 (208) 883-2839
504 E Sprague Ste D, Spokane WA 99202 (509) 838-3999

Company Name:	Project Manager:	**Turn Around Time & Reporting**
Address:	Project Name & #:	Please refer to our normal turn around times at www.anateklabs.com/pricing-lists
City: State: Zip:	Purchase Order #:	__Normal __Next Day* __2nd Day* __Other* __Phone __Email
Phone:	Sampler Name & Phone:	*All rush order requests must have prior approval
Email Address(es):		

Lab ID	Sample Identification	Sampling Date/Time	Matrix	List Analyses Requested: Preservative: # of Containers	Sample Volume											Note Special Instructions/Comments

Inspection Checklist

Received Intact?	Y	N
Labels & Chains Agree?	Y	N
Containers Sealed?	Y	N
No VOC Head Space?	Y	N
Cooler?	Y	N
Ice/Ice Packs Present?	Y	N

Temperature (°C):________________
Number of Containers:________________
Shipped Via:________________
Preservative:________________

Date & Time:________________
Inspected By:________________

	Printed Name	Signature	Company	Date	Time
Relinquished by					
Received by					
Relinquished by					
Received by					
Relinquished by					
Received by					

Samples submitted to Anatek Labs may be subcontacted to other accredited labs if necessary. This message serves as notice of this possibility. Subcontracted analyses will be clearly noted on the analytical report.

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soiltest
farm consultants, inc.

Laboratory Chain of Custody

Client: Please fill out:	Copy of report sent to:	Job #/ Name
Company:	Company:	Payment Method: Credit Card ___ Est. Acct. ___
Contact:	Contact:	
Address:	Address:	
City, ST, Zip.:	City, ST, Zip.:	
Telephone:	Telephone:	
Fax:	Fax:	
e mail:	e mail:	

			Requested Tests		Tests required	Tests required	Tests required	Tests required	Lab Use Only	
Sample Identification	Date Sampled	Sample Matrix			Other 1	Other 2	Other 3	Other 4	Sample Condition	LAB ID
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										

Releasing	Receiving	Date	Time
Releasing Signature 1	Receiving Signature 1		
Releasing Signature 2	Receiving Signature 2		
Releasing Signature 3	Receiving Signature 3		

Submission of samples to Laboratory with a Chain of Custody constitutes a contract for services requested. Provide payment detail with each COC. If no payment information is provided, you will be contacted by the laboratory. We will make every effort to provide an accurate analysis of this sample. For reasonable cause, we will repeat the tests, but because of factors beyond our control, in sampling procedures and inherent sample variability in compost, soils and plants, our liability is limited to the price of the tests.

CONCOR/ETS
ENVIRON TECH SERV
975 Transport Way, Suite 2
Petaluma, CA 94954

CHAIN OF CUSTODY – E T S

Client:	Delivery by: Site/Location:	Job #:

Sample ID	# of Containers	Container Size	Transfer to:	Description	Analysis

Record of Transfer

Sample Sequence	Transfer # 1	2	3	4	5	6	7
1							
2							
3							
4							
5							
6							
7							

#	Received by:	Date	Time
1			
2			
3			
4			
5			
6			

Client Representative: Signature: Date:

Received by: Signature: Date:

Appendix G. Corrective Action Plan Table

Corrective Action Plan Table				
#	**Date Need for Corrective Action Was Identified**	**Issue Identified**	**Summary of Corrective Action**	**Implementation Date of Corrective Action**

Appendix H. Deviations from QAPP

Deviations from QAPP				
Revision #	**Section and Page**	**Original Instructions**	**Suggested Revision**	**Reason for Deviation**

Appendix I. Data Logger Threshold Calculations

The threshold values entered into the data logger determine when the data logger and ISCOs initiate sampling: once a threshold is reached, the data logger sends the signal to the respective automated sampler to begin sampling. At the study location, the threshold values refer to the volume of water which is expected to enter the monitoring system and BMP. The values vary depending on the precipitation depth of the upcoming storm and are calculated in Excel using a modified version of the Rational Method. An example of the spreadsheet is shown in

Table I-1

Table I-1 and the analysis methods are described in this section. Note: the total volume sampled in Table I-1 is for example purposes only and does not reflect the total volume to be sampled at the site.

