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Annual Report

Number	Permit Section	Question
1	S5.A.3	Attach updated annual Stormwater Management Program Plan (SWMP Plan). (S5.A.3) **Saved Document Name: Attachment 1 - SWMP_1_03252019101705**
2	S9.D.5	Attach a map and copy of any annexations, incorporations or boundary changes resulting in an increase or decrease in the Permittee's geographic area of permit coverage during the reporting period per S9.D.5. **Not Applicable**
3	S5.A.4.a.ii	Tracked the estimated costs of implementation of each component of the SWMP. (S5.A.4.a.ii) **Yes**
4	S5.A.5.b	Coordinated among departments within the jurisdiction to eliminate barriers to permit compliance. (S5.A.5.b) **Yes**
5	S5.B.1.a and b	Attach description of public education and outreach programs and stewardship activities conducted per S5.B.1.a and b. **Saved Document Name: Attachment 4 - Education Activ_5_03282019095435**
6	S5.B.2.a	Describe the opportunities created for the public to participate in the decision making processes involving the development, implementation and updates of the Permittee's SWMP. (S5.B.2.a) **Saved Document Name: Attachment 1 - SWMP_6_03252019101749**
7	S5.B.2.b	Posted the updated SWMP Plan and latest annual report on your website no later than May 31. (S5.B.2.b) **Yes**
7b	S5.B.2.b	List the website address. **https://www.spokanecounty.org/971/Water-Quality-NPDES-UIC-LID**
8	S5.B.3.a	Maintained a map of the MS4 that includes the requirements listed in S5.B.3.a. **Yes**
9	S5.B.3.b.vi	Implemented a compliance strategy, including informal compliance actions as well as enforcement provisions of the regulatory mechanism described in S5.B.3.b. (S5.B.3.b.vi) **Yes**

Number	Permit Section	Question
10	S5.B.3.b.vii	Updated, if necessary, the regulatory mechanism to effectively prohibit illicit discharges into the MS4 per S5.B.3.b.vii. (Required, if applicable, no later than February 2, 2019) **Not Applicable**
11	S5.B.3.c	Implemented procedures for conducting illicit discharge investigations in accordance with S5.B.3.c. **Yes**
12	S5.B.3.c.iii	Percentage of MS4 coverage area screened in reporting year per S5.C.3.c.i. (Required to screen 40% of MS4 no later than December 31, 2018 and 12% on average each year thereafter, S5.B.3.c.iii) **81**
13	S5.B.3.c.iv	Publicized a hotline telephone number for public reporting of spills and other illicit discharges. (S5.B.3.c.iv) **Yes**
13b	S5.B.3.c.iv	List the hotline number. **(509) 477-7525**
14	S5.B.3.c.v	Implemented an ongoing illicit discharge training program for all municipal field staff per S5.B.3.c.v. **Yes**
15	S5.B.3.c.vi	Informed public employees, businesses, and the general public of hazards associated with illicit discharges and improper disposal of waste. (S5.B.3.c.vi) **Yes**
15b	S5.B.3.c.vi	Describe actions. **See SWMP Section 3 on Public Education and Outreach Program, Section 4 on Public Involvement and Participation, Section 5 on IDDE requirements, Attachment 4 on Educational Activities, and Attachment 5 on IDDE Actions.**
16	S5.B.3.d	Number of illicit discharges, including illicit connections, eliminated during the reporting period. (S5.B.3.d) **5**
17	S5.B.3.d.iv	Attach a summary of actions taken to characterize, trace and eliminate each illicit discharge found by or reported to the permittee. For each illicit discharge, include a description of actions according to required timelines per S5.B.3.d.iv. **Saved Document Name: Attachment 5 - IDDE Actions_17_03252019101924**
18	S5.B.3.e	Implemented an ongoing illicit discharge training program for all staff responsible for implementing the procedures and program, as described in S5.B.3.e. **Yes**
19	S5.B.4.a	Implemented an ordinance or other regulatory mechanism and enforcement procedures for construction site stormwater runoff control as described in S5.B.4.a. **Yes**

Number	Permit Section	Question
20	S5.B.4.b	Reviewed Stormwater Site Plans, including construction SWPPPs for all new development and redevelopment projects. S5.B.4.b. **Yes**
20b	S5.B.4.b	Number of site plans reviewed during the reporting period. **191**
21	S5.B.4.c	Implemented procedures for site inspection and enforcement of construction stormwater pollution control measures. (S5.B.4.c) **Yes**
21b	S5.B.4.c.iii	Number of permitted construction sites inspected during the reporting period, (S5.B.4.c.iii) **147**
22	S5.B.4.c	Number of enforcement actions taken during the reporting period based on construction phase inspections at new development and redevelopment projects. (S5.B.4.c) **0**
23	S5.B.4.b.ii and S5.B	Trained the staff involved in permitting, plan review, field inspections and enforcement for construction site runoff control. (S5.B.4.b.ii and S5.B.4.c.ii) **Yes**
24	S5.B.4.d	Provided information to construction site operators and design professionals about training available on how to comply with the requirements in Appendix 1 and the BMPs in the SWMMEW, or an equivalent document. (S5.B.4.d) **Yes**
24b	S5.B.4.d	Cite website address, if located on your website. **https://www.spokanecounty.org/500/Building-Permit-Tips**
25	S5.B.4.e	The number of construction sites that provided their intent to apply for the "Erosivity Waiver" as described in (S5.B.4.e). **Not Applicable**
26	S5.B.4.e	The number of complaints investigated about sites that have received an "Erosivity Waiver" and describe any enforcement actions taken as a result. (S5.B.4.e) **Not Applicable**
27	S5.B.5.a.	Implemented ordinance or other regulatory mechanism and enforcement procedures as described in S5.B.5.a. **Yes**
28	S5.B.5.a.ii(a)	Allowed non-structural preventive actions and source reduction approaches such as Low Impact Development techniques to be used. (Required no later than December 31, 2017, S5.B.5.a.ii(a)) **Yes**

Number	Permit Section	Question
29	S5.B.5.a.ii(b)(2)	Required projects approved under S5.B.5 to retain runoff generate on-site for, at a minimum, the 10-year, 24-hour rainfall event or a local equivalent, using either on-site or regional stormwater facilities. (Required no later than December 31, 2017, S5.B.5.a.ii(b)(2)) **Yes**
30	S5.B.5.a.ii(b)(2)	Attach criteria developed and implemented to determine when it is infeasible to meet requirement for on-site retention, or provide citation from existing ordinances or from LID Manual developed by eastern Washington permittees, as per S5.B.5.a.ii(b)(2), (Required to be submitted by March 31, 2018). **Saved Document Name: Chapter_9.14___ROADS__APPROACH_30_03252019102641**
31	S5.B.5.b	Implemented procedures for post-construction site plan review. (S5.B.5.b) **Yes**
32	S5.B.5.c.ii	Inspected post-construction stormwater controls, including structural BMPs, during installation at new development and redevelopment projects. (S5.B.5.c.ii) **Yes**
32b	S5.B.5.c.ii	Number of sites inspected during the reporting period. (S5.B.5.c.ii) **15**
33	S5.B.5.c	Number of enforcement actions taken during the reporting period? (S5.B.5.c) **0**
34	S5.B.5.c.iii	Inspected structural BMPs at least once every five years after final installation. (S5.B.5.c.iii) **Yes**
34b	S5.B.5.c.iii	Number of BMPs inspected during the reporting period. (S5.B.5.c.iii) **3531**
35	S5.B.5.d	Trained the staff involved in permitting, plan review, inspection and enforcement for post-construction stormwater control. (S5.B.5.d) **Yes**
37	S5.B.6.a	Implemented the schedule of Operation and Maintenance activities for municipal operations. (S5.B.6.a) **Yes**
38	S5.B.6.a.i (f) and (	Have NPDES permit coverage for all applicable Permittee construction projects and industrial facilities. (S5.B.6.a.i (f) and (g)) **Yes**
39	S5.B.6.a.ii (a)	Inspected stormwater treatment and flow control facilities (except catch basins) owned or operated by the Permittee at least once every two years. (S5.B.6.a.ii (a)) **Yes**

Number	Permit Section	Question
39b	S5.B.6.a.ii (a)	Number of facilities inspected during the reporting period. (S5.B.6.a.ii (a)) **8424**
40	S5.B.6.a.ii (b)	Inspected and, if needed, cleaned catch basins and inlets owned or operated by the Permittee, or used an alternative approach. (Required at least once no later than December 31, 2018 and every two years thereafter. (S5.B.6.a.ii (b)) **Yes**
41	S5.B.6.a.ii (b)	If used an alternative to standard schedule for catch basin inspections for all or a portion of the MS4, attach description of the method used. (S5.B.6.a.ii(b)) **Not Applicable**
42	S5.B.6.a.ii(c)	Conducted spot checks of stormwater facilities after major storms. (S5.B.6.a.ii (c)) **Yes**
43	S5.B.6.b	Trained the staff with primary construction, operations, or maintenance job functions that are likely to impact stormwater quality. (S5.B.6.b) **Yes**
44	S7.A	Complied with the Total Maximum Daily Load (TMDL)-specific requirements identified in Appendix 2. (S7.A) **Yes**
45	S7.A	For TMDLs listed in Appendix 2: Attach a summary of relevant SWMP and Appendix 2 activities to address the applicable TMDL parameter(s). (S7.A) **Saved Document Name: Attachment 1 - SWMP_45_03252019103157**
46	S8.A	Attach a description of any stormwater monitoring or stormwater-related studies as described in S8.A. **Saved Document Name: Attachment 6 - Effectiveness S_46_03252019103231**
47	S8.B	Participated in the regional group to select, develop and conduct effectiveness studies as described in S8.B. **Yes**
48	G3	Notified Ecology in accordance with G3 of any discharge into or from the Permittees MS4 which could constitute a threat to human health, welfare or the environment. (G3) **Yes**
49	G3.A	Took appropriate action to correct or minimize the threat to human health, welfare, and/or the environment per G3.A. **Yes**
50	G20	Notified Ecology of the failure to comply with the permit terms and conditions within 30 days of becoming aware of the non-compliance. (G20) **Not Applicable**

Number	Permit Section	Question
52	S4.F.3.d	Attach a summary of the status of implementation of any actions taken pursuant to S4.F.3 and the status of any monitoring, assessment, or evaluation efforts conducted during the reporting period. (S4.F.3.d) **Not Applicable**

Attachments:

View Files Attached to Submission

	DocDescr	DocName	DocExt	DocID	SubID	AppName
View	WAR046506_1_03252019101705	Attachment 1 - SWMP_1_03252019101705	.docx	789786	1667478	wqwebportal
View	WAR046506_45_03252019103157	Attachment 1 - SWMP_45_03252019103157	.docx	789787	1667478	wqwebportal
View	WAR046506_6_03252019101749	Attachment 1 - SWMP_6_03252019101749	.docx	789788	1667478	wqwebportal
View	WAR046506_5_03282019095435	Attachment 4 - Education Activ_5_03282019095435	.pdf	789794	1667478	wqwebportal
View	WAR046506_17_03252019101924	Attachment 5 - IDDE Actions_17_03252019101924	.docx	789790	1667478	wqwebportal
View	WAR046506_46_03252019103231	Attachment 6 - Effectiveness S_46_03252019103231	.pdf	789791	1667478	wqwebportal
View	WAR046506_30_03252019102641	Chapter_9.14___ROADS__APPROACH_30_03252019102641	.pdf	789792	1667478	wqwebportal
View	Submitted Copy of Record for Spokane County	Copy of Record SpokaneCounty Thursday March 28 2019	.pdf	789801	1667478	wqwebportal
View	Submitted Cover Letter for Spokane County	Cover Letter SpokaneCounty Thursday March 28 2019	.pdf	789802	1667478	wqwebportal

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Attachment 1

2018 Stormwater Management Program (SWMP) Plan

SPOKANE COUNTY
STORMWATER MANAGEMENT PROGRAM (SWMP) PLAN

Eastern Washington Phase II Municipal Stormwater Permit

Permit WAR 04-6506

Permit Cycle – August 1, 2014, to July 31, 2019

Prepared for Annual Reporting Year 2018

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Appendix A – Definitions and Acronyms from the Phase II Permit

SECTION 1 – INTRODUCTION

1.1 Background

> *"Stormwater runoff is a leading pollution threat to lakes, rivers, streams, and marine water bodies in urbanized areas of Washington State… In urban areas, the large amount of impervious surfaces interrupts infiltration and groundwater recharge, concentrates surface flows, and increases the frequency and quantity of runoff sent to receiving waters."* – Fact Sheet for the Phase 1, Western Washington Phase II, and Eastern Washington Phase II Municipal Stormwater Permits. Washington Department of Ecology, August 15, 2018.

Since the passing of the Clean Water Act in 1972, national and regional water pollution control efforts have focused primarily on point source water discharges from facilities such as factories and sewage treatment plants, with less emphasis focused on non-point sources. While these efforts have led to improved water quality, new efforts are now needed to address the remaining sources of water pollution. Urban stormwater runoff can contain contaminants including particulates, metals, nutrients, pesticides, and organic compounds. In many areas, stormwater runoff receives no treatment prior to being discharged to a waterbody.

On December 8, 1999, the Environmental Protection Agency (EPA) promulgated a rule requiring smaller municipalities, those with populations fewer than 100,000 people located in urbanized areas (where population density is greater than 1,000 persons per square mile), to develop a Stormwater Management Program addressing stormwater runoff that enters surface waters. In Washington, EPA's smaller municipality rule is directed to local jurisdictions through the National Pollution Discharge Elimination System (NPDES) – Phase II Permits that are under the direction of the Department of Ecology.

Pictured: Bioinfiltration swales are a Best Management Practice (BMP) frequently used in Spokane County to treat and dispose of urban stormwater runoff.

The Bioretention Soil Media Study is a stormwater effectiveness study taking place on the Gonzaga University Campus to test the capacity of bio-amended swales to remove pollutants from stormwater runoff.

Spokane County (County) was issued coverage under the first *Eastern Washington Phase II Municipal Stormwater Permit* (Permit), Permit No. WAR 04-6506, effective February 16, 2007, for Permit cycle 2007-2014, and again on August 1, 2014, for Permit cycle 2014-2019. The next version of the Permit will be effective August 1, 2019. The Permit states, "All Counties shall develop and implement a *Stormwater Management Program* (SWMP) during the term of this Permit." The Permit primarily addresses stormwater discharges to surface waters. Stormwater that is directed to Underground Injection Control (UIC) wells is regulated under the State of Washington's Underground Injection Control Program and is not addressed within the SWMP.

1.2 Purpose

The purpose of this SWMP Plan is to describe the programs, practices, and responsibilities adopted by the County to manage the Municipal Separate Storm Sewer System (MS4) and implement the requirements of the Permit. The Plan describes the activities that have and will be performed to comply with Permit conditions, provides measurable goals for key activities, and outlines staffing and funding responsibilities for the County. The current version of the Permit became effective on August 1, 2014. This Plan applies to the 5-year duration of the current Permit cycle (expiring July 31, 2019), furthering the County's long-term commitment to reducing pollutants discharged to Waters of Washington State.

1.3 Authorization

This SWMP was prepared by the Spokane County Stormwater Utility, a section within the Public Works department. The Stormwater Utility was established by the Board of County Commissioners in 1992 and is funded through the Stormwater Rate Ordinance passed by the Board during that year. Section 2 of this plan details the administrative and legal authority given to the Stormwater Utility to carry out the responsibilities of the Permit.

1.4 Area of Coverage

The area of coverage is defined in Section 1 of the Permit: "For all Counties required to obtain coverage under this Permit, the geographic area of coverage is the urbanized areas and the urban growth areas associated with Cities within the urbanized areas that are under the jurisdictional control of the County. The geographic area of coverage also includes any urban growth areas that are contiguous to urbanized areas that are under the jurisdictional control of the County."

Consistent with this language, the activities described in the SWMP will be conducted within the urban growth areas of Spokane County. See *Attachment 2 – 2018 NPDES Permit Area Maps* for a detailed Spokane County map of the NPDES Permit boundary, as well as the current Stormwater Service Area (SWSA) boundary.

Spokane County coordinates with the municipalities of the City of Spokane and the City of Spokane Valley to help accomplish stormwater related goals. Coordination is encouraged amongst permittees to develop and implement programs involving Public Education and Outreach, stormwater-related policies, and projects within adjoining shared areas. The means of coordination are detailed within various sections of this Plan and in *Attachment 3 – Internal Coordination Mechanisms*.

1.5 Period of Performance

This SWMP Plan applies to the 5-year effective period of the Permit, valid from August 1, 2014 to July 31, 2019. The SWMP Plan refers to Permit years specifying when various activities are scheduled to occur. Permit years are defined as follows:

- Permit Year 1 – August 1, 2014 to July 31, 2015
- Permit Year 2 – August 1, 2015 to July 31, 2016
- Permit Year 3 – August 1, 2016 to July 31, 2017
- Permit Year 4 – August 1, 2017 to July 31, 2018
- Permit Year 5 – August 1, 2018 to July 31, 2019

In addition, the Permit also requires annual reports that are subject to the following reporting periods:

- Annual Report, Year 1 – January 1, 2015 to December 31, 2015
- Annual Report, Year 2 – January 1, 2016 to December 31, 2016
- Annual Report, Year 3 – January 1, 2017 to December 31, 2017
- Annual Report, Year 4 – January 1, 2018 to December 31, 2018
- Annual Report, Year 5 – January 1, 2019 to July 31, 2019

1.6 Stormwater Management Program Permit Requirements

There are six essential components of the SWMP. To the extent allowable under state and federal law, all the following components are mandatory for each permittee covered under the permit:

1. Public Education and Outreach
2. Public Involvement and Participation
3. Illicit Discharge Detection and Elimination (IDDE)
4. Construction Site Stormwater Runoff Control
5. Post-Construction Stormwater Management for New Development and Redevelopment
6. Municipal Operations and Maintenance (O&M)

Additional requirements are detailed in Sections 7-9 of the permit and address the following:

7. Compliance with Total Maximum Daily Load (TMDL) Requirements
8. Monitoring and Assessment
9. Reporting and Recordkeeping

This Plan has been organized to provide comprehensive background on Spokane County's Stormwater Program, and to address each question listed in Permit *Appendix 3 – Annual Report questions for Cities, Towns, and Counties*. As required by Permit Section 9, this SWMP Plan has been prepared in 2019 for the previous calendar year (2018). The most recent draft of the 2019 permit establishes the same Annual Report Calendar, thus the report prepared in 2020 will be for the calendar year 2019.

SECTION 2 – STORMWATER MANAGEMENT PROGRAM ADMINISTRATION

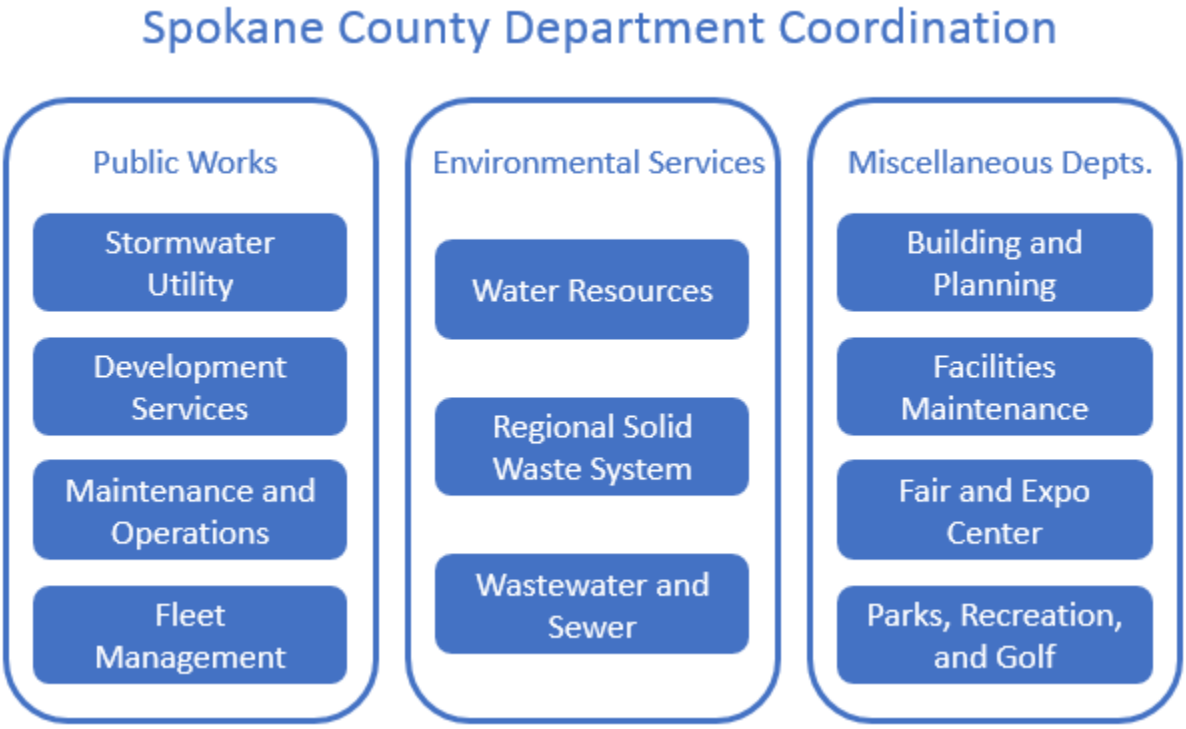
2.1 Introduction

This section addresses the Eastern Washington Phase II Municipal Permit requirements of administering the SWMP. The objective is to provide documentation that the County: 1) has adequate legal authority to conduct all necessary activities; 2) is organized in a way that facilitates the administration of these activities; and 3) has a means for creating further authority as Permit changes occur.

2.2 Spokane County – Stormwater Utility and Internal Coordination

The Spokane County Stormwater Utility was formed in 1992 to prepare and implement stormwater basin management plans. The Utility is funded through stormwater service charges based on impervious coverage on developed parcels. On January 17, 2006, the Board of County Commissioners adopted the Comprehensive Stormwater Management Plan along with individual Capital Improvement plans for Glenrose, North Spokane, and West Plains. Each of the individual basin plans emphasize protection of natural drainage features as the most cost-effective means of managing stormwater long-term.

Although the Stormwater Utility is the lead entity on addressing stormwater concerns within the unincorporated areas of Spokane County, many other departments perform essential activities to operate and maintain the Municipal Separate Storm Sewer System. *Attachment 3 – Internal Coordination Mechanisms* details the means used within the County to facilitate effective and efficient implementation of Permit requirements. Permit implementation and internal coordination occurs between the departments in the following figure:



2.3 Legal Authority

Spokane County adopted engineering design standards and stormwater Best Management Practices (BMPs) as described within the *Spokane Regional Stormwater Manual* (SRSM). The SRSM was approved by the Board of County Commissioners on April 15, 2008, and became law on June 1, 2008, replacing the existing *Spokane County – Guidelines for Stormwater Management.* The SRSM is considered by the Department of Ecology to be an equivalent to the *Stormwater Management Manual for Eastern Washington* (SWMMEW). Sections of the Spokane County Code of Ordinances[1] address municipal stormwater regulations and are available online.

The following chapters address stormwater design, management, and maintenance requirements: 1) Chapter 9.14 – Roads Approach and Drainage in New Construction; 2) Chapter 12.400 – Subdivisions; and 3) Chapter 14.802.060 – Parking Lot Location and Design.

Spokane County Code, Title 8, Health and Sanitation Code, Chapter 8.03 – Sanitary Sewer, includes various sections that address illicit discharges within Spokane County. The primary relevant sections include: 8.03.1570 POTW; 8.03.1710 – Private Storm Sewer; 8.03.1730 – Prohibited Discharge Standards or Prohibited Discharges; 8.03.1750 – Public Sewer; 8.03.1830 – Sewer; 8.03.1990 – Stormwater; 8.03.2010 – Storm Sewer or Storm Drain; 8.03.3200 – Prohibited Uses of Sanitary Sewer; 8.03.3220 – Use of Storm Sewers--Combined Sewers--Natural Outlets; 8.03.3260 – Obstructing Sewer Prohibited; 8.03.3300 – Unauthorized Connection to Public Sewers; 8.03.3240 – Prohibited Uses--Public Sewers; 8.03.4040 – Prohibited Discharge Standards--General Prohibitions; 8.03.4060 – Prohibited Discharge Standards--Specific Prohibitions.

2008 amendments to Spokane County Code, Chapter 9.14 – Roads, Approach and Drainage in New Construction, were developed and approved (Resolution No. 09-0672) to address illicit discharge regulations, including:

- Prohibition of illicit discharges to the MS4
- Spill control, dumping, and disposal of materials other than stormwater to the MS4
- Compliance with conditions in ordinances related to stormwater discharges
- Inspection and monitoring procedures necessary to determine compliance and enforce the prohibition of illicit discharges to the MS4

Spokane County Code, Title 8, Health and Sanitation Code, Chapter 8.26 – Litter and Discriminate Dumping, includes various sections that are relevant to protecting the integrity of stormwater and other surface waters, such as Section 8.26.020 – Litter in General, which addresses the disposal of litter upon any public place or private property, or within any waters in Spokane County. This Chapter also addresses notice of violation, enforcement, and penalty.

Spokane County Code, Chapter 8.60.030 – Oil Sellers--Educational Responsibilities, requires sellers of lubricating oil to post educational materials that describe the importance of used oil recycling and how and where used oil may be recycled, and provide for the sale of reusable used oil containers.

[1] https://library.municode.com/wa/spokane_county/codes/code_of_ordinances

Spokane County implements flood controls through Title 3, Buildings and Structures, Chapter 3.20 – Flood Damage Protection. This is a comprehensive flood control ordinance that manages development within delineated floodplains in compliance with the National Flood Insurance Program.

In 2013, the Eastern Washington Low Impact Development (LID) Guidance Manual was developed as a supplemental guidance for the design, construction, and maintenance of LID stormwater Best Management Practices (BMPs). This manual was a regional effort led by the County in conjunction with many Eastern Washington municipalities, including the Washington Stormwater Center, experienced consultants, Ecology, and regional LID experts.

2.4 Additional Required Legal Authority

If the review of current regulations and ordinances identifies additional deficiencies in the ability to implement SWMP programs, a plan for addressing the deficiencies will be developed.

2.5 Staffing, Funding, and Training for Program Elements

Staffing and funding for each primary Stormwater Management Program element are detailed individually in the following sections. In general, new training materials are developed following regulatory changes such as new Permit requirements or manual revisions. Relevant regional stormwater manuals (Stormwater Management Manual for Eastern Washington, Spokane Regional Stormwater Manual) are continually referenced for information pertaining to the design, operation, and maintenance of stormwater treatment and disposal structures.

2.5.1 Public Education and Outreach

The annual budgets of the Spokane County Stormwater Utility, Water Resources Department, and Regional Solid Waste System fund public education and outreach programs related to water quality and pollution prevention. The funds are specifically used for staff time, producing publications and other education and outreach materials, and for assisting in developing long-term education and outreach strategies. Additionally, staff time is spent collaborating with local jurisdictions on developing programs that encompass regional goals.

2.5.2 Public Involvement and Participation

Funding and staffing for the public participation program is led by the Stormwater Utility with collaboration from various Spokane County departments, primarily those in Public Works and Environmental Services sections. Collaboration occurs among local jurisdictions including the Spokane Regional Health District, City of Spokane, and the City of Spokane Valley.

2.5.3 Illicit Discharge Detection and Elimination

Staffing is provided by Stormwater Utility employees with technical support from Spokane County Information Technology Department, and field support provided by the Maintenance and Operations department. Fees collected by the Stormwater Utility and monies from the general budgetary fund contribute to server and mapping maintenance.

The IDDE program is an excellent training tool for new employees and temporary staff, such as summer field crews, to learn the sources of stormwater pollution. MS4 mapping exercises, such as the 2018 Little Spokane outfall identification project, act as valuable field assessment activities, as well as training on use of GPS equipment, GIS, investigation procedures, and job safety. On-the-job training used frequently by the Stormwater Utility always includes a job safety element and is continuously improved through: literature review; past project experience; guidance received from regulatory entities; on-the-job training; skill certifications; and the attendance of educational seminars, webinars, and conferences. Attachment 5 – IDDE Actions, provides more details on elements of the IDDE program.

2.5.4 Construction

In coordination with the Department of Ecology, Spokane County is responsible for preparation of materials and the development of a process for notifying the public, developers, and design professionals of construction permitting, inspection, and compliance requirements. Spokane County departments involved with construction permitting and inspection will keep a record of all relevant data, documentation, and information. Relevant trainings are made available to employees whose primary job responsibilities are heavily focused on design, implementation, and project management of construction projects.

Spokane County employees who design, manage, and implement County construction projects receive relevant training on stormwater pollution prevention procedures to minimize stormwater pollution from County construction activities. Training is specific to the various departments' operations and functions. Refresher training will be provided to County staff as requested or needed. See Section 2.5 – Staffing, Funding, and Training for Program Elements for details about additional employee construction training activities. Additionally, the County employs several engineers and/or field technicians who are CESCL-trained and tasked to inspect private construction site stormwater controls.

2.5.5 Post-Construction

The various Spokane County departments involved in compliance with the Permit will provide relevant data, documentation, and information to Spokane County's municipal Permit coordinators to support the successful implementation of this section of the SWMP. Funding for Post-Construction activities are provided through the Public Works fund, and through Stormwater Utility fees.

Spokane County employees who design, manage, and implement County's post-construction monitoring receive relevant training on stormwater pollution prevention procedures to minimize stormwater pollution from structural BMPs. Training is specific to the various departments' operations and functions.

2.5.6 Operations and Maintenance

All Spokane County staff whose primary duties have the potential to impact stormwater quality will be trained on specific operations and functions that protect water quality. The overall objectives of the program are to inform the employee about important water quality issues, regulations, BMPs, and other practices related to stormwater management. The goal is to

influence the behavior of the employee to reduce activities that have a negative impact on stormwater runoff quality while increasing activities that have a positive impact on stormwater runoff quality.

The evaluation of existing procedures and practices relating to Operation and Maintenance pollution prevention and good housekeeping measures are funded by multiple Spokane County departments within Public Works.

2.5.7 TMDL

The provisions of this Permit component are managed by the Spokane County Stormwater Utility. Staff time is funded through Spokane County general fund and by Stormwater Utility service fees. Should any capital projects result from TMDL requirements, funding and staff time would be provided by Public Works.

2.5.8 Effectiveness Studies

Spokane County collaborates with Eastern Washington Stormwater Group (EWSG) members to ensure successful implementation of this section of the SWMP. Spokane County is currently the lead entity on two Effectiveness Studies: 1) Sand Filter Sidewalk Vault BMP, and 2) Bioretention Soil Media Thickness Study. The current versions of each Study Design Proposal are provided in *Attachment 6 – Effectiveness Studies.* To support this Permit component, staff time will be provided and funded by Spokane County. Study contractors are funded by Spokane County funds and from EWSG member funds, if applicable.

SECTION 3 – PUBLIC EDUCATION AND OUTREACH

Pictured: Saint George's 8th Grade class posing with the completed "Storm Garden" on campus, Summer 2018. The class helped with construction of the swale as part of education on sustainability and the environmental impacts of urban stormwater.

3.1 Introduction

The Permit requires the implementation of an education and outreach program regarding stormwater quality impacts "designed to achieve improvements in the target audience's understanding of the problem and what they can do to solve it" (S5.B.1). The target audiences of education are:

- The public, regarding improvement of water quality, protection of valuable natural resources, and methods for avoiding, minimizing, reducing, and/or eliminating the adverse impacts of stormwater discharges.
- Businesses, regarding prevention of illicit discharges, proper management of waste, and storage of hazardous chemicals in a manner that prevents release.
- Engineers, construction contractors, developers, and land use planners, regarding technical standards, development of stormwater site plans, erosion control, best management practices, and techniques and requirements of low impact development.

3.2 Public Education and Outreach Program Elements

The overall objectives for Spokane County's Education and Outreach Program are to:

a) Inform the public in Spokane County about important water quality issues related to stormwater runoff.
b) Inform businesses and the public of the means and requirements to prevent illicit discharges.
c) Inform engineers, construction contractors, developers, development review staff, and land use planners on the importance of best management practices, erosion control plans, and low impact development on improving stormwater runoff quality.
d) Influence behavior of the public, businesses, and those involved in the land development sector to reduce activities that have a negative impact on stormwater runoff quality and increase activities that have a positive impact on stormwater runoff quality.

3.3 Public Education and Outreach Activities

Spokane County continues to work individually and, where mutually beneficial, with the Cities of Spokane and Spokane Valley to develop public education and outreach programs. Activities include, but are not limited to:

a) **Community Events:** The County uses community events related to environmental awareness and regional water issues as opportunities for education and outreach (e.g. Spokane County Interstate Fair, Earth Day, etc.).
b) **Educational Workshops:** The County sponsors and/or hosts workshops for local teachers which advance stormwater curricula in the classroom environment. Other workshops may include a focus on important stormwater concepts, including reducing the impacts of stormwater runoff by practicing low impact development, harvesting rainwater, and using native plants in landscaping.
c) **Media Materials:** The County evaluates the production or distribution of media materials to disseminate public education and outreach information. Media materials may include programs for local public television, including general information on stormwater quality issues, public service announcements, or commercials for targeted messages and audiences.
d) **Rain Garden construction with Saint George's Middle School**: Spokane County coordinated with the City of Spokane on the construction of a Rain Garden with Saint George's middle school. Students were actively involved in the construction of a stormwater treatment facility.
e) **Storm Drain Stenciling / Art Program**: The County continues to sponsor a storm drain stenciling program to be implemented by local volunteer groups and students.
f) **Printed Materials:** The County will continue to develop, produce, and distribute printed materials for specific topics related to stormwater quality (e.g. brochures, flyers, activity books, promotional items, etc.). Older printed materials will be updated as necessary.
g) **Grants:** The County continues to pursue opportunities for obtaining grants and loans through Ecology for specific projects addressing stormwater quality issues, public education and outreach, and low impact development projects. This is done in cooperation with state and/or local Permitted jurisdictions, as well as other regional planning and management agencies.
h) **Website:** The County will continue to enhance, maintain, and update the existing Spokane County website to provide information to the public on stormwater topics. The website is located at (www.spokanecounty.org).
i) **School Programs:** The County will continue to conduct outreach activities in public schools around Spokane County to promote awareness of water quality issues, pollution prevention, and basic watershed principles.
j) **Involvement in Other Organizations:** The County will continue to be active in regional and local organizations that promote interagency cooperation and those that have education and outreach functions (for example, the Eastern Washington Stormwater Group).
k) **Construction Program:** The County will continue education and outreach activities targeting construction industry organizations (developers, contractors, engineers, surveyors, etc.) about technical standards, development of stormwater site plans, erosion control plans, and BMPs for reducing adverse impacts from development sites. Spokane County attempts

to work through professional engineering and land planning groups to provide education regarding compliance with the *Spokane Regional Stormwater Manual* and other Permit requirements.

l) **Illicit Discharge Program:** The County continues to provide information to businesses and the public about illicit discharges to encourage proper management and disposal of toxic materials.

m) **Stormwater Facilities:** The County will continue to construct and maintain interpretive signage at regional stormwater facilities and demonstration swales to explain the meaning of watersheds and the value of using natural stormwater systems to control and treat runoff. Where possible, stormwater facilities will include opportunities for hands-on education about wetlands, the stormwater cycle, and the value of clean water.

3.4 Priorities and Measurable Goals

Spokane County continues to implement existing public outreach and education programs in and around the community, in cooperation with neighboring jurisdictions, and within internal County departments.

Completed by	Measurable Goals/Milestones
End of current Permit period (July 31, 2019) and on-going.	• Staff community events related to environmental awareness and regional water issues • Conduct outreach activities in public schools around Spokane County • Develop, produce, and disseminate education and outreach materials pertaining to stormwater quality and pollution prevention • Update informational materials, as necessary • Conduct education and outreach activities targeting the construction industry • Construct and maintain interpretive signage at regional stormwater facilities and demonstration swales • Enhance, maintain, and update the existing Spokane County website • Actively participate in work groups, and/or committees that advance regional and local public education and outreach campaigns • Pursue grant opportunities for projects addressing stormwater education and outreach

SECTION 4 – PUBLIC INVOLVEMENT AND PARTICIPATION

4.1 Introduction

Pictured: Storm Drain Art - Mead Alternative H.S. (2017)

In meeting the requirements of the Permit, Spokane County integrates the stormwater management program into existing programs and activities. Spokane County has, under the State's Growth Management Act, adopted the *Public Participation Program Guidelines* (PPPG) which describes procedures to ensure a wide range of opportunities for public participation in land use decisions.

The County uses the PPPG[2] to ensure ongoing opportunities for public involvement and participation in the development and update of stormwater-related codes. This section describes the public involvement and participation activities used to meet the municipal permit requirements for such a program (S5.B.2).

4.2 Public Involvement and Participation Objectives

The overall objectives of the Public Involvement and Participation Program are to:

a) Provide opportunities for public participation in the decision-making processes related to development of stormwater management plans and regulations.
b) Ensure the public has opportunities to participate in the development and implementation of the SWMP.
c) Make the Annual Report (including the SWMP plan) available online for public review and comment.

4.3 Public Involvement and Participation Activities

Spokane County provides public involvement and participation opportunities including the following:

a) **Public Meetings and Open Houses**: Spokane County engages the public in decision making processes including, but not limited to, code updates, plan amendments, capital construction project proposals, and public meetings and workshops. Public meetings and workshops will be conducted according to State and local public participation and noticing guidelines.
b) **Stormwater Questionnaire**: During the previous Permit cycle (February 2007 – July 2014), the SWU conducted a randomly distributed public survey to gauge the level of the public's

[2] https://www.spokanecounty.org/DocumentCenter/View/1213/Public-Participation-Program-Guidelines-PDF?bidId=

knowledge on stormwater pollution related issues to gain an understanding of where future education efforts should be focused. A follow-up survey to evaluate the effectiveness of stormwater education efforts will be conducted at the end of the current permit cycle.

c) **Website**: In addition to maintaining and updating the website content, the County provides an online comment form[3] where the public can share feedback and/or submit questions regarding the Stormwater Utility's programs.

d) **Illicit Discharge Detection and Elimination (IDDE) Hotline (509) 477-7525**: The County operates an IDDE hotline for the public to report spills and other suspected illicit discharge activities.

e) **SWMP Plan and Annual Report[4]:** The SWMP Plan and Annual Report is made available for review and/or download on the Spokane County webpage; public comment is encouraged.

4.4 Priorities and Measurable Goals

The Public Involvement and Participation measurable goals are outlined below:

Completed by	Measurable Goals/Milestones
End of current Permit Period (July 31, 2019)	• Engage the public in various decision-making processes • Follow-up "Stormwater Questionnaire" • Compile results of "Stormwater Questionnaire" by July 31, 2019 • Sponsor the volunteer storm drain stenciling program • Provide opportunities for the public to participate in native planting events at stormwater facilities • Continue operating the IDDE hotline for the public to report spills and suspected illicit discharge activities • Provide a public comment form on website • Post updated SWMP and Annual Report online for public review and comment by May 31st each year

[3] https://www.spokanecounty.org/FormCenter/Engineering-Roads-14/Contact-Stormwater-Utility-61
[4] https://www.spokanecounty.org/971/Water-Quality-NPDES-UIC

SECTION 5 – ILLICIT DISCHARGE DETECTION AND ELIMINATION

5.1 Introduction

This section describes the elements of the Illicit Discharge Detection and Elimination Program required by Permit section S5.B.3. To meet the various requirements of this Permit section, Spokane County must:

a) Keep an up-to-date map of the MS4
b) Implement an ordinance or other regulatory mechanism to prohibit illicit discharge and authorize enforcement actions to prevent them.
c) Identify potential illicit discharges or illicit connections to the MS4.
d) Detect, record, and report the scope of those discharges or connections.
e) Eliminate any illicit discharges/connections.
f) Utilize education and outreach programs to prevent illicit discharges/connections from occurring.

Pictured: Example of an Illicit Discharge entering a storm drain

In 2009 the County began the process of developing an IDDE Guidance Manual that defines procedures for locating, assessing, characterizing, tracing, and eliminating illicit discharges. The Guidance Manual was completed in 2010 and provides direction on how to conduct field assessments on three high-priority waterbodies; the Spokane River, Little Spokane River, and Liberty Lake.

Unincorporated Spokane County has developed mostly without an extensive system of storm sewers. Much of the runoff discharged into the ground recharges the aquifer, which has an interchange of flows with both the Spokane River and the Little Spokane River. These water bodies are protected by requirements of the Underground Injection Control program, which drive elements of inspection and maintenance activity pertaining to infiltration structures, such as drywells. Providing a comprehensive approach to inventorying the County's stormwater system requires combining an inventory of any municipal discharges to surface waters with an inventory of County facilities that discharge stormwater into the ground.

5.2 Illicit Discharge Data and Mapping

Spokane County maintains a Geographic Information System (GIS) map of the MS4. The mapping system contains useful data pertaining not just to stormwater structures, but also to Critical Areas, contours, zoning, floodplains, maintenance districts, etc. The Permit requires that "Each Permittee continue to maintain a map of the MS4, showing the location of all known and new connections to

the MS4 authorized or approved by the Permittee…" (S5.B.3.a). This map is invaluable to the various departments within the County, the public, regulatory agencies, and others by documenting the area and determining where potential stormwater quality problems may exist. The mapping data is based on fieldwork conducted regularly within the Stormwater Service Area since the Stormwater Utility's formation in 1992.

The MS4 in Spokane County is comprised of roads with ditches, culverts, curbs, bridge drains, swales, detention ponds, drywells, and piping systems that direct stormwater into groundwater and surface waterbodies such as a DNR stream, river, wetland, pond, lake, etc.

5.2.1 Previous Permit Cycle Actions

The basemaps prepared during the previous Permit cycle (February 2007 – July 2014) were developed using existing stormwater data generated during a span of over twenty-five years. Data layers included facilities such as: catch basins, swales, inlets, drywells, roadside ditches, culverts, etc. These maps indicate the locations of major regional stormwater drainage and collection systems, stormwater control facilities, and known outfalls.

5.2.2 Current Permit Cycle Actions

In early 2015, the Stormwater Utility initiated development of a facility inventory application with dedicated internet servers. This application integrates GIS data into a program that allows field crews to update data in real time while inspecting County structures, scheduling maintenance activities, and reporting details of maintenance activities.

Seasonal crews are hired and trained to inspect 100% of the facilities within the County's MS4. Using internet-connected tablets, GIS software, and GPS equipment, data was collected on stormwater structures. This information has provided a crucial baseline for continued inspections and maintenance. In 2018 alone, seasonal crews inspected 81% of the County's storm structures, including collecting new data on facilities constructed since the previous year's inventory.

Analysis of each years' data provides essential information on facilities that require more frequent inspection, facilities reaching the end of their designed lifespan, and facilities that are due for maintenance. Analysis of the MS4 via map creation, color-coding, and creation of data tables provides a practical and cost-effective resource for continuing operation and maintenance activities. *Attachment 5 – IDDE Actions* includes actions taken to prevent illicit discharges and connections, which includes maintaining various maps of the MS4.

5.3 Illicit Non-Stormwater Discharges

Spokane County Code, Chapter 9.14.215 Roads, Approach, and Drainage in New Construction, Discharge of Unauthorized Waters – Prohibited, historically prohibited the discharge of unauthorized waters onto County property or rights-of-way. Unauthorized waters include: groundwater; surface water containing sediment; discharges from swimming pools and hot tubs; discharges to detention or evaporation ponds; water discharged from the cleaning of containers or equipment used in laying, cutting, or processing concrete and mortar; and water discharged from the cleaning of equipment or containers holding paint solvents or similar contaminants. The Code also

requires control of pollutants on construction sites in a manner that does not cause contamination of stormwater or groundwater.

The County underwent an extensive public review process (as required by Permit section S5.B.2) and adopted code revisions to Chapter 9.14.215 that address all IDDE Permit requirements. This code amendment (Resolution 09-0672) was formally adopted by the Spokane County Commissioners on July 21, 2009.

Finally, Spokane County Code, Title 8, Health and Sanitation Code, Chapter 8.03 – Sanitary Sewer Code, includes various sections that address illicit discharges within Spokane County's MS4. See Section 2.3 – Existing Legal Authority for a detailed list of relevant sections.

5.4 Visual Inspection Program Elements

Field inspections are conducted on a regular basis by Stormwater Utility staff to identify the structural integrity of stormwater structures and to monitor potential water quality issues. Visual observation is a useful indicator of potential illicit discharges, which may include: unauthorized direct connections to the County MS4 (i.e. piped systems, pumped non-stormwater); illicit dumping activities; structural issues leading to bypassed treatment structures; visual pollution originating from runoff; etc. *Attachment 5 – IDDE Actions* provides more detail on visual inspection methods.

Spokane County trains employees on the importance of erosion and sediment controls regarding construction activities. The Certified Erosion and Sediment Control Lead (CESCL) is an Ecology approved training program that educates field staff on up-to-date methods of reducing or preventing contaminated runoff from leaving construction sites. *Attachment 4 – Public Education and Outreach Activities* provides more detail on the CESCL program.

Spokane County Road Maintenance Department staff are also trained to look for evidence of non-stormwater discharges by visually observing open channel sections. A procedure for reporting potential problems is included with the existing *Hotline* (509-477-7525) and *Request for Investigation* processes currently utilized by the County.

5.5 Outfall Identification and Elimination on High-Priority Waterbodies

Numerous field investigations have been performed to identify outfalls and illicit discharges to high-priority water bodies including portions of the Spokane River, Little Spokane River, Silver Lake, and Liberty Lake. Starting with the previous permit cycle and continuing today, Spokane County continually assesses existing and potential outfalls originating from County MS4 to systematically prioritize and implement BMP retrofit opportunities.

Past examples of outfall elimination projects include:

- 2011, Spokane River. Three culverts running under Upriver Drive discharged roadside stormwater from the riverbank into the Spokane River. Spokane County coordinated with the City of Spokane during an adjacent City sewer project to remove these culverts.
- 2015, Liberty Lake Outfall Elimination Project, funded by Ecology (G1400499), removed three pipe connections that flowed directly into the lake.

- 2015, Spokane County completed construction of a series of catch basins, swales, and drywells to intercept and infiltrate stormwater runoff from Ella Road. Since the installation of this new stormwater system, no discharge to and from the outfall pipe to the Spokane River has been observed. See *Attachment 5 – Illicit Discharge Detection and Elimination Activities* for more information regarding the Ella Road outfall.

5.6 Spill Prevention and Response Program

Hazardous spill prevention and response programs and procedures are in place through the County's Fire Department, Emergency Management, and/or contracts with special emergency response providers. These programs and procedures are designed to address safe storage, handling, containment, and cleanup of hazardous substances that have the potential to contaminate surface or groundwater. For protection of human health, property, and the environment, spill incidents exceeding the County's capacity for in-house response is always referred to appropriate emergency management services, including Department of Ecology notification (per General Condition G3), spill response contractors, or 911 emergency services.

5.7 Public Reporting Program Elements

Spokane County continues to maintain an IDDE "Hotline" developed during the previous Permit cycle and follows an established process for investigating calls. On occasion, informational inserts describing the Hotline and its purpose have been distributed to County residents along with County utility billing mailings. Public reporting of illicit discharges or other water quality problems is currently available through the following avenues:

a) Calls to the Stormwater Hotline (509) 477-7525
b) Calls to Spokane County Public Works (509) 477-3600
c) Email via Spokane County website (www.spokanecounty.org)
d) Calls to Spokane Regional Health District (509) 314-1500
e) Calls directly to the Department of Ecology spill hotline 1-800-258-5990

5.8 Hazardous Waste Disposal Program

The County is responsible for providing the framework for solid waste disposal, recycling, and educational outreach (which includes the Household Hazardous Waste Pollution Prevention Program) within unincorporated Spokane County and System-member jurisdictions. The Spokane County Comprehensive Solid Waste Management Plan will guide the solid waste decisions and activities of the System.

Spokane County Code, Title 8, Health and Sanitation Code, Chapter 8.26 – Litter and Discriminate Dumping, Litter in General, addresses the deposition of litter or material upon any public place or private property, or within any waters in Spokane County. Further information on the control of Hazardous Waste Disposal is discussed in Section 8 – Operations and Maintenance. Information regarding public education of Hazardous Waste Disposal is discussed in Section 3 – Public Education and Outreach and Attachment 4 – Public Education and Outreach Activities.

5.9 Priorities and Measurable Goals

Specific Illicit Discharge Detection and Elimination measurable goals are outlined below:

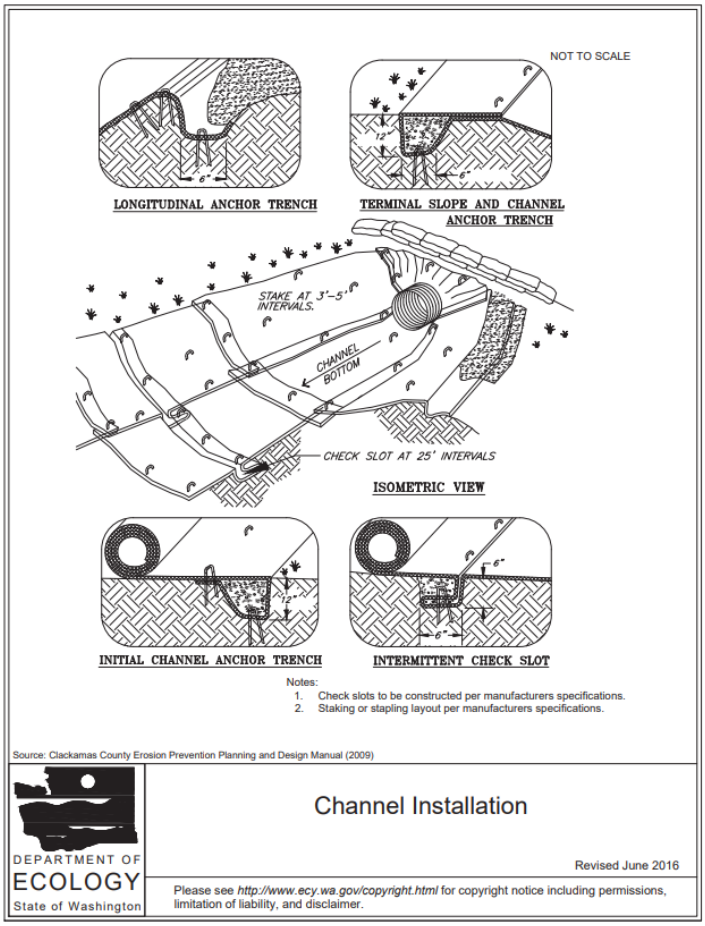
Completed by	Measurable Goals/Milestones
End of Permit Year 1 (July 31, 2015)	• Conduct field inspections of MS4 • Inspect at least 40% of MS4 by December 31, 2018 • Update MS4 basemaps and outfall coverage (see Section 3 – Stormwater Baseline Data and Maps) • Continue to identify and eliminate illicit connections located within the County's MS4 • Pursue opportunities to obtain grants and loans through Ecology for IDDE projects, where possible • Maintain IDDE Hotline, and respond to non-stormwater discharge complaints • Maintain and update database of illicit connections and non-stormwater discharge sites • Continue to train field crews and maintenance staff on the IDDE Program • Update training materials for field crews and maintenance staff, as needed • Inform the public and businesses of hazards associated with illicit discharges and improper disposal of waste • Continue storm drain stenciling program
End of Permit Year 2 (July 31, 2016)	• Continue informing the public and businesses of hazards associated with illicit discharges and improper disposal of waste • Continue implementing previous year's Permit requirements
End of Permit Year 3 (July 31, 2017)	• Continue implementing previous year's Permit requirements
End of Permit Year 4 (July 31, 2018)	• Continue implementing previous year's Permit requirements
End of Permit Year 5 (July 31, 2019)	• Maintain an MS4 inspection frequency of at least 12% every year • Update IDDE Guidance Manual and Spokane County Code (Chapter 9.14), as necessary • Continue implementing previous year's other Permit requirements

SECTION 6 – CONSTRUCTION SITE STORMWATER RUNOFF CONTROL

6.1 Introduction

This section describes the construction site engineering design standards and Best Management Practice programs required by S5.B.4 of the municipal Permit. Construction activity has been identified by the EPA as a high source of pollutants requiring special attention.

Program elements include activities intended to provide guidance to public and private groups in Spokane County regarding appropriate construction practices, as well as activities which support Ecology in implementing its own construction permitting program.



Pictured: An example of an Ecology guidance document for Erosion and Sediment Control BMPs provided in the SWMMEW.

6.2 NPDES Construction Stormwater Permit – Ecology

Any construction project disturbing one (1) acre or more of ground, or construction project of less than one acre that is part of a common plan of development or sale shall receive an NPDES Construction Stormwater General Permit from Ecology prior to beginning any construction activities. Spokane County notifies applicants of the criteria needed for NPDES coverage as part of the permit application process.

6.3 Spokane Regional Stormwater Manual

In 1980, Spokane County Commissioners approved Resolution No. 80-1592, which included the *Guidelines for Stormwater Management* (GSM). The GSM was prepared to provide engineers and developers information regarding drainage requirements for land development in Spokane County. Amendments to this document include the adoption of "Erosion and Sediment Control" components in 1998, among others.

The GSM was replaced by the Spokane Regional Stormwater Manual, adopted by the Board of County Commissioners in June 2008. The SRSM has been accepted by Ecology as equivalent to the Stormwater Management Manual for Eastern Washington.

The SRSM establishes standards for stormwater management to protect water quality, natural drainage systems, and downstream/down-gradient properties as urban development occurs. The

purpose of the SRSM is not only to protect surface and groundwater quality, but also to control stormwater runoff and reduce adverse impacts from flooding. The SRSM describes recommended design criteria for BMPs that will be applied to new development and redevelopment. The SRSM also provides practices and procedures that reflect current LID practices in stormwater design. BMPs include criteria for wetlands, bioinfiltration swales, biofiltration channels, oil-water separators, emerging technologies, etc. All proposed development and redevelopment projects must comply with the standards described in the SRSM (or equivalent manual), and the public is made aware of these standards.

6.4 Erosion and Sediment Control Plan – General Requirements

Erosion and Sediment Control Plans (ESC Plans) in Spokane County are deemed equivalent to Construction Stormwater Pollution Prevention Plans (SWPPPs) under the SRSM (see *Appendix 1* of the Permit). An ESC Plan must be submitted with each project application for any development that is proposing to disturb more than one acre of land, and for projects of less than one acre that are part of a common plan of development or sale (as required by the municipal Permit). For applicable projects that involve ground disturbance, stormwater BMPs are required on site to protect water quality. BMPs must be inspected by certified inspectors; the CESCL program is required for inspectors of construction BMPs in Spokane County.

6.5 Construction Site BMP Elements

Construction site engineering design standards and BMPs are described within the SWMMEW and the SRSM. Proven practices are addressed in these manuals, with newly developed technologies being implemented into manual revisions. The SRSM includes language to adopt, by reference, any BMP authorized by the SWMMEW. In addition, the following chapters of Spokane County Code include provisions on stormwater-related planning, design, construction, and maintenance: 1) Chapter 9.14 – Roads, Approach and Drainage in New Construction; 2) Chapter 12.400 – Subdivisions; and, 3) Chapter 14.802.060 – Parking Lot Location and Design.

6.6 Construction Education and Training Program

When a landowner or developer submits a development application to the County, they are notified of the requirement to prepare a drainage plan meeting state and local regulations. Public notification and approval of the prepared plan is required for construction to move forward. Spokane County conveys erosion and sediment control and BMP requirements for development and redevelopment to contractors and construction site operators through the SRSM, the Planning/Permitting process, brochures, publication, and via the County website.

Existing outreach and education materials for the construction site management program continue to be reviewed and updated as necessary. Various materials for the construction site management program are available through Ecology, the EPA, and on Spokane County's website. Spokane County offers printed materials to developers and contractors during the land-use application process; these materials can also be provided to field staff to distribute at construction sites during field visits.

6.7 Priorities and Measurable Goals

The "Construction Stormwater Management" measurable goals are outlined as follows:

Completed by	Measurable Goals/Milestones
End of Permit Year 1 (July 31, 2015)	• Continue to review all construction site plans for potential water quality impacts • Provide information to construction site operators on training in methods for erosion and sediment control • Ensure erosion control plans are being implemented and maintained at construction sites • Enforce erosion control at construction sites, where necessary • Review and refine procedures for conducting construction inspections and enforcement, as necessary • Continue recordkeeping of construction inspections and enforcement actions • Improve the database for construction permits, inspections, and enforcement, as necessary • Require CESCL training for County engineers and field technicians tasked with inspecting stormwater controls • Include construction permitting information in public education and outreach efforts
Successive Permit Years (July 31, 2016-2019)	Continue implementing previous year's Permit requirements

SECTION 7 – POST-CONSTRUCTION STORMWATER MANAGEMENT FOR NEW DEVELOPMENT AND REDEVELOPMENT

7.1 Introduction

Post-construction stormwater management has been identified by the EPA as an important potential source of stormwater pollution that requires special regulatory attention. Permit section S5.B.5 requires the addition of post-construction inspection, maintenance, and management as part of the SWMP.

Pictured: A functional Post-Construction Stormwater BMP

7.2 Regulatory Mechanisms for Development and Redevelopment

In June 2008, Spokane County formally codified the SRSM, as a comprehensive manual which establishes standards for stormwater design and management for urban development and redevelopment. The SRSM, developed in coordination with the cities of Spokane and Spokane Valley, meets or exceeds relevant criteria from Ecology's SWMMEW. The SRSM provides engineers, developers, construction site operators, and the public with relevant information to design and maintain stormwater BMPs specific to Spokane area needs. Information includes design standards, relevant regulations, engineering calculations, maintenance practices, and more.

7.3 Post-Construction General Requirements and Site Inspection Elements

Section 7 of the SRSM – Construction Site Stormwater Runoff, details the requirement of ESC Plans. These plans are to be submitted with each application for development or redevelopment projects that either alone, or part of a larger development, disturb more than one acre of land. Post-construction review, inspection, and compliance requirements are also described within the following chapters of the Spokane County Code Chapter 9.14 – Roads, Approach and Drainage in New Construction; and Chapter 12.400 – Subdivisions.

Spokane County delegates maintenance and monitoring responsibilities to responsible parties, whether it be an individual or a Homeowners Administration (HOA), via regulatory ordinance. Finalized Plats will often detail maintenance responsibilities for a completed project and to whom responsibility has been delegated. Programs like the Swale Bond program require a deposit that is refundable given proper establishment and maintenance of the swale is achieved. If a stormwater structure is not assigned to another entity, it is added to the GIS mapping system whereby all stormwater structures are inspected every two years. Items referred to as Drainage Accounts or Regional Facilities are often Post-Construction BMPs that are maintained by the County and funded via the collection of special stormwater fees.

7.4 Education and Training Elements of Post-Construction.

Public education and notification of post-construction program elements will continue to be part of the public education and outreach efforts described in Section 3 of the SWMP. Spokane County provides information on erosion and sediment control and BMP requirements for development and redevelopment to construction site operators through the SRSM, the Planning/Permitting process, brochures, publications, and on the County's webpage.

To ensure that structural BMPs continue to be adequately maintained after final installation, relevant Spokane County staff are trained to inspect and enforce post-construction stormwater controls. Training is specific to various departments' operations and functions and will include follow-up trainings as needed. See also Section 2.5 – Staffing, Funding, and Training for Program Elements for details about additional employee construction training activities. Where possible, Spokane County will work with Ecology and other jurisdictions to conduct post-construction inspection training for County personnel. This may include providing venues for workshops, handling local logistics, assisting with advertising, and providing staff to assist with training activities.

7.5 Priorities and Measurable Goals

The "Post-Construction Stormwater Management for New and Redevelopment" measurable goals are outlined below:

Completed by	Measurable Goals/Milestones
End of Permit Year 1 (July 31, 2015)	• Include post-construction stormwater permitting and training information in public education and outreach efforts • Encourage developers and property owners to maintain natural drainages to the maximum extent possible • Allow non-structural preventative actions and Low Impact Development (LID) techniques, measures to minimize the amount of impervious surfaces, and measures to minimize soil disturbance for all new and redevelopment projects • Provide training for staff involved in permitting, planning, review, inspection, and enforcement of post-construction stormwater controls, as needed • Inspect post-construction stormwater BMPs at least once during installation; and, once every five (5) years thereafter • Keep records of post-construction stormwater inspections and enforcement actions • Review processes for post-construction stormwater inspections, enforcement, and recordkeeping; and modify, as necessary • Revise existing code relative to post-construction stormwater inspection, enforcement, and compliance, as necessary
Permit Years 2-5 (July 31, 2016 – July 31, 2019	Continue implementing Permit requirements

SECTION 8 – OPERATIONS AND MAINTENANCE

8.1 Introduction

The Operations and Maintenance program is an essential shared responsibility between multiple Spokane County departments. To effectively integrate stormwater regulatory maintenance requirements into existing Spokane County maintenance practices, the Stormwater Utility developed an Operations and Maintenance Plan. The full Stormwater O&M Plan is available online[5], with hard copies available at the County Public Works Building, Department of Stormwater Utility.

The Spokane County Stormwater Operations and Maintenance Plan adopts pollution prevention practices as the primary method reducing or eliminating pollution at its source. Examples of pollution prevention include Good Housekeeping, BMPs, LID, and ongoing preventative maintenance operations. Pollution prevention, when applied to public operations and facilities, helps to mitigate the effects of urbanization on water quality. These structural, operational, and treatment BMPs address the miscellaneous requirements described in S5.B.6 of the Permit.

8.2 Municipal Facilities Stormwater Program

The Permit identifies minimum performance measures for the operation and maintenance of publicly owned facilities and public activities with the potential to impact stormwater quality. These facilities/activities are divided into the following categories:

a) Stormwater collection and conveyance systems
b) Roads, highways, and parking lots
c) Vehicle fleets
d) Municipal buildings
e) Parks and open space
f) Construction Projects
g) Industrial activities
h) Material storage areas, heavy equipment storage areas, and maintenance areas
i) Flood management projects
j) Other facilities that would reasonably be expected to discharge contaminated runoff

Stormwater Utility works in concert with the following County departments: Environmental Services; Facilities Maintenance, including maintenance supervisors at the County shops within the Permit boundary; Parks, Recreation, and Golf; Fair and Expo; Human Resources; and Sherriff. Employees periodically review site management practices; the use of herbicides, pesticides, and other chemicals; the disposal of vactor wastes; and the treatment and disposal of stormwater runoff from various sites. Existing maintenance plans will be reviewed and updated as necessary.

8.2.1 Roadway Stormwater Facilities and Conveyance Systems

The County is responsible for the construction of new roads and improvements to existing roads, including selection, installation, and retrofit of stormwater BMPs. Stormwater Utility

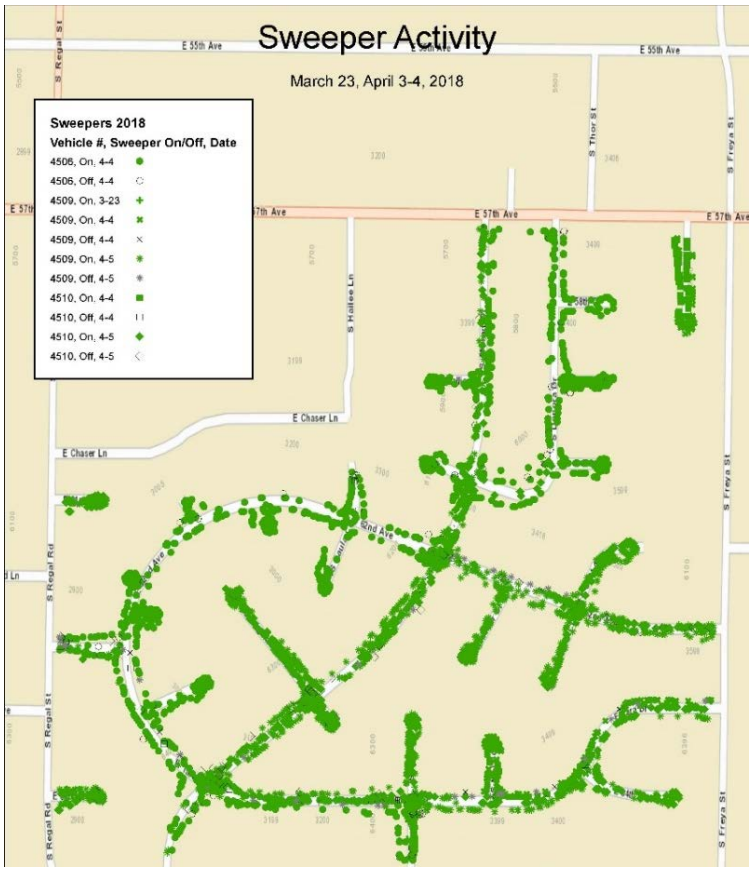
[5] https://www.spokanecounty.org/DocumentCenter/View/1715/Spokane-County-Stormwater-OM-Plan-PDF?bidId=

works with the Public Works design section to ensure that all proposed road projects comply with the design, operation, and maintenance requirements outlined in the SRSM or SWMMEW. Future maintenance needs are heavily considered when designing any new stormwater treatment and disposal structures within County roads.

Curbs, gutters, culverts, and ditches alongside County roads comprise a large portion of the permitted MS4. The Stormwater Utility works in conjunction with County Road Maintenance crews to update the inventory of these facilities and implement preventative or proactive maintenance activities. Field crews are continually inspecting structures, and scheduling maintenance activities based on need. Frequent inspection helps to develop adequate maintenance frequencies for catch basins, inlets, storm drains, ditches, and culverts.

The sweeping of roads is a pollution prevention practice that removes materials that would otherwise be deposited in stormwater structures such as catch basins, drywells, and swales. County streets are cleaned frequently, while County parking lots are swept twice per year (spring and fall). In 2018, more than 13,000 miles of County roads maintained using street sweepers. Furthermore, additional spot cleaning operations are conducted based on field inspections, guidance from regional manuals, or in response to public request.

Spokane County placed GPS units on all street sweepers to provide documentation of sweeping activities, as well as provide the public an opportunity to view street sweeping progress. See below snapshot of selected sweeper activity within a section of the Glenrose Watershed that occurred during the 2017 calendar year:



Pictured left: Example of 2018 street sweeper activity in Spokane County.

Pictured below: Street sweeper in use.

The Stormwater Utility regularly consults with the Roads Maintenance Department and Public Works Information Technology on procedures for tracking and reporting stormwater facility maintenance activities. This includes, but is not limited to, standardization of the data that will be collected and how it will be reported.

8.2.2 Municipal Buildings, Parks, and Open Space

Municipal buildings, parks, golf courses, and natural areas all require maintenance which, if improperly managed, could result in environmental impact. The application of chemicals such as cleaners, fertilizers, herbicides, pesticides, and deicers have the potential to runoff and enter downstream receiving waters. When performed improperly, maintenance activities such as washing of windows, sweeping sidewalks and parking lots, mowing grass, and maintaining structures may also contaminate surface waters with harmful pollutants including sediments, metals, and nutrients.

Maintenance activities require an Operational BMP approach to effectively prevent stormwater pollution. Pollution prevention and good housekeeping practices are essential, recurring activities that require responsible decisions to protect valuable water resources. The Spokane County Operations and Maintenance plan details specific sources of pollution involved in each maintenance activity and describes methods of minimizing adverse impacts to the environment.

Training is provided to employees, as needed, regarding pollution prevention practices such as good housekeeping. The Stormwater Utility works with Facilities Maintenance and Parks and Recreation staff to evaluate individual training needs and provide resources to improve the practices of pollution prevention.

Pictured: The Liberty Lake Golf Course, owned and operated by the Spokane County Parks, Recreation, and Golf Department

Golf courses are an example of facilities that, if not maintained properly, can impact water quality via surface runoff.

8.2.3 Industrial Facilities

Spokane County owns a wastewater treatment plant, the Spokane County Regional Water Reclamation Facility (Facility or SCRWRF), which provides advanced treatment for sewage before discharging reclaimed water to the Spokane River. The Facility is currently regulated under the provisions of a municipal wastewater NPDES Permit, Permit WA-0093317, effective December 1, 2011. On-site systems have been designed to prevent or reduce the availability, release, or transport of substances that adversely affect surface and ground waters. These systems typically include source control practices; spill response, prevention, and containment; reducing exposure of materials to the elements; stormwater collection and treatment; and groundwater monitoring.

8.2.4 Municipal Waste Management

Spokane County monitors five closed landfills situated within the NPDES Permit boundary. These landfills, which no longer accept waste, are undergoing post-closure activities to prevent any potential impacts to the environment. The County operates two waste transfer stations which began operation in 1991: The North County Transfer Station and the Valley Transfer Station. The Valley Transfer Station is located within the municipal boundary of the City of Spokane Valley. The North County Transfer Station is located to the north of the NPDES Permit boundary. Both stations have separate areas set aside for customers to dispose of municipal solid waste, yard debris, refrigerant, appliances, scrap metal, non-burnable materials, recyclable materials, and moderate-risk waste.

In 2012, the County received a grant from the Department of Ecology (G120559) to construct a vactor waste decant facility at the Old Corral site, located at 15 E Farwell Rd. Spokane, WA 99260. The project, completed in 2015, was designed in accordance with the SRSM. Procedures for using the decant facility are detailed in the site's Operation and Maintenance Plan, with a formal training conducted in 2015 to educate operators on proper operational procedures. Additional training is conducted for any new employees, and as needed to account for regulatory change. Waste generated from the cleaning of catch basins, drywells, swales, and other stormwater facilities are transferred to the decant facility. The decant facility allows water to separate from the solids, treating and infiltrating the water or allowing it to evaporate. The dried solids are then disposed of according to applicable waste regulations.

Lastly, the Spokane Regional Solid Waste System was created by an Interlocal Agreement between Spokane County and the City of Spokane on October 11, 1988. All ten of the existing regional cities and towns, as well as Fairchild Air Force Base, subsequently joined the Spokane Regional Solid Waste System by executing interlocal agreements with the City and County of Spokane. In 2003 the newly incorporated cities of Liberty Lake and Spokane Valley also executed interlocal agreements and joined.

8.2.5 Material Storage, Heavy Equipment Storage, Maintenance Areas, and Vehicle Fleets

The Stormwater Utility reviews operations and maintenance practices and implements improvements for performing activities in environmentally responsible ways. Spokane County has developed SWPPPs for required facilities, as required by S5.B.6.a.i.h the Permit. SWPPPs

are site specific stormwater plans that act as living documents to guide employees on stormwater regulations and methods of compliance. With the draft version of the 2019 Permit released, Spokane County has been preemptively evaluating facility SWPPPs in preparation for meeting future compliance guidelines. Some examples of Good Housekeeping practices include:

- Cover vehicle or material storage areas to prevent stormwater impact.
- Install treatment BMPs, like bioinfiltration swales, to capture and treat runoff prior to discharge.
- Conduct vehicle and equipment washing in self-contained covered building or in designated wash areas designed to keep wash-water contaminants out of the MS4.
- Follow general storage guidelines at each facility, with specific storage needs addressed on a site-by-site basis in SWPPPs.
- Inspections occur at least annually to ensure Permit compliance is met.

Staff are trained on the additional requirements regarding pollution prevention and good housekeeping practices at vehicle and heavy equipment maintenance shops. At facilities without adequate vehicle wash stations, washing occurs off-site at contracted wash stations.

In 2015/2016, Spokane County Engineering and Roads put together a six-year capital plan to update and build six equipment maintenance shops for road field operations. The facilities are designed to treat stormwater in accordance with SRSM, which is an approved equivalent to the Department of Ecology's SWMMEW. All on-site stormwater runoff will be collected and treated according to Permit, manual, and UIC guidelines prior to discharge.

8.2.6 Construction Projects

Spokane County will continue to comply with the applicable standards for pollution prevention control measures related to construction activities. The local and regional stormwater manuals detail engineering design standards which including implementation and maintenance of stormwater BMPs relevant to construction projects. See Section 6 and Section 7 of this SWMP for construction and post-construction site stormwater management objectives.

NPDES Construction Stormwater General Permits are required by the Department of Ecology for construction projects exceeding one acre or are part of a larger development exceeding one acre, that also have the potential to impact surface waters of the state via stormwater runoff. These permits require the submittal of stormwater pollution prevention plans; implementation of sediment, erosion, and pollution prevention measures; and are subject to inspection and enforcement by Ecology.

8.2.7 Flood Management Projects

Spokane County is responsible for reviewing, implementing, and enforcing local, state, and federal floodplain management requirements. Floodplain management measures reduce the risk of current and future flooding, issues which can negatively impact water quality. Coordination occurs between permitting entities, such as the Army Corps of Engineers, to prevent human activities from significantly and adversely affecting the environment. Uncontrolled construction

within a floodplain, improper design, and lack of floodplain maintenance lead to problems that can otherwise be avoided with proper floodplain management.

8.3 Priorities and Measurable Goals

The "Operations and Maintenance" measurable goals are outlined in the following table:

Completed by	Measurable Goals/Milestones
End of Permit Year 1 (July 31, 2015)	• Update good housekeeping and pollution prevention materials for maintenance staff and field crews, as necessary • Continue to implement inspection schedule of fleet operations, heavy equipment and equipment storage areas, and maintenance areas • Continue assessment of existing fleet operations, and make improvements based on assessment findings, as necessary • Continue implementing SWPPPs for existing vehicle fleets, heavy equipment storage areas, and maintenance areas • Continue implementing the County's spill response plan for vehicle fleets, heavy equipment storage areas, and maintenance areas • Continue inspections and assessment of material storage locations, and make improvements based on findings, as necessary • Continue to conduct catch basin inspections within the County's MS4 • Continue the County's street sweeping program • Continue the County's parking lot sweeping program • Continue to monitor and track MS4 cleaning activities
End of Permit Year 1 (July 31, 2015)	• Continue to implement erosion controls for County construction projects that meet Ecology's 1-acre land disturbance threshold • Continue to train in-house inspectors in erosion and stormwater controls • Continue to train maintenance staff, field crews, and other County employees in good housekeeping and pollution prevention practices Continue recordkeeping of O&M actions and activities
End of Permit Year 2 (July 31, 2016)	• Continue implementing previous year's Permit requirements
End of Permit Year 3 (July 31, 2017)	• Identify any new or recently acquired County-owned properties, and revise the County's O&M program accordingly to include development of SWPPPs for any new vehicle fleets, heavy equipment storage areas, and maintenance areas, as necessary • Review and update other aspects of the County's O&M program, if needed • Continue implementing previous year's Permit requirements
End of Permit Year 4 (July 31, 2018)	• Accomplish inspections of all County catch basins by December 31, 2018 • Continue implementing previous year's Permit requirements
End of Permit Year 5 (July 31, 2019)	• Increase catch basin inspection frequency to 95% of MS4 every two years • Continue implementing previous year's Permit requirements

SECTION 9 – TOTAL MAXIMUM DAILY LOAD REQUIREMENTS

9.1 Introduction

The state of Washington identifies the need for clean water for both economic development and a healthy environment. For waterbodies not meeting current water quality standards, development of a TMDL is one way to return them to a healthy condition. TMDL programs identify sources of pollution to streams, rivers, and lakes, and outline how to reduce pollution to those waters. They also assist local communities with finding solutions to restore and maintain clean water.

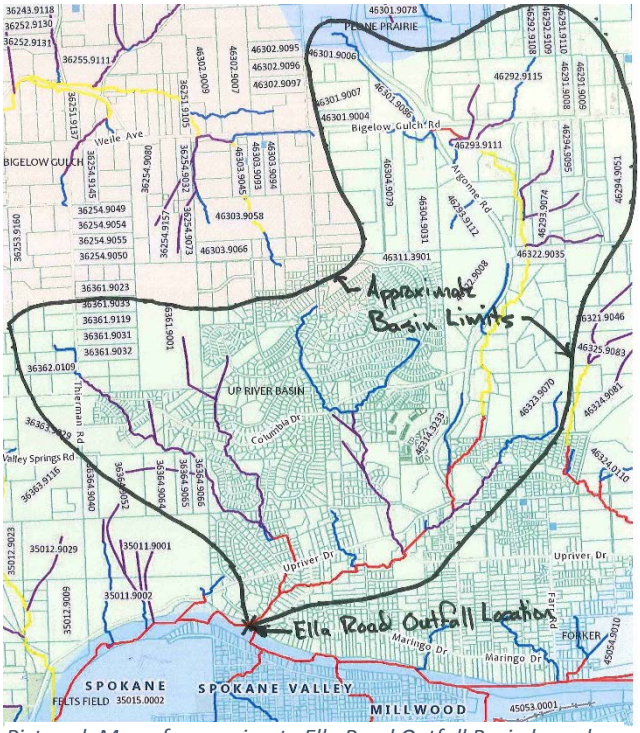
A TMDL is a calculation of the maximum amount of a pollutant that a water body can receive to still safely meet water quality standards. TMDLs describe the type, amount, and sources of water pollution in a particular waterbody; analyze how much the pollution needs to be reduced or eliminated to meet water quality standards; and, provide targets and strategies to control the pollution. Ecology determines the reduction of pollutant discharge needed to be compliant with water quality standards.

Multiple local waterbodies are designated as impaired, including the Spokane River, for which several water quality parameters do not meet State-established standards. Parameters of concern include dissolved oxygen, metals, phosphorus, and toxics. As such, Ecology has developed TMDLs for sections of the Spokane River that address these impairments.

This section details the implementation of special provision S7 – Compliance with Total Maximum Daily Load Requirements, of the Permit.

9.2 Upriver Watershed Drainage Basin and Ella Road Outfall

At the time of Permit issuance in 2014, the Ella Road outfall was one of Spokane County's two known remaining outfalls to the Spokane River (the other being the Seven Mile Bridge). The portion of the Upriver Watershed that contributes to the Ella Road outfall encompasses approximately 2,500 acres. The basin originates up near the Argonne Road and Bigelow Gulch intersection and continues south and west to the outfall location at the south end of Ella Road. Land use is predominantly residential in varying densities. The lower portion of the drainage basin is part of a Federal Emergency Management Agency (FEMA) designated floodway. It is very broad and flat, and the native soils are coarse and infiltrate water rapidly. Additionally, the basin is located north of the Spokane River and overlies the Spokane Valley-Rathdrum Prairie aquifer.



Pictured: Map of approximate Ella Road Outfall Basin boundary

As of 2018, the Ella Road Outfall has received no water discharge since the completion of the Ella Road Outfall Elimination Project. This section details the actions taken during the elimination project; *Attachment 5* contains further details on outfall monitoring and elimination projects.

9.3 TMDL Requirements and Responsibilities

Per the current Permit, Appendix 2 – TMDL Requirements, Spokane County is tasked with developing and implementing a monitoring program to evaluate stormwater discharges to the Spokane River via the Ella Road outfall to determine pollutant loading for carbonaceous biochemical oxygen demand (CBOD), total phosphorus, and ammonia. Further, procedures for field activities and laboratory analyses associated with said monitoring are to be documented in an Ecology-approved Quality Assurance Project Plan (QAPP). Specific to-date requirements are described as follows.

No Later than August 31, 2014, Spokane County shall:

a) Prepare a monitoring plan to evaluate its stormwater discharges to the Spokane River to determine pollutant loading for CBOD, phosphorus, and ammonia;
b) Conduct sampling at the Ella Road outfall and calculate discharge volume estimates at least once per month during the months of March through October during the first precipitation event in a month that produces adequate stormwater for analysis; and,
c) Prepare and submit a QAPP to Ecology for review and approval that follows *Quality Assurance Project Plans for Environmental Studies*, July 2004, Ecology Publication No. 04-03-030. Monitoring shall be conducted using Ecology-approved Standard Operating Procedures. If the QAPP needs to be modified, Spokane County will provide the updated QAPP for review and approval within 90 days of receiving Ecology comments.

No later than August 31, 2015, Spokane County shall:

d) Start sampling and implement the Ecology-approved monitoring plan; and,
e) Enter all applicable seasonal results of the monitoring into Ecology's EIM database by December 21st of each year. Include a summary and discussion of the monitoring results with the respective Annual Report.

No later than December 31, 2016, Spokane County shall:

f) Analyze the results of the monitoring plan to evaluate pollutant loading with respect to Spokane County's share of the Stormwater Wasteload Allocations (WLA) in the TMDL. If the monitoring results indicate that WLAs are being exceeded, then an adaptive management response to reduce pollutant loading shall be initiated.