Column 1. The first column lists possible (predicted) precipitation depths.

Column 2. The second column is the cumulative runoff calculated in cubic feet from the following equation:

$$V = CiA$$

Where:

$V = predicted\ volume\ of\ runoff, ft^3$

$C = rational\ method\ coefficient\ for\ impervious\ surfaces, 0.90$

$i = precipitation\ depth, ft.$

$A = contributing\ basin\ area, ft^2$

As mentioned previously, the precipitation depth is listed in the first column. The contributing basin area at the study location is approximately 26,572 square feet, as described in **Section 2.3**.

Column 3. The third column is the cumulative runoff from column 2 converted to liters.

Columns 4 & 5. represent the number of aliquots and volume of each aliquot pulled by the ISCO, respectively. The minimum number of aliquots that can be taken by the ISCO is 10, and the maximum number of aliquots that can be taken is 35. During the study, the ISCO will be set to sample 35 aliquots.

Columns 6 & 7. The threshold value is equal to the total runoff in liters divided by the number of aliquots pulled by the ISCO. This volume determines when the data logger should start to obtain a representative sample by obtaining equal volumes (aliquots) spaced evenly throughout the storm. The influent threshold is twice the effluent because the flow splits and only half the runoff volume is directed to each bioretention cell.

Column 8. is equal to the total volume pulled by the automated sampler, calculated as the product of the fourth and fifth columns. The total volume pulled by the automated samplers must be sufficient for the quantity and types of samples needed at the study location.

For example,

Table I-1 displays the threshold value for a storm rainfall depth of 0.15 inches (highlighted in green). Given the amount of runoff that is expected for the rainfall depth, the ISCOs would need to start sampling once 1,935 liters had entered the influent pipe and 967 liters entered each effluent pipe to obtain the aliquots and total sample volume needed during the storm.

Table I-1. Example Threshold Value Calculation

Rainfall (in)	Cumulative Runoff (cft)	Cumulative Runoff (L)	Number of Aliquots	Aliquot Volume (L)	Influent Threshold (L)	Effluent Threshold (L)	Total Volume Sampled (L)
0.000	0	0	0	0.200	0	0	0
0.01	20	564	35	0.200	16	8	7
0.02	40	1,693	35	0.200	48	24	7
0.03	60	3,386	35	0.200	97	48	7
0.04	80	5,643	35	0.200	161	81	7
0.05	100	8,465	35	0.200	242	121	7
0.06	120	11,851	35	0.200	339	169	7
0.07	140	15,801	35	0.200	451	226	7
0.08	159	20,316	35	0.200	580	290	7
0.09	179	25,395	35	0.200	726	363	7
0.1	199	31,038	35	0.200	887	443	7
0.11	219	37,245	35	0.200	1,064	532	7
0.12	239	44,017	35	0.200	1,258	629	7
0.13	259	51,354	35	0.200	1,467	734	7
0.14	279	59,254	35	0.200	1,693	846	7
0.15	299	67,719	35	0.200	1,935	967	7
0.16	319	76,748	35	0.200	2,193	1,096	7
0.17	339	86,342	35	0.200	2,467	1,233	7
0.18	359	96,500	35	0.200	2,757	1,379	7
0.19	379	107,222	35	0.200	3,063	1,532	7
0.2	399	118,508	35	0.200	3,386	1,693	7
0.21	419	130,359	35	0.200	3,725	1,862	7
0.22	438	142,774	35	0.200	4,079	2,040	7
0.23	458	155,754	35	0.200	4,450	2,225	7
0.24	478	169,298	35	0.200	4,837	2,419	7
0.25	498	183,406	35	0.200	5,240	2,620	7
0.26	518	198,078	35	0.200	5,659	2,830	7
0.27	538	213,315	35	0.200	6,095	3,047	7
0.28	558	229,116	35	0.200	6,546	3,273	7