Additionally, no later than December 31, 2017, Spokane County shall:

g) Evaluate the results of the monitoring plan in consultation with Ecology to determine pollutant loading with respect to Spokane County's share of the stormwater WLAs in the TMDL. If the monitoring results indicate that stormwater WLAs are being exceeded, then an adaptive management response to reduce pollutant loading shall be initiated.
h)

9.4 TMDL Implementation Actions and Activities

In August 2015, the Spokane County Stormwater Utility prepared and submitted a draft QAPP to Ecology that proposed to evaluate stormwater discharges to the Spokane River via the Ella Road outfall. The summary of tasks was divided into two phases:

a) **Phase 1**: Flow monitoring will take place for the first year to determine if, and how much, flow is entering the culvert and discharging to the Spokane River. Data from rainfall events will be evaluated and compared to outflow data to determine if runoff is produced during various-sized storm events. Once the flow data for the year has been analyzed, Spokane County will coordinate with Ecology staff on the results to determine if the flows are sufficient and/or feasible for future monitoring.
b) **Phase 2**: If it is determined by Spokane County and Ecology staff that flows are occurring in sufficient quantity to allow for water quality sampling, the second phase will be implemented. Phase II will consist of flow-weighted sampling using an auto-sampler positioned at the inlet to the discharge culvert at the south end of Ella Road.

Not long after the draft QAPP was submitted, Spokane County learned that the Ella Road outfall pipe is sited in a designated floodway, and its removal would require an overarching restudy of the Upriver basin and a Conditional Letter of Map Revision (CLOMR) from the Federal Emergency Management Agency (FEMA). The County instead constructed a series of catch basins, swales, and drywells in advance of the outfall pipe to intercept and infiltrate the stormwater runoff flowing down Ella Road. Since installation of these new drainage facilities, staff has performed site visits during and after significant rainfall events. No flow to the outfall pipe was observed on any of these inspections, and the sediment past the mouth of the outfall was found to be dry and undisturbed each time.

It is important to note that the drainage basin has changed over time due to development and other land activities that have effectively intercepted and infiltrated stormwater runoff via deep roadside embankments and large bioretention facilities. Because of these development changes, overall runoff within the basin has decreased dramatically, contributing to the lack of stormwater flow reaching the Ella Road outfall pipe.

Because the NPDES Permit requires water quality monitoring at this location, Spokane County proposed an adaptive monitoring study in 2016 to address the Permit requirement for this outfall. The goal of the study was to determine if adequate flows exist to facilitate comprehensive water quality sampling. Since stormwater discharges were determined to be insufficient during regular site inspections, monitoring and sampling plans for qualifying storms were not proposed within the updated QAPP.

9.5 Ongoing SWMP Actions and Activities

Spokane County requires design and implementation of construction and post-construction Best Management Practices (BMPs) for flow and pollution control to protect surface waterbodies and meet water quality and TMDL goals. Spokane County also employs good housekeeping in the form of maintenance of storm drainage facilities within road rights-of-way, and County-owned properties, to reduce nutrient and other pollutant-loading impacts on surface waterbodies. Spokane

County intends to continue monitoring outfall locations for evidence of illicit discharges and illicit connections, as these structures have the potential to immediately impact surface water quality should any problems occur.

9.6 Future TMDL Activities

As of March 2019, Spokane County is not included in Appendix 2 of the most recent version of the draft 2019-2024. Permit section S7.B states that "For applicable TMDLs not listed in Appendix 2, compliance with this permit shall constitute compliance with those TMDLs." Thus, it is anticipated that during the next permit cycle, Spokane County will not be responsible for the management of any QAPPs. The County will continue regular monitoring activities for known outfalls, as well as continue monitoring for unknown outfalls on applicable water bodies.

9.7 Priorities and Measurable Goals

The "Total Maximum Daily Load Requirements" measurable goals are outlined below:

Completed by	Measurable Goals/Milestones
End of Permit Year 1 (July 31, 2015)	• Prepare Ella Road stormwater discharge monitoring plan by August 31, 2014 • Prepare and submit a Quality Assurance Project Plan (QAPP) to Ecology by August 31, 2014 • Modify QAPP, if necessary, and resubmit within 90 days of receiving Ecology comments • Include documentation of progress in Annual Report
End of Permit Year 2 (July 31, 2016)	• Implement monitoring plan by August 31, 2015 • Include documentation of progress in Annual Report
End of Permit Year 3 (July 31, 2017)	• Consult with Ecology to evaluate results of monitoring plan prior to December 31, 2016 • If monitoring results exceed Ecology's Waste Load Allocations (WLA) for pollutant loading, prepare and submit an Action Plan to Ecology by March 31, 2017 • Include documentation of progress in Annual Report
End of Permit Year 4 (July 31, 2018)	• Implement Action Plan conditions, as required • Include documentation of progress in Annual Report
End of Permit Year 5 (July 31, 2019)	• Continue implementing previous year's Permit requirements

SECTION 10 – STORMWATER MANAGEMENT PROGRAM EFFECTIVENESS STUDIES

10.1 Introduction

Effectiveness studies are integral for the continual improvement and development of municipal stormwater programs. Effectiveness studies are aimed at determining how successful a program or program element is at complying with NPDES Permit requirements, changing behavior, decreasing inputs of target pollutants to the environment, and developing new technologies, such as BMPs, that can be utilized by permittees.

This section addresses the Eastern Washington Phase II Municipal Stormwater Permit, special provision S8.B, which requires Permittees to propose, select, develop, and conduct Ecology-approved studies to assess the effectiveness of Permit-required stormwater management activities and BMPs.

Pictured: Sand Filter Sidewalk Vault BMP Effectiveness Study site

10.2 Planning and Development

Cities and counties within Central and Eastern Washington have created a working group, known as the Eastern Washington Stormwater Group (EWSG), to collaborate on regional guidance documents and draft permits. In 2013, the EWSG began discussing how to cooperatively develop and implement studies to test the effectiveness of Stormwater Management Program (SWMP) components. In developing study ideas, the goal was to make sure that the studies evaluated stormwater management activities that are currently being implemented by member jurisdictions, and/or could be efficiently managed by staff.

The City of Spokane Valley has been awarded two grants from Ecoloy to assist Permittees in meeting this program component and has been coordinating all phases of this effort through 2017. Key documents compiled to-date are published on the City of Spokane Valley's website[6].

10.3 Formulating Study Ideas

In 2014, the EWSG produced a list of 40 potential effectiveness study ideas. The list was narrowed down to 24 study ideas and a conceptual study design was subsequently developed for each study. On June 30, 2015, a report outlining the work completed was submitted to the Department of Ecology (Ecology). The following table summarizes the study ideas initially compiled by the EWSG.

[6] http://www.spokanevalley.org/

Proposed Effectiveness Study Ideas			
Study No.	**Study Title**	**Permit Category**	**Study Summary**
1	Modernizing Education & Outreach Strategies	Public Education & Outreach	A marketing firm would be hired to develop an education and outreach program utilizing modern communication tools (apps, social media) would be developed for one stormwater Permit-related topic (e.g., reporting illicit discharges). Public awareness and behaviors about the topic would be assessed via survey before and after deliver of the educational campaign to assess results.
2	Mobile Contractor Illicit Discharge Education	Public Education and Outreach	This study will involve the development and testing of a new educational program for educating contractors that move on a daily basis about illicit discharge prevention. The study will focus, in particular, on ways of reaching mobile contractors and delivering the material.
3	Illicit Discharge Detection Methods	IDDE	The study will survey stormwater managers to gather information regarding illicit discharges detected by various IDDE methods. The purpose is to identify which methods result in the highest detection rate.
5	Business Inspection Program Strategies	IDDE	This survey study will query Phase II Western Washington jurisdictions with business inspection programs. The purpose of the survey will be to qualitatively assess the effectiveness of business inspection programs in Western Washington, and to learn effective strategies that can be adopted into the developing business inspection programs of Eastern Washington jurisdictions.
6	Soil Amendments for Erosion Control & Revegetation	Construction Site Stormwater Runoff Control	This study will test commercially available soil amendments claiming to improve plant growth by enhancing soil structure and water holding capacity. The study will be conducted at a plot scale using typical erosion control seed grass mixes.
7	Stormwater BMP Owner Awareness	Post-Construction Stormwater Management	This simple, survey study will be delivered to homeowners, homeowners associations, and businesses that have structural stormwater BMPs installed on their properties. The survey will assess their general knowledge about the stormwater BMPs on their land, the maintenance requirements of the BMP, and their responsibility to continually maintain the BMP.
8	Long-Term Maintenance of Privately Owned BMPs	Post-Construction Stormwater Management	This two-part study will review existing inspection and maintenance records to evaluate the effectiveness of each Eastern Washington Jurisdiction's inspection and maintenance program, and survey Permittees to learn about the most significant impediments to conducting BMP inspections.
9	BMP Inspection & Maintenance Responsibilities	Post-Construction Stormwater Management	A survey will be used to gather information from Washington Jurisdictions to learn novel and effective ways that municipalities are meeting the challenge of ensuring ongoing maintenance of structural BMPs on private property. In particular, the survey will question Permittees about different models of BMP ownership and responsibility for continued maintenance of BMPs.

Proposed Effectiveness Study Ideas (Continued)			
Study No.	**Study Title**	**Permit Category**	**Study Summary**
10	Impact of Privately Owned BMPs on MS4s	Post-Construction Stormwater Management	This study will evaluate the percentage of privately owned BMPs that would drain to the MS4 in the event of failure. The study will use GIS analysis at the sub-basin scale.
11	Comparison of Conventional & LID BMPs	Post-Construction Stormwater Management	This study will evaluate flow control benefits through sizing and modeling various BMPs (both common infiltration BMPs and LID BMPs) for typical residential and commercial development in Eastern Washington. The study would also include a cost comparison among various BMPs and compile an Eastern Washington Stormwater BMP cost database.
12	Long-term Permeable Pavement Sidewalk Infiltration Performance	Municipal Operations & Maintenance	Test strips of permeable pavement sidewalks will be constructed in four Eastern Washington communities. Infiltration measurements will occur twice yearly for a 10-year study period. No maintenance will take place, so the infiltration measurements will document decreases in infiltration performance over time as the pavement becomes clogged with sediment.
13	Permeable Pavement Parking Lot Maintenance	Municipal Operations & Maintenance	Test segments will be designated within the traveling lanes of a newly constructed permeable pavement parking lot. Each test segment will be subjected to different maintenance regimes ranging from no-maintenance to monthly vacuuming. The infiltration rate of the pavement will be measured on a quarterly basis and the infiltration performance of each test segment will be tracked over time.
14	Sharp Avenue Porous Pavement Study	Municipal Operations & Maintenance	A porous pavement "laboratory" will be constructed in the traveling and parking lanes of a City arterial street near Gonzaga University. A porous concrete intersection, full-width pervious asphalt, pervious asphalt in the parking lanes only, and a control section will be installed. Gonzaga University students will monitor water quality, pavement condition over time (especially with respect to studded tire use) and operations and maintenance impacts.
15	Street Sweeping & Catch Basin Cleaning Comparison	Municipal Operations & Maintenance	This study will use a small-scale, "paired" basin approach for evaluating differences in the amount of material removal by street sweeping and catch basin cleaning compared to only catch basin sweeping. One of the basins will be swept regularly, and the other will not. The total amount of material removed will be calculated for both basins and compared. All Eastern Washington jurisdictions will also be surveyed about their street sweeping and catch basin cleaning procedures.
16	Seasonal Differences in Street Sweeping Material Removal	Municipal Operations & Maintenance	All the roadways within four or five communities will be swept on a monthly basis. The amount of material and pollutants removed during each sweeping event will be totaled. Statistical analysis will be used to identify whether there are significant factors (timing, region) affecting the amount of material removed by each sweeping event (a surrogate for sediment deposition rate).

Proposed Effectiveness Study Ideas (Continued)			
Study No.	**Study Title**	**Permit Category**	**Study Summary**
17	Catch Basin Insert Monitoring Protocol	Municipal Operations & Maintenance	The objective of this study is to develop a protocol (QAPP) for evaluating the effectiveness of commercially available catch basin inserts at bench and field scales. Having this procedure in place will streamline testing and evaluation, and will ensure uniformity of methods allowing for objective performance comparisons. This protocol would be developed with input from Ecology and interested vendors. Vendors who chose to have their product tested would provide the funding for the testing.
18	Catch Basin Retrofit Device Placement	Municipal Operations & Maintenance	The objective of this research is to evaluate gross solids removal differences between two, similarly sized and located catchments; one in which a downturned elbow type retrofit is only installed at the most downstream catch basin and one in which retrofits are installed at multiple locations within the catchment.
19	Seeding and Irrigation for Vegetated BMPs	Monitoring & Assessment	Test plots simulating conditions in vegetated BMPs (e.g., bioretention, bioinfiltration, dispersion) will be constructed. Different seeding densities of seed mixes typically used in Eastern Washington, and irrigation regimes will be applied to each test plot. Beneficial plant and weed growth will be monitored. Jurisdictions will be able to use this information to help with plants establishment in vegetated BMPs, resulting in better performance, reduced maintenance needs, and cost savings.
20	Planting Options for Bioretention BMPs	Monitoring & Assessment	A plant list of climate-appropriate plants will be developed based on literature sources. Test plots simulating conditions in bioretention BMPs will be constructed. Combinations of seed mixes and substrates, as well as at least one option that has no plants, will be applied to the test plots. Infiltration and soil cation exchange capacity will be measured throughout the study.
21	Media Component Study	Monitoring & Assessment	This project would mimic the Western Washington study conducted at the Washington Stormwater Center that evaluated media mixes used in bioretention facilities. The purpose of this study would be to develop bioretention media better suited for Eastern Washington conditions, and if possible maximize usage of locally sourced materials.
22	Treatment for Comingled Stormwater & Agricultural Discharges	Monitoring & Assessment	Synthetic water blends with nutrient, metal, bacteria, and pesticide concentrations typical of those found in agricultural runoff in eastern Washington will be run through test columns with different media and native soil combinations found in Eastern Washington infiltration and UIC stormwater treatment devices. The purpose of this experiment is to determine if existing stormwater treatment is capable of treating agricultural water that is comingled with stormwater to a level that is safe and protective of water quality so that decision makers can make more informed decisions.

Proposed Effectiveness Study Ideas (Continued)			
Study No.	**Study Title**	**Permit Category**	**Study Summary**
24	Biochar Media Stormwater Treatment Study	Monitoring & Assessment	Two types of biochar are being studied for their stormwater treatment capacity (Kentucky bluegrass and wood-based biochars). A bench-scale laboratory study was completed in 2015. A field scale pilot study began construction in 2014 and will be implemented in 2015. The field portion of the study includes construction and water quality monitoring of storm gardens with biochar-supplemented treatment media along Garland Avenue in Spokane.
27	Media Thickness Study	Monitoring & Assessment	This study will help to determine optimal media depths for maximizing performance and cost-effectiveness bioinfiltration BMPs in Eastern Washington. A bioinfiltration pond with two treatment cells (12- and 18-inch media depth) was constructed adjacent to the parking area at Gonzaga University's Rudolph Fitness Center. Influent and effluent concentrations for each of the treatment cells will be compared to determine treatment efficiency of each of the cells. From this analysis, differences in treatment efficiency and performance attributable to the different media depths of each of the cells should be determined.

10.4 Ranking and Selecting Study Proposals for Implementation

The EWSG collaborated throughout the 2015 and 2016 calendar years to make the final selection of study ideas, choose lead agencies to champion each study, and explore different structures for organizing the work. Ultimately the EWSG chose 14 ideas, ranked them in order of readiness for implementation, and submitted the proposal to Ecology for approval by June 30, 2016.

The following table summarizes the ranked studies, lead entities, and secondary Permittees that will participate in each effectiveness study. The official ranked list of effectiveness study ideas[7] is published on the City of Spokane Valley's website.

[7] http://www.spokanevalley.org/filestorage/6836/6896/6914/8301/10121/Phase_2_Ranked_List_of_Study_Ideas.pdf

Effectiveness Study Ranking, Lead Entities, and Participating Permittees				
EWSG Rank	**Study No.**	**Study Title**	**Lead Entity**	**Participating Permittees**
1	1	Modernizing Education & Outreach Strategies	City of Kennewick	**Cities**: Asotin, Clarkston, Pasco, Pullman, Spokane Valley, West Richland, Wenatchee, Yakima **Counties**: Asotin, Spokane, Yakima
2	20	Planting Options for Bioretention BMPs	City of Pasco	**Cities**: Asotin, Clarkston, Kennewick, Moses Lake, Pullman, Richland, Spokane Valley, Walla Walla, West Richland, Yakima **Counties**: Asotin, Douglas, Walla Walla, Yakima
3	15	Street Sweeping and Catch Basin Cleaning Comparison	City of Ellensburg	**Cities**: Asotin, Moses Lake, Spokane, Spokane Valley, Walla Walla, Wenatchee, West Richland **Counties**: Asotin, Douglas, Walla Walla, Yakima
4	2	Mobile Contractor Illicit Discharge Education	City of Wenatchee	**Cities**: East Wenatchee, Ellensburg, Kennewick, Pasco, Spokane Valley, Walla Walla, West Richland, Yakima **Counties**: Chelan, Douglas, Yakima
5	28	Sand Filter Vault BMP	Spokane County	**Cities**: Moses Lake, Pullman, Spokane Valley, Wenatchee, West Richland
6	9	BMP Inspection and Maintenance Responsibilities	Yakima County	**Cities:** Pasco, Wenatchee, West Richland, Yakima **Counties**: Walla Walla
6	16	Seasonal Differences in Street Sweeping Material Removal	City of Spokane Valley	**Cities**: East Wenatchee, Ellensburg, Kennewick, Pasco, Pullman, Wenatchee, Yakima **Counties**: Chelan, Douglas, Walla Walla
6	18	Catch Basin Retrofit Device Placement	Asotin County & City of Spokane Valley	**Cities**: Kennewick, Pullman, Wenatchee
9	7	Stormwater BMP Owner Awareness	City of Wenatchee	**Cities**: East Wenatchee, Ellensburg, Kennewick, Pasco, Pullman, Yakima **Counties**: Chelan, Douglas, Walla Walla
10	29	Determining Pollutant Contributions from Municipal Stormwater in EWA using GIS	City of Spokane Valley	**Cities**: East Wenatchee, Moses Lake, Yakima
11	27	27a. Media Thickness Study	Spokane County	**Cities**: Richland, Spokane Valley **Counties**: Walla Walla
12	14	Sharp Avenue Porous Pavement Study	City of Spokane	**Cities**: Spokane Valley
12	24	Biochar Media Stormwater Treatment	City of Spokane	**Cities**: Spokane Valley **Counties**: Spokane
14	12	Long-term Permeable Pavement Sidewalk Infiltration Performance	City of Richland	**Cities**: Spokane Valley **Counties**: Yakima

10.5 Development of Experimental Design – QAPP Templates and Study Proposals

Under the direction of the EWSG, consultants began drafting Quality Assurance Project Plan (QAPP) templates for the proposed studies in July 2016. And, in March 2017, the EWSG selected 8 studies – from the condensed list of 14 study ideas – to begin planning and developing *detailed* effectiveness study design proposals (Proposals). The eight Proposals were completed and subsequently submitted to Ecology by June 30, 2017.

Spokane County is the intended lead entity (ILE) on two studies: the *Sand Filter Vault Effectiveness Study*, and the *Bioretention Soil Media Effectiveness Study*. Summaries of the County's Proposals are listed below. Additionally, a report outlining the steps taken[8] by the EWSG and consultants to develop the QAPP templates and eight Proposals is published on the City of Spokane Valley's website.

Attachment 6 contains the full report for each Effectiveness Study led by Spokane County. The goals for each study are:

- **Sand Filter Vault Study:** The purpose of this study is to evaluate the effectiveness of a sand filter BMP that can be installed within a sidewalk vault. Effectiveness will be based upon: 1) The infiltration performance, specifically infiltrating the water quality volume (2-year 24-hour event) without overflowing into the bypass system within the maintenance cycle; and, 2) The treatment performance of the BMP for reducing stormwater runoff pollutants to include total suspended solids (TSS), dissolved metals (Copper and Zinc), and oils.

- **Bioretention Soil Media Study:** This study will help to determine optimal media depths for maximizing performance and cost-effectiveness for bioinfiltration BMPs in Eastern Washington. A bioinfiltration pond with two treatment cells (12- and 18-inch media depth) was constructed adjacent to the parking area at Gonzaga University's Rudolph Fitness Center. Influent and effluent concentrations for each of the treatment cells will be compared to determine treatment efficiency of each of the cells. From this analysis, differences in treatment efficiency and performance attributable to the different media depths of each of the cells should be determined.

10.6 Priorities and Measurable Goals

Detailed "Stormwater Management Program Effectiveness Studies" measurable goals are outlined below:

Completed by	Measurable Goals/Milestones
End of Permit Year 1 (July 31, 2015)	• Eastern WA Permittees collaborate to review effectiveness study ideas, define sub-regions, and potential partnerships • Compile list of 12 to 15 study ideas • Include County participatory details in SWMP and Annual Report (see also *Attachment 6: Effectiveness Studies*)

[8] http://spokanevalley.org/filestorage/6836/6896/6914/8301/10121/EWA_Effectiveness_Studies_Final_Report.pdf

Completed by	Measurable Goals/Milestones
End of Permit Year 2 (July 31, 2016)	• Eastern WA Permittees collaborate to submit ranked list of 12 to 15 effectiveness study ideas • Each study idea to include a summary of data collection needed, lead entity, and participating Permittees • Include County participatory details in SWMP and Annual Report
End of Permit Year 3 (July 31, 2017)	• Lead entities submit a total of 8 to 12 detailed study proposals to Ecology for review/approval • Include County participatory details in SWMP and Annual Report
End of Permit Year 4 (July 31, 2018)	• Include County participatory details in SWMP and Annual Report
End of Permit Year 5 (July 31, 2019)	• Within 6 months of Ecology approval, lead entities to submit QAPPs for a combined total of 8 to 12 effectiveness studies • Within 6 months of QAPP approval, lead entities of at least 4 studies begin implementing each study • Within 15 months of QAPP approval, lead entities begin to implement remaining 4 to 8 studies • Within 6 months of completing each study, submit reports and recommendations to Ecology • Prior to end of Permit Year 5, enter data/results in to Ecology's Environmental Information Management (EIM) database

Appendix A

Definitions and Acronyms from the Phase II Permit

DEFINITIONS AND ACRONYMS

"40 CFR" means Title 40 of the Code of Federal Regulations, which is the codification of the general and permanent rules published in the Federal Register by the executive departments and agencies of the federal government.

"ADT" means Average Daily Traffic.

"AKART" means All Known, Available, and Reasonable methods of prevention, control, and Treatment. See also the State Water Pollution Control Act, sections 90.48.010 RCW and 90.48.520 RCW.

"All known, available, and reasonable methods of prevention, control, and treatment" refers to the state Water Pollution Control Act, RCW 90.48.010 and 90.48.520.

"Applicable TMDL" means a TMDL which has been approved by EPA on or before the issuance date of this permit, or prior to the date that Ecology issues coverage under this permit, whichever is later.

"Average Daily Traffic" means the expected number of vehicles using a roadway. Projected average daily traffic volumes are considered in designing a roadway or roadway improvement. ADT volumes shall be estimated using "Trip Generation" published by the Institute of Transportation Engineers or from a traffic study prepared by a professional engineer or transportation specialist with expertise in traffic volume estimation. ADT volumes shall be estimated for the design year or expected life of the project (the intent is for treatment facilities to be added in the soonest period of disruptive construction). For project sites with seasonal or varied use, evaluate the highest period of expected traffic impacts.

"Beneficial Uses" means uses of waters of the state, which include but are not limited to: use for domestic, stock watering, industrial, commercial, agricultural, irrigation, mining, fish and wildlife maintenance and enhancement, recreation, generation of electric power and preservation of environmental and aesthetic values, and all other uses compatible with the enjoyment of the public waters of the state.

"Best Management Practices" are the schedules of activities, prohibitions of practices, maintenance procedures, and structural and/or managerial practices approved by Ecology that, when used singly or in combination, prevent or reduce the release of pollutants and other adverse impacts to waters of Washington State.

"BMP" means Best Management Practice.

"Bypass" means the diversion of stormwater from any portion of a stormwater treatment facility. "Census urban area" means Urbanized Area.

"Certified Erosion and Sediment Control Lead" means an individual who is knowledgeable in the principles and practices of erosion and sediment control. The CESCL shall have the skills to assess: the site conditions and construction activities that could impact the quality of stormwater; and the effectiveness of erosion and sediment control measures used to control

the quality of stormwater discharges. The CESCL shall have current certification through an approved erosion and sediment control training program that meets the minimum training standards established by Ecology (see BMP C160 in the Stormwater Management Manual for Eastern Washington (2004)).

"CESCL" means Certified Erosion and Sediment Control Lead.

"Circuit" means a portion of a MS4 discharging to a single point or serving a discrete area determined by, traffic volumes, land use, topography, or the configuration of the MS4.

"Common plan of development or sale" means a site where multiple separate and distinct construction activities may be taking place at different times on different schedules and/or by different contractors, but still under a single plan. Examples include: 1) phased projects and projects with multiple filings or lots, even if the separate phases or filings/lots will be constructed under separate contract or by separate owners (e.g. a development where lots are sold to separate builders); 2) a development plan that may be phased over multiple years, but is still under a consistent plan for long-term development; and 3) projects in a contiguous area that may be unrelated but still under the same contract, such as construction of a building extension and a new parking lot at the same facility. If the project is part of a common plan of development or sale, the disturbed area of the entire plan shall be used in determining permit requirements.

"Component" or "Program Component" means an element of the Stormwater Management Program listed in S5 Stormwater Management Program for Cities, Towns, and Counties or S6 Stormwater Management Program for Secondary Permittees, S7 compliance with Total Maximum Daily Load Requirements, or S8 Monitoring of this permit.

"Co-Permittee" means any owner or operator of a regulated small MS4 that is in a cooperative agreement with at least one other applicant for coverage under this permit. A Co-Permittee owns or operates a regulated small MS4 located within or in proximity to another regulated MS4. A Co-Permittee is only responsible for complying with the conditions of this permit relating to discharges from the MS4 the Co-Permittee owns or operates. See also 40 CFR 122.26(b)(1)

"CWA" means the federal Clean Water Act (formerly referred to as the Federal Water Pollution Control Act or Federal Water Pollution Control Act Amendments of 1972) Pub. L. 92-500, as amended in Pub. L. 95-217, Pub. L. 95-576, Pub. L. 96-483, and Pub. L. 97-117, 33 U.S.C. 1251 et. seq.

"Director" means the Director of the Washington State Department of Ecology, or an authorized representative.

"Entity" means a governmental body or a public or private organization. "EPA" means the U.S. Environmental Protection Agency

"Existing conditions" are the impervious surfaces, drainage systems, land cover, native vegetation and soils that exist at a site prior to any changes associated with achieving the

proposed development conditions. Approved permits and engineering plans may be required. If sites have impervious areas and drainage systems that were built without approved permits, then the existing condition is defined as those that existed prior to the issue date of this Permit. Existing conditions may be verified by using aerial photography or other records. Existing conditions are used for hydrologic analysis at the site unless a City or County imposes other requirements.

"General Permit" means a permit which covers multiple dischargers of a point source category within a designated geographical area, in lieu of individual permits being issued to each discharger.

"Ground water" means water in a saturated zone or stratum beneath the surface of the land or below a surface water body. Refer to chapter 173-200 WAC.

"Hazardous substance" means any liquid, solid, gas, or sludge, including any material, substance, product, commodity, or waste, regardless of quantity, that exhibits any of the physical, chemical, or biological properties described in WAC 173-303-090 or WAC 173-303-100.

"Heavy equipment maintenance or storage yard" means an uncovered area where any heavy equipment, such as mowing equipment, excavators, dump trucks, backhoes, or bulldozers are washed or maintained, or where at least five pieces of heavy equipment are stored on a long term basis.

"High ADT Roadways and Parking Areas" are any road with ADT greater than 30,000 vehicles per day; and parking areas with more than 100 trip ends per 1,000 SF of gross building area or greater than 300 total trip ends are considered to be high-use traffic areas. Examples include commercial buildings with a frequent turnover of customers and other visitors.

"High-Use Sites" generate high concentrations of oil due to high traffic turnover or the frequent transfer of oil and/or other petroleum products. High-use sites are land uses where sufficient quantities of free oil are likely to be present such that they can be effectively removed with special treatment. A high-use site is any one of the following:

- A road intersection with expected ADT of 25,000 vehicles or more on the main roadway and 15,000 vehicles or more on any intersecting roadway, excluding projects proposing primarily pedestrian or bicycle use improvements; or
- A commercial or industrial site with an expected trip end count equal to or greater than 100 vehicles per 1,000 square feet of gross building area (best professional judgment should be used in comparing this criterion with the following criterion); or
- A customer or visitor parking lot with an expected trip end count equal to or greater than 300 vehicles (best professional judgment should be used in comparing this criterion with the preceding criterion); or
- Commercial on-street parking areas on streets with an expected total ADT count equal to or greater than 7,500; or
- Fueling stations and facilities; or

- A commercial or industrial site subject to petroleum storage and transfer in excess of 1,500 gallons per year (not including locations where heating fuel is routinely delivered to end users and the annual amount of heating oil used at the site is the sole basis for the site meeting this definition; heating fuel handling and storage facilities are subject to this definition); or
- A commercial or industrial site subject to use, storage, or maintenance of a fleet of 25 or more diesel vehicles that are over 10 tons gross weight (trucks, buses, trains, heavy equipment, etc.); or
- Maintenance and repair facilities for vehicles, aircraft, construction equipment, railroad equipment or industrial machinery and equipment; or
- Outdoor areas where hydraulic equipment is stored; or
- Log storage and sorting yards and other sites subject to frequent use of forklifts and/or other hydraulic equipment; or
- Railroad yards.

"Hydrologic modification of a wetland" means, for the purpose of stormwater management, that the wetland will receive a greater total volume of surface runoff following the proposed development than it receives in the current condition.

"Hyperchlorinated" means water that contains more than 10 mg/Liter chlorine.

"Illicit connection" means any infrastructure connection to the MS4 that is not intended, permitted or used for collecting and conveying stormwater or non-stormwater discharges allowed as specified in this permit (S5.B.3 and S6.D.3). Examples include sanitary sewer connections, floor drains, channels, pipelines, conduits, inlets, or outlets that are connected directly to the MS4.

"Illicit discharge" means any discharge to a MS4 that is not composed entirely of storm water or of non-stormwater discharges allowed as specified in this permit (S5.B.3 and S6.D.3).

LID means Low Impact Development.

"Low ADT Roadways and Parking Areas" are urban roads with ADT fewer than 7,500 vehicles per day; rural roads and freeways with ADT less than 15,000 vehicles per day; and parking areas with less than 40 trip ends per 1,000 SF of gross building area or fewer than 100 total trip ends per day are considered to be low-use traffic areas. Examples include most residential parking, and employee-only parking areas for small office parks or other commercial buildings. Urban roads are located within designated Urban Growth Management Areas; rural roads are located outside designated Urban Growth Management Areas. Freeways, defined as fully controlled and partially controlled limited access highways, may be located either inside or outside of Urban Growth Management Areas.

"Low Density Residential Land Use" means, for the purpose of permit section S8 Monitoring and Assessment, one dwelling unit per 1 to 5 acres.

"Low Impact Development" means a stormwater and land use management strategy that strives to mimic pre-disturbance hydrologic processes of infiltration, filtration, storage, evaporation and transpiration by emphasizing conservation, use of on-site natural features, site planning, and distributed stormwater management practices that are integrated into a project design.

"Material Storage Facilities" means an uncovered area where bulk materials (liquid, solid, granular, etc.) are stored in piles, barrels, tanks, bins, crates, or other means.

"Maximum Extent Practicable" refers to paragraph 402(p)(3)(B)(iii) of the federal Clean Water Act, which reads as follows: "Permits for discharges from municipal storm sewers shall require controls to reduce the discharge of pollutants to the maximum extent practicable, including management practices, control techniques, and system, design, and engineering methods, and other such provisions as the Administrator or the State determines appropriate for the control of such pollutants."

"MEP" means Maximum Extent Practicable.

"Moderate ADT Roadways and Parking Areas" are urban roads with ADT between 7,500 and 30,000 vehicles per day; rural roads and freeways with ADT between 15,000 and 30,000 vehicles per day; and parking areas with between 40 and 100 trip ends per 1,000 SF of gross building area or between 100 and 300 total trip ends per day are considered to be moderate-use traffic areas. Examples include visitor parking for small to medium commercial buildings with a limited number of daily customers. Urban roads are located within designated Urban Growth Management Areas; rural roads are located outside designated Urban Growth Management Areas. Freeways, defined as fully controlled and partially controlled limited access highways, may be located either inside or outside of Urban Growth Management Areas.

"Moderate-Use Sites" include moderate ADT roadways and parking areas (see definition above); primary access points for high-density residential apartments; most intersections controlled by traffic signals; and transit center bus stops. These sites are expected to generate sufficient concentrations of metals that additional runoff treatment is needed to protect water quality in non-exempt surface waters.

"MS4" means Municipal Separate Storm Sewer System.

"Municipal Separate Storm Sewer" means a conveyance, or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, manmade channels, or storm drains):

i. owned or operated by a state, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to State Law) having jurisdiction over disposal of wastes, storm water, or other wastes, including special districts under State Law such as a sewer district, flood control district or drainage district, or similar entity, or an Indian tribe or an authorized Indian tribal organization, or a designated and approved management agency under section 208 of the CWA that discharges to waters of Washington State;

ii. designed or used for collecting or conveying stormwater;
iii. which is not a combined sewer; and
iv. which is not part of a Publicly Owned Treatment Works (POTW) as defined at 40 CFR 122.2.
v. which is defined as "large" or "medium" or "small" or otherwise designated by Ecology pursuant to 40 CFR 122.26.

"National Pollutant Discharge Elimination System" means the national program for issuing, modifying, revoking, and reissuing, terminating, monitoring and enforcing permits, and imposing and enforcing pretreatment requirements, under sections 307, 402, 318, and 405 of the Federal Clean Water Act, for the discharge of pollutants to surface waters of the state from point sources. These permits are referred to as NPDES permits and, in Washington State, are administered by the Washington State Department of Ecology.

"New development" is the conversion of previously undeveloped or pervious surfaces to impervious surfaces and managed landscape areas not specifically exempt in the "Exemptions" or "Partial Exemptions" sections of Appendix 1. Projects that add new lanes on an existing roadway or otherwise expand the pavement edge are included in the definition of new development because they create new impervious surfaces; these projects are subject to the thresholds and requirements for new development as set forth in Appendix 1.

"New Permittee" means a City, Town or County that is subject to the Eastern Washington Phase II Municipal Stormwater General Permit and was not subject to the permit prior to August 1, 2014.

"New Secondary Permittee" means a Secondary Permittee that is covered under a municipal stormwater general permit and was not covered by the permit prior to August 1, 2014.

"NOI" means Notice of Intent.

"Non-Pollutant Generating Impervious Surfaces" are considered to be insignificant sources of pollutants in stormwater runoff. Roofs that are subject only to atmospheric deposition or normal heating, ventilation, and air conditioning vents are considered NPGIS, unless the roofing material is uncoated metal. The following may also be considered NPGIS: paved bicycle pathways and pedestrian sidewalks that are separated from and not subject to drainage from roads for motor vehicles, fenced fire lanes, infrequently used maintenance access roads, and "in-slope" areas of roads. Sidewalks that are regularly treated with sand, salt or other de-icing/anti-icing agents are not considered NPGIS.

"Notice of Intent" means an application or request for coverage under a General NPDES Permit pursuant to WAC 173-226-200.

"NPDES" means National Pollutant Discharge Elimination System. "NPGIS" means Non-Pollutant Generating Impervious Surfaces.

"Outfall" means point source as defined by 40 CFR 122.2 at the point where a discharge leaves the MS4 and discharges to waters of the State. Outfall does not include pipes, tunnels, or

other conveyances which connect segments of the same stream or other surface waters and are used to convey primarily surface waters (i.e. culverts).

"Permittee" unless otherwise noted, includes Co-Permittee, Secondary Permittee, and New Secondary Permittee.

"PGIS" means Pollutant Generating Impervious Surfaces.

"Physically interconnected" means that one MS4 is connected to another storm sewer system in such a way that it allows for direct discharges to the second system. For example, the roads with drainage systems and municipal streets of one entity are physically connected directly to a storm sewer system belonging to another entity.

"Pollutant Generating Impervious Surfaces" are surfaces that are considered to be significant sources of pollutants in stormwater runoff. Such surfaces include those that are subject to vehicular use, industrial activities, or storage of erodible or leachable materials that receive direct rainfall or run-on or blow-in of rainfall. Metal roofs are considered to be PGIS unless coated with an inert, non-leachable material. Roofs that are subject to venting of indoor pollutants from manufacturing, commercial or other operations or processes are also considered PGIS. A surface, whether paved or not, will be considered PGIS if it is regularly used by motor vehicles. The following are considered regularly-used surfaces: roads, unvegetated road shoulders, bike lanes within the traveled lane of a roadway, driveways, parking lots, unfenced fire lanes, vehicular equipment storage yards, and airport runways.

"Proposed development conditions" are the impervious surfaces, drainage systems, land cover, native vegetation and soils that are proposed to exist at the site at the completion of the project (complete build-out). Also called "post-developed conditions."

"QAPP" means Quality Assurance Project Plan.

"Qualified Personnel" means someone who has had professional training in the aspects of stormwater management for which they are responsible and are under the functional control of the Permittee. Qualified Personnel may be staff members, contractors, and/or volunteers.

"Quality Assurance Project Plan" means a document that describes the objectives of an environmental study and the procedures to be followed to achieve those objectives.

"RCW" means the Revised Code of Washington State.

"Redevelopment" is the replacement or improvement of impervious surfaces on a developed site. The project proponent shall identify what Core Elements in Appendix 1 apply to all of the new and replaced impervious surfaces created by the project. All new impervious surfaces added during a redevelopment project are subject to the Core Elements in Appendix 1. The requirements for redevelopment projects set forth in the Core Elements in Appendix 1 apply to the impervious surfaces altered or replaced by a redevelopment project. Impervious surface replacements defined as exempt activities in the "Exemptions" section of Appendix 1 and at other projects identified in the "Partial Exemptions" section of Appendix 1 have reduced requirements.

"Regulatory Threshold" refers to the one-acre size, including the exception noted below, of new development and redevelopment projects that shall be regulated under this permit. The threshold includes construction site activities and new development and redevelopment projects that result in a land disturbance of equal to or greater than one acre and construction activities and projects less than one acre that are part of a larger common plan of development or sale. This threshold is a minimum requirement that may be exceeded by a local jurisdiction.

"Replaced impervious surfaces" means, for structures, the removal and replacement of any exterior impervious surfaces or foundation; or, for other impervious surfaces, the removal down to bare soil, or base course, and replacement. Exemptions and partial exemptions are defined in Appendix 1 of this permit.

"Runoff" is water that travels across the land surface, or laterally through the ground near the land surface, and discharges to water bodies either directly or through a collection and conveyance system. See also "Stormwater."

"Rural roads" are roads located outside designated Urban Growth Management Areas. "Secondary Permittee" is an operator of a MS4 that is not a city, town or county. Secondary Permittees include special purpose districts and other public entities that meet the criteria in S1.B.

"Shared water bodies" means water bodies, including downstream segments, lakes and estuaries that receive discharges from more than one Permittee.

"Short Duration Storm" means the 3-hour duration design storm distribution, described in Chapter 4.2.1 of the Stormwater Management Manual for Eastern Washington (2004), which represents the short durations, high intensities, and smaller volumes that characterize summer thunderstorms in eastern Washington.

"Significant contributor" means a discharge that contributes a loading of pollutants considered to be sufficient to cause or exacerbate the deterioration of receiving water quality or instream habitat conditions.

"Small Municipal Separate Storm Sewer System" or "Small MS4" is a conveyance or system of conveyances including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, and/or storm drains which is not defined as a "large" or "medium" MS4 pursuant to 40 CFR 122.26(b)(4) & (7) or designated under 40 CFR 122.26 (a)(1)(v).

"Stormwater" means runoff during and following precipitation and snowmelt events, including surface runoff, drainage or interflow.

"Stormwater Associated with Industrial and Construction Activity" means the discharge from any conveyance used for collecting and conveying stormwater directly related to manufacturing, processing or raw materials storage areas at an industrial plant, or associated

with clearing, grading and/or excavation, and required to have an NPDES permit in accordance with 40 CFR 122.26.

"Stormwater Management Manual for Eastern Washington" means the technical manual (Publication No. 04-10-076) published by the Department of Ecology in September 2004.

"Stormwater Management Program" means a set of actions and activities designed to reduce the discharge of pollutants from the MS4 to the MEP and to protect water quality, and comprising the components listed in S5 or S6 of this permit and any additional actions necessary to meet the requirements of applicable TMDLs pursuant to S7 Compliance with TMDL Requirements and S8 Monitoring and Assessment.

"SWMMEW" means the Stormwater Management Manual for Eastern Washington (2004).

"SWMP" means Stormwater Management Program.

"SWMP Plan" means Stormwater Management Program Plan. "TMDL" means Total Maximum Daily Load.

"TMDL waste load allocation" means the allowable load of a single pollutant from a single contributing point source.

"Total Maximum Daily Load" means a water cleanup plan. A TMDL is a calculation of the maximum amount of a pollutant that a water body can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources. A TMDL is the sum of the allowable loads of a single pollutant from all contributing point and nonpoint sources. The calculation shall include a margin of safety to ensure that the water body can be used for the purposes the state has designated. The calculation shall also account for seasonable variation in water quality. Water quality standards are set by states, territories, and tribes. They identify the uses for each water body, for example, drinking water supply, contact recreation (swimming), and aquatic life support (fishing), and the scientific criteria to support that use. The Clean Water Act, section 303, establishes the water quality standards and TMDL programs.

"Trip Ends" means the expected number of vehicles using a parking area. Projected trip end counts for a parking area are associated with the proposed land use. Trip end counts shall be estimated using "Trip Generation" published by the Institute of Transportation Engineers or from a traffic study prepared by a professional engineer or transportation specialist with expertise in traffic volume estimation. Trip end counts shall be made for the design year or expected life of the project (the intent is for treatment facilities to be added in the soonest period of disruptive construction). For project sites with seasonal or varied use, evaluate the highest period of expected traffic impacts.

"UA" means Urbanized Area.

"Urban Growth Area" means the designated area within which urban growth shall be encouraged and outside of which growth can occur only if it is not urban in nature, as defined at chapter 36.70A.110 RCW (Growth Management Act).

"Urbanized Area" is a federally-designated land area comprising one or more places and the adjacent densely settled surrounding area that together have a residential population of at least 50,000 and an overall population density of at least 1,000 people per square mile. Urbanized Areas are designated by the U.S. Census Bureau based on the most recent decennial census.

"Urban roads" are roads located within designated Urban Growth Areas. Partially controlled limited access highways located inside of Urban Growth Management Areas are considered urban roads. Freeways, as defined above, are not considered urban roads for the purpose of applying the Core Elements in Appendix 1.

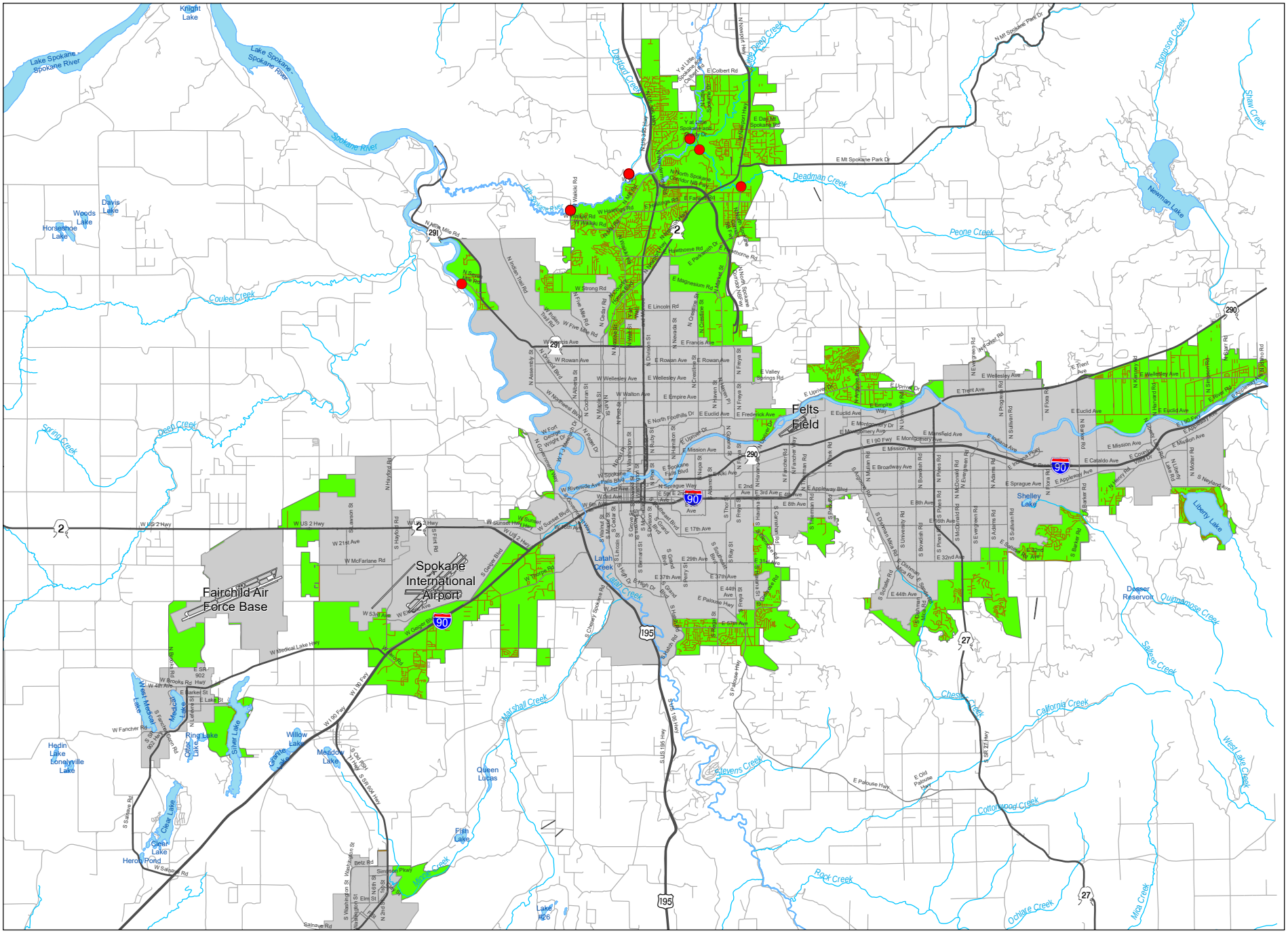
"Waters of the state" includes those waters as defined as "waters of the United States" in 40 CFR 122.2 within the geographic boundaries of Washington State and "waters of the state" as defined in Chapter 90.48 RCW which includes: lakes, rivers, ponds, streams, inland waters, underground waters, salt waters and all other surface waters and water courses within the jurisdiction of the State of Washington.

"Waters of the United States" is as defined in 40 CFR 122.2.

"Water quality standards" means Surface Water Quality Standards, Chapter 173-201A WAC; Ground Water Quality Standards, Chapter 173-200 WAC; and Sediment Management Standards, Chapter 173-204 WA

Attachment 2

2018 NPDES Permit Area Maps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Fairchild Air Force Base
Felts Field
Spokane River
Lake Spokane
Knight Lake
Davis Lake
Woods Lake
Horseshoe Lake
Newman Lake
Liberty Lake
Shelley Lake
Deadman Creek
Peone Creek
Couleé Creek
Deep Creek
Spring Creek
Latah Creek
Marshall Creek
Hangman Creek
Queen Lucas
Fish Lake
Silver Lake
Ring Lake
Willow Lake
Meadow Lake
Clear Lake
Hedin Lake
Lonely Ville Lake
Herron Pond
Lake #26
Deer Reservoir
Quinnamose Creek
Saltese Creek
Chester Creek
California Creek
Cottonwood Creek
Rock Creek
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Mica Creek
West Lake Creek
Thompson Creek
Shaw Creek
Stevens Creek
Darlington Creek
Little Deep Creek
Lake Spokane Spokane River
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E Lincoln Rd
E Francis Ave
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W Walton Ave
E Empire Ave
E Euclid Ave
E Mission Ave
E Sprague Ave
E Appleway Ave
E Trent Ave
E 90 Fwy
W US 2 Hwy
W 21st Ave
W McFarlane Rd
W Medical Lake Hwy
W I 90 Fwy
E Palouse Hwy
E Broadway Ave
E 8th Ave
E 17th Ave
E 29th Ave
E 37th Ave
E 44th Ave
E 32nd Ave
E Cataldo Ave
E Euclid Ave
E Mansfield Ave
E Montgomery Ave
E Uprivers Dr
E Valley Springs Rd
E Frederick Ave
E Colbert Rd
E Deer Park Spokane Rd
E Hawthorne Rd
E Parkwish Dr
E Magnesium Rd
E Ruby St
E Sharp Ave
E Spokane Falls Blvd
W Spokane Falls Blvd
W Riverside Ave
W Sunset Hwy
W Sunset Blvd
W Sumner
W Boone Ave
W Pacific Ave
W Trent Ave
W Fancher Rd
W Brooks Rd
E Barker St
E Lake St
E SR 902 Hwy
S Salnave Rd
S Betz Rd
S Simmons Pkwy
S Sullivan Rd
S Sullivan Rd
S Adams Rd
S Evergreen Rd
S Bowdish Rd
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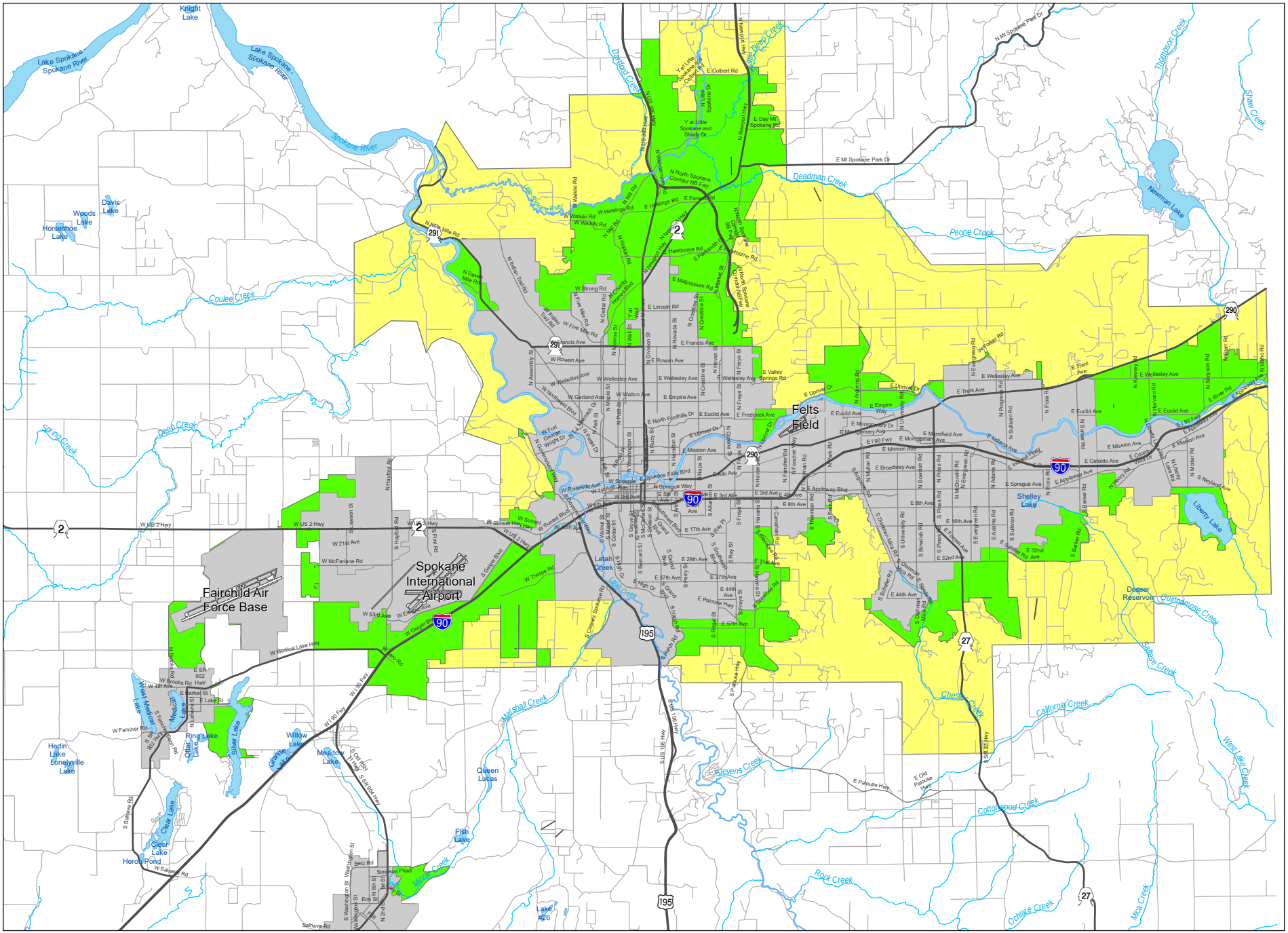
S Dishman Mica Rd
S Sullivan Rd
S Barker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Latah Creek
Hangman Creek
Marshall Creek
Stevens Creek
Rock Creek
Cottonwood Creek
California Creek
Chester Creek
Saltese Creek
Quinnamose Creek
Thompson Creek
Shaw Creek
Newman Lake
Shelley Lake
Liberty Lake
Dessor Reservoir
Queen Lucas
Fish Lake
Meadow Lake
Willow Lake
Silver Lake
Ring Lake
Medical Lake
West Medical Lake
Hedin Lake
Lone Ville Lake
Clear Lake
Herron Pond
Lake R26
Ochiate Creek
Mica Creek
West Lake Creek
Darlwood Creek
Willy Deep Creek
Y at Little Spokane and Shady Dr
Y at Little Spokane and Colbert Rd
E Colbert Rd
E Day Mt Spokane Rd
N Mt Spokane Park Dr
E Mt Spokane Park Dr
N Newport Hwy
N Nevada St
N Division St
N Ruby St
N Hamilton St
N Freya St
N Ash St
N Pittsburg St
N Washington St
N Monroe St
N Cedar St
N Howard St
N Post St
N Lincoln St
N Stevens St
N Cannon St
N Assembly St
N Hatch Rd
N Nolan Hill Rd
N Sunset Hwy
N Five Mile Rd
N Indian Trail Rd
N Seven Mile Rd
N Ninth Mile Rd
W Strong Rd
W Francis Ave
W Rowan Ave
W Wellesley Ave
W Garland Ave
W Walton Ave
W Northwest Blvd
W Fort George Wright Dr
W Riverside Ave
W Sprague Ave
W 1st Ave
W 3rd Ave
W Sunset Blvd
W Sunset Hwy
W Maxwell Ave
W US 2 Hwy
W 21st Ave
W McFarlane Rd
W 53rd Ave
W Geiger Blvd
W Medical Lake Hwy
W Thorpe Rd
W Fancher Rd
W Brooks Rd
W 4th Ave
E Sprague Ave
E Appleway Ave
E Mission Ave
E Cataldo Ave
E Trent Ave
E Wellesley Ave
E Euclid Ave
E Mansfield Ave
E Montgomery Ave
E Broadway Ave
E 8th Ave
E 6th Ave
E 3rd Ave
E 17th Ave
E 29th Ave
E 37th Ave
E 44th Ave
E 57th Ave
E 32nd Ave
E Palouse Hwy
E Old Palouse Hwy
E Francis Ave
E Frederick Ave
E Valley Springs Rd
E Upriver Dr
E Empire Ave
E Hawthorne Rd
E Magnesium Rd
E Lincoln Rd
E Hastings Rd
E Farwell Rd
E Wakiki Rd
E Hartson Ave
E Sharp Ave
E Dalton Ave
E Ninth Ave
E Lake St
E Barker St
E SR 902 Hwy
S Hayford Rd
S Lawson St
S Cedar St
S Grove St
S Stevens St
S Ray St
S Freya St
S Ash St
S Pittsburg St
S Washington St
S Monroe St
S Cedar St
S Howard St
S Post St
S Lincoln St
S Stevens St
S Cannon St
S Assembly St
S Hatch Rd
S Nolan Hill Rd
S Sunset Hwy
S Five Mile Rd
S Indian Trail Rd
S Seven Mile Rd
S Ninth Mile Rd
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S Salnave Rd
S Saltese Rd

Attachment 3

Internal Coordination Mechanisms

Internal Coordination Mechanisms

1. Introduction and Permit Requirements

The Eastern Washington Phase II Municipal Stormwater Permit (Permit), Special Condition requirements S5.A.5.b states:

The Stormwater Management Program (SWMP) shall "*...include coordination mechanisms among departments within each jurisdiction to eliminate barriers to compliance with the terms of this Permit. Permittees shall include a written description of internal coordination mechanisms in the Annual Report…*"

This document addresses important coordination mechanisms among various departments within Spokane County during the calendar year 2018. Successful coordination is critical to remove barriers, promote understanding of the NPDES Permit, and facilitate Permit compliance between County departments.

2. County Department Involvement

The Spokane County Stormwater Utility is the lead on coordinating implementation and documentation of Permit compliance, informing staff of Permit requirements, providing necessary training, and ensuring mechanisms for tracking and coordination are in place. Stormwater Utility staff also have the primary responsibility of implementing and enforcing municipal stormwater regulation. The following is a list of divisions and departments in the County that are most impacted by the Permit.

- Public Works
  - Stormwater Utility
  - Development Services
  - Maintenance and Operations
  - Fleet Management
- Building and Planning
- Environmental Services
  - Regional Solid Waste System
  - Wastewater/Sewer
  - Water Resources
- Parks, Recreation, and Golf
- Facilities Maintenance
- Fair and Expo Center

3. Coordination Efforts

3.1. Public Education and Outreach

The Stormwater Utility coordinates with Water Resources, the Regional Solid Waste System, and Parks, Recreation, and Golf, to staff, fund, and implement ongoing education and outreach programs that are designed to reduce behaviors and practices that contribute to or cause water

pollution. The programs target both school-aged children and adults. Topics of importance include:

- Impacts of stormwater on surface waters
- Impacts of illicit discharges and how to report them
- Principles of Low Impact Development (LID)
- Best Management Practices (BMPs)
- Natural yard care and the benefits of xeriscaping
- Outdoor use and storage of chemicals
- Hazardous materials disposal
- Vehicle maintenance

3.2. Public Involvement and Participation

The Stormwater Utility affords the public the ability to participate in the decision-making process involving the development and implementation of the NPDES Permit-related activities and programs. This is accomplished by making the SWMP Plan and the most recent Annual Report available on the County's website, with an opportunity to provide public comment via online submittal. The Stormwater Utility coordinates with the County's Information Technology Department to provide technical expertise to manage networks and computer systems to realize this task.

3.3. Illicit Discharge Detection and Elimination

Spokane County implements an Illicit Discharge Detection and Elimination (IDDE) program designed to prevent, detect, characterize, and eliminate illicit connections and illicit discharges into the County's MS4. Required components of the program include mapping the MS4, development of a regulatory and enforcement mechanism, and an ongoing process to identify and eliminate sources of stormwater pollution.

The County provides opportunities for IDDE training for staff, in the previously mentioned departments, that conduct field-related activities. Employees are trained to identify potential sources of stormwater pollution and how to report concerns. Public Works Road Maintenance staff has primary responsibility for responding to emergencies related to surface water in the County. This consists of providing 24-hour emergency response to flooding of streets or structures, pollutant spills, and illegal discharge of pollutants to the storm and surface water systems.

The County's IDDE ordinance, which prohibits non-stormwater discharges, spills, illicit connections, and illegal dumping into the stormwater system, is enforced by the Stormwater Utility staff and, where applicable, the local Spill Response Team with the Department of Ecology.

3.4 Construction and Post-Construction

The responsibility for controlling runoff from construction sites is shared by all of Public Works. Development Services is responsible for reviewing all stormwater site plans and pollution prevention BMPs for development activities, ensuring that projects meet the standards documented in both the *Stormwater Management Manual for Eastern Washington* (SWMMEW) and *Spokane Regional Stormwater Manual* (SRSM). Various departments must review and approve stormwater site plans and pollution prevention BMPs for County capital improvement projects under the same standards and permitting requirements.

For all construction projects within the County's MS4, regular inspections are conducted to review all erosion and sediment control requirements on-site. Public Works inspects and enforces erosion and control measures on County capital improvement project construction sites while Development Services within Public Works is responsible for inspecting and enforcing private development. Public Works staff are CESCL-certified to conduct these inspections, and continue to track records of all inspections, violations, and enforcement activities.

3.5 Operations and Maintenance

The Public Works Maintenance Department performs the maintenance of the County's storm drainage infrastructure, which includes catch basins, pipes, open channels, swales, and regional retention/detention facilities. Spokane County Stormwater Utility staff regularly inspect stormwater treatment and flow control facilities, and refer concerns, cleaning, and/or repair needs to Maintenance to direct the prioritization of required maintenance activities. Stormwater Utility employees inspect stormwater facilities during and after major storm events to ensure the systems are functioning properly. A monitoring list, referred to as the Rain List, is frequently updated to prioritize which sites need inspection during and after stormwater events. Records of inspections and maintenance or repair activities are kept in accordance with the Permit.

Public Works Road Maintenance; Fleet Management; Parks, Recreation, and Golf; Regional Solid Waste System; and Facilities Maintenance staff also implement practices and procedures designed to prevent stormwater impacts associated with their respective maintenance activities including: 1) Pipe and culvert cleaning; 2) Swale and ditch maintenance; 3) Street cleaning; 4) Road repair; 5) Snow and ice control; 6) Vactor waste disposal; 7) Storage, handling, and application of pesticides and fertilizers; 8) Hazardous material storage and disposal; and, 9) Vehicle washing and repair.

3.6 Reporting

The Spokane County Stormwater Utility oversees the preparation of the Annual Report, due on March 31st of each calendar year. The Report details compliance with the requirements outlined in the Eastern Washington Phase II Municipal Stormwater Permit. The Stormwater Utility coordinates with the various County departments to collect data that is tracked for compliance, and annually updates the SWMP Plan.

Attachment 4

PUBLIC EDUCATION and OUTREACH ACTIVITIES

1. Introduction and Permit Requirements

The Eastern Washington Phase II Municipal Stormwater Permit, Special Condition, Requirement S5.B.1 reads:

The Stormwater Management Program (SWMP) shall include "*…a public education and outreach program to distribute educational materials to the community or conduct equivalent outreach activities about the impacts of stormwater discharges to waterbodies, and the steps the public and take to reduce pollutants in stormwater. Outreach and educational efforts should include a multimedia approach and shall be targeted and presented to specific audiences…*".

This attachment addresses both the County's Public Education and Outreach and Public Involvement and Participation programs, describing the educational materials utilized to implement these programs in the calendar year 2018.

2. 2018 Program Focus

The program's focus is to educate Spokane County residents about stormwater concerns. Of importance is demonstrating how everyone's individual actions add up to negatively affect the quality of our lakes, rivers, and our drinking water. The desired result is to change behavior in ways that will improve water quality throughout the County.

Spokane County Stormwater Utility's Education and Outreach and Public Involvement and Participation Plan has the following objectives:

- Encourage public reporting of illicit discharges or improper disposal of materials into the MS4 conveyances and clogged catch basin inlets. The reporting is accomplished using a countywide hotline telephone number;
- Utilize the County website to convey information about stormwater permitting, water quality issues, BMPs, and hyperlinks to other important websites; and provide an opportunity for public comment and feedback regarding the Stormwater Utility's programs.
- Educate residents concerning potential impacts of pollutants from the MS4 conveyances serving their place of residence, their workplace, and the roads on which they drive, including the need for members of the public to take stewardship of their water resources;
- Continue to provide informative materials and live presentations to school children on stormwater pollution issues;
- Provide opportunities for the public to actively participate in activities and events that improve the health of our watersheds, such as storm drain stenciling and swale planting days, thus broadening the sense of responsibility and understanding of water quality issues throughout the region;
- Use applicable public notification protocol, seeking input from the public in the SWMP through meetings or other means, and support efforts to improve water quality in the MS4 area;
- Educate construction site operators, contractors, and engineers on the importance of stormwater management techniques and structural BMPs to reduce pollutants in runoff from construction sites; and,

- Educate the public on the proper management and disposal of toxic materials, including the availability and locations of facilities for disposal or drop-off of household hazardous wastes, chemicals, grass clippings, leaf litter, animal wastes, and motor fluids.

3. Public Education and Outreach and Public Involvement and Participation Programs

The Spokane County Stormwater Utility (SWU), in cooperation with the Spokane County Water Resources Department, continues to conduct a significant amount of public education based on the perceived needs of our community and that of successful programs implemented in other communities. See *Appendix A* for spreadsheet of 2018 activities.

3.1. Spokane County Water Resource Center

Learning events for all ages of students and adults are held at the *Water Resource Center* throughout the year. The *Water Resource Center* (WRC) has three separate areas for education and meetings:

- **Indoor Exhibits** – There is an indoor exhibit area, which has permanent informative displays highlighting important features of the Spokane regional water cycle, the geology of the Spokane Valley-Rathdrum Prairie aquifer, a model of the Water Reclamation Facility process, in addition to interactive water cycle quizzes on two Apple iPads. Portable activities include a stream table; EnviroScape and other watershed models; Stormwater Plinko; stormwater pollution jars; and the "Flush-o-matic," an electrically powered agitator that simulates the breakdown of flushables in sewer or septic systems.
- **Conference Room –** The indoor conference room provides tables and chairs for hosting meetings up to 80 people. This room also exhibits a "stormwater maze" taped to the floor which is utilized for K-6 non-point pollution education during the winter and spring months.
- **Patio/Landscaping –** The outdoor patio and facility grounds allow visitors to view and learn about the Center's xeriscaping and on-site stormwater treatment facilities, including swales and pervious pavement.

3.2. Participation in Community Events

Spokane County successfully reaches a wide variety of the public through outreach at community events each Permit year.

- **SCC Free Car Care Fair** – This bi-annual event, taking place on April 7, 2018, and October 6, 2018, saw City of Spokane and Spokane County staff teaming up with the Spokane Community College (SCC) Automotive School to promote the importance of regular car maintenance *and* protecting local waterways. Both times, SCC Automotive School students, under the supervision of their professors, conducted vehicle inspections free-of-charge to the public. While the students checked for leaks and topped off fluids carefully, City and County employees chatted with approximately 250 drivers and

passengers and distributed *Don't Drip & Drive* coupons[1] for 10% off leak repairs at participating local shops.

- **Go Green Zone at Spokane County Interstate Fair –** The SWU, Spokane County Water Resources, Spokane County Regional Solid Waste System, City of Spokane, City of Spokane, Spokane Conservation District, Spokane Regional Clean Air Agency, National Weather Service, Spokane Joint Aquifer Board, and EnviroStars staffed a joint space at this event from September 7-16, 2018. Over the span of ten days, hundreds of youth and adults learned about storm drains and the aquifer, in addition to such things as hazardous waste recycling and air quality. The items for distribution included Storm Drain Dan activity books, Aquifer Atlases, pencils, and various brochures on pollution prevention.
- **Rain Garden construction with Saint George's Middle School**: Spokane County coordinated with the Lands Council and the City of Spokane on the construction of a Rain Garden with Saint George's middle school. Students were actively involved in the construction of a stormwater treatment facility where they learned about employing aspects of engineering, construction, and maintenance related to stormwater structures.

3.3. K-12 and Adult Education and Outreach and Public Participation Programs

Spokane County successfully reaches youth and adults via classroom activities and public participation projects each Permit year.

- **Central Valley School District Outdoor Environmental Education Program –** In 2018 the SWU and Spokane County Water Resources continued its participation in an environmental program for 5th graders. During the months of April and May, more than 1,000 5th grade students from the Central Valley School District (CVSD) learned about watersheds, the water cycle, stormwater pollution, stewardship regarding their storm drains, and drinking water protection. Each day, about 50 kids worked their way through four (4) stations. The first station focused on the aquifer and water quality/stormwater. The second station, staffed by the Liberty Lake Sewer and Water District, involved a lesson on beavers, wetland ecology, and identifying macroinvertebrates in a nearby creek. The third station was a nature hike, and the final station was a ropes course. All sessions were hands-on with students collecting information and being tested.
- **Rain Barrel Program**[2] **–** In 2016, the Spokane Conservation District, City of Spokane Water Department, and Spokane County Stormwater Utility cooperatively developed the first rain barrel program in the region. Five (5) events for Spokane City and unincorporated County residents were held in 2018 with a total attendance of 110. The purpose of the program is to encourage the public to act to conserve water; manage stormwater; and address pollution issues, thereby improving water quality. The program not only provides free or low-cost rain barrels to the public, but includes workshops on how to set up, use, and maintain the barrels. To obtain a rain barrel through the program,

[1] https://static.spokanecity.org/documents/blog/2017/03/31/fix-a-leak-help-the-river/drip-and-rrive-april-utility-insert.pdf
[2] http://sccd.org/departments/education/rain-barrel-program

workshop attendance is mandatory. All workshops last between 60-90 minutes and include everything needed to retrofit a used 50-gallon food-grade barrel.

- **EnviroKids Club** [3]**–** Spokane County Stormwater Utility continues to partner in this regionally-cooperative environmental education program for K-6 students. When kids join the Club, they receive quarterly newsletters in the mail which tackle a wide variety of environmental subjects, including water quality issues. The kids are also encouraged to visit partner booths at community events and, when they do so, are awarded points toward earning prizes. Other partners supporting the EnviroKids Club include Spokane County Water Resources, Spokane County Regional Solid Waste System, City of Spokane Water Department, National Weather Service, Spokane Aquifer Joint Board, Spokane Conservation District, and Spokane Regional Clean Air Agency.
- **Storm Drain Stenciling Program** [4]**–** Many people mistakenly believe that storm drain inlets empty water to treatment facilities, so they pour chemicals or sweep debris directly into the storm drains. This dumping greatly increases the level of non-point source pollution (i.e., leaves, soil, trash, fertilizers, pesticides, street residue, etc.) already present in urban stormwater runoff, and can contribute substantially to a decline in water quality. The program is a hands-on, service-learning project for volunteers who are interested in educating the public about stormwater pollution prevention. Storm drain stenciling involves placing a "clean water" message next to a drain. The County's stencil messages, "Dump No Waste, Drains to Aquifer" and "Keep It Clean, Drains to Aquifer," remind would-be dumpers and passersby that most storm drains in Spokane County connect to the aquifer, and that dumping has the potential to pollute our drinking water. In addition to stenciling, volunteers are asked to distribute an informational door hanger to all residents within the stenciling area, which discusses the stenciling program and stormwater pollution. Spokane County believes storm drain stenciling educates threefold: 1) to the crew of stenciling volunteers; 2) to the neighboring residents who receive the door hanger; and 3) to public citizens who happen upon the stenciled messages. The most recent event took place in Fall 2017, the Stormwater Utility and City of Spokane Wastewater Management co-sponsored a storm drain art event with Mead Alternative High School[5] on and around their campus. Thus far, participants in the program have included Boy Scouts, area 5th graders, high school students, non-profit organizations, and Spokane County summer help.

3.4. Educational Tools

Spokane County utilizes existing and creates new educational tools and resources to educate the public at community events, in classrooms, and at the *Water Resource Center* each Permit year.

- **EnviroScape Model –** The SWU continues to educate school children and their parents using EnviroScape's *Nonpoint Source/Stormwater Pollution and Prevention* model and *Groundwater Liner* kit. The EnviroScape is a 3D mini-watershed model that simulates

[3] https://sites.google.com/site/spokaneenvirokids/home
[4] https://www.spokanecounty.org/FormCenter/Engineering-Roads-14/Storm-Drain-Stenciling-Info-Request-Form-84
[5] https://www.krem.com/article/news/local-high-school-students-use-art-to-raise-awareness/479610198

the many sources of both point and nonpoint source pollution. It allows students and adults to observe the interactions of precipitation with various land use practices, and the impacts those practices have on streams, lakes, and groundwater.

- **Stormwater Plinko -** The SWU continues to use a 4' x 2' Plinko game as a stormwater pollution teaching tool at community events. Players are asked to release a Ping-Pong ball "water droplet" at the top. The "water droplet" ultimately falls into one of nine spaces at the bottom. Three of the spaces are swales/grass, four spaces are storm drains, and two spaces involve infiltration through bare soil. Optimally, a player's "water droplet" will land in the grass/grassed swale, where plant medium acts as a filter for removing pollutants from rainwater. Those whose "water droplets" land in the storm drain are asked to describe a type of pollution found on the street that would not get filtered by a storm drain, potentially percolating to harm our groundwater.

- **Stream Table –** The Spokane County Water Resources Department purchased a stream table for use at educational events held the County's Water Resource Center. Stream tables demonstrate the dynamic nature of a river within a watershed. The flow of water in the stream table can be increased or decreased to mimic the real-world effects of rain and stormwater runoff. The stream table simulates a stream flowing through shallow spots, deep channels, and stream banks that face rapid erosion if trees or other vegetation are lacking. Stormwater staff can add houses, remove trees, and increase or decrease the flow and the volume of water — similar to what happens when storms generate vast amounts of runoff — to show how those changes affect the stream and downstream properties. When development occurs in the watershed, these activities often exacerbate stream bank erosion and increase deposits of sediment downstream. The stream table is equally enjoyed by grade school and high school groups, teachers, parents, civic groups, and other organizations.

- **Stormwater Magic –** The Spokane County SWU employs this activity at various community events to educate adults and children as to where stormwater really goes, and how pollution on our streets doesn't get filtered by storm drains. The trick works as follows: 1) a teaspoon of sodium polyacrylate is placed in a white Styrofoam cup; 2) the top of the cup is then covered with a black shower drain strainer to give the cup the appearance of being a miniature storm drain; 3) when water is poured into the cup, the powder acts like a sponge and turns the water into a clear solid; and 4) the cup and lid are turned upside down to show that the water doesn't come flowing back out. Adults and children are then asked what happens to stormwater once it enters a real storm drain. Does polluted stormwater "magically" disappear like the water poured into our *Magic Storm Drain*?

- **Stormwater *Mis*Match Game –** The Stormwater Utility developed this game in 2014, and most often uses it to educate the region's 5th graders at our Outdoor Environmental Education programs. Students are broken into two teams, and each team is given a large poster and various photos of good and bad behaviors/actions that can affect water quality. Both teams have identical batches of photos. The object of the game is to have

the students make correct "matches" using the photos, and then attach them – as pairs – to their respective poster. For example, one photo shows dog waste that was left by the side of the road (the bad behavior), while its "match" depicts a woman picking up after her dog with a pet waste bag (the good behavior). Once both teams have filled their poster by making "matches" with all the photos, the entire group is then encouraged to discuss each "match" by explaining how each good and bad behavior helps or harms our region's rivers, lakes, and aquifer.

- **Poo Toss Game –** Taking a cue from the Snohomish County Surface Water Division, the SWU and Spokane County Water Resources Department introduced the Poo Toss game in 2016 to engage a wide audience and start conversations about the importance of picking up dog waste. The directions on how to play are as follows: 1) give each player a pet waste bag; 2) have them scoop up a fake/plastic poop with their hand inside the bag, then turning the bag inside out around the "poo"; 3) ask participants where they think pet waste should go (NOTE: the waste should always be placed in a trash can!); and 4) tell the players to toss their bagged "poo" – like a basketball – into the trash from a set distance away. Depending on the number of people waiting, participants are given a few tries and/or allowed to move closer to the trash can when making a toss. Those who properly toss their "poo" into the trash can, rather than in the yard waste bin or near a storm drain, are given a prize – mini-Frisbees for their pets to play with. The Frisbees also outline the steps to proper pet waste disposal for continued message exposure which, in turn, helps to foster long-term behavior change.

- **Storm Drain Shell Game -** This game was created for use at various community events, including Earth Day and Unity in the Community. The "Storm Drain Shell Game," where three mini storm drains – two of them with "stormwater pollution" inside (i.e., the kind of pollution one might see in a street drain, including some rocks and dirt, a few leaves, wrappers, etc.) – are shuffled quickly and the player is to guess which storm drain is the "clean" one. This game is not only a lightweight and portable option for educating the public about storm drains and pollution, but proved highly engaging to both adults and children, too.

- **Spokane Valley-Rathdrum Prairie Aquifer Atlas –** The Stormwater Utility and Spokane County Water Resources Department, in cooperation with other local NPDES Permittees and regional water quality protection groups, participated in a comprehensive update of the Spokane Valley-Rathdrum Prairie Aquifer Atlas during the 2014-2015 calendar years. Of note, the new edition features several pages on stormwater runoff, stormwater pollution, swales and LID, in addition to pollution prevention instruction for businesses and homeowners. Spokane County continued to disseminate the Atlases throughout 2018 at various community events, and classes and meetings held at the Water Resource Center. The Atlas can also be accessed online via the County's Water Resources webpage[6] or the Spokane Aquifer Joint Board website[7].

[6] https://www.spokanecounty.org/1227/SVRP-Aquifer-Home
[7] http://www.spokaneaquifer.org/2015-aquifer-atlas/mobile/index.html

- **EnviroKids Newsletters –** The Spokane County Stormwater Utility, Spokane County Water Resources, Spokane County Regional Solid Waste System, City of Spokane Water Department, National Weather Service, Spokane Aquifer Joint Board, Spokane Conservation District, and Spokane Regional Clean Air Agency disseminate quarterly newsletters, which focus on topics that tackle a wide variety of environmental subjects including water quality, to area K-6 students through the mail and at community events.

3.5. Public Education and Outreach Campaigns

- **Canines for Clean Water –** Spokane County continues its poo-llution prevention marketing campaign, titled "Canines for Clean Water." The campaign goal is to inform dog owners about the impacts pet waste can have on our water, if not properly disposed of in the trash. For adults who take a "pledge" to always pick up after their pooch, we give away either "Canines for Clean Water" bandanas for their dogs to wear and/or a "Canines" mousepad. For residents unable to attend an event but still wishing to "pledge," there is an online pledge form[8]. The County also distributes "Canines for Clean Water" brochures and temporary tattoos at community events. Throughout 2018, the SWU utilized the Poo Toss game (first implemented in Washington State by Snohomish County). Participants bag fake "poo" and try to toss it like a basketball into the trash can. Those who make their toss into the trash, rather than in the yard waste bin or near a storm drain, are given a prize – mini-Frisbees for themselves and/or their pets to play with. The Frisbees also outline the steps to proper pet waste disposal for continued message exposure which, in turn, helps to foster long-term behavior change.

- **Got waste? Put it in the right place![9] –** The local non-profit organization, Spokane Aquifer Joint Board, continues to promote this public outreach campaign to educate the public about proper disposal of various types of waste products. In cooperation with the Spokane County Regional Solid Waste System, kids and adults are now more aware of differences between garbage, recyclables, and hazardous waste.

- **Don't Drip & Drive –** In cooperation with the City of Spokane, Spokane County helped co-launch the Puget Sound STORM [10]group's marketing campaign, "Don't Drip & Drive,"[11] to residents in the greater-Spokane region. The bi-annual SCC Car Care event was attended by the County on October 6, 2018. City and County also conducted social marketing and published press releases[12] on several occasions. Participating shops in the Spokane Region offer free visual leak checks and discounts on leak repairs.

- **Pool Mailings –** In 2018 the Stormwater Utility conducted a survey of homes with outdoor swimming pools. Swimming pools are a major contributor to pollutants such as chlorine entering the MS4. Residents with pools received educational mailings detailing

[8] https://www.spokanecounty.org/FormCenter/Engineering-Roads-14/Canines-Pledge-Form-93
[9] https://spokaneriver.net/wastedirectory/
[10] http://pugetsoundstorm.weebly.com
[11] https://fixcarleaks.org/
[12] https://www.spokanecounty.org/CivicSend/ViewMessage/message?id=45721

the harmful effect that swimming pool water can have on the environment, and the correct methods of emptying pools at the end of the summer.

3.6. Erosion and Sediment Control Education for County Employees, Contractors and Developers

During the Spokane County Development Review and/or the Site Plan Review processes and while conducting on-site inspections, Public Works staff provides Erosion and Sediment Control (ESC) guidance to contractors and developers. The Stormwater Utility also has a minimum of three CESCLs on-staff who are ready to field questions regarding the County's ESC ordinances, and local, state, and federal regulations.

In addition, the Stormwater Utility has compiled a calendar, which displays the dates of – and hyperlinks to – all Certified Erosion and Sediment Control Lead (CESCL) trainings and recertification courses within the entire State of Washington. Contractors and/or developers can access the calendar via the County's Stormwater webpage[13].

The County's Building and Planning Department also includes relevant flyers[14] in building permit application packets to remind contractors and developers to contact the Department of Ecology to find out if their project will require a Construction General Permit (CGP).

3.7. Stormwater Hotline – (509) 477-7525

Spokane County understands that citizen participation is vital to an effective stormwater program. Likewise, the public is key to timely enforcement. The Stormwater Utility maintains a reporting hotline, as required by the Permit, to help eliminate polluted stormwater discharges. Through this hotline – available 24 hours a day – anyone can report illegal dumping, illicit discharges into storm drains, or material spills. The County continues to advertise the hotline via the County website and through magnets handed out at community events.

3.8. Stormwater Utility Webpage[15]

The County provides a website for information about stormwater and surface water management. Available resources include education and outreach materials, public announcements regarding current and potential SWU capital construction projects, the County's Annual Report, Spokane Regional Stormwater Manual, and the Eastern Washington LID Guidance Manual are all available for download on the site. The public is also encouraged to participate in the decision-making process involving the development and implementation of NPDES Permit related activities and programs via the Stormwater Utility's online comment form.

3.9. Local Media

An education documentary on one of the County's regional stormwater facilities was produced during the 2009 Permit year. The 20-minute piece tells the story of how the facility uses natural

[13] https://www.spokanecounty.org/DocumentCenter/View/24397/2019-CESCL-Calendar-2?bidId=
[14] https://www.spokanecounty.org/500/Building-Permit-Tips
[15] https://www.spokanecounty.org/918/Stormwater-Utility

processes to remove pollutants from urban stormwater, in addition to discussing the public's involvement before, during, and after the construction of the facility. This piece continues to be rebroadcasted periodically on Cable Channel 5, the City of Spokane's Community Access station. The documentary[16] can also be viewed on the County's website.

4. 2019 and Future Program Focus

Spokane County Stormwater Utility will supplement its current public education and outreach program by updating it to maintain compliance as the Department of Ecology phases in new Permit requirements in 2019. Actions recommended for further program development include:

- Increased collaboration with other NPDES municipalities;
- Collaboration with the Spokane Regional Health District to reach businesses on source control topics;
- Pursue opportunities offered by state and federal agencies to support education programs;
- Measure the understanding and adoption of targeted behaviors for target audiences;
- Continue to pursue opportunities for improvement in NPDES implementation through education and outreach activities;

[16] https://www.spokanecounty.org/1999/Price-Wall-Regional-Stormwater-Facility-

Appendix A

2018 EDUCATION and OUTREACH and PUBLIC INVOLVEMENT and PARTICIPATION TRACKING SPREADSHEET

Spokane County Water Resources & *Stormwater Utility*

2018 Education & Outreach and Public Involvement & Participation Tracking

	Date	Staff	Organization	Event	Audience	Topic or Purpose	Outreach Category	Youth Estimate	Adult Estimate	Total
1	1/17/2018	Taylor	Mead High School	Mead STEM Night	MS, HS	Water quality, reclamation, & careers	Off-site	60	16	76
2	1/21/2018	Hess, Hall, & Zimmer	St. George's School (8th grade)	LID Lesson #1	MS	Water quality, stormwater, & rain gardens	Off-site	26	4	30
3	2/14/2018	Taylor	Gonzaga University	Env. Org. Career & Networking	College	Water careers	Off-site	10	0	10
4	2/21/2018	Hess, Hall, & Zimmer	St. George's School (8th grade)	LID Lesson #2	MS	Water quality, stormwater, & rain gardens	Off-site	26	4	30
5	2/26/2018	Boese & Zimmer	Balboa Elementary (1st grade)	Field Trip	Elementary	Aquifer & wastewater	WRC	45	6	51
6	2/27/2018	Hess, Hall, & Zimmer	St. George's School (8th grade)	LID Lesson #3	MS	Water quality, stormwater, & rain gardens	Off-site	26	4	30
7	2/27/2018	Taylor & WVOLC	City School	Field Trip	MS	Aquifer & wastewater	WRC	50	3	53
8	2/28/2018	Taylor & WVOLC	City School	Field Trip	MS	Aquifer & wastewater	WRC	50	3	53
9	3/1/2018	Taylor & WVOLC	City School	Field Trip	MS	Aquifer & wastewater	WRC	50	3	53
10	3/10/2018	Hess & Selcho	Spokane County Stormwater & SCCD	Rain Barrel Workshop	Adult	Water conservation & stormwater	Off-site	0	18	18
11	3/12/2018	Boese	Evergreen Elementary	Science Night	Elementary	Aquifer & water quality	Off-site	50	20	70
12	3/20/2018	Hess, Hall, & Zimmer	St. George's School (8th grade)	LID Lesson #4	MS	Rain gardens (plant species selection)	Off-site	26	4	30
13	3/20/2018	Hess, Hall, & Zimmer	St. George's School (8th grade)	LID Lesson #5	MS	Rain gardens (soil types and infiltration test)	Off-site	26	4	30
14	3/21/2018	Boese & Hess	Otis Orchards Elementary	Science Extravaganza	Elementary	Aquifer & water quality	Off-site	100	40	140
15	4/7/2018	Hess & Zimmer	Spokane Community College, Radio Spokane, Motion Auto, Spokane County, & City of Spokane	SCC Auto Care Fair	Adult	Don't Drip & Drive, water quality, & stormwater	Off-site	30	210	240
16	4/11/2018	Hess & Selcho	Spokane County Stormwater & SCCD	Rain Barrel Workshop	Adult	Water conservation & stormwater	Off-site	1	21	22
17	4/13/2018	Hess, Hall, & Zimmer	St. George's School (8th grade)	Rain Garden/Swale Construction (Day 1)	MS	Water quality, stormwater, & rain gardens	Off-site	26	4	30
18	4/14/2018	Boese	Eagle Ridge Neighborhood	Community and Canine Fair	Variety	Aquifer & stormwater	Off-site	100	100	200
19	4/16/2018	Taylor & WVOLC	Centennial Middle School	Field Trip	MS	Aquifer, watersheds, & wastewater	WRC	210	6	216
20	4/18/2018	Taylor, Boese, Hess, & Steven Gimpel	Summit School (3rd grade)	Field Trip	Elementary	Water cycle, reclamation, & recycling	WRC	48	3	51
21	4/19/2018	Boese & Taylor	Palisades Christian Academy (3rd grade)	Field Trip	Elementary	Water cycle, aquifer, & stormwater	WRC	18	4	22
22	4/20/2018	Boese & Hess	CVSD - Liberty Lake Elementary (5th grade)	Outdoor Environmental Education	Elementary	Water cycle, aquifer, & stormwater	Off-site	50	8	58
23	4/23/2018	Taylor, WVOLC, & Rose	South Pines Elementary (1st grade)	Field Trip	Elementary	Water cycle, aquifer, & stormwater	WRC	38	10	48
24	4/23/2018	Hess	CVSD - Liberty Lake Elementary (5th grade)	Outdoor Environmental Education	Elementary	Water cycle, aquifer, & stormwater	Off-site	50	8	58
25	4/24/2018	Hess	CVSD - Liberty Lake Elementary (5th grade)	Outdoor Environmental Education	Elementary	Water cycle, aquifer, & stormwater	Off-site	50	8	58
26	4/25/2018	Taylor, Rose, & Brattebo	Wilson Elementary (2nd grade)	Field Trip	Elementary	Water cycle, aquifer, & stormwater	WRC	52	4	56
27	4/25/2018	Hess & Clary	CVSD - Liberty Lake Elementary (5th grade)	Outdoor Environmental Education	Elementary	Water cycle, aquifer, & stormwater	Off-site	50	8	58
28	4/27/2018	Hess & Boese	CVSD - Sunrise Elementary (5th grade)	Outdoor Environmental Education	Elementary	Water cycle, aquifer, & stormwater	Off-site	50	8	58
29	4/30/2018	Boese & Rose	CVSD - McDonald Elementary (5th grade)	Outdoor Environmental Education	Elementary	Water cycle, aquifer, & stormwater	Off-site	50	8	58
30	5/1/2018	Boese & Hess	CVSD - Ponderosa Elementary (5th grade)	Outdoor Environmental Education	Elementary	Water cycle, aquifer, & stormwater	Off-site	50	8	58
31	5/2/2018	Boese & Hess	CVSD - Sunrise Elementary (5th grade)	Outdoor Environmental Education	Elementary	Water cycle, aquifer, & stormwater	Off-site	50	8	58
32	5/3/2018	Hess, Hall, & Zimmer	St. George's School (8th grade)	Rain Garden/Swale Construction (Day 2)	MS	Water quality, stormwater, & rain gardens	Off-site	26	4	30
33	5/4/2018	Hess & Clary	CVSD - Liberty Lake Elementary (5th grade)	Outdoor Environmental Education	Elementary	Water cycle, aquifer, & stormwater	Off-site	50	8	58
34	5/7/2018	Hess & Rose	CVSD - Broadway Elementary (5th grade)	Outdoor Environmental Education	Elementary	Water cycle, aquifer, & stormwater	Off-site	50	8	58
35	5/8/2018	Hess & Clary	CVSD - Opportunity Elementary (5th grade)	Outdoor Environmental Education	Elementary	Water cycle, aquifer, & stormwater	Off-site	50	8	58
36	5/9/2018	Hess & Clary	CVSD - Chester Elementary (5th grade)	Outdoor Environmental Education	Elementary	Water cycle, aquifer, & stormwater	Off-site	50	8	58
37	5/10/2018	Taylor, WVOLC, & Rose	St. Mary's Catholic School (7th grade)	Field Trip	MS	Aquifer, watershed, & wastewater	WRC	30	3	33
38	5/10/2018	Hess, Hall, & Zimmer	St. George's School (8th grade)	LID Lesson #6	MS	Water quality, stormwater, & rain gardens	Off-site	26	4	30
39	5/11/2018	Hess & Rose	CVSD - Greenacres Elementary (5th grade)	Outdoor Environmental Education	Elementary	Water cycle, aquifer, & stormwater	Off-site	50	8	58
40	5/14/2018	Boese & Hess	CVSD - Adams Elementary (5th grade)	Outdoor Environmental Education	Elementary	Water cycle, aquifer, & stormwater	Off-site	50	8	58
41	5/14/2018	Taylor	Paideia High School	Field Trip	HS	Wastewater & cleaning water	SCRWRF Tour	25	2	27
42	5/15/2018	Boese & Hess	CVSD - University Elementary (5th grade)	Outdoor Environmental Education	Elementary	Water cycle, aquifer, & stormwater	Off-site	50	8	58
43	5/15/2018	Taylor & Rose	All Saints Catholic School (7th grade)	Field Trip	MS	Combo Swap Tour	SCRWRF Tour	37	3	40
44	5/16/2018	Boese & Hess	CVSD - Progress Elementary (5th grade)	Outdoor Environmental Education	Elementary	Water cycle, aquifer, & stormwater	Off-site	50	8	58
45	5/18/2018	Boese & Hess	CVSD - Greenacres Elementary (5th grade)	Outdoor Environmental Education	Elementary	Water cycle, aquifer, & stormwater	Off-site	50	8	58
46	5/21/2018	Boese & Hess	CVSD - Opportunity/Ponderosa Elementary (5th grade)	Outdoor Environmental Education	Elementary	Water cycle, aquifer, & stormwater	Off-site	50	8	58
47	5/22/2018	Taylor & Rose	Liberty Creek Elementary (2nd grade)	Field Trip	Elementary	Aquifer, watersheds, & wastewater	WRC	34	4	38
48	5/22/2018	Taylor & Rose	Selkirk High School	Field Trip	HS	Wastewater & cleaning water	SCRWRF Tour	20	1	21
49	5/22/2018	Boese & Hess	CVSD - Adams/Broadway Elementary (5th grade)	Outdoor Environmental Education	Elementary	Water cycle, aquifer, & stormwater	Off-site	50	8	58
50	5/23/2018	Boese & Hess	CVSD - Chester Elementary (5th grade)	Outdoor Environmental Education	Elementary	Water cycle, aquifer, & stormwater	Off-site	50	8	58
51	5/23/2018	Taylor, WVOLC, & Rose	Liberty Creek Elementary (2nd grade)	Field Trip	Elementary	Aquifer & watersheds	WRC	102	6	108
52	5/25/2018	Taylor, WVOLC, & Rose	Liberty Creek Elementary (2nd grade)	Field Trip	Elementary	Aquifer & watersheds	WRC	51	3	54
53	5/25/2018	Boese & Hess	CVSD - Summit/SVLA Elementary (5th grade)	Outdoor Environmental Education	Elementary	Water cycle, aquifer, & stormwater	Off-site	50	8	58
54	5/29/2018	Boese & Taylor	Cooper Elementary (1st grade)	Field Trip	Elementary	Water cycle, watersheds, & stormwater	WRC	40	4	44
55	6/4/2018	Hess, Hall & Zimmer	St. George's School (8th grade)	Rain Garden/Swale Construction (Day 3)	MS	Water quality, stormwater, & rain gardens	Off-site	26	4	30
56	6/4/2018	Boese, Taylor, & Clean Air	Evergreen Elementary (5th grade)	Outdoor Environmental Education	Elementary	Watersheds, wastewater, & air quality	WRC	90	4	94
57	6/5/2018	Boese, Taylor, & Clean Air	Brentwood Elementary (5th grade)	Outdoor Environmental Education	Elementary	Watersheds, wastewater, & air quality	WRC	90	4	94
58	6/6/2018	Boese & Taylor	Cooper Elementary (1st grade)	Field Trip	Elementary	Water cycle, watersheds, & stormwater	WRC	40	2	42

	Date	Staff	Organization	Event	Audience	Topic or Purpose	Outreach Category	Youth Estimate	Adult Estimate	Total
59	6/26/2018	Taylor, Hess, & Solid Waste	Gonzaga Prep Spokane Plunge - Eco Club	Field Trip	HS	Wastewater, stormwater, recycling, & waste	WRC	25	3	28
60	7/5/2018	Boese & Hess	Spokane Parks & Recreation	Parks & Recreation Adventure Camp	Elementary	Watersheds & stormwater	WRC	6	2	8
61	7/6/2018	Boese & Hess	Parkview Early Learning Center	Field Trip	Elementary	Water use, stormwater, & wastewater	WRC	18	4	22
62	7/9/2018	Boese, Hess & Oullette	Summer Express	Field Trip	Elementary	Water use, stormwater, & wastewater	WRC	44	8	52
63	7/10/2018	Boese, Hess & Oullette	Spokane Parks & Recreation	Parks & Recreation Adventure Camp	Elementary	Water use, stormwater, & wastewater	WRC	9	2	11
64	7/12/2018	Boese, Hess & Oullette	Summer Express	Field Trip	Elementary	Water use, stormwater, & wastewater	WRC	26	4	30
65	7/12/2018	Boese, Hess & Oullette	Summer Express	Field Trip	Elementary	Water use, stormwater, & wastewater	WRC	27	4	31
66	7/13/2018	Taylor	SCRAPS	Lola's on the Loose	Adult	Pet waste & stormwater	WRC	3	5	8
67	7/16/2018	Boese, Hess & Oullette	Shaw Middle School	Summer STEM Camp	MS	GIS & stormwater mapping	Off-site	15	3	18
68	7/19/2018	Boese & Hess	Spokane Parks & Recreation	Parks & Recreation Adventure Camp	MS	Watersheds & stormwater	WRC	7	2	9
69	7/20/2018	Boese & Hess	MOBIUS Science Day	Community Event	Variety	Wastewater	Off-site	26	5	31
70	7/23/2018	Boes & Hess	Regal Elementary	Go Forth Summer Camp	Elementary	GIS & stormwater mapping	Off-site	66	2	68
71	7/24/2018	Hess & Selcho	Spokane County Stormwater & SCCD	Rain Barrel Workshop	Adult	Water conservation & stormwater	Off-site	0	22	22
72	7/25/2018	Boese & Hess	Spokane Parks & Recreation	Parks & Recreation Adventure Camp	Elementary	River-aquifer interchange & water conservation	WRC	12	2	14
73	7/26/2018	Taylor	Greater Spokane, Inc.	Business After Hours	Adult	SCRWRF and WRC tours	WRC	3	25	28
74	7/26/2018	Boese & Hess	Browne Elementary	Go Forth Summer Camp	Elementary	GIS & stormwater mapping	Off-site	48	2	50
75	7/31/2018	Boese & Hess	Grant Elementary	Go Forth Summer Camp	Elementary	GIS & stormwater mapping	Off-site	66	3	69
76	8/1/2018	Boese & Hess	South Hill Library	Summer Library Reading	Variety	Aquifer	Off-site	30	15	45
77	8/2/2018	Boese & Hess	Spokane Parks & Recreation	Parks & Recreation Adventure Camp	MS	River-aquifer interchange & stormwater	WRC	10	2	12
78	8/9/2018	Taylor & Clean Air	Spokane Parks & Recreation	Parks & Recreation Adventure Camp	Elementary	Wastewater & air quality	WRC	10	2	12
79	8/14/2018	Boese & Taylor	Advent Lutheran Care	Field Trip	Elementary	Water cycle, aquifer, & wastewater	WRC	15	2	17
80	8/16/2018	Boese & Hess	Spokane Parks & Recreation	Parks & Recreation Adventure Camp	MS	River-aquifer interchange & stormwater	WRC	10	2	12
81	8/23/2018	Boese & Hess	Spokane Parks & Recreation	Parks & Recreation Adventure Camp	Elementary	Watersheds & stormwater	WRC	9	2	11
82	8/28/2018	Hess & Selcho	Spokane County Stormwater & SCCD	Rain Barrel Workshop	Adult	Water conservation & stormwater	Off-site	0	25	25
83	9/7/2018	Boese, Hess, & Taylor	Spokane County Interstate Fair	Community Event	Variety	Aquifer, stormwater, & wastewater	Off-site	0	0	0
84	9/12/2018	Boese & Hess	Water Festival	Field Trip	Elementary	Water cycle	Off-site	264	15	279
85	9/13/2018	Boese & Feiten	Water Festival	Field Trip	Elementary	Water cycle	Off-site	287	15	302
86	9/25/2018	Hess & Selcho	Spokane County Stormwater & SCCD	Rain Barrel Workshop	Adult	Water conservation & stormwater	Off-site	0	23	23
87	10/2/2018	Taylor, Boese, & Neil	St Georges 7th grade	Field Trip	MS	River-aquifer interchange & SCRWRF tour	SCRWRF Tour	2	28	30
88	10/6/2018	Hess	SCC Car Care Fair	Community Event	Adult	Don't Drip and Drive & proper disposal of cigarette butts	Off-site	30	220	250
89	10/11/2018	Boese, Hess, & Major	Five Mile Prairie Home School Group	Field Trip	Elementary	Water cycle, stormwater, recycling	WRC	23	10	33
90	10/18/2018	Taylor & Lindsay	Eastern Washington University	Science and Technology Career Fair	College	Share Water Resources Career information	Off-site	55	4	59
91	10/24/2018	Boese & Hess	Riverday School	Field Trip	Elementary	Water Cycle, Stormwater maze, WSYF	WRC	17	5	22
92	10/26/2018	Boese, Hess, & Neil	Nine Mile Elementary	Field Trip	Elementary	Wastewater video, Clarifier and Stormwater activities	WRC	32	2	34
93	10/29/2018	Boese, Hess, & Neil	HUB 360 - North Pines Middle	After-School Program	MS	River-aquifer interchange & stormwater	Off-site	15	2	17
94	10/30/2018	Boese, Hess, & Neil	HUB 360 - Millwood Community Center	After-School Program	MS	River-aquifer interchange & stormwater	Off-site	6	2	8
95	11/1/2018	Boese, Hess, & Neil	HUB 360 - HUB Sports Center	After-School Program	MS	River-aquifer interchange & stormwater	Off-site	24	2	26
96	11/5/2018	Boese, Hess, & Neil	HUB 360 - East Valley Middle	After-School Program	MS	River-aquifer interchange & stormwater	Off-site	9	1	10
97	11/8/2018	Taylor, Boese, Hess, & Neil	Pride Prep School	Field Trip	HS	Wastewater, stormwater, & human impact	WRC	50	2	52
98	11/13/2018	Boese & Taylor	Newport High School	Field Trip	HS	Water quality & wastewater	WRC	28	1	29
99	11/14/2018	Taylor, Major, Neil, & Hess	SWAC Student Reception	Award Ceremony	MS	Ceremony for recycling calendar winners, aquifer, stormwater, & composting activities	WRC	18	35	53
101	11/20/2018	Boese	Lewis & Clark Science classes	After-School Program	HS	Aquifer and filtering water	Off-site	60	2	62
103	11/29/2019	Boese, Taylor, Neil	Lewis & Clark MESA	Field Trip	HS	Aquifer, stormwater, wastewater	WRC	23	2	25
104	12/4/2018	Boese, Neil	Home School group	Field Trip	Elementary	Water Cycle, Aquifer, wastewater, stormwater	WRC	30	7	37
								4213	**1233**	**5446**

Attachment 5

ACTIONS TAKEN TO CHARACTERIZE, TRACE, AND ELIMINATE ILLICIT DISCHARGES AND ILLICIT CONNECTIONS TO THE MS4

1. Introduction and Permit Requirements

The Eastern Washington Phase II Municipal Stormwater Permit, Special Condition, Requirement S5.B.3 addresses the requirements of an Illicit Discharge Detection and Elimination (IDDE) program. The elements of an IDDE program include Municipal Separate Storm Sewer System (MS4) mapping, the development of local regulatory ordinance, regulatory enforcement, field investigation, monitoring, and staff training. Elements of Spokane County's IDDE program are addressed in the Stormwater Management Program (SWMP) Plan in Section 5 – Illicit Discharge Detection and Elimination.

This attachment has been prepared to address Annual Report Question 17, which states:

"Attach a summary of actions taken to characterize, trace and eliminate each illicit discharge found by or reported to the permittee. For each illicit discharge, include a description of actions according to required timelines per S5.B.3.d.iv.

2. Administrative Actions Taken to Prevent Illicit Discharges and Illicit Connections

Spokane County's IDDE program is administered by the Stormwater Utility Department within Public Works. The Stormwater Utility is responsible for implementing Phase II Permit requirements, which include means of preventing illicit discharges and illicit connections through multiple program elements. These programs include:

- Maintaining a Map of the MS4 – Spokane County maintains a map of the MS4 that details all known outfalls; the names and locations of all waters of the state that receive discharges from those outfalls; and all areas that receive discharges to the ground via infiltration BMPs (i.e. drywells, swales). MS4 mapping software helps to facilitate multiple objectives of the Permit, including the identification of potential illicit discharges.
- Discharge of Unauthorized Waters Ordinance – The Spokane County Code of Ordinances includes language to enforce unlawful non-stormwater discharges. These ordinances establish enforcement procedures aimed at discouraging non-stormwater illicit discharges through penalties and regulatory actions. These ordinances can be found in Spokane County Code chapter *9.14* – Roads, Approach and Drainage in New Construction.
- Illicit Discharge Education – Spokane County educates target audiences on the hazards of illicit discharges and illicit connections. Education activities are detailed in SWMP Section 3 – Public Education and Outreach, and Attachment 4 – Public Education and Outreach Activities.

3. Inspection Activities

One of the most effective means of identifying illicit discharges and illicit connections to the MS4 is by thoroughly inspecting individual storm structures such as catch basins, swales, drywells, ditches, treatment BMPs, and outfalls for evidence of non-stormwater pollution. A

range of monitoring techniques can be used to track and trace potential illicit non-stormwater sources of pollution. The following field activities are performed for IDDE purposes:

3.1. Outfall Inspection and Identification

Outfalls are high priority structures that require frequent inspection to ensure no illicit discharges or illicit connections are present. Since outfalls have a direct connection from the MS4 to waters of the state, potential sources of pollution can immediately impact water quality. Spokane County monitors locations with the potential to outfall to waters of the state including bridges, roads running parallel to water bodies, roads bordering wetlands, and areas served by regional stormwater systems.

Methods of outfall identification include investigation via review of aerial satellite imagery; review of design plans and as-built construction plans; visual field inspection of the MS4 bordering water bodies; and visual inspection by watercraft of stormwater structures bordering water bodies.

In 2018, the Stormwater Utility investigated a portion of the Little Spokane River to (1) identify potential outfalls originating from the County MS4, (2) train employees on proper field identification methods, and (3) collect additional data for follow-up investigation. Inspections are conducted during the dry season via watercraft so that hard to reach locations, such as sloped embankments, can be observed in a safe and efficient manner. Once the survey was completed, a follow-up investigation was conducted based on the findings.

The inspection identified two previously unidentified outfalls originating from the Dartford Bridge near State Highway 395. The outfalls were added to GIS mapping software and to the County's Outfall Inventory for future monitoring activities. A map of existing Spokane County outfalls can be found in Attachment 2 – 2018 NPDES Permit Area Maps.

3.2. Stormwater BMP Inspections

The inspection of stormwater conveyance and treatment structures is an integral component of the County's IDDE and Operations and Maintenance (O&M) programs. Spokane County implements IDDE elements into O&M requirements as an efficient opportunity to address each program. In 2018, Spokane County inspected over 8400 individual structures, including drywells, swales, catch basins, outfalls, and detention/retention ponds.

Spokane County staff are trained to identify evidence of illicit discharges, such as dumping activities. The *Illicit Discharge Detection and Elimination Guidance Manual*, which was prepared by Stormwater Utility staff in 2010, contains guidance on field investigation. If an illicit discharge or connection is ever discovered during a structural inspection, investigative action is initiated through the County's Request For Investigation (RFI) process, and is tracked in the IDDE Database.

3.3. Incidental Discovery

Municipal staff are trained to always be aware of potential water quality issues. Employees such as field technicians, maintenance personnel, engineers, and construction managers are educated on identifying potential illicit discharges and are aware of the proper steps to take following the discovery of a potential illicit discharge.

3.4. Rain List

The Rain List is a database of sites throughout the County that are receiving increased monitoring attention. Sites on the rain list are visited during or following precipitation events to monitor for stormwater concerns. A site will be added to the rain list for concerns including:

- A citizen's Request for Investigation
- Flow observed during dry conditions
- Internal planning/project prioritization
- Suspected illicit discharge (i.e. dumping activities)
- Flooding concerns
- Structural concerns

Resolution and removal of items on the rain list occur through a variety of means depending on the scope of the issue. In some instances, monitoring of rain list sites often results in small works or capital projects for issues deemed high priority.

4. IDDE Hotline

Spokane County operates an IDDE hotline for the public to report spills and other illicit discharge activities. Calls related to illicit discharges begin the *Request for Investigation* (RFI) process which results in follow-up actions to address the concern. Immediate follow-up actions in the event of spills may include the notification of the Department of Ecology or the Washington Emergency Management Division, per General Condition G3.

Informational inserts describing the Hotline and its purpose have been distributed to County residents along with County utility billing mailings. The Hotline is also publicized on Spokane County's website.

5. Eliminating Illicit Discharges and Illicit Connections

Once non-stormwater discharges or other connections are discovered, they can be fixed, repaired, or eliminated through several different mechanisms. Fixes can be as simple as containing and cleaning up a spill, or as complex as retrofitting a BMP for current treatment standards or engineering the removal to an illicit connection. Municipalities are required to establish targeted education, training, and capital construction programs to promote timely corrections.

The County continually responds to potential sources of illicit discharges in a timely manner by following the compliance schedule detailed in Permit S5.B.3.d.iv. The following table details the actions taken in 2018 to address illicit discharges and illicit connections.

IDDE Database Summary for 2018

Discharge Type	Location	Material of Concern	Date of Report or Discovery	Date of Investigation	Did the Spill or Illicit Discharge leave MS4?	Code Enforcement Action, if necessary	Date Investigation Terminated	Notes
Illegal Dumping	125 S Havana	Carpet Cleaning wastewater	3/8/2018	N/A	No – Located in City of Spokane Valley MS4	N/A	N/A	Resident called IDDE hotline to report that a carpet cleaning van was emptying its water tank in an apartment complex's parking lot. The information of the cleaning company was referred to the City of Spokane Valley for further action.
Illegal Dumping	Sorrel Rd 7300-4600 block	Pet Waste	8/7/2018	8/7/2018	No	Letters sent to all neighborhood residents detailing importance of illicit discharge prevention.	8/31/2018	Routine inspection of drywell discovered a resident has been dumping bags of pet waste directly into drywell. The drywell was vactored on 8/31/2018 with follow-up monitoring to be performed.
Oil Residue	Fairview Dr. at SR-206	Oil	9/19/2018	9/20/2018	No	No	10/1/2018	Oil residue was reported via RFI received 9/19/18. Maint. Dist. 1 investigated same day and determined material present was minimal and stable. Stormwater technician visited site first thing next day and cleaned residue with litter and broom.

Discharge Type	Location	Material of Concern	Date of Report or Discovery	Date of Investigation	Did the Spill or Illicit Discharge enter the MS4?	Code Enforcement Action, if necessary	Date Investigation Terminated	Notes
Oil Residue on Roadway	Canal at Rowan	Oil	10/4/2018	10/12/2018	No	Letter with information packet sent to property owner 11/16/2018	12/4/2018	RFI received from resident concerned that neighbor was impacting road with oil from vehicle maintenance occurring in street. Letter and info packet was sent to home owner. Follow up on 12/4/2018 to property showed owner built a shop to store vehicles. No cars in street and no visible oil residue present. Investigation considered closed.
Residue on Roadway	Trent at Flora	Powder/ Unknown Product	10/15/2018	N/A	No	No	N/A	Located within City of Spokane Valley MS4 – referred to Valley staff.

Attachment 7

STORMWATER MANAGEMENT PROGRAM EFFECTIVENESS STUDIES

Eastern Washington Stormwater Effectiveness Studies

Quality Assurance Project Plan

Sand Filter Sidewalk Vault BMP

Study Classification: Structural BMP

Study Objective(s): ☑ Evaluate Effectiveness ☑ Develop New BMP

November 1st, 2018

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Proposal and QAPP Publication Information

This Detailed Study Design Proposal (Proposal) and Quality Assurance Project Plan (QAPP) will be stored and accessible to the public on the Spokane County's website: https://www.spokanecounty.org/918/Stormwater-Utility. For questions regarding the Proposal, please contact Matt Zarecor by email MZarecor@spokanecounty.org or phone (509) 477-7255.

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Document History

This document was developed following the Eastern Washington (EWA) Detailed Study Design Proposal and Quality Assurance Project Plan Template for Structural Best Management Practices (BMPs). A copy of the template is located on the City of Spokane Valley's website at the following web link: http://www.spokanevalley.org/content/6836/6896/6914/8301/10121/default.aspx

The Detailed Study Design Proposal (Proposal) was submitted to Ecology on June 30, 2017. Ecology approved the Proposal via email to Spokane County on November 8th, 2017. Appendix A contains a copy of the email along with Ecology's comments on the Proposal. Appendix B contains a summary of HDR's responses to Ecology's comments including how the comments were incorporated into the Quality Assurance Project Plan (QAPP).

The draft QAPP was reviewed by members of the Technical Advisory Group (TAG) in April 2018. Appendix C contains a summary of the TAG's comments along with a summary of HDR's response to these comments including how the comments were addressed in this document. The QAPP was submitted to Ecology by the May 8, 2018 deadline for their review and comment. Comments from Ecology on the QAPP were provided via email on August 30th. Appendix D contains a copy of Ecology's QAPP review comments along with HDR's responses to the comments including how the comments were incorporated into the final QAPP document.

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2.0 Executive Summary

Constructing BMPs at sites with space constraints creates a challenge for jurisdictions. A viable solution is to develop BMPs that can fit into these built areas, such as the proposed sand filter sidewalk vault. A sand filter sidewalk vault is a variation of the basic sand filter vault BMP that is defined the Ecology stormwater manuals for Washington State. Specifically, a sand filter sidewalk vault is located below grade in a vault that fits underneath the sidewalk. The primary differences between the proposed sand filter sidewalk vault and the basic sand filter vault are, the proposed BMP does not utilize a pretreatment cell and is designed to accept runoff from a larger contributing basin area. The goal for this study is to evaluate the effectiveness of the proposed BMP. Effectiveness will be based upon:

- The ability of the BMP to infiltrate stormwater during 6-month 24-hour storm events without overflowing into the bypass system within the maintenance cycle
- The efficacy of the BMP to reduce the concentrations of total suspended solids (TSS), dissolved copper (Cu) and zinc (Zn), and oils, which will be evaluated to determine whether the BMP can achieve the respective Ecology treatment goals

If these objectives can be met, the results from this study will be used to justify the development of a new BMP that is approved for 'general use' on future projects.

The goals for this study will be achieved by conducting flow-through column testing and field testing the BMP. The column testing was conducted prior to the development of this QAPP. The purpose of this testing was to define BMP design and maintenance guidance. The field testing includes installing the sand filter sidewalk vault at a test-site in Spokane, WA and using automated equipment to collect data. The data to be collected includes pollutant concentrations from water quality samples (influent and effluent), the flow rate (influent, effluent, and overflow), and precipitation depth. Data will be collected from a minimum of 12 qualifying storm events over two wet seasons starting in the fall of 2018.

3.0 Introduction and Background

3.1 Introduction to the Structural BMP

The focus of this study is to evaluate the effectiveness of a new sand filter BMP (referred to as the sand filter sidewalk vault). This BMP will be installed below grade in a sidewalk vault (Figure 3.1). The top of the vault is a section of the sidewalk and runoff enters the vault through a curb cut located in the gutter. The sidewalk vault is 5-feet long and the same width as the sidewalk (4-feet). The primary components of this BMP are a sand filtration layer, an underdrain pipe, and a bypass pipe. The sand filtration layer will consist of an 18-inch layer of coarse sand which is overlaid by an organic material (coconut coir mat) that provides some pre-treatment through cation exchange capacity (CEC) and dissipates the energy of stormwater runoff that enters the sidewalk vault. Treated runoff infiltrates through a 3 inches of the choke stone layer (3/8-inch Pea Gravel) and discharges into an underdrain which routes runoff to a drywell or to a storm drain network.

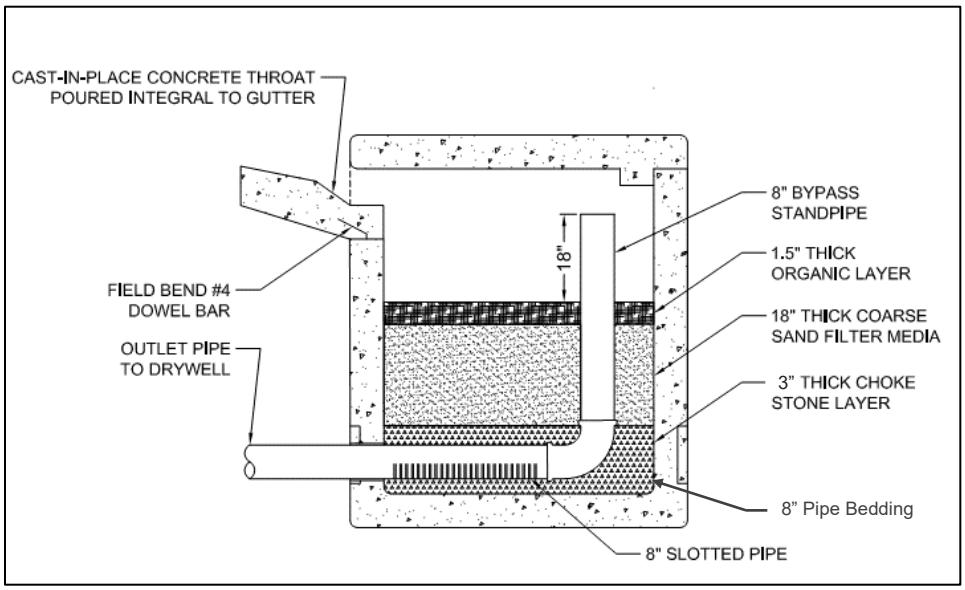

Figure 3.1 Cross Section of Sand Filter in Sidewalk Vault

The proposed sand filter sidewalk vault BMP design criteria is similar to the existing basic sand filter vault BMP defined in the Ecology Stormwater Manual (Ecology, 2004). Specifically, the proposed BMP is designed to treat 90% of the annual runoff volume (6-month 24-hour depth), while the volume of runoff from larger storms will overflow into a bypass pipe located 18-inches above the sand media. Differences between the proposed and existing sand filter vault BMP are summarized in Table 3.1. A primary difference is that the proposed BMP does not have a pretreatment cell to collect and remove gross solids prior to discharging into the BMP. As such the maintenance cycle of the proposed BMP is expected to be shorter (less time between cycles) when compared to the existing BMP.

Table 3.1 Comparison of Existing Basic Sand Filter Vault and Proposed Sand Filter Sidewalk Vault

	Existing Sand Filter Vault BMP (Ecology, 2004)		Proposed Sand Filter Sidewalk Vault BMP	
Pretreatment	This BMP is contained in a vault which consists of two cells: a pretreatment cell and a sand filtration cell. Stormwater runoff enters the pretreatment cell where the runoff velocity is reduced and gross solids and oils are removed. Runoff then overflows into the sand filtration cell where TSS is reduced as runoff infiltrates through the sand media.		This BMP consists of a single cell with no pretreatment. Stormwater runoff along with gross solids and oils from the contributing basin area enter the sand filtration cell where the runoff velocity is reduced by the coconut coir mat. Gross solids settle on top of the BMP and TSS is reduced as runoff infiltrates through the sand media.	
Sand Media Gradation	Medium Sand		Coarse Sand	
	Particle Diameter (mm)	Gradation Range	Particle Diameter (mm)	Gradation Range
	9.50	100	9.50	100
	4.75	95-100	4.75	90-100
	2.36	70-100	2.36	45-85
	1.19	40-90	1.19	9-45
	0.60	25-75	0.60	0-18
	0.30	2-25	0.30	0-10
	0.15	0-4	0.15	0-7
	0.07	0-2	0.07	0-2
Design Infiltration Rate	1 in/hr		124 in/hr	
BMP Size	Varies depending on the size of contributing basin area		Fixed at 4-feet by 5-feet (20-sqft footprint)	

This study will evaluate the effectiveness of a sand filter sidewalk vault BMP. Specifically, the runoff treatment performance, for reducing total suspended solids (TSS), dissolved Copper (Cu) and Zinc (Zn), and oils, and infiltration performance overtime. The primary treatment mechanism provided by this BMP include gravity separation, filtration, and sorption. Gravity separation relies on variations in material density for pollutant removal: pollutants denser than water (i.e., TSS and gross solids) will descend and settle on top of the BMP. While pollutants lighter than water (i.e. oils and grease) ascend to the top of ponded water, oils are known to sorb to sediment and are expected to reduce the concentration of oils (rather than discharge through the bypass pipe during events that exceed the water quality event). Filtration removes TSS as stormwater infiltrates through the sand filter becoming physically trapped in the media pore spaces (Minton, 2011). Sorption, due to the reportedly high cation exchange capacity (CEC) of coconut coir, is expected to provide some removal of dissolved metals. CEC values reported range from 21 to 186 meq/100g (Abad, 2002; Evans, 1996; Jeyaseeli 2010; Meerow, 1994).

3.2 Problem Description

Constructing BMPs at sites with space constraints creates a challenge for jurisdictions, particularly for retrofit or redevelopment projects that are located in built urban areas. A viable solution is to develop BMPs that can fit into these built areas, such as the proposed sand filter sidewalk vault.

Since the BMP is contained and provides treatment within the vault which can be installed under the sidewalk, it can be connected to existing (or new) storm drain networks. This BMP could eliminate (or reduce) the need for constructing a treatment BMP downstream and subsequently reduce the overall cost of stormwater management on future projects.

The primary reason for conducting this study is to meet Spokane County's permit requirements for evaluating the effectiveness of permit required stormwater management practices (see Section 3.4 for more details). This study is also being conducted to determine whether the proposed BMP meets the Ecology treatment criteria (Table 14.1) for basic (TSS), dissolved metals (Cu and Zn), and oils treatment as defined in the Technology Assessment Protocol Ecology (TAPE). In particular, TAPE requires that the treatment performance be evaluated in a field study. If the treatment performance goals are achieved, the results from this study will be used to justify the development of a new BMP that is approved for 'general use' on future projects. Results from this study will also be used to optimize the BMP design and maintenance guidance.

3.3 Results of Column Testing Sand Media

Flow through column testing was conducted on the proposed sand media for the purpose of: defining the BMP design and maintenance guidance; assessing the BMP treatment performance, and identifying the BMP design infiltration rate. The media selected consists of an 18-inch layer of coarse sand which is overlaid by a coconut coir mat (Appendix L). The column testing included two parts: 1) evaluate the treatment performance of the BMP for reducing TSS, dissolved Cu and dissolved Zn as well as assessing total phosphorus leaching potential; and 2) evaluate the change in infiltration rate over the duration of the testing period. This section provides an overview of the testing methods and a summary of the results.

3.3.1 Water Quality Treatment Performance

The column testing included simulating rainfall events using a synthetic stormwater solution. Two 2-inch schedule 40 clear plastic columns were packed with 18-inches of coarse sand in 6-inch layers (Figure 3.2). Each layer was compacted using a water settling method, which is consistent with the method Spokane County will use in the field for installing the sand in the sidewalk vaults. A synthetic stormwater solution composed of tap water and chemical standards for TSS, dissolved Cu and dissolved Zn (SIL-CO-SIL®, Copper Sulfate, and Zinc Chloride, respectively) was continuously mixed in a 70-liter tank using a mixer. The mixer ran continually during the testing to prevent the SIL-CO-SIL® from settling to the bottom of the tank. The synthetic stormwater was distributed to the columns using a peristaltic pump which ran continuously at a flow rate of 150 mL/min (the equivalent peak flow rate at the test site during the water quality event from the Type 1A rainfall distribution). The column testing system was designed to be representative of the sand filter sidewalk BMP constructed in the field. Specifically, the surface area of the column (0.022 sqft) was assumed equivalent to the surface area from the same diameter section in the sand filter sidewalk vault BMP in the field. In addition, the pollutant loading distributed to the columns (TSS, Cu, and Zn) was equivalent to the loading expected in the field annually, assuming a contributing basin area of 18,000 sqft and a mean annual precipitation rate of 16-inches over 2-years for a total of 32-inches. The annual pollutant loading was calculated using equivalent runoff from the contributing basin area (19.6 sqft) to the columns times the TAPE influent concentration range

(Ecology, 2011): the upper limit for Cu (0.02 mg/L) and Zn (0.30 mg/L) and the average of the range for TSS (150 mg/L).

Figure 3.2 Column Testing Setup (left), Expected TSS Accumulation in Sand Filter Media (middle), and TSS Accumulation in the Sand Filter Sidewalk Vault Media (right)

Samples were collected at the beginning of the simulated rainfall event. This included collecting the influent sample from the combined discharge of the pump distribution tubing. Then effluent samples was collected approximately 30-minutes after the influent sample to allow time for the stormwater solution to completely pass through the sand media. The samples were tested for TSS (SM 2540D-97), dissolved Cu and Zn (EPA 200.8), and total phosphorus (EPA 365.4). The average influent concentration and pollutant reduction is summarized in Table 3.2 (results represent the average values measured from the two columns).

The pollutant reduction was calculated to assess the treatment performance of the sand media (Table 3.2). Specifically, to assess whether the proposed BMP can achieve the Ecology treatment performance criteria for TSS, dissolved Cu, dissolved Zn, as well as the potential for the sand media to leach phosphorus. Since the average influent concentrations for Cu and Zn exceeded the upper influent concentration limit defined by TAPE, the pollutant reduction was calculated using the upper concentration limit as well as the measured influent concentration. As shown in Table 3.2, both TSS and dissolved Cu achieved the treatment performance goal, however the average dissolved Zn reduction was slightly less than the treatment performance goal. Since dissolved metals are known to sorb to the sediment in roadway runoff (which was not included in this portion of the column testing), metals removal is expected to be higher in the field (Minton, 2011). The columns leached total phosphorus (TP) during the first rainfall simulation, however TP was not detected in the samples collected for the 1- and 2-year event (equivalent to 16- and 32-inches of rainfall). These results suggest that TP leaching may only be a concern during the initial period after the BMP is installed in the field.

Table 3.2 Summary of Water Quality Testing

Average Influent Concentration	TSS=180 mg/L	Cu=0.04 mg/L	Cu=0.02[a] mg/L	Zn=0.46 mg/L	Zn=0.30[a] mg/L	TP=0 mg/L
Equivalent Precipitation Depth (inches)	TSS Average Reduction	Dissolved Cu Average Reduction	Dissolved Cu Average Reduction (TAPE Limit)	Dissolved Zn Average Reduction	Dissolved Zn Average Reduction (TAPE Limit)	Total Phosphorus Average Reduction
<1	95%	96%	96%	98%	97%	-120%
4	92%	NT	NT	NT	NT	NT
8	83%	NT	NT	NT	NT	NT
16	78%	62%	57%	30%	0%	ND
24	90%	NT	NT	NT	NT	NT
32	50%	65%	60%	46%	24%	ND
Average Pollutant Reduction	81%	74%	71%	58%	40%	
TAPE Treatment Performance Goal	80%	30%	30%	60%	60%	
TAPE Goal Achieved	✓	✓	✓	✗	✗	

NT - not tested, ND – not detected

a. The influent concentration represents the upper limit for each parameter as defined in TAPE.

The pollutant reduction ratio is the effluent concentration divided by the influent concentration (C_e/C_i). This value was calculated and graphed for each sampling event to assess the trend in the treatment performance over the testing period. As shown in Figures 3.3, 3.4, and 3.5 the treatment performance declines (C_e/C_i increases) over the testing period for all parameters. In particular, the effluent reduction for TSS was less than 80% until break-through occurred after the equivalent loading from 26-inches of rainfall. These results are different than what has been observed at other sand filter BMPs installations (i.e., the existing basic sand filter vault BMP). Specifically, the sand media typically clogs from TSS accumulation on top of and within the top 6-inches of the sand media (Figure 3.1). Clogging is due to sedimentation, as particles settle on the surface of the BMP, and filtration, as stormwater infiltrates through the sand media and particulates become physically trapped in the media pore spaces (Hatt, 2008; Hunt & Lord, 2006; Li & Davis, 2008). The primary reason for the difference in these results is that coarse sand consists of a larger grain size sand compared to the existing basic sand filter BMP (Table 3.1). The larger grain size media is associated with a larger porosity. The pore spaces of the entire depth of media appear to be filling with TSS (Figure 3.2) and once full, the influent appears to be displacing TSS from the columns during rainfall simulations.

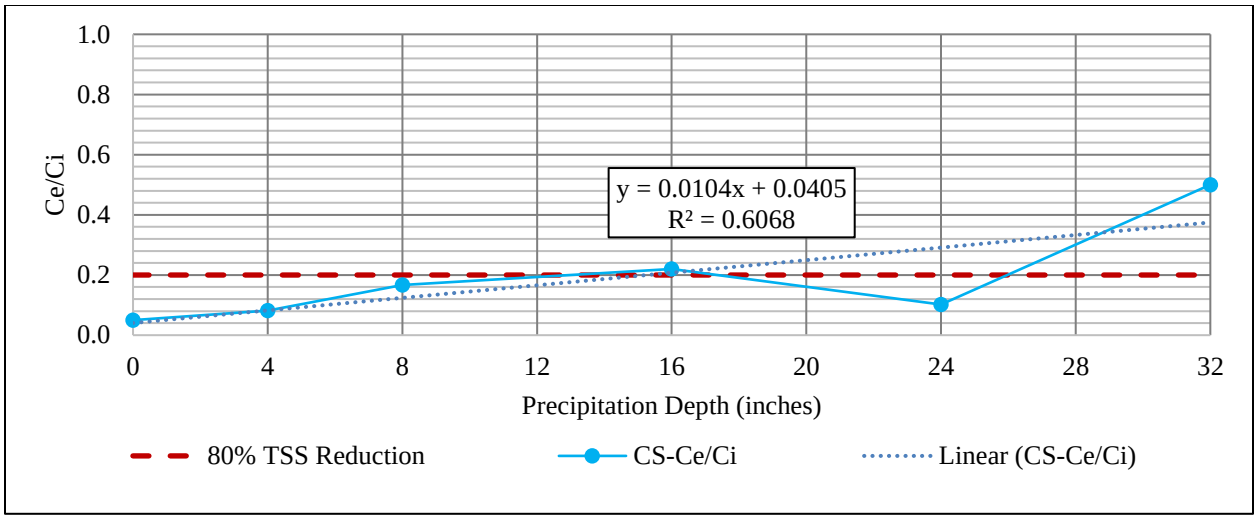

Figure 3.3 TSS Reduction Ratio (Ce/Ci) vs. Precipitation Depth (SIL-CO-SIL® 106 only)

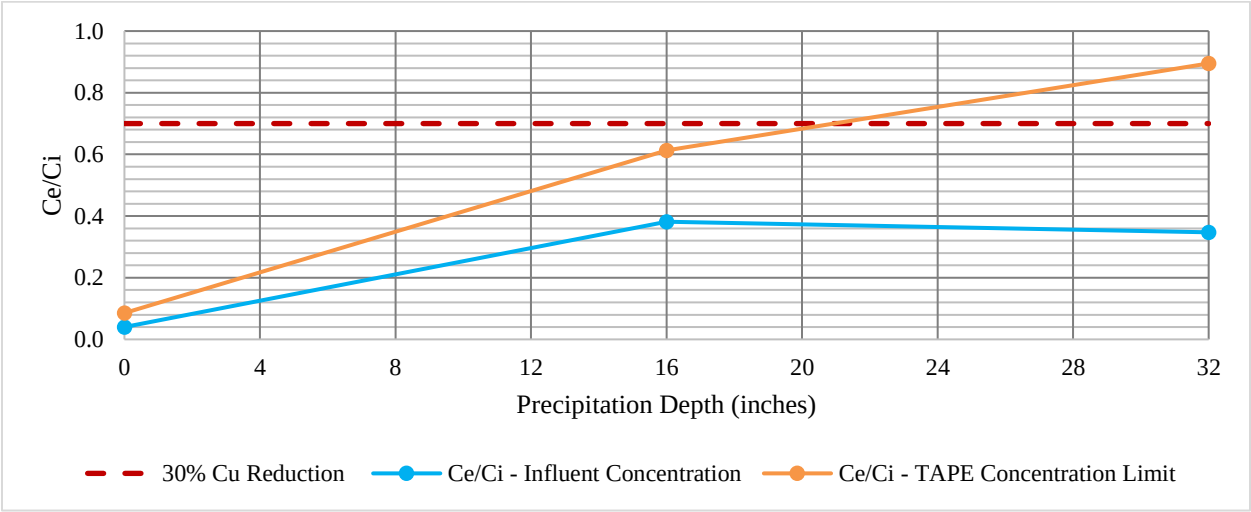

Figure 3.4 Dissolved Cu Reduction Ratio (Ce/Ci) vs. Precipitation Depth

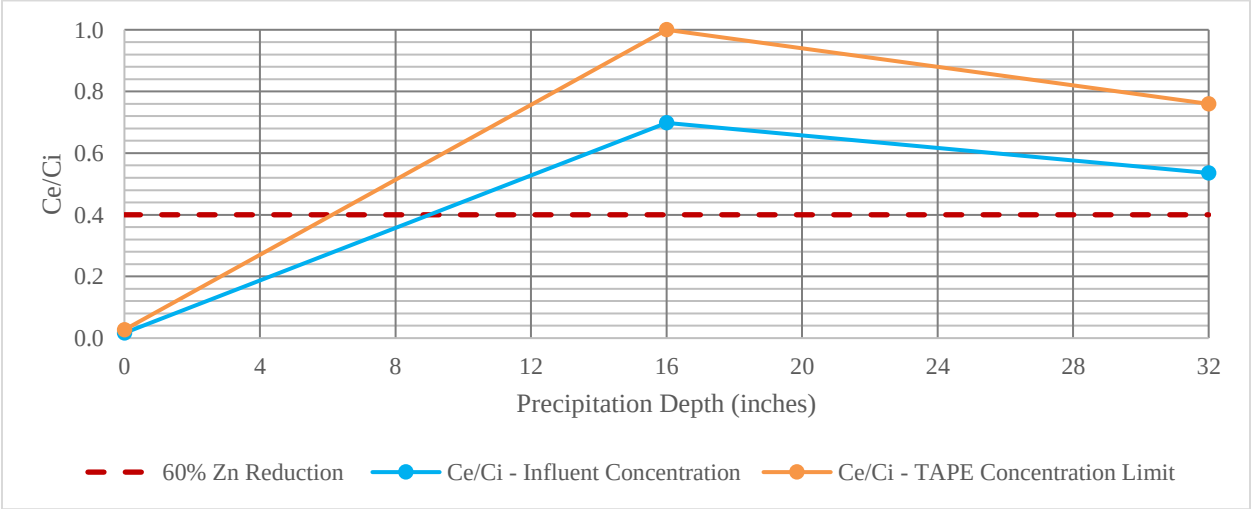

Figure 3.5 Dissolved Zn Reduction Ratio (Ce/Ci) vs. Precipitation Depth

3.3.2 Infiltration Rate Performance

The primary purpose of the infiltration rate performance testing was to predict the maintenance cycle of the sand filter sidewalk vault BMP. The following bullets provide a summary of the testing conducted. The subsequent sections provide the details of the testing conducted as well as the maintenance cycle predicted.

- Singe Event Modeling – the proposed BMP was modeled to determine the design infiltration rate. For this study, the design infiltration rate is the sand filter media infiltration rate just before runoff from the contributing basin area, during a 6-month 24-hour rainfall event, overflows into the bypass pipe. The bypass flow height is 18-inches above the sand filter media.

- Falling Head Testing Post Water Quality Testing using SIL-CO-SIL® – This testing occurred during and after the water quality treatment performance testing. The purpose of the testing was to determine the change in infiltration rate from *only* TSS loading.

- Falling Head Testing Post Water Quality Testing using SIL-CO-SIL® and Roadway Sediment - This testing occurred during and after the water quality treatment performance testing. The purpose of this testing was to determine the change in infiltration rate *from TSS loading and gross solids* from the contributing basin area.

Single Event Modeling
A single event model was used to determine the design flow rate and infiltration rate of the sand filter media. The design flow rate is the peak flow rate during the water quality event (6-month 24-hour event) and the design infiltration rate is the minimum infiltration rate needed to infiltrate the volume of runoff during the water quality event without overflowing into the bypass pipe. The design flow rate and infiltration rate were determined by modeling the sand filter BMP as a vault using StormShed 3G, a single event modeling software. The discharge for the vault was modeled as infiltration starting at a rate of 0-in/hr which was increased in 15-in/hr intervals up to 200-in/hr for a contributing basin area of 18,000 sqft. This contributing basin areas was selected because it is the area of the test-site where the sand filter media will be tested in the field which consists of 14,000 sqft, from impervious roads and sidewalks, and 4,000 sqft, from pervious lawns (See Section 4.3). Modeling was conducted assuming all 18,000 sqft was impervious (CN=98) to account for frozen ground conditions during the winter. The design infiltration rate was determined by modeling the BMP with 18-inches of stormwater ponded on top of the sand filter media. This is the maximum depth stormwater can pond without overflow into the bypass during the water quality event. Modeling consisted of using level pool routing, the Type 1A rainfall distribution, the Santa Barbara Urban Hydrograph (SBUH) method, and the precipitation depth from the 6-month 24-hour event for Spokane (approximately 1-inch of rainfall). The results indicate the peak flow rate is 0.08 cfs and the design infiltration rate is 124 in/hr (Figure 3.6). A copy of model output is located in Appendix F.

See Section 3.3.3 for discussion regarding methods for sizing this BMP. More specific details regarding the BMP sizing are located in Section 7.3.

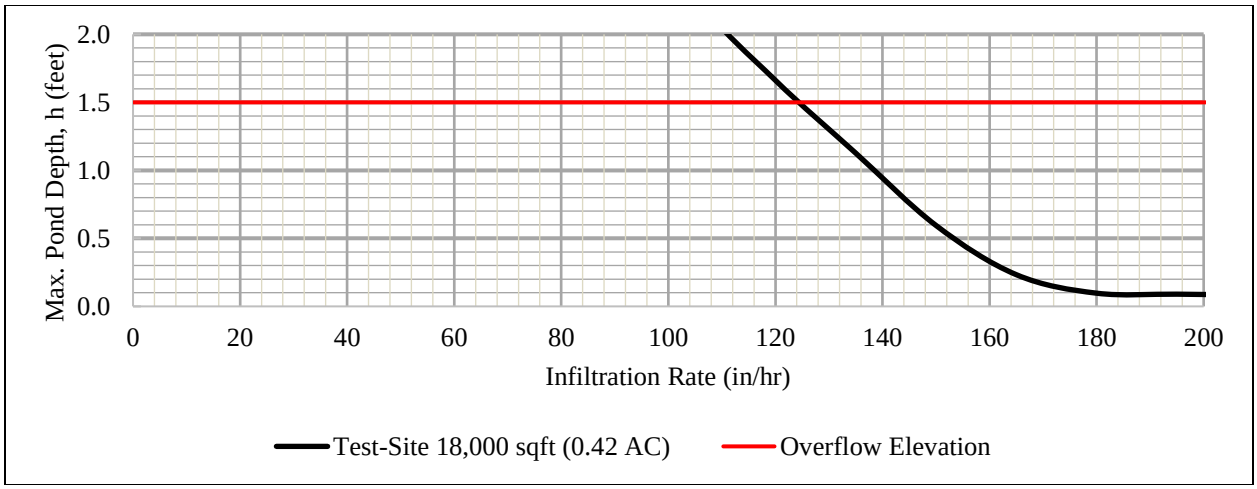

Figure 3.6 Design Infiltration Rate Based on Results from Single Event Modeling

3.3.2.1 Falling Head Testing After Treatment Performance Testing

The purpose of the falling head testing after the treatment performance testing (SIL-CO-SIL®) was to determine the change in infiltration rate from TSS loading. Falling head testing was conducted after the equivalent of every 4-inches of precipitation. This consisted of filling the column up to 6-inches higher (24-inches) than the maximum ponding depth (18-inches). Then the rate of fall was recorded from the maximum ponding depth of 18-inches to the top of the sand media. The results from this testing is summarized in Figure 3.7 (results represent the average values measured from the two columns). As shown, the infiltration rate declines as the TSS loading increases, and after the equivalent of 2-years of TSS loading, the measured infiltration rate (300-in/hr) is still greater than the design infiltration rate (124-in/hr). Comparing these results to the water quality results (Table 3.2 and Figure 3.3), breakthrough of TSS will occur before the infiltration rate is reduced below the design infiltration rate.

3.3.2.2 Falling Head Testing using SIL-CO-SIL® 106 and Roadway Sediment

The results from the falling head testing described in section 3.3.2.1 are different than what has been observed in the field. The test-site was constructed in 2016 and contains the sand media and coconut coir mat described in this section. Based on field observations it appears that the roadway sediment is clogging the top layers of the media, and as a result the sediment has to be removed from the top of the media at least once a year to restore the infiltration rate. Because of the observed differences, the column testing was modified and repeated in an effort to create conditions that are more representative of those expected in the field. The Spokane County Project Manager has visually observed approximately 3-inches of sediment and gross solids (i.e. debris, trash, large particulate matter, and TSS) accumulates on top of the sand media each year for a 36,000 sqft contributing basin area. Since the test-site will be configured to only receive runoff from an 18,000 sqft basin area, 1.5-inches of sediment accumulation is anticipated annually.

Rainfall simulations were run using the same methods as described in the Water Quality Treatment Performance section except the synthetic stormwater solution was only composed of TSS (SIL-CO-SIL®) and tap water (no metals were added to the solution). During the rainfall events, the equivalent amount of roadway sediment as visually observed in the field (1.5-inches annually; 0.10-inches for each 1-inch rainfall event) was added to the top of the column periodically during the event. After each rainfall event, falling head testing was conducted using the same methods as

described in the previous section. Testing was conducted until the infiltration rate decreased to 4-in/hr. The results from the falling head test are shown in Figure 3.7 (results represent the average values measured from the two columns).

As shown in Figure 3.7, the rate of decline of the infiltration rate is faster using both TSS (SIL-CO-SIL®) and roadway sediment (compared to just SIL-CO-SIL®). The results from this testing predict that the infiltration rate of the sand media at the test site will drop below the design infiltration rate after the equivalent pollutant loading from 8-inches of rainfall. This is more frequent than has been observed at the test site. The differences are likely due to the differences in the gradation of the actual roadway sediment compared to what was used in the columns. Specifically, roadway sediment was collected from the top of the sand filter media and the sediment contained material larger than could not fit in the columns (i.e., leaves, vegetative material, etc.). As a result, only material less than 3/8-inch was added to the columns. Since the material has a smaller gradation than what is present in the field, the porosity of the sediment used during column testing is smaller, as such the infiltration rate is expected to be lower. Therefore, it is expected that the rate of decline of the sand media infiltration rate in the columns is faster than is expected in the field. These results indicate that clogging of the sand media due to roadway sediment loading will occur before the TSS break through described in the Water Quality Treatment Performance section (after 26-inches of rainfall). Additionally, it is expected that the TSS treatment performance goal (≥80% TSS reduction) will be achieved using the proposed BMP as long as maintenance is provided at the test site before the field infiltration rate drops below the design infiltration rate (124 in/hr).

A comparison of the sand media gradation (the existing sand filter BMP medium sand and the proposed BMP coarse sand) as well as the roadway sediment gradation (CB Sediment Geo) is shown Figure 3.8. Appendix M contains a copy of the results from the roadway sediment gradation testing.

3.3.2.3 Predicted Maintenance Cycle

Based on the results from the second falling head testing (SIL-CO-SIL® and roadway sediment) the required maintenance cycle is predicted after every 8-inches of rainfall. As noted in the last section, this is more frequent than has been observed in the field. Therefore, field data will be collected and analyzed to confirm the maintenance cycle. Specifically, the sediment accumulation will be measured (on top of the sand filter media) and compared to the change in infiltration rate (see Section 14.1.5 and 14.16). The required maintenance will consist of removing the coconut coir mat (with the sediment on top) and cleaning the mat (rinsing mat using tap water). Then the top 6-inches of the sand media will be removed and replaced with another 6-inches of sand and the coconut coir mat will be placed back on top of the sand media.

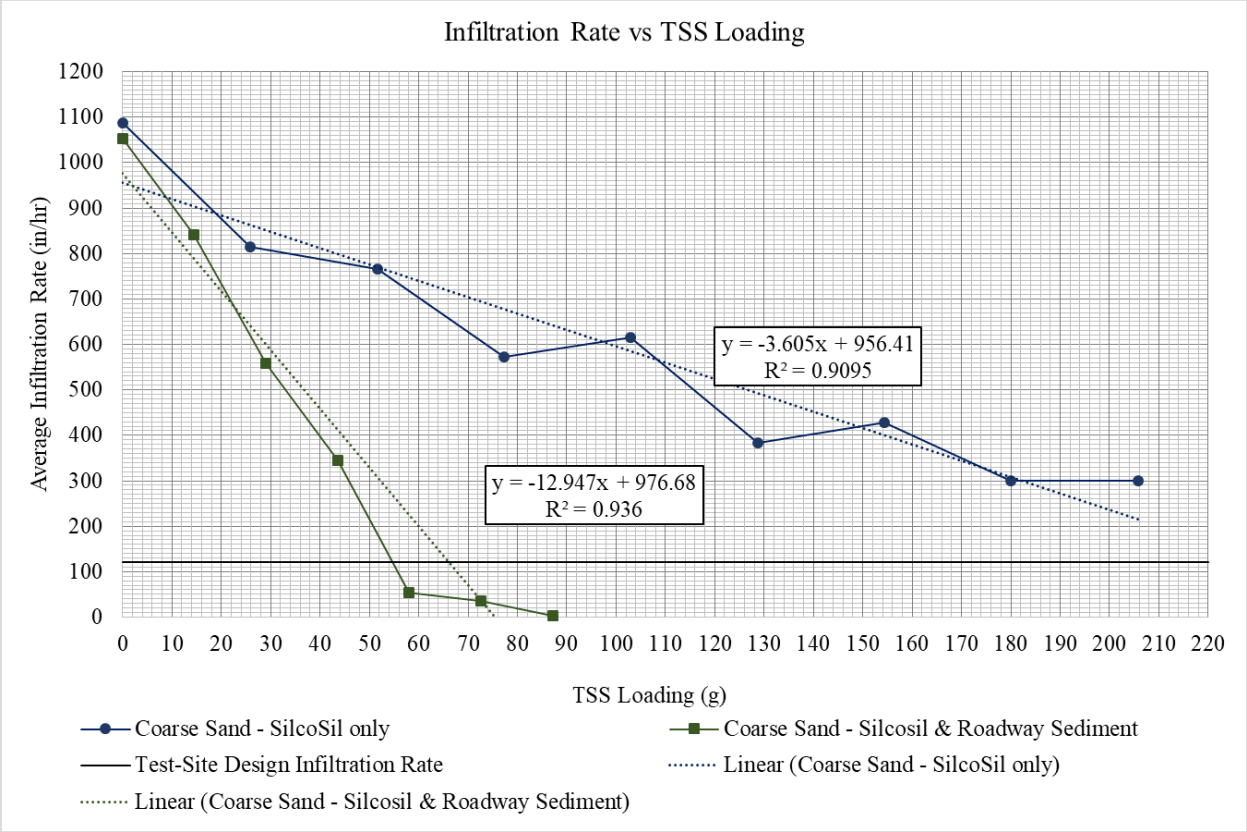

Figure 3.7 Results from Falling Head Testing

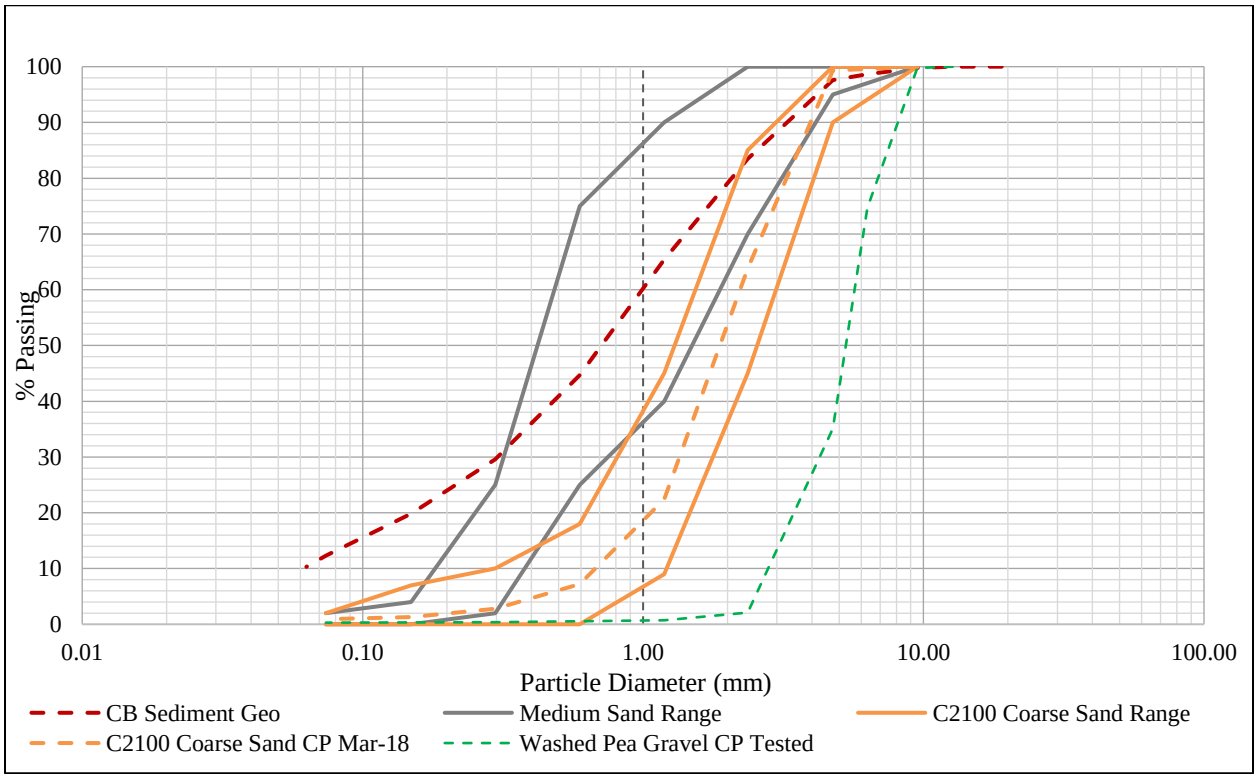

Figure 3.8 Comparison of Gradations: Medium Sand, Coarse Sand, and Roadway (CB) Sediment

3.3.3 BMP Sizing Discussion

The Type 1A rainfall distribution was selected for the column testing because it most closely reflects historical precipitation patterns in eastern Washington compared to the other methods (WSDOT, 2006). Methods identified in the EWA Ecology Stormwater Manual for Eastern Washington (SWMMEW) as acceptable for designing volume based BMPs include the Type 1A and Type II 24 hour rainfall distributions as well as the Rational Method. However, the TAPE Guidance Manual limits the BMP sizing methods for the BMP evaluation to either the Soil Conservation Service (SCS) Type II 24 hour rainfall distribution (6 month return frequency) or the Rational Method (6 month Mean Recurrence Interval).

The test-site was modeled using the Type II and the Rational Method to compare the differences in the sand filter sizing. The modeling for the Type II method was the same as described in Sections 3.3.1 and 3.3.2 for the Type 1A modeling except the SCS method was used instead of the SBUH. For the Rational Method, the Bowstring Method was used which is a Modified version of the Rational Method. The methods for this approach are defined in the SRSM (Spokane County, City of Spokane, and Spokane Valley, 2008). A copy of the modeling output is located in Appendix F. As shown in Table 3.3, the largest flow rate (0.41 cfs) was produced from the Type II event whereas the Type 1A rainfall event produced the smallest flow rate (0.08 cfs). Based on these results, 1 sand filter is required using the Type 1A event whereas 4.3 are required using the Type II event and 3.22 using the Bowstring Method. For this study, the Bowstring Method will be used for sizing the BMP system (Section 7.3).

Table 3.3 Comparison of Sand Filter Sizing using the Type 1A, Type II, and Rational Methods

	Q_{6m24h} Type IA	Q_{6m24h} Type II	Q_{6m} Rational	Units
Peak Flow Rate	0.08	0.41	0.38	cfs
Sand Filter Media Infiltration Rate	124			in/hr
Sand Filter Surface Area	20			sqft
Contributing Basin Area (Test Site)	18,000			sqft
Surface Area Required	20	84	65	sqft
# of Sand Filter BMPs Needed for 18,000 sqft area (test site)	1	4.30	3.22	
Contributing Basin Area: Sand Filter Surface Area	900	209	277	
Contributing Basin Area Size for One Sand Filter	18,000	4,270	5,538	sqft

3.4 Regulatory Requirements

The Eastern Washington Phase II Municipal Stormwater Permit issued to Spokane County by Ecology requires the Stormwater Management Program Effectiveness Studies as defined in Section 8 (S8), Monitoring and Assessment. Specifically, "*each city and county permittee listed in the permit shall collaborate with other permittees to select, propose, develop, and conduct Ecology-approved studies to assess, on a regional or sub-regional basis, effectiveness of permit-*

required stormwater management program activities and best management practices" (Ecology 2014b). This document addresses S8.B.6: *"Lead entities shall submit a Quality Assurance Project Plan (QAPP) for each study within six months of Ecology's written approval of each detailed proposal".*

Spokane County is the lead entity for the effectiveness study defined in this QAPP. The permit requirement that the study addresses is defined in S5.B.5, Post-Construction Stormwater Management for New Development and Redevelopment: "*all Permittees shall implement and enforce a program to address post-construction stormwater runoff to the MS4 from new development and redevelopment projects that disturb one acre or more, and from projects of less than one acre that are part of a larger common plan of development or sale"* (Ecology 2014b).

4.0 Project Overview

4.1 Study Goal

The goal of this study is to evaluate the effectiveness of a sand filter BMP that can be installed within a sand filter sidewalk vault. Effectiveness will be based upon:

- The infiltration performance, specifically infiltrating the water quality volume (6-month 24-hour event) without overflowing into the bypass pipe (set 18-inches above the sand media) within the maintenance cycle (based on design infiltration rate)
- The treatment performance of the BMP will be evaluated for reducing the following stormwater runoff pollutants: total suspended solids (TSS), dissolved Cu and Zn, and oils

If the infiltration performance can be achieved as well as the Ecology treatment goals for basic (TSS), dissolved metals (enhanced), and oils, the results from this study will be used to justify the development of a new BMP that is approved for '*general use*' on future projects.

4.2 Study Description and Objectives

The goal for this study will be achieved by meeting the following objectives:

- Define the BMP design and maintenance guidance

- Determine the pollutant removal efficiency of the BMP by measuring and comparing the pollutant concentrations in the influent and effluent

- Verify the maintenance cycle defined in Section 7.3 using the results from infiltration testing. Specifically determine the time required between maintenance cycles based upon when infiltration rate declines to the design infiltration rate.

- Establish a design flow in gallons per minute per square foot of the sand filter surface area

- Determine whether the treatment performance goals were achieved by comparing study results to TAPE goals and requirements

Prior to the start of the field study, the BMP design and maintenance guidance was defined (Section 7.3) for the new BMP. The guidance was developed based on the results of the column testing (Section 3.3). This included conducting a literature search to develop a specification that defines the physiochemical properties and quantities of materials in the sand filter media. Flow through column testing was conducted to assess the treatment and infiltration performance of the sand filter media and define the BMP design guidance.

The focus of this QAPP, is the field testing. This will include installing new sand filter media, choke stone, and coir mat in the sidewalk vault prior to testing and evaluating the treatment and infiltration performance. Composite samples will be collected from qualifying rainfall events following the TAPE guidelines (Ecology 2011). Samples will be collected from a minimum of 12 storm events and tested for the required and screening parameters as defined in TAPE for basic, dissolved metals, and oil treatment (Table 4.2). The infiltration performance of the sand filter

media will also be evaluated using data collected from falling head tests and the effluent flow rate measured by the autosamplers. The study duration is expected to extend through two wet seasons. The data will be evaluated to determine which pollutants meet Ecology's treatment performance criteria as defined in TAPE (Table 14.1). Affirmative results will result in a recommendation for the application of BMP design and maintenance guidance for providing runoff treatment. Specifically, if some or all the treatment performance goals are achieved, the final report will recommend approval of the new BMP and be submitted following the TAPE process for review This study also includes submitting a TAPE application that enters the new BMP into the evaluation program, and submitting a technical evaluation report (TER) to Ecology and the TAPE Board of External Reviewers (BER) for review and approval.

4.3 Study Location

This study will be conducted near the intersection of Hawthorne Road and U.S. 2 in Spokane, Washington (Figure 4.1). At this location, the land use is a mix of residential and commercial. The contributing basin area (Basin 19 in Figure 4.2) is approximately 18,000 sqft of which 14,000 sqft is impervious surfaces (roadway and sidewalks) and 4,000 sqft is pervious surfaces (lawns). The contributing roadway is primarily an urban arterial with some runoff from a residential road. Per the Web Soil Survey, the pervious area is defined as urban land-marble, disturbed complex with 0 to 3 percent slopes. No Hydrologic Soil Group (HSG) is provided for the contributing basin area however soils in the area are listed as class A HSG (Soil Survey Staff, 2018).

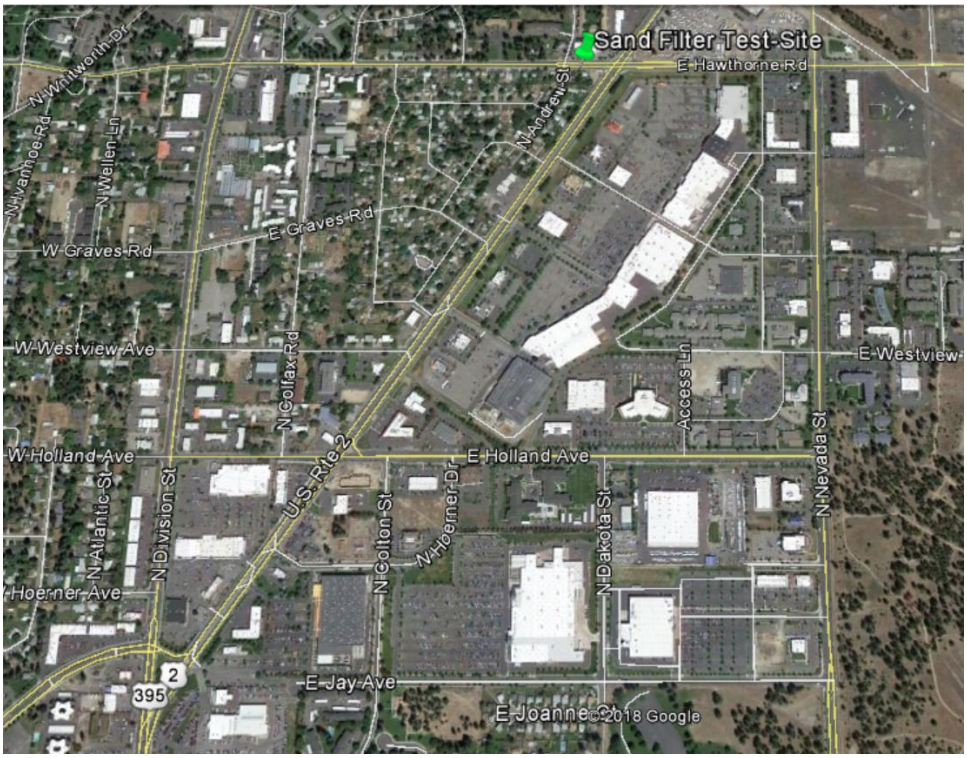

Figure 4.1 Test-Site Area Map

Figure 4.2 Test-Site Location and Contributing Basin Area

4.4 Data Needed to Meet Objectives

The data needed to conduct this study is summarized in Table 4.1. The water quality parameters that will be tested to demonstrate that the BMP meets the Ecology treatment performance goals are summarized in Table 4.2

Table 4.1 Data Needed to Meet Objectives

Data Type	How Data Will Be Collected	Purpose
Sand Filter media physiochemical properties	Samples of sand filter media will be collected prior to installing the media in the vault (see Section 8.0 SOPs) and sent to lab for analysis	Verify properties meet the media requirements defined in the design guidance (Section 7.3) and identify media properties which may influence the media treatment performance
Precipitation	A rain gauge connected (via cable) to the data logger at the test-site; data transmitted via cellular network	Determine whether rainfall event meets TAPE guidelines for a qualifying storm
Flow Depth, Temperature (influent, effluent, bypass)	Measured continuously using a pressure transducer located upstream of a control weir; Depth is converted to flow rate using a weir equation	Calculate flow rates and measure temperature (influent, effluent, bypass); determines when sampling should begin (if storm meets qualifying)
Composite Water Quality Samples; Table 4.2 parameters except oils	Autosamplers collect composite samples when triggered by the data logger when qualifying rainfall conditions occur	Quantify the influent and effluent concentrations of parameters; assess effectiveness of the structural BMP; PSD influent, quantify size range of TSS
Oils[1], Grab Samples	Collect grab samples during storm events from influent and effluent	Quantify removal of Northwest Total Petroleum Hydrocarbons, motor oil and diesel fractions (NWTPH-Dx)
Instantaneous pH Measurement, Oil Sheen Observations	Collect pH measurements from small amount of composite sample; observe oil sheen in effluent, sand filter, and composite sample	Quantify pH of influent and effluent; determine whether oils have entered the sand filter sidewalk vault
Sediment PSD from influent	Collect composite flow weighted samples from influent	Characterize the size of the sediment that enters the BMP
Sediment Depth on BMP, Sediment grain size (on top of & in top, middle, bottom layer of sand media	Measure depth on top of coir mat using decimal measuring tape; collect grab samples from influent	Verify maintenance cycle: calculate sediment accumulation rate on sand filter (with infiltration rate change); determine change in particle size in sand media layers (compared to pre-test gradation)
Infiltration rate	Modified falling head test (See Section 8.1.8 for SOP); autosampler effluent flow rate	Calculate change in infiltration rate of media and identify when the rate will decline to the design infiltration rate

1. References to oils throughout this document refers to the required screening parameter, NWTPH-Dx, which includes total petroleum hydrocarbons (TPH), motor oil and diesel fuel.

Table 4.2 Summary of Water Quality Testing Data

Performance Goal	Required Parameters	Required Screening Parameters
Basic	TSS	Particle size distribution (PSD), pH, total phosphorus (TP), orthophosphate, hardness, total and dissolved Cu and Zn
Dissolved metals	TSS, hardness, total and dissolved Cu and Zn	PSD, pH, TP, orthophosphate
Oils	NWTPH-Dx, visible sheen	pH, TP, orthophosphate, hardness, total and dissolved Cu and Zn

4.5 Tasks Required to Conduct Study

Tasks required to conduct the study include:

- **Grant Funding**
  - Centennial Grant Application - Applied for grant to fund study
- **Experiment Design**
  - Developed Detailed Study Design Proposal
    - Ecology Proposal Review; Respond to comments
  - Monitoring System Design
  - Sand Media Column Testing – developed BMP design and maintenance guidance
- **Monitoring Equipment**
  - Selected, ordered, and install equipment at test-site
  - Develop and provide monitoring equipment training for sampling staff
  - Developed standard operating procedures (SOPs) for operating, maintaining, and calibrating equipment
- **Quality Assurance Project Plan (QAPP)**
  - Develop TAPE application; Submit TAPE application to Ecology and board of external (BER) for review; Respond to comments
  - Developed QAPP; Submit QAPP to Ecology and BER for review; Respond to comments
- **Technical Advisory Group (TAG) Meetings**
  - Schedule 7 meetings with TAG for the purpose of discussing the project status, upcoming tasks, and soliciting input from the TAG on the study documents
- **Data Collection and Analysis:**
  - Test sand filter media (prior to installation)
  - Track and select storms (daily)
  - 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 12 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, influent, effluent, and bypass flow rate), analyze data
  - Measure sediment accumulation (following each qualifying rainfall event)
  - Conduct falling head testing (quarterly)
  - Develop and manage a database that contains all the collected data
  - Conduct audits; verify data and assess usability of data
  - Collect samples from on top of and in the top, middle, and bottom layers for grain size analysis (once post testing)
- **Develop Technical Report:**
  - Develop annual reports
  - Develop technical evaluation report (TER)
  - Develop study fact sheet
  - Submit TER to Ecology and BER for Review and Comment; Respond to comments

4.6 Potential Constraints

Potential constraints are conditions that may impact the project schedule, budget, or scope. The potential constraints identified in this section, 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 4.3 Summary of Potential Constraints and Mitigation Approaches

Potential Constraint	Mitigation Approach
Insufficient qualifying rainfall events	Extend monitoring period or collect data from lower depth (<0.15-inches) rainfall events
Spills: oil or other chemicals	Large spills could impact the treatment performance of the BMP. Visually inspect the sand filter media following each rainfall event; if a spill occurs, the appropriate maintenance will be conducted and the incident will be noted in the data collection log
Monitoring equipment malfunctions	Frequent inspection of equipment and review system output variables after each storm for any anomalies. If problems are encountered, equipment will be fixed promptly.

5.0 Organization and Schedule

The purpose of this section to describes who is responsible for completing the tasks, when the tasks will be completed, and how the study will be funded.

5.1 Key Project Team Members: Roles and Responsibilities

Table 5.1 Key Project Team Members: Roles and Responsibilities

Name Organization	Role	Contact Information
Matt Zarecor Spokane County	Lead Entity[1]	509.477.7255 mzarecor@spokanecounty.org
Jake Saxon Spokane County	Lead Entity[1] Project Manager[1] TAG Member[6]	509.477.7245 jsaxon@spokanecounty.org
Bill Galle Spokane County	Lead Entity[1] TAG Member[6]	509.477.7261 bgalle@spokanecounty.org
Ethan Murnin Spokane County	Lead Entity[1] TAG Member[6]	509.477.7261 emurnin@spokanecounty.org
Danielle Mullins City of West Richland	Participating Entity TAG Member[6]	509.967.5434 dmullins@westrichland.org
Bill Aukett City of Moses Lake	Participating Entity TAG Member[6]	509.764.3792 baukett@cityofml.com
Rob Buchert City of Pullman	Participating Entity TAG Member[6]	509.338.3314 rob.buchert@pullman-wa.gov
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Adriane Borgias Ecology	Ecology Reviewer[11]	509.329.3515 abor461@ecy.wa.gov
Brandi Lubliner Ecology	Ecology Reviewer[11]	360.407.7140 brwa461@ecy.wa.gov
Kathy Sattler, Laboratory Anatek Laboratories	Laboratory Manager[5]	509-838-3999 technical@anateklabs.com
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1. Lead Entity or Project Manager – Responsible for ensuring the study is conducted as described in this QAPP. The Project Manager is the primary point of contact for the lead entity.
2. Principal Investigator – Responsible for developing an Ecology approved Proposal and QAPP. Serves as the primary point of contact for the laboratory manager, the project manager, sampling staff, the auditor, the TAG Members, and the Advisory Review Panel. Responsible for conducting the study

as defined in the Ecology approved QAPP. Responsible for submitting the study documents to Ecology including the Proposal, QAPP, and Final Technical Report. 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.

3. Researcher - Responsible for assisting the Principal Investigator.
4. Sampling Staff – 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 (Section 8.0) 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.
5. 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 6.0); 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.
6. Technical Advisory Group (TAG) Member - The goal of the TAG is to provide insight, suggestions, and professional opinions to the Principal Investigator and Lead Entity throughout the study. The primary responsibilities of TAG members include: attending project meetings (by webinar or in person) and participating in the meeting discussion; review/comment on research materials (i.e. QAPP, data collected, data analyzed, final report, etc.) prior to submitting the documents to Ecology.
7. Technical Advisory Group (TAG) Lead – Responsible for organizing/scheduling meetings with the TAG members and distributing the project/meeting documents prior to the meeting. During meetings the TAG lead is responsible for ensuring that the TAG member's comments are heard and addressed as well as developing/distributing meeting notes of any actions items from the meeting.
8. Data Verifiers - Data verifiers will review the analyzed data and verify the analysis is correct and that the data being analyzed matches the data collected. *See Section 11.0 of this document.*
9. Financial Support – Responsible for providing the lead entity with some level of financial support toward the cost of the study.
10. Auditor - Responsible for conducting audits to verify the study conforms to the plan and procedures as defined in *Section 12.0* of this document. This may include: verifying staff collecting the data are trained and follow SOPs for data collection; verifying data management procedures are followed including reviewing data records to ensure they are consistent, correct and complete, with no errors or omissions; and traveling where the data is stored to review the data records compared to the QAPP Data Management Plan. Auditors will report their findings directly to the lead entity Principal Investigator and Lead Entity.
11. Ecology Reviewer – Responsible for reviewing and approving the study documents: the Proposal, QAPP, and Final Report.

5.2 Project Schedule

A task timeline based on monthly activities is shown in Table 5.2.

Table 5.2 Proposed Study Timeline

Task Name	2017									2018												2019												2020											
	Q2: Apr-Jun			Q3: Jul-Sept			Q4: Oct-Dec			Q1: Jan-Mar			Q2: Apr-Jun			Q3: Jul-Sept			Q4: Oct-Dec			Q1: Jan-Mar			Q2: Apr-Jun			Q3: Jul-Sept			Q4: Oct-Dec			Q1: Jan-Mar			Q2: Apr-Jun			Q3: Jul-Sept			Q4: Oct-Dec		
Experimental Design																																													
Proposal Development																																													
Ecology Proposal Review																																													
Monitoring System Design																																													
Column Testing																																													
Monitoring Equipment																																													
Select & Order Equipment																																													
Equipment Installation																																													
Equipment Training																																													
Develop Equipment SOPs																																													
QAPP																																													
QAPP Development																																													
Ecology QAPP Review																																													
TAPE Application																																													
BER TAPE & QAPP Review																																													
TAG Meetings													1/2											3						4						5						6		
Data Collection & Analysis																																													
Technical Reports																																													
Annual Reports																																													
Technical Evaluation Report (TER)																																													
Study Fact Sheet																																													
Ecology & BER TER Review																																													

5.3 Budget and Funding Sources

This study is funded by Spokane County with supporting funds from an Ecology Centennial Grant.

Table 5.3 Estimate Study Budget

Task Name	Total
Project Management	$31,000
Monitoring Equipment and Maintenance	$86,000
QAPP Development[1,2]	$62,000
Data Collection and Analysis[2,3]	$77,000
Technical Evaluation Report (TER)	$38,000
Total	$294,000

1. The cost for QAPP Development includes the cost to develop the detailed study design proposal and the QAPP.
2. The work associated with developing the BMP design and maintenance guidance (column testing) is split between QAPP development and Data Collection and Analysis
3. Includes the cost for sand filter media material testing as well as water quality testing

6.0 Quality Objectives

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 study.

The purpose of a QAPP is to ensure that the data collected during the study 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 study is embedded throughout the QAPP and emphasizes how the data quality indicators (DQIs) and respective measurement performance criteria (MPCs) are addressed during the study.

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 study. 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 Operational BMP studies are (Ecology, 2004):

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

Once established, 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. Table 6.1 first defines each DQI, then the approach for addressing DQIs and the respective MPCs for this study are described.

Reference Section 13.0 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.

Table 6.1 Summary of the Data Quality Indicators (DQIs) and Measurement Performance Criteria (MPC) for Structural BMP Studies

Precision DQIs for This Study	Precision MPCs for This Study
Precision – A measure of agreement among repeated measurements of the same property taken under identical or substantially similar conditions (EPA, 2006; Erickson, 2013; EPA, 2002). 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).	
Developing and consistently following SOPs for collecting samples and measuring data will reduce the potential of collecting imprecise data.	An audit (Section 12.0) 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 6.2.	If the results of the duplicate sampling meet the respective relative percent difference (RPD) for the parameters listed in Table 6.2, the results of the analytical testing will be considered acceptable. Reference Section 6.1.
Rain gauge and flow measurements will also be assessed.	If the flow measurements and rain gauge data meet the RPD defined in section 6.1, that data will be considered acceptable. Reference Section 6.1.
Bias DQIs for this Study	**Bias MPCs for This Study**
Bias – 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).	
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 8.0, per in manufacturer's specifications. An audit (Section 12.0) will be conducted to verify that sampling staff are following the calibration procedures.
Lack of maintenance at the site can be a source of bias in sample values or measurements. For example, if ISCO tubing is not cleaned regularly, sediment, oils, etc. can accumulate in the tubing and affect sample results. For that reason, manufacturer's recommendations for maintenance frequency and procedures will be followed to reduce the potential for bias.	An audit (Section 12.0) will be conducted to verify that sampling staff are following the SOPs outlined in Section 8.0 (written to match manufacturer's specifications).
SOPs defined in Section 8.0 will be followed when collecting samples and measuring data to limit bias.	An audit (Section 12.0) will be conducted to verify that sampling staff are following the SOPs outlined in Section 8.0.
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 6.2. Please note that percent recovery for matrix spikes is defined in section 6.2.

Representativeness DQIs for This Study	Representativeness MPCs for This Study
Representativeness – 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).	
The location selected for this study is on an urban arterial, within commercial and residential zones. The space constraints at the site would preclude the use of a basic sand filter BMP.	These conditions reflect the characteristics of a location where a sand filter sidewalk vault would be installed: a developed, urban area with space constraints and the presence of a sidewalk.
Hydrologic conditions at the site should be representative of a range of weather patterns and conditions seen throughout the wet season.	Local stormwater hydrologic conditions are represented by conducting the study over two wet seasons and collecting data from a minimum of 12 qualifying storm events (described in Section 7.5).
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 sand filter sidewalk vault 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, effluent, and bypass pipes, which will mimic typical sand filter sidewalk vault construction • Water quality samples (except oils grab samples, due to NWTPH-Dx method requirements) 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.	
Completeness DQIs for This Study	**Completeness MPCs for This Study**
Completeness - The amount of valid data needed to be obtained during the study to meet the project objectives (Ecology, 2004).	
A minimum of 12 qualifying rainfall events (Section 7.5) are required to be sampled for the duration of the study, per TAPE. Additionally, at least 10	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

aliquots and 75% of the hydrograph must be sampled during the qualifying rainfall event.	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 study.	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 from the results reported by 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 11.0. 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 SOPs outlined in Section 8.0, to limit the possibility of missing or invalid data.	An audit (Section 12.0) will be conducted to verify that sampling staff are following the SOPs outlined in Section 8.0 (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.	
Comparability DQIs for This Study	**Comparability MPQs for This Study**
Comparability - 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.	
The test site is located on an arterial in a developed urban area with commercial and residential land use surrounding the site.	The process for selecting the study area is defined in section 7.2: the process focused on having a test site that is representative of locations where the sand filter sidewalk vault will be installed.
Define and consistently follow SOPs for sample collection and field measurements	SOPs were developed and will be consistently followed during this study
All data and sample collection will be conducted in accordance with the SOPs outlined in Section 8.0.	An audit (Section 12.0) will be conducted to verify that sampling staff are following the SOPs outlined in Section 8.0.
Standard testing methods will be used to analyze samples submitted to the lab.	Anatek, the laboratory proposed for water quality testing in this study, is certified by Ecology and will follow standard methods approved by the US Environmental Protection Agency (EPA) (APHA et al. 1992, 1998; US EPA 1983, 1984). The methods to be used are listed in Table 9.1. Deviations from methods will be noted on analytical reports.

Sensitivity DQIs for This Study	Sensitivity MPQs for This Study
Sensitivity - The capability of a method or instrument to discriminate between measurement responses representing different levels of the variable of interest (EPA, 2002).	
Analytical results for water quality samples will be reported if they are above the reporting limit.	Reporting limits for water quality parameters are listed in Table 6.2. Data reported as below the detection limit will be calculated using the reporting limit shown in Table 9.1
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 9.1.
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 G.

6.1 *Precision*

Water quality sample and measurement precision will be assessed using laboratory and field duplicates. Precision for laboratory duplicates will be ± 40 percent relative percent difference (RPD) for oils (NWTPH-Dx), ± 25 percent for TSS, and 20 percent for all other water quality parameters (Table 6.1). Precision for field duplicates will be ± 40 percent RPD for oils (NWTPH-Dx) and ± 20 percent for all other water quality parameters. In all cases, the RPD of duplicate samples will be calculated using the following equation:

$$\text{RPD} = \frac{|C_1 - C_2|}{\bar{x}} \times 100\%$$

Where: RPD = relative percent difference
C_1 = concentration (or value) of original sample
C_2 = concentration (or value) of duplicate
$\bar{x}$ = mean of samples

Rain gauge and flow measurement precision will be assessed at the beginning and end of the study. The rain gage precision will be assessed by pouring a known quantity of water into the tipping bucket two times. Precision for the rain gage measurements will be ± 20 percent RPD. Precision for flow will be assessed by comparing repeated pressure measurements with a known depth of water over each of the respective pressure transducers. Precision for pressure transducer measurements will be ± 20 percent RPD.

6.2 *Bias*

Bias will be assessed based on analyses of method blanks, rinsate blanks matrix spikes, and control standards (Table 6.1). Method blank values will not exceed the reporting limit. Rinsate blank values will not exceed two times the reporting limit. The percent recovery of matrix spikes will be ± 25 percent for total phosphorus, ortho-phosphorus, hardness, total and dissolved metals, and oils (NWTPH-Dx). Duplicate matrix spikes will also be run on a portion of the samples. The laboratory control sample recovery will be ± 20 percent for TSS, total phosphorus, and ortho-phosphorus, and ± 30 percent for hardness, total and dissolved metals and oils (NWTPH-Dx). Percent recovery (%R) for matrix spikes will be calculated using the following equation:

$$\%R_m = \frac{(X_s - X_o)}{C_s} \times 100\%$$

Where: $\%R$ = percent recovery
X_s = spike sample result
X_o = original sample amount
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:

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

Where: %R = percent recovery
M = measured value
T = true value

6.3 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 Study is representative of an urban area with space constraints that would preclude the use of a basic sand filter BMP (see Section 3.2, Problem Description). Local stormwater hydrologic conditions are represented by conducting the study over two wet seasons and collecting data from a minimum of 12 storm sampling events. Qualifying storm events are described in Section 7.5. 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 6.2 Measurement Performance Criteria (MPC) for Water Quality, Sediment, and Sand Filter Media Data.

Matrix	Parameter	Units	Method	RL	Method Blank	Rinsate Blank	LCS Recovery (Percent)	MS Recovery (Percent)	MSD (RPD)	Field Duplicate (RPD)[a]
Water Quality	Total Suspended Solids (TSS)	mg/L	SM 2540D	1	<RL	<2X RL	80 - 120	N/A	NA	≤25%
	Particle Size Distribution (PSD)	%	ASTM D3977-97[b]	NA	NA	NA	NA	NA	NA	≤10%
	pH	std. units	EPA 150.1	NA	NA	NA	NA	NA	NA	≤10%
	Water Temperature	Celsius	EPA 170.1[c]	NA	NA	NA	NA	NA	NA	≤10%
	Dissolved Copper (Cu)	µg/L	EPA 200.8 (ICP/MS)	0.1	<RL	<2X RL	70 - 130	75-125	≤20% or ± 2 x RL	≤20%
	Dissolved Zinc (Zn)	µg/L	EPA 200.8 (ICP/MS)	5	<RL	<2X RL	70 - 130	75-125	≤20% or ± 2 x RL	≤20%
	Total Copper (Cu)	µg/L	EPA 200.8 (ICP/MS)	0.1	<RL	<2X RL	70 - 130	75-125	≤20% or ± 2 x RL	≤20%
	Total Zinc (Zn)	µg/L	EPA 200.8 (ICP/MS)	5	<RL	<2X RL	70 - 130	75-125	≤20% or ± 2 x RL	≤20%
	Hardness as CaCO3	mg/L	SM 2340B (ICP)	1	<RL	<2X RL	70 - 130	75-125	≤20% or ± 2 x RL	≤20%
	Ortho-phosphate (OP)	mg/L	SM 4500-P G	0.01	<RL	<2X RL	80 - 120	75-125	≤20% or ± 2 x RL	≤20%
	Total Phosphorus (TP)	mg/L	SM 4500-P F	0.01	<RL	<2X RL	80 - 120	75-125	≤20% or ± 2 x RL	≤20%
	NWTPH-Dx	mg/L	Ecology NWTPH Dx	0.25	<RL	NA	70 - 130	70 - 130	≤40% or ± 2 x RL	≤40%
Sediment	Sediment PSD	percent	ASTM D422 and Modified SSC method (based on ASTM Method D3977-97)	NA	NA	NA	NA	NA	NA	≤25%

a. The relative percent difference will be less than or equal to the indicated percentage for values greater than 5 times the reporting limit, and ± 2 times the reporting limit for values less than or equal to 5 times the reporting limit.

b. 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)

c. Continuous temperature data is field metered (EPA, 2014).

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

7.0 Experimental Design

7.1 Study Design Overview

The BMP design and maintenance guidance was developed using the results from flow through column testing conducted prior to the development of this QAPP (Section 3.3). The BMP will be sized such that the maximum ponding in the vault will not overflow into the bypass pipe (18-inches above the sand media) during a water quality event. The water quality event is defined as the 6-month 24-hour storm. Maintenance will occur before the field measured infiltration rate drops below the design infiltration rate. Maintenance includes removing and cleaning the coconut coir mat, replacing the top six inches of the sand media, and placing the coconut coir mat back on top of the sand media.

The test-site was constructed in 2016 and includes a non-sumped inlet box with a grate inlet, concrete monitoring vault and the sand filter sidewalk vault (Figure 7.1). A tipping bucket rain gauge will also be installed at the test-site to monitor rainfall depth overtime. This data will be used to confirm that rainfall events meet Ecology's requirements for qualifying events for sample collection. The sidewalk vault will contain the sand filter media, an underdrain, and a bypass pipe.

Major components of the monitoring system are shown in Figure 7.1 and defined below:

- A non-sumped inlet box with a concrete inlet type 1 that captures runoff from the contributing basin area which is conveyed to a treatment cell (i.e., the sand filter sidewalk vault).
- The sand filter sidewalk vault contains the sand filter media mix (an organic blanket overlaying an 18-inch medium sand layer), gravel drain rock, underdrain pipe, and an bypass pipe (for overflow)
- A concrete monitoring vault will house the monitoring equipment including two automated samplers, a data logger, flow and temperature (pressure transducers)
- Two monitoring vault pipe networks, which consist of 6-inch polyvinylchloride (PVC) pipe and tees, located in the monitoring vault where influent, bypass and effluent flow rates and water quality samples will be collected

Runoff, primarily from impervious surfaces, is intercepted by a non-sumped inlet box with a grate inlet and conveyed to the sand filter via a 6" pipe. After infiltrating through the sand filter, the treated stormwater (effluent) will discharge to an underdrain. The underdrain will convey the treated runoff back to the monitoring vault through the effluent monitoring and sampling tees. Then runoff will be discharged to an adjacent drywell. Stage and temperature data will be collected using a pressure transducer that is located upstream of a control weir. The data logger is programmed to calculate the flow rate at the weir using the stage measured by the pressure transducer. Auto samplers will collect stormwater samples from another tee located just downstream of the control weir. The bypass flow rate will also be measured using a control weir and a pressure transducer. Figure 7.2 is a process drawing of the monitoring system and Table 7.1 provides a summary of all the monitoring equipment.

The duration of this study is expected to occur over two wet seasons and samples from the influent and effluent will be collected from a minimum of 12 rainfall events. The samples will be submitted

to an Ecology certified lab for analytical testing. The samples will be tested for the required and screening parameters identified in Table 4.1 for basic, dissolved metals, and oil treatment.

The data will be evaluated to determine which pollutants meet Ecology treatment performance requirements defined in TAPE. For those pollutants that meet Ecology treatment goals, the final technical evaluation report will include recommendation for approving the BMP for a '*general use*' designation. This study also includes submitting a TAPE application that enters the new BMP into the evaluation program, submitting annual reports, developing the QAPP and technical evaluation report for Ecology and the TAPE Board of External Reviewers (BER) to review and approve.

The final report will also be submitted to Ecology at the end of the study to meet the requirements for an effectiveness study. Annual reports will be developed and included in the city's annual stormwater report.

Note: The photos were taken prior to installation of monitoring equipment in the monitoring vault.

1. Concrete Type 1 non-sumped inlet box with a grate inlet
2. 6-inch PVC inlet pipe in monitoring vault (upper right) and in sand filter sidewalk vault (lower right)
3. Concrete monitoring vault
4. Sand filter sidewalk vault
5. 6-inch PVC overflow pipe in sand filter sidewalk vault
6. 6-inch PVC effluent pipe in monitoring vault

Figure 7.1 Monitoring system and sand filter BMP located at the Test-Site

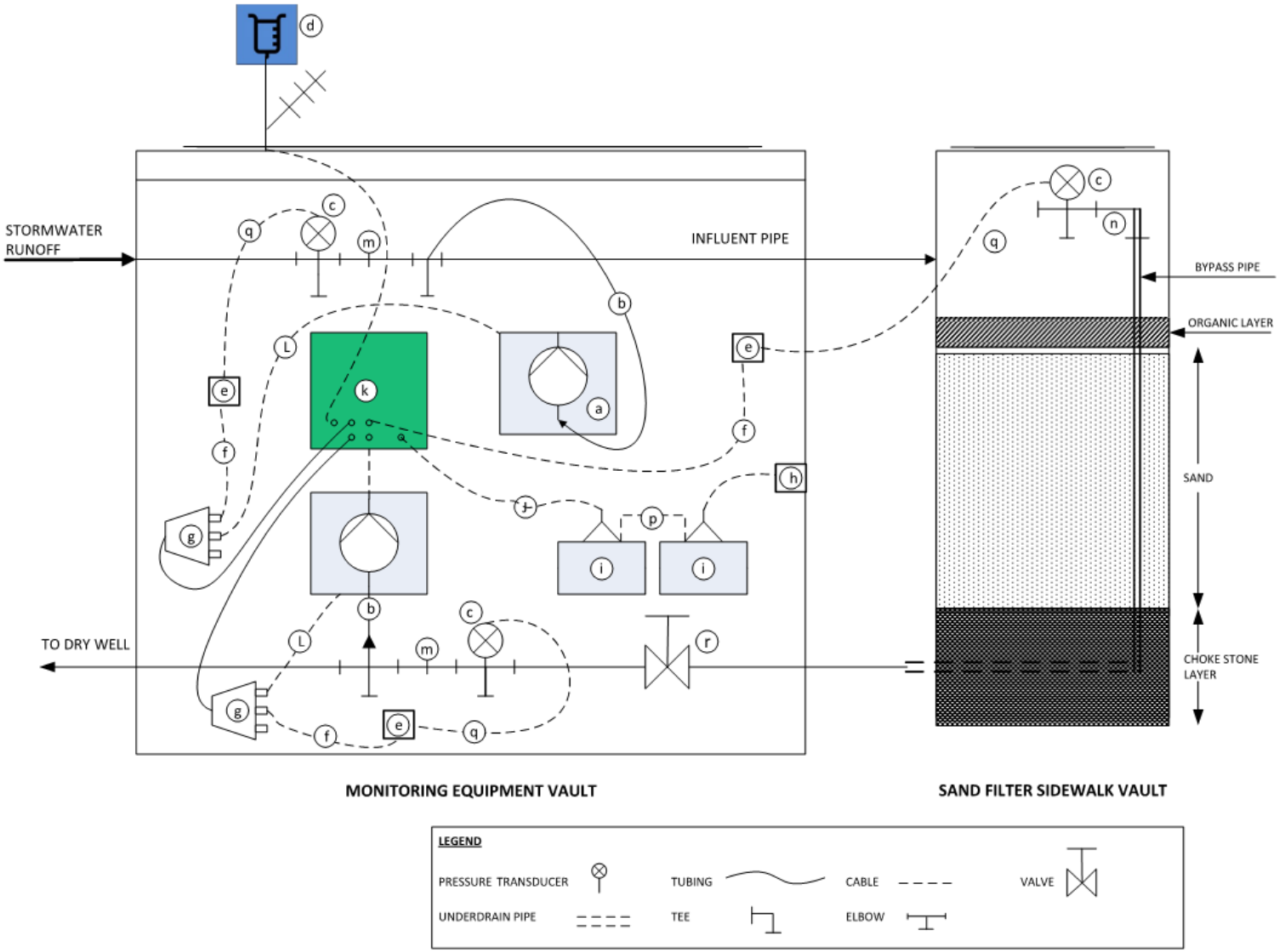

Figure 7.2 Water Quality Monitoring System Process Drawing: Cross-Section View

Table 7.1 Summary of Monitoring Equipment and Instrumentation

Symbol	Equipment Name	Equipment Function	Quantity
a	ISCO Avalanche Refrigerated Autosampler	Collects and stores influent and effluent samples	2
	Avalanche 2.5 Gallon Nalgene Bottle Configuration		2
b	3/8 inch ID x 25 ft. Vinyl Suction Line, with Standard Weighted Polypropylene Strainer and Tubing Coupler	Suction tubing conveys influent and effluent to the samplers	2
c	OTT Pressure Level Sensor (PLS), 0-4 meter Range, SDI-12 Communication	Measures depth of water in pipes which is used with the Thel-Mar weirs to determine the influent, effluent, and bypass flow rates	3
d	Rain Gauge, Tri-leg Mount and 20 ft Armored Cable	Records rainfall data	1
e	FAD 5 Humidity Absorber Connection Box	Controls humidity within the monitoring equipment vault	3
	Replacement Desiccant Cartridge	Humidity indicator within the monitoring equipment vault	3
f	Cable, Terminal Strip to SDI Port, 1.5 ft	Connects SDI port to the humidity box and samplers	3
g	Cable, SDI Connectors to SDI Port, 2 ft	Connects SDI port to the trickle battery charger	2
h	Trickle Battery Charger (AC to DC Charger)	Continually charges batteries	1
i	Battery, GNB Sunlyte, 100AH, Starved Electrolyte	Battery powers samplers and data logger	2
j	Battery Cable, Dual 10A Fuse, F6 & H2, 8.5ft	Connects data logger and samplers to battery	1
k	Axiom H2 Data logger	Records data over time via connected external instruments and sensors	1
l	SDI-ISCO Interface, 4.5ft Cable	Connects pressure transducer to humidity box and samplers	2
m	Thel-Mar Volumetric Weir 6”	Measures influent and effluent flow rates	1
n	Thel-Mar Volumetric Weir 8”	Measures overflow flow rate	1
o	Plastic Pressure Transducer/Sample Tubing Supports	Supports pressure transducer and sample tubing	5
p	Cable, Two Batteries in Parallel	Connects batteries to operate in parallel	1
q	PLS Probe Cable	Connects pressure transducer to SDI port and data logger	3
r	Valve	Allows effluent pipe to be closed and allows falling head test to be performed	1
s	Spears Mfg. Pressure Transducer Molded Flange	Supports pressure transducer and secures in an upright position	3

7.2 Test-Site(s) Selection Process

The proposed test-site is located near the intersection of Hawthorne Road and U.S. 2 in Spokane, Washington (see section 4.3 for aerial photos of the site). This site was selected because the average daily traffic (ADT) count on both roads exceeds 15,000 and the site is adjacent to a signaled intersection where high traffic turn-over is expected. As defined in the EWA Phase II NPDES MS4 permit and the Underground Injection Control (UIC) guidance manual, this type of land use triggers runoff treatment requirements for dissolved metals and spill containment of oils and hydrocarbons. As such, it is anticipated that sufficient quantities of pollutants will be present to meet Ecology's influent pollutant range goals defined in TAPE (Table 14.1).

7.3 The Structural BMP System Sizing

The new BMP is sized to provide runoff treatment for the water quality event (6-month 24-hour event) with larger flows managed with the bypass pipe which is located 18-inches above the sand filter media. The methods and assumptions for sizing the BMP include:

- The BMP will be sized using the Bowstring Method as defined in the SRSM (Spokane County, City of Spokane, and Spokane Valley, 2008).
- The sand filter sidewalk vault footprint is 20 sqft (internal base area of the vault)
- The sand filter media design infiltration rate is 124 in/hr (K_{sat} = 248 in/hr)
- The maximum ponding depth in the sand filter is 18-inches (height of overflow pipe) during the water quality event.

7.3.1 Recommended Design Guidance and Sand Media Specification

This section provides a summary of the recommended design guidance for the sand filter sidewalk vault and sand media specification. Performance objectives, applications, limitations, siting, design criteria, sand filter media criteria, construction criteria, and maintenance criteria are outlined in the following paragraphs. The guidance presented in based on the results of the column testing (Section 3.3) combined with the design guidance defined in the Eastern Washington Stormwater Management Manual for the basic sand filter BMP (Ecology, 2004).

Performance Objectives
The sand filter sidewalk vault is designed to meet the following performance objectives:

- Basic Treatment Goal: 80% reduction of TSS (at influent event mean concentrations of 100-200 mg/L)
- Dissolved Metals Treatment Goals: greater than 30% reduction of dissolved copper; greater than 60% dissolved zinc
- Oil Performance Treatment Goal: oil and grease in effluent is below 10 mg/L daily average and below 15 mg/L at any time; no visible sheen in discharge

Applications and Limitations
The applications of the sand filter sidewalk vault include the areas listed below where basic, dissolved metals, and/or oils treatment are required:

- Residential and commercial roadways
- Locations with space constraints
- Retrofit or re-development projects

The limitations of the sand filter sidewalk vault include:

- Design infiltration rate = 124 in/hr
- Sized to treat only the 6-month, 24-hour storm event (72% of the intensity calculated using the 2 year 24 hour Rational Method)
- Not designed to handle pollutant loads higher than those expected from residential or commercial roadways

Site Suitability Criteria
The characteristics to consider when assessing a potential sand filter sidewalk vault site include:

- Space availability (5 feet long, 4 feet wide) in sidewalk
- Access to a dry well or storm drain network for effluent discharge
- Adequate access for operation and maintenance of the sand filter sidewalk vault
- Contributing basin is residential or commercial roadway

Design Criteria
The sand filter sidewalk vault is sized according to the criteria in the bulleted list below.

- Size to infiltrate the water quality event, 6-month 24-hour storm (72% of the intensity calculated using the 2 year 24 hour Rational Method)
- Up to 18-inch ponding depth allowed above media during the water quality event
- Bypass pipe set at 18 inches above media
- Design using the Bowstring Method
- Design infiltration rate is 124 in/hr

<u>Sand Filter Media Criteria</u>
The sand filter media placed within the sand filter sidewalk vault will be 18 inches minimum in depth and must consist of a coarse sand meeting the size gradation provided in Table 7.2.

Table 7.2 Sand Filter Media (C2100 Coarse Sand) Gradation

U.S. Sieve Number	Particle Diameter (mm)	Percent Passing Range (%)
3/8	9.50	100
4	4.75	90-100
8	2.36	45-85
16	1.19	9-45
30	0.60	0-18
50	0.30	0-10
100	0.15	0-7
200	0.07	0-2

The sand filter media is placed on top of a 3 inch thick layer of choke stone which overlays a 8 inch layer of pipe bedding. Pea Gravel is used for both the choke stone and pipe bedding. The gradation of Pea Gravel is summarized in Table 7.3.

Table 7.3 Choke Stone and Pipe Bedding (Washed Pea Gravel) Gradation

U.S. Sieve Number	Particle Diameter (mm)	Percent Passing Range (%)
1/2	12.7	100
3/8	9.50	99.8
1/4	6.30	74.7
4	4.75	35.1
8	2.36	2.10
16	1.19	0.70
50	0.30	0.40
200	0.07	0.29

Within the pea gravel layer is an underdrain which collects flow and conveys the effluent to a collector pipe and then drywell or storm drain network. The underdrain pipe should meet the specifications listed below.

- 3-inches of the choke stone should be placed above the underdrain and underneath the sand filter media
- Size to handle the two-year return frequency flow, assuming at least one foot of hydraulic head above the invert of the collector pipe leaving the sand filter sidewalk vault
- Use an underdrain pipe with an internal diameter of 8 inches, with two rows of ½-inch holes spaced six inches apart longitudinally, and holes 120° apart (pipe laid with holes downward)
- Slope underdrain at a minimum of 0.5 percent
- Cleanout wyes should extend to the surface and provide access to clean all underdrain piping in the sand filter sidewalk vault.

Coconut coir is laid on top of the sand filter media in the sand filter sidewalk vault to dissipate energy of influent stormwater, assist with distributing runoff over the sand filter media surface, and provide some treatment through the CEC of the material. The coconut coir to be used is approximately 1.5 inches thick. A specification sheet for the coconut coir used in the study is included in Appendix L.

Construction Criteria

No runoff should enter the sand filter sidewalk vault prior to completion of construction and approval of site stabilization by the responsible inspector. Level placement of sand filter media during installation is important to avoid formation of voids within the sand that could lead to short-circuiting. Sand filter media will be placed into the vault in 6-inch lifts above the choke stone layer. After each 6-inch lift, water will be used to compact and settle the sand filter media. Once all of the 6-inch lifts have been settled, the coconut coir mat can be placed on top of the sand filter media.

Maintenance Criteria

Maintenance frequency of the sand filter sidewalk vault will be confirmed during the study. Prior to measured infiltration dropping below the design infiltration rate, the coconut coir mat will be removed, and the top 6 inches of sand filter media will be removed by a vactor truck. A new 6-inch lift will be placed and settled using the procedures outlined in the previous section (Construction Criteria). The coconut coir mat will also be cleaned by either sweeping or rinsing accumulated debris from the top of the mat. The mat will be shaken to remove remaining debris, and replaced on the sand filter media.

7.4 Type of Data Being Collected

Sampling process design has been developed based on monitoring requirements identified in the Eastern Washington NPDES Phase II Permit (Ecology, 2014) and in TAPE (Ecology, 2011). This section addresses the steps and processes taken to develop these monitoring sites and sampling strategies and to ensure the data collection and monitoring methods satisfy the requirements of TAPE and the permit. Table 7.4 provides a summary of the type of data that will be collected along with the frequency of data collection, sampling method, and the sampling location.

Table 7.4 Summary of Data to be Collected

Parameters	Frequency	Sampling Method and Sampling Location
Precipitation	Continuous, year-round	Rain Gage, on-site
Stage (Discharge)	Continuous[1], year-round	PT: influent, effluent, and by-pass
Time	Continuous[1], year-round	PT, influent, effluent, and by-pass
Temperature	Continuous[1], year-round	PT, influent, effluent, and by-pass
TSS, Metals, Hardness, pH	Storm events (min. of 12 events)	Composite with Autosampler, Influent and effluent
OP, TP	Storm events (min. of 3 events)	Composite with Autosampler, Influent and effluent
NWTPH-Dx, visible sheen observation	Storm events (min. of 12 events)	Grab sample, influent and effluent
PSD influent	Storm events (min. of 3 events)	Composite with Autosampler, Influent
Infiltration Rate	Quarterly (falling head test); after each qualifying event (effluent flow rate)	Falling head test; close effluent valve, fill vault using water (from water truck or fire hydrant), measure rate of fall with yard sticks; Composite with Autosampler, effluent flow rate
Sediment Accumulation	After each qualifying rainfall event; once after testing is completed	Measure sediment accumulation depth on top of sand filter media using a measuring tape and calculate average of 5 measurements; post testing, three samples of the sand filter media will be collected from on top of the sand filter media as well as the top, middle, and bottom layers of the media, PSD will be graphed and compared to PSD measured prior to testing
Sand filter media	Once	Grab sample, BMP media prior to installing media in vault

1. Measured in 5-minute intervals when storms are monitored and 15-minute intervals during all other times. PT = Pressure transducer data logger; Metals = Total and Dissolved Copper and Zinc; PSD = Particle Size Distribution; OP = Ortho-phosphate; TP = Total Phosphorus

The study is expected to last two wet seasons. Water quality samples will be collected during a minimum of 12 qualifying rainfall events (see Table 7.5 for definition of qualifying rainfall events). This will include collecting flow weighted composite and grab samples from the influent and the effluent. Composite samples collected will represent 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 (12 minimum samples) and screening parameters (three minimum samples) as defined in TAPE in order to demonstrate treatment performance goals for basic, dissolved metals, and oils.

The discharge flow rate for the influent, effluent, and bypass are calculated by the data logger using stage values measured by the pressure transducers (PTs) combined with weir equations specific to the pipe diameter. Weirs are located upstream of the PT in the influent, effluent, and bypass pipes. 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 (Rantz at al, 1982; USEPA, 2002c). However, weirs tend to be more influenced by debris than flumes (Church et al., 2003) and need to be carefully monitored and maintained. Equations for the weirs are derived specifically for each size of weir (based on the pipe diameter) and are provided by the manufacturer below. These equations are programmed into the data logger logic and calculate the discharge flow rate at each time interval using the stage (feet) measured by the PTs based on the flow over the weirs at the site (see Figure 7.2) for the 8-inch weir (in the overflow pipe) and the 6-inch weirs (in the influent and effluent pipes):

<u>8-inch Weir – Bypass Flow</u>

$$Q = 7807.1 \times (d_{PT})^{2.6316}$$

<u>6-inch Weir – Influent and Effluent Flow</u>

$$Q = 6085.1 \times (d_{PT})^{2.5756}$$

Where:

Q=flow rate (liters per minute)
d_{PT}=depth measured at pressure transducer (feet)

7.5 Precipitation Monitoring

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

7.5.1 Storm Event Prediction

Sampling will be attempted for storms that are predicted to meet the storm event guidelines defined in TAPE (Ecology, 2011). These events are referred to as 'qualifying rainfall events' in this document which have the characteristics included in Table 7.5.

Table 7.5 Storm Event Guidelines for TAPE Monitoring

Parameter	Definition	Guideline [a]
Minimum storm depth	Total rainfall amount during storm event	0.15 inches
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 hour)	Range of rainfall intensities [b]

[a] Will provide justification in the Technical Evaluation Report (TER) for storm event data that does not meet the storm event guidelines, but is included in the data analysis. . Currently the data logger is programed to only collect samples during qualifying events.
[b] To assess performance on an annual average basis and performance at the system's peak design rate, samples will be collected over a range of rainfall intensities.

The National Oceanic and Atmospheric Administration's (NOAA) National Weather Service, Spokane forecast office website will be monitored daily for storm forecasts. (http://graphical.weather.gov/sectors/otx.php). These observations will determine if a predicted storm will meet the qualifying event criteria and whether sample collection will occur.

7.5.2 Rainfall Measurements

Precipitation monitoring will be conducted to quantify rainfall during storm events and to measure the duration, intensity and distribution of rainfall throughout a discrete storm event. Precipitation will be monitored in 15 minute increments during typical operating conditions and every 5 minutes during rainfall events. The information is downloaded from the data logger at the test site. 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.

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. Rain gage placement will follow the National Weather Service (NWS) specifications (http://www.weather.gov/om/coop/standard.htm) as closely as practical for the site. Minor deviations from NWS specifications may be needed due to site specific constraints.

Rain gages will be mounted to the antenna mast approximately 6 to 8 feet from the ground unless otherwise specified. The rain gage will be calibrated prior to installation and maintained in accordance with the manufacturers' specifications. If a deviation from NWS or manufacturer's specification is needed, notation will be made regarding the alteration and included in the Technical Evaluation Report (TER).

Actual precipitation data at the site will be available remotely through a cellular connection with the data logger. The data will be used to identify on-site weather characteristics and estimate when

sampling crew need to deploy for sample collection. During each station visit, the rain gage will be inspected, cleared of debris, and maintained in accordance with the manufacturers' specifications. All rain gage data collected will be downloaded from the data logger following each time samples are collected or during the maintenance schedule.

7.6 Water Quality Sampling

This section describes the two types of water quality sampling methods that will be used during this study: grab sampling and composite sampling.

7.6.1 Grab Sampling

TAPE states that grab samples should be collected on the rising limb of the hydrograph. Sampling staff are to collect grab samples as early in the runoff event as practical to ensure representativeness of the sample. A minimum of twelve samples will be collected for statistical comparison following TAPE guidelines.

If grab samples are not collected or are missed during qualifying storm events, allowable non-qualifying sized storm events may be sampled to ensure statistical requirements are met. An allowable non-qualifying storm means that only the stormwater rainfall depth can be the reason the storm is non-qualifying. Samples collected from non-qualifying storms will be noted and flagged in the dataset.

Grab samples are collected manually in jars or measured in situ with a probe. For this study, the oils samples will be collected manually in jars. The oils grab sample will be collected by placing a bottle beneath the opening of the influent pipe in the sand filter sidewalk vault and by dipping a bottle into an opening on the top of a tee in-line with the effluent pipe. pH and temperature will be measured in situ using a probe in a small amount of composite sample placed into a clean container. Visible sheen will be noted by observation of effluent in the pipes and composite sample. Additional details regarding the grab sample collection and probe measurement procedures are defined in the SOPs which are located in Section 8.1.4.

7.6.2 Composite Sampling

TAPE specifies that stormwater runoff must be collected by in-situ flow-weighted composite sampling. Each monitoring station will be equipped with an autosampler and a 2.5-gallon glass bottle for sample containment. Autosamplers such as an ISCO or a similar product will be used at each of the monitoring stations to collect stormwater samples during a qualifying storm event. Autosamplers will be programmed to begin sampling when initiated by the data logger. Autosamplers are programmed to begin sampling at the predetermined rates required for the collection of at least 75 percent of the event hydrograph. Sample collection into autosampler bottles will be triggered by the characteristics of a 'qualifying rainfall event' as described in Section 7.5. Specifically, the data logger is programmed to only collect samples when qualifying conditions occur. If conditions fall outside the limits of a qualifying event, the data logger is programmed to stop sampling. The characteristics (i.e., water temperature, rainfall, discharge, and time) are necessary to determine whether the antecedent criteria and rainfall criteria required by TAPE were met, stormwater runoff is occurring and the water is not frozen. Water temperature, rainfall, and discharge will be measured using external probes connected to the data logger. Time

will be measured by the data logger itself. If these characteristics are not met during the storm, samples will not be collected.

7.7 Infiltration Testing

The infiltration rate of the sand filter media will be evaluated following each qualifying storm event using the effluent flow rates. Flow rates will be based on PT depth data and the associated equation for the 6-inch weir defined in Section 7.4. If a reduction in infiltration rates are observed below the design infiltration rate, the BMP will be inspected and maintenance cycle will be assessed.

Collecting a representative infiltration rate measurement using the influent and effluent flow data recorded by the data logger requires that the media is saturated. This condition is expected to occur when the influent flow rate exceeds the effluent discharge rate for a sufficient period of time. However, the initial infiltration rate of the sand filter media is expected to be approximately 1000 in/hr which will most likely be higher than the influent flow rate (from rainfall runoff) for the initial rainfall events. During these events it will not be possible to measure a representative infiltration rate using the flow data until the infiltration has declined and saturated (ponding) conditions occur in the sand filter vault. As such, a modified version of the falling head tests will also be (see Section 8.1.8) performed a minimum of four times per year.

7.8 Sediment Sampling

After testing is complete (post testing) the sediment that accumulates on top of the BMP and within the top, middle, and bottom layer of the sand filter will be collected and sent to the laboratory to determine the particle size distribution (PSD). Composition of sediments on top of the BMP will be noted on field forms (based on visual observation) as well to assist with characterization and corroborate the laboratory findings.

7.9 Sand Filter Media Material Testing

The sand filter media will be tested once prior to installation at the test site. The purpose of this testing is to define the media physiochemical properties. This information will be used to define the media properties for the BMP design specification. The physiochemical properties selected for testing include those that are known to influence treatment and flow control performance. The testing anticipated for this study is summarized in Table 7.6.

Table 7.6 Summary of Sand Filter Media Material Testing Parameters and Methods

Parameter	Standard Methods
pH	S-2.20
Moisture Content	ASTM D2216
Cation Exchange Capacity (CEC)	S10.10
Maximum Dry Density	ASTM D1557
Saturated Hydraulic Conductivity (K_{sat}) @ 85% compaction rate	ASTM D2434
Particle Size Distribution for the following sieve sizes: 4, 8, 16, 30, 50, 60, 100, 200, 230, retained on 1.5µm glass fiber filter	ASTM D422 and Modified SSC method
Total Elements: Zn, Cu, Pb, TP, Mg, Ca	EPA 3050A/6010B
Total Organic Carbon	EPA 415.3
Carbon to Nitrogen ratio	EPA 415.3/351.2

8.0 Sampling Procedures

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

8.1 Procedures for Collecting Field Measurements

Water quality samples will be collected in the field, following standard operating procedures (SOPs). The SOPs developed for this study define how to conduct storm selection, sample collection, site measurements and equipment maintenance and calibration in detail, including the frequency of the activity. All visits to the site should be conducted with a partner or multiple personnel. SOPs included in this section are:

- Storm Selection and Tracking
- Storm Monitoring Equipment Maintenance
- Preparing Stormwater Monitoring Equipment for Storm Sampling
- Stormwater Grab Sampling
- Stormwater Sample Collection and Processing
- Monitoring Equipment Data Download
- Sediment Accumulation Rate
- Falling Head Test

8.1.1 Storm Selection and Tracking

The purpose of this SOP is to define the procedures for selecting and tracking 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 H) to record the decision process, weather activity, and outcome of the event

A summary of the procedures for storm tracking prior to a monitoring event and storm selection are as follows. Note: throughout this section and document, the term sampling event and monitoring event are used interchangeably. Both terms refer to a predicted qualifying storm event in which the data logger and autosamplers are set to the *sample mode* to collect storm data and water quality samples.

- 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 7.5 of this document. Storm event probability will be tracked via the NOAA National Weather Service Spokane forecast office website at the following link:

https://forecast.weather.gov/MapClick.php?lat=47.75&lon=-117.41&unit=0&lg=english&FcstType=graphical

- 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 (0.15-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 monitor the rainfall event. Specifically:
    - 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 project manager will determine whether the conditions of the storm look favorable or not using their professional judgment. The judgment will take storm characteristics 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 as soon as possible in advance (preferably 24 to 48 hours in advance) of the anticipated monitoring event.
- Step 4: If a storm event is selected for monitoring, sample bottles will be obtained from the lab as necessary and equipment will be prepared in accordance with the procedures outlined in Section 8.1.3.
- Step 5: Prior to and during a storm event that is selected for sampling, actual rain gauge data at the test-site will be monitored remotely through a cellular connection to the data logger. The data will be used to determine when sampling personnel will go to the site to collect grab samples or composite samples.

8.1.2 Storm Monitoring Equipment Maintenance

The purpose of this SOP is to outline the steps required for maintaining stormwater monitoring equipment at the test site. Maintenance of storm monitoring equipment should occur at minimum once per month, unless otherwise specified.

Equipment needed:

- Traffic cones
- Personal Protective Equipment (PPE) including: eye protection, gloves, high visibility vest, work boots, etc.
- Tools necessary to access vaults
- Periodic Maintenance Checklist Field Form (Appendix H)

- Wet-dry vacuum
- Soft brush
- Volt meter
- USB drive
- Screwdriver
- Replacement suction, head, and pump tubing
- Volumetric plastic beaker
- Adjustable wrench
- Telescopic mirror
- Torpedo level
- Flashlight
- Replacement battery
- Spare desiccant bags (for ISCO and PT)
- Electronic water level indicator (tapedown tool)
- Nitrile gloves
- Cellular phone

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

- Step 1: Place traffic cones as needed to call attention to the presence of staff along the roadway. 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 (Field Form) in Appendix H.
- Step 2: Open the monitoring equipment vault and sand filter vault and remove the inlet grate. Visually inspect pipes, cables, wiring, tubing, and monitoring equipment. Note any frayed wires or damaged equipment on the Periodic Maintenance Checklist Field Form. Contact principal investigator or project manager on how to proceed if damage is significant. *Note: When accessing the equipment in the vaults, 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 or sediment are observed in pipes, tees, or weirs, clean pipes according to Steps 3 – 5 in Section 8.1.3. Then immediately replace the grate inlet.
- 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 Periodic Maintenance Checklist and reconnect power to the battery.
    - If battery voltage is not within the specified range, replace battery with the spare, fully charged 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 14, 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 three months, 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. Note any discrepancies and reset level of rain gage platform if needed. Replace cover on rain gage and plug rain gage back in to the data logger.
- Step 7: Inspect ISCO suction tubing, head tubing and pump tubing for wear. Note and describe condition on the Periodic Maintenance Checklist. 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.
- 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 Periodic Maintenance Checklist.
    - 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 Periodic Maintenance Checklist.
    - 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 Periodic Maintenance Checklist.
        - 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 PT humidity absorbing systems. Record the observed color on the Periodic Maintenance Checklist.
    - 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 per the manufacturer's instructions. Note that either the desiccant cartridge needs to be replaced, or has been replaced in the field on the Periodic Maintenance Checklist.
- 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 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: Once all maintenance, cleaning, and calibration has been completed, end the visit report on the data logger, close the monitoring vault and sand filter vault, and secure as needed before leaving the site. Collect any traffic cones used.
  - 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.

8.1.3 Preparing Stormwater Monitoring Equipment for Storm Sampling

The purpose of this SOP is to outline the steps required for cleaning and calibrating stormwater sampling equipment and the pH probe prior to monitor and sample storms, and preferably within 24-hours of the start of the monitoring event. Additional, general steps to prepare for stormwater sampling and processing are also covered in this SOP. *Note: prior to performing the steps outlined in this SOP, the lab will be notified that sampling is expected to occur, and that rinsate blanks, grab samples, and composite samples will be transported to the lab. An estimate of when each set of samples will be delivered will be provided to the lab.*

Equipment:

- Tools necessary to access vaults
- Telescopic mirror
- Adjustable wrench
- Torpedo level
- Volt meter
- Flashlight

- Wet-dry vacuum
- Soft brush
- Water source or 5 gallon bucket (with lid) filled with tap water
- Cleaning solutions for tubing (10% HNO3 acid solution, liquinox soap solution) in 5-gallon buckets (one for each solution) with lids
- Carboy(s) filled with DI water
- Sample bottles for rinsate blanks
- Cooler for sample bottles
- Hard ice packs for cooler
- 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
- Traffic cones
- Clean, powder-free nitrile gloves
- Personal Protective Equipment (PPE) including: eye protection, gloves, high visibility vest, work boots, etc.
- Electronic water level indicator (tape down tool)
- Cellular phone
- Pre-Storm Event Maintenance Checklist, Chain of Custody Form

Summary of procedures to prepare monitoring equipment for storm sampling:

- Step 1: Place traffic cones as needed to call attention to the presence of staff along the roadway. 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: Open the monitoring equipment vault and sand filter vault and remove the inlet grate. Start a visit report on the data logger according to Step 5 in Section 8.1.2. *Note: In accordance with "clean hands/dirty hands" procedures, one staff member will be designated to install new ISCO composite bottles, if necessary, in Step 16. This staff member may not handle other equipment during the site visit. Additionally, 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 equipment vault and catch basin, do not disturb pipes or pipe tees*.
- Step 4: Before starting to clean, collect a water surface elevation measurement from the reference point on the control tee. Record the measurement and reference elevation on the

Pre-Storm Event Maintenance Checklist in the assigned space. Assign a + or – value to your reading if there is any uncertainty due to debris, blockage, etc. Subtract the measurement from the reference elevation to determine water surface elevation and record the value on the form. Compare this value to the measurement collected by the data logger to identify any prior instrument drift.

- Step 5: 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.
- Step 6: Inspect the pump, suction, and head tubing for the ISCO. If kinks or bellies are observed in the tubing, replace the tubing. Clean any ISCO tubing that was not replaced as follows:
    - Triple rinse the tubing with 10% HNO3 acid solution, then wash the tubing with liquinox soap solution, and finally triple rinse the tubing with DI water.
- Step 7: Put on a new pair of clean nitrile gloves and obtain the sample bottles provided for the rinsate blank.
- Step 8: 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 9: Replace the cap on the sample bottle, taking care to not touch the inside of the cap.
- Step 10: Repeat Steps 8-9 for the effluent autosampler and associated rinsate blank bottle.
- Step 11: Once both rinsate bottles have been filled, place bottles in the cooler and fill out the Chain of Custody form for the rinsate samples.
- Step 12: 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 Pre-Storm Event Maintenance Checklist.
- Step 13: Inspect pressure transducers (PT) and mounts. If PTs and/or mounts are dirty, remove PT 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 14: 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 PT reading. The PT reading may take a few minutes to update.
- Step 15: Once the PT reading updates, verify using the data logger that the PT reading value is zero. Take another water surface elevation reading using the electronic water level indicator to verify the PT 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 or project manager of the drift as soon as possible.
- Step 16: Access the sample bottle inside the ISCO and check bottle configuration. 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 17: Make sure all tubing is connected properly, bulkhead caps are secured and that cables are properly attached.

- Step 18: Before leaving the site, set the data logger and ISCO autosampler mode to sample if the criteria for qualifying rainfall event (see Section 7.5) 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 19: Additionally, set the threshold on the data logger to tell the system when to trigger influent and effluent sampling.
    - The threshold is determined through the spreadsheet calculator described in Appendix N.
    - 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 value determined from the spreadsheet calculator in Appendix N is entered for both the influent and effluent thresholds.
- Step 20: Once all maintenance, cleaning, and calibration has been completed, end the visit report on the data logger (according to Step 14 in Section 8.1.2), close the monitoring vault and sand filter vault, and secure as needed before leaving the site. Collect any traffic cones used. Return rinsate samples and associated Chain of Custody to Anatek Laboratory in Spokane.
- Step 21: Upon returning to the HDR lab, obtain the pH meter and turn on the meter. Put on nitrile gloves and eye protection.
- Step 22: Inspect the electrode for cracks in the electrode stem or bulb. If scratches or cracks are present, the electrode must be replaced.
- Step 23: 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 24: 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 25: Inspect connectors and ensure they are clean and dry. Rinse off any deposits with deionized water.
- Step 26: 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 27: 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.
- Step 28: 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 29: 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 30: 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 31: Once the pH value is stable, confirm the reading and record on the Pre-Storm Event Maintenance Checklist.
- Step 32: 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 33: 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 34: 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.

8.1.4 Stormwater Grab Sampling

The purpose of this SOP is to outline the steps required to collect grab samples for oils grab samples. 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 event.

Equipment:

- Traffic Cones
- 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
- Sample Collection Field Form (Appendix H)
- Falling Head Test Form from most recent infiltration test
- Chain of custody form (Appendix I) 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: Place traffic cones as needed to call attention to the presence of staff along the roadway. 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 monitoring vault (containing the monitoring equipment) and sand filter vault. If any visible sheen is observed in the sand filter vault, note that in the Sample Collection Field Form. Start a visit report on the data logger according to Step 5 in Section 8.1.2. *Note: In accordance with "clean hands/dirty hands" procedures, one staff member will be designated to handle sample bottles, collect samples, and package samples for the lab during a sampling event. This staff member may not handle other equipment during the sampling event. Additionally, 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 and return the bottles to the bag after collection of samples.*
- Step 4: Put on clean nitrile gloves and obtain the bottles for the influent oils samples.
- Step 5: Carefully remove the lid of the oils bottle without touching the inside of the lid. Place the bottle below the opening of the influent pipe in the sand filter vault. 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: Step not used.
- Step 8: Put on new, clean nitrile gloves and obtain the bottles for the effluent oils 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 sand media that was calculated and recorded on the Falling Head Test Form during the previous sample event.
- Step 9: Carefully remove the lid of the first oils sample bottle without touching the inside of the lid. Dip the bottle for the oils effluent sample into the opening in the top of the tee so the surface of the water is captured in the bottle. Pull the bottle forward to fill.
- Step 10: Once the bottle is full, place the cap on the bottle and transfer the bottle to the plastic bag in the cooler.
- Step 11: Repeat steps 9 and 10 for the remaining oils sample bottles.
- Step 12: Fill out the Chain of Custody for the grab samples according to the procedures outlined in Section 8.5. Measure the temperature in the cooler using the pH meter and record the temperature on the Chain of Custody form.
- Step 13: When ready to leave the site, end the visit report on the data logger (according to Step 14 in Section 8.1.2), close the monitoring vault and sand filter vault. Collect any traffic cones used.
- Step 14: Transport samples to Anatek Laboratory in Spokane.
    - If samples have been collected after laboratory hours, keep samples below 6°C in a cooler or refrigerator until the laboratory reopens.

8.1.5 Stormwater Sample Collection and Processing

The purpose of this SOP is to outline the steps required for pH measurement and sample collection and processing at the test site.

Equipment:

- Traffic Cones
- Tools necessary to access vaults
- USB flash drive
- Electronic water level indicator (tape down tool)
- Cellular phone to enable communication between staff and project manager or principal investigator
- Flashlight
- Volt meter
- Torpedo level
- pH meter
- 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
- Chain of custody form (Appendix I), sample tag, Sample Collection Field Form (Appendix H)

Summary of procedures for preparation of stormwater sampling equipment prior to monitoring and sampling.

- 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: Place traffic cones as needed to call attention to the presence of staff along the roadway. 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 monitoring equipment vault and sand filter vault. Start a visit report on the data logger according to Step 5 in Section 8.1.2. *Note: "clean hands/dirty hands" procedures as defined in Step 3 of Section 8.1.4 will be followed during sample collection.*
- Step 4: Measure the water surface elevation using the electronic water level indicator. Note the current water surface elevation measurement on the field form.

- Step 5: Check the ISCO and data logger to verify that the ISCO has completed its sampling and/or 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 6: 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 (i.e., if the number of aliquots reported is 20, and very little to no water is present, there has been a malfunction).
- Step 7: Pour some of the sample into a small beaker to a depth of at least 1 ½ inches (100 mL) 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.
- Step 8: Replace the lid on the composite jar with a lab-cleaned, solid lid.
- Step 9: Remove jar from the ISCO and place the composite sample into a plastic bag within the cooler for transport to the HDR lab.
- Step 10: Check the pH reading to see if it has stabilized. If it has, record the pH and temperature reading on the field form. If not, wait for the reading to stabilize before recording pH and temperature 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.
- Step 11: End the visit report (according to Step 14 in Section 8.1.2) after all samples have been collected and the ISCO indicates that the program has been reset.
- Step 12: When ready to leave the site, close the monitoring vault and sand filter vault, and secure as needed before leaving the site. Collect any traffic cones used.
- Step 13: Return to the HDR lab. Composite samples are transported to the HDR lab prior to Anatek to transfer composite samples in ISCO bottles to the laboratory-specified bottles listed in Table 8.1 and to filter samples for dissolved metals and ortho-phosphate analysis.
    - 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 14: Place the filled laboratory bottles in the plastic bags provided by the lab, and place the plastic bag(s) in the cooler.
- Step 15: Fill out the Chain of Custody for the samples according to the procedures outlined in Section 8.5. Measure the temperature in the cooler using the thermometer and record the temperature on the Chain of Custody form.
- Step 16: 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.

8.1.6 Monitoring Equipment Data Download

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

Equipment:

- Traffic Cones
- Tools necessary to access vaults
- USB flash drive
- Cellular phone to enable communication between staff and principal investigator or project manager
- Flashlight
- Personal Protective Equipment (PPE) including but not limited to: high visibility vest, gloves, work boots, etc.
- Monitoring Equipment Data Download Field Form

Summary of procedures for download of data from test site:

- Step 1: Place traffic cones as needed to call attention to the presence of staff along the roadway. 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 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 the monitoring vault and collect the cones.

8.1.7 Sediment Accumulation Rate

This section describes the procedures for measuring the sediment depth on top of the sand filter media and collecting samples of the sand media from the top, middle, and bottom layers of the sand filter media.

Equipment needed:

- Traffic Cones
- Tools necessary to access vaults
- Personal Protective Equipment (PPE) including but not limited to: high visibility vest, gloves, work boots, etc.
- Decimal measuring tape
- Clean stainless steel scoop
- Clean stainless steel bowl
- Sample containers

- Gallon plastic bags
- Cooler for sample bottles
- Hard ice pack for cooler
- Chain of Custody form (Appendix I) and Field Data Collection Form: Sand Filter Media Sediment Depth Measurements (Appendix H)

Summary of procedures for taking measurements prior to the start of the study:

- Step 1: At the start of the study, immediately after the sand filter media and coconut coir mat have been installed, the depth from the top of the mat to the top of the sidewalk will be measured in order to compare later sediment accumulation measurements
- Step 2: Randomly select a location in the sidewalk vault
- Step 3: Place the measuring tape on top of the coir mat without compressing the mat
- Step 4: Verify the tape is perpendicular to the bottom of the sidewalk, record the depth on the measuring tape taken at the top of the sidewalk on the field data collection form
- Step 5: Repeat steps 2-4 at four more locations in the sidewalk vault
- Step 6: Calculate the average depth of the five measurements and record the value on the data collection form

Summary of procedures for taking measurements following the start of the study. These measurement will be taken after each qualifying rainfall event and immediately prior to the falling head test.

- Step 7: This process will be followed after sample collection (SOP 8.1.5).
- Step 8: Open the sidewalk vault that contains the sand filter media.
- Step 9: Randomly select a location on top of the sand filter media
- Step 10: Lower the measuring tape onto the top of the accumulated sediment
- Step 11: Once the measuring tape is on top of the sediment, verify the rod is perpendicular to the sidewalk and record the depth reading on the measuring tape taken at the top of the sidewalk on the data collection form
- Step 12: Repeat steps 9-11 at four more locations in the sidewalk vault
- Step 13: Calculate the average depth of the five measurements and record the value on the data collection form.
- Step 14: Calculate the average depth of sediment on top of the sand filter media: subtract the average depth measured in the clean sidewalk vault (Step 6) from the Step 13 average depth calculated.
    - If samples have been collected after laboratory hours, keep samples below 6°C in a cooler or refrigerator until the laboratory reopens.

Samples of the sediment on top of the sand filter media and within the top, middle, and bottom layer of the sand filter media will be collected. Samples will only be collected once after all testing is completed.

- Step 15: Randomly select three locations on the accumulated sediment on top of the sand filter sidewalk vault. Create a 3 inch by 4 inch transect in those locations. Scoop sediment

accumulated on the coconut coir for the full transect are into the sample containers provided by the laboratory (3 samples total).

- Step 16: Collect samples from the top layer of the sand filter media (3 inch horizon). A push probe will be used to collect samples from each of the four quadrants and one from the center of the sand filter.
- Step 17: Samples will be homogenized in a stainless-steel bowl and transferred to the laboratory bottles in the plastic bags provided by the lab, and place the plastic bag(s) in the cooler.
- Step 18: Repeat steps 16 and 17 for the middle layer of the sand filter media (9 inch horizon).
- Step 19: Repeat steps 16 and 17 for the middle layer of the sand filter media (15 inch horizon).
- Step 20: Fill out the Chain of Custody for the samples according to the procedures outlined in Section 8.5.
- Step 21: Transport the samples to Budinger for analysis.

8.1.8 Falling Head Test

The purpose of this SOP is to outline the steps required to perform a modified version of the falling head test on the sand filter media in the vault and measure the infiltration rate.

Equipment needed:

- Traffic Cones
- Tools necessary to access vaults
- Personal Protective Equipment (PPE) including but not limited to: high visibility vest, gloves, work boots, etc.
- A water source sufficient to saturate the sand filter media and fill the vault to the top of the overflow pipe
- Timer
- Yard stick
- Falling Head Test Field Form (Appendix H)

Summary of procedures for the falling head test:

- Step 1: Once the monitoring vault and sand filter sidewalk vault have been accessed, turn the valve in the monitoring vault on the effluent pipe to the closed position to prevent water from discharging through the pipe.
- Step 2: measure the height from the top of sediment to the top of the bypass pipe in five different locations in the vault. Calculate the average height of the bypass pipe above the sediment.
- Step 3: Fill the sand filter sidewalk vault with water until the water surface is even with the top of the overflow pipe. Wait an hour to allow time for the media to become saturated. Add water until the water surface elevation is again even with the overflow pipe.
- Step 4: Open the valve on the effluent pipe and start the timer.

- Step 5: Stop the timer once all of the water has infiltrated below the sand media surface. Record the time on the Falling Head Test Field Form. *Note: the infiltration rate is calculated by dividing the average height of the water (step 2) by the time it takes water to infiltrate below the media surface.*
- Step 6: Close and secure the vaults before leaving the site.

8.2 Containers, Preservation Methods, Holding Times

Clean sample bottles and associated preservatives will be provided by Anatek Laboratory and Budinger (PSD only) in Spokane, WA, according to Table 8.1. 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 8.1 Sample containers, preservative, and holding times

Matrix	Parameter	Method	Sample Container & Volume	Preservative	Pre-Filtration Holding Time	Total Holding Time
Water Quality	pH	EPA 150.1	100 mL	NA	15 min.	15 min.
	PSD, influent	Modified SSC	Plastic; 1L	NA	NA	NA
	Total Suspended Solids (TSS)	SM 2540D	Plastic; 125 mL	Cool, ≤6°C	NA	7 days
	Dissolved Metals (Cu, Zn)	EPA 200.8 (ICP/MS)	Plastic; 125 mL	Cool, ≤6°C; filtration, 0.45 µm; HNO3 to pH<2	12 hours	180 days
	Total Metals (Cu, Zn)	EPA 200.8 (ICP/MS)	Plastic; 125 mL	Cool, ≤6°C; HNO3 to pH<2	NA	180 days
	Hardness as CaCO3	SM 2340B (ICP)	Plastic; 500 mL	HNO3 ph<2	NA	180 days
	Ortho-phosphate (OP)	SM 4500-P G	Plastic; 1 L	Cool, ≤6°C; filtration, 0.45 µm	12 hours	2 days
	Total Phosphorus (TP)	SM 4500-P F	Glass; 1 L	Cool, ≤6°C; H2SO4 to pH < 2	NA	28 days
	NWTPH-Dx	Ecology NWTPH Dx	Glass; 1L	Cool, ≤6°C; HCL to pH < 2	NA	14 Days
Sediment	Sediment PSD	ASTM D422 and Modified SSC	Plastic; 1L	NA	NA	NA
Sand Filter Media	pH	S-2.20	Plastic; 0.5 grams	Cool, ≤6°C	NA	NA
	Moisture Content	ASTM D2216	4 oz. Clear Glass Wide Jar; 10 grams	Cool, < 6°C	NA	NA
	Cation Exchange Capacity	S-10.10	Plastic; 2 grams	Cool, ≤6°C	NA	NA
	Maximum Dry Density	ASTM D1557	Plastic; 200 grams	Cool, ≤6°C	NA	NA
	Saturated Hydraulic Conductivity	ASTM D2434	Plastic; 500 grams	Cool, ≤6°C	NA	NA
	Particle Size Distribution	ASTM D422	Plastic; 500 grams	Cool, ≤6°C	NA	NA
	Total Elements (Zn, Cu, Pb, TP, Mg, Ca)	EPA 3050A/6010B	Plastic; 20 grams	Cool, ≤6°C	NA	NA
	Total Organic Carbon	EPA 415.3	Plastic; 0.5 grams	Cool, ≤6°C	NA	NA
	C:N Ratio	EPA 415.3/351.2	Plastic; 50 grams	Cool, ≤6°C	NA	NA

8.3 Equipment Decontamination

Equipment decontamination will follow procedures in SOP "Preparing Stormwater Monitoring Equipment for Storm Sampling". The following equipment will be decontaminated between sampling events:

- pH Meter
- ISCO Sample Bottles (laboratory)
- ISCO Sample Tubing
- Grab sample bottles (laboratory)
- Pressure transducers

8.4 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)

8.5 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:

- Name(s) of field personnel
- Date and time of sample collection
- Location of sample collection
- Printed names, signatures and contact information 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, samples will be immediately delivered to Anatek and/or Budinger in Spokane, WA. 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 HDR principal investigator or project manager. The sampling staff will record the date and time of sample deliveries for the project file. The chain of custody form is in Appendix I.

8.6 Field Log Requirements

Field observations and measurements associated with a monitoring event will be recorded on the field forms (Appendix H). 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 equipment condition
- Samples collected (checklist)
- QC samples collected (checklist)
- Water temperature, pH, and oil sheen measurements/ observations
- Instrument calibration results
- Comments on activities or issues that may influence the quality of the data

9.0 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.

9.1 Procedures for Collecting Field Measurements

Field measurements will be made for precipitation, discharge (influent, effluent, and bypass flow rate), water quality (stormwater influent and effluent), pH, stormwater temperature, and the accumulated sediment volume. Precipitation and discharge measurements will be collected during data download (from the data logger) at the test-site as described in Section 8.1.6. Grab and composite samples will be collected according to the procedures in Section 8.1.4 and 8.1.5, respectively. The pH and water temperature measurements will be instantaneous measurements collected with a calibrated pH meter, as described in Section 8.1.5. Sediment accumulation measurements will be made as described in Section 8.1.7.

Field measurement quality will be evaluated in terms of bias and precision (See Section 6.2 and 6.1). Measurement bias will be measured and corrected by calibrating the rain gauge at the beginning and end of the study, checking the depth measurements of the PTs during each maintenance cycle, calibrating the pH meter prior to sampling events, and calibrating the ISCO quarterly. Detailed calibration procedures are in the Sections 8.1.2 and 8.1.3. Measurement precision will be evaluated for pH and water temperature by collecting duplicate measurements for at least 10% of all measurements.

9.2 Laboratory Procedures

Laboratory analytical procedures will follow methods approved by the US Environmental Protection Agency (EPA) (APHA et al. 1992, 1998; US EPA 1983, 1984). These 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 9.1. HDR will filter for parameters requiring filtration (i.e., ortho-phosphorus, 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 8.1 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, is certified by Ecology. SoilTest Farm Consultants, Inc. Laboratory (SoilTest) is the lab identified for soil analytical samples. PSD sample analysis will be performed by Budinger & Associates, Inc. (Budinger). These performance and system audits have verified the adequacy of the laboratory's standard operating procedures, which include preventive maintenance and data reduction procedures.

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

Table 9.1. Laboratory measurement methods.

Matrix	Parameter	Units	Method	Reporting Limits	Expected Range of Results	Minimum Number of Sample Events	Samples Per Event
Water Quality Stormwater	pH	units	EPA 150.2	0.2	6.5-8.0	12	2
	PSD, influent	%	Modified SSC method	NA		3	2
	Total Suspended Solids (TSS)	mg/L	SM 2540D	1.0	20 - 500	12	2
	Dissolved Copper (Cu)	µg/L	EPA 200.8 (ICP/MS) or SM 3125 (ICP/MS)	0.1	0.1 - 20	12	2
	Dissolved Zinc (Zn)	µg/L		1.0	5 - 300	12	2
	Total Copper (Cu)	µg/L		0.1	0.1 - 40	12	2
	Total Zinc (Zn)	µg/L		5.0	5 - 600	12	2
	Hardness as CaCO3	mg/L	SM 2340B (ICP)	1.0	1 - 100	12	2
	Ortho-phosphate (OP)	mg/L	SM 4500-P G	0.01	0.01 - 0.5	3	2
	Total Phosphorus (TP)	mg/L	SM 4500-P F	0.01	0.01 - 0.5	3	2
	NWTPH-Dx	mg/L	Ecology NWTPH Dx	0.25-0.50		12	2
Sediment	Sediment PSD	percent	ASTM D422 and Modified SSC method	NA	< 3/8 sieve to > 1.5µ	3	3
Sand Filter Media	pH	std. units	S-2.20	NA	6-9	1	1
	Moisture Content	%	ASTM D2216	NA	< 2%	1	1
	Cation Exchange Capacity	meq/100g	S-10.10	NA	< 5meq/100g	1	1
	Maximum Dry Density	lb/ft^3	ASTM D1557	NA		1	1
	Saturated Hydraulic Conductivity	ft/day	ASTM D2434	NA	2-4	1	1
	Particle Size Distribution	percent	ASTM D422 and Modified SSC method	NA	< 3/8 sieve	1	1
	Total Elements (Zn, Cu, Pb, TP, Mg, Ca)	mg/kg	EPA 3050A/6010B	5.0 (Zn); 0.01 (P) 0.1 (others)		1	1
	Total Organic Carbon	mg/kg	EPA 415.3			1	1
	C:N Ratio	Ratio	EPA 415.3/351.2	NA		1	1

9.3 Sample Preparation Methods

Ortho-phosphorus, dissolved, copper, and dissolved zinc require filtration and preservation prior to delivery to Anatek. HDR personnel will filter and preserve the samples which will be analyzed for those parameters according to the methods outlined in Section 8.1.5.

9.4 Special Method Requirements

Anatek, SoilTest, and Budinger do not require any special methods for the parameters to be analyzed during the study.

9.5 Lab(s) Accredited for Methods

Anatek laboratory is accredited by Ecology for the stormwater parameters collected for this study (Table 9.1) and participates in audits and inter-laboratory studies by Ecology and EPA. SoilTest will analyze the sediment and sand filter media parameters collected for this study and is also accredited by Ecology. Budinger is USACE accredited for materials testing in accordance with ASTM and WSDOT methods.

10.0 Quality Control

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

10.1 Field QC Required

Field quality control will be maintained by personnel training, SOP 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 (see Section 8.1.4 and 8.1.5) and measurement procedures, (see section 9.0). Field staff must become familiar with all associated SOPs (Section 8.0) 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 or project manager. Completion of each element of training will be verified and documented by the principal investigator or project manager in a training completion log (Appendix H).

Equipment maintenance and calibration will ensure that the BMP, the sampling equipment, and the water quality meters are working properly. Equipment maintenance will occur once in early fall, prior to the first monitoring event of the wet season, and monthly between monitoring events. Calibration of the ISCO pumps will likely occur during equipment maintenance, according to the frequency specified by the manufacturer. Calibration of the remaining storm monitoring equipment, including the pH meter will occur prior to field measurements, preferably on the day of a monitoring event. Details of equipment maintenance and calibration are provided in Sections 8.1.2 and 8.1.3 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 pH meter, pressure transducer, rain gage, 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 H). Recordkeeping procedures will be developed and consistently followed (see Section 11.0).

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 not be collected for grab samples, since those samples are collected directly into the sample containers or measured in situ. Rinsate blanks will be collected three times throughout the study for TSS, total phosphorus, orthophosphate, hardness, oils (NWTPH-Dx), 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 (see Table 6.2, Table 9.1 for reporting limits).

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 and sediment parameters (Table 10.1) and must meet the associated relative percent difference MPCs in Table 6.2. Field duplicates will also be collected for sediment PSD and filter media variables.

10.2 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 (Table 10.1). MPCs associated with the quality control samples are in Table 6.1. 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.

10.3 Corrective Action

The auditor will notify the lead entity and principal investigator in writing (via email) within 2 business days if corrective actions is needed based on the audit findings. The lead entity and principal investigator are 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 in Appendix K) and included in the final report.

Table 10.1. Quality control samples.

Matrix	Parameter	Sample Type	Field		Laboratory				
			Equipment Rinsate Blanks	Field Duplicates	Laboratory Control Standards	Method Blanks	Laboratory Duplicates	Matrix Spike	Matrix Spike Duplicates
Stormwater	Total Suspended Solids (TSS)	Composite	3	10% of samples	1/batch	1/batch	1/batch	NA	NA
	PSD, influent	Composite	NA	10% of samples	NA	NA	NA	NA	NA
	Dissolved Copper (Cu)	Composite	3	10% of samples	1/batch	1/batch	1/batch	1/batch	1/batch
	Dissolved Zinc (Zn)	Composite	3	10% of samples	1/batch	1/batch	1/batch	1/batch	1/batch
	Total Copper (Cu)	Composite	3	10% of samples	1/batch	1/batch	1/batch	1/batch	1/batch
	Total Zinc (Zn)	Composite	3	10% of samples	1/batch	1/batch	1/batch	1/batch	1/batch
	Hardness as CaCO3	Composite	3	10% of samples	1/batch	1/batch	1/batch	1/batch	1/batch
	Ortho-phosphate (OP)	Composite	3	10% of samples	1/batch	1/batch	1/batch	1/batch	1/batch
	Total Phosphorus (TP)	Composite	3	10% of samples	1/batch	1/batch	1/batch	1/batch	1/batch
	NWTPH-Dx	Grab	NA	10% of samples	1/batch	1/batch	1/batch	1/batch	1/batch
Sediment	Sediment PSD	Grab	NA	10% of samples	NA	NA	NA	NA	NA

11.0 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.

11.1 Data Recording & Reporting Requirements

Field data will be recorded on standard field forms (Appendix H). The field form includes the date and time, data collectors name(s), sample identification, field measurements, field observations, a checklist of samples collected for laboratory analysis, and comment field. All field measurements will be entered manually into the project database (Microsoft Access) within 24 hours of sample collection. HDR's quality assurance lead for the project 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. HDR's quality assurance lead will qualify or reject field measurements based on field DQIs and associated MPCs (Section 6.0). All files will be archived for the duration of the study on an HDR server and transferred to Spokane County after completion of the study.

Laboratory results from Anatek, SoilTest, and Budinger will report the analytical 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. HDR's quality assurance 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 6.0). A new qualifier column will be created in each EDD that represents HDRs independent data verification and will include both field and laboratory qualifiers. HDR's quality assurance 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 (archived) in a database such as Microsoft Access on HDRs server for 1-year after the technical evaluation report has been approved.

11.2 Electronic Transfer Requirements

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

11.3 Laboratory Data Package Requirements

Anatek and SoilTest will provide Level II data packages, corresponding to Stage 2A verification and validation checks (USEPA 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 (Tables 6.1 and 6.2)
- Frequency of QC samples
- Sample results are evaluated and qualified based on meeting holding times and sample-related QC results (Table 6.2)

11.4 Procedures for Missing Data

Missing data will be qualified as missing, and will have a qualifier code (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 also 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 DQI and MPC of 95% valid data collection.

11.5 Acceptance Criteria for Existing Data

No existing data will be used for this study.

11.6 Data Upload Procedures

At the end of the study, the data collected will be uploaded to the International BMP database. Additionally, a spreadsheet of all applicable data collected, including rejected or un-useable data, will be sent to the municipal stormwater permit manager with the final report.

12.0 Audits

12.1 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 project manager or principal investigator. The technical system audits will be performed by a third party. The field audit will verify that field staff are following the SOPs for sample collection, all field data are being recorded, and equipment and instruments are being maintained and calibrated per manufacturer's requirements. Results from these audits will be documented in field audit worksheets (Appendix H) 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 (6.1) 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 H) that will be prepared for each batch of samples.

In the event that a potential QA issue is identified through these audits, HDR'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.

12.2 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.

13.0 Data Verification and Usability Assessment

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

- Water quality data
- Flow measurements
- Rainfall data

13.1 Data Verification

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. Data will be reviewed 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 validation reviews will be summarized in quality assurance worksheets (Appendix C) that are prepared for each sample batch. The HDR quality assurance officer 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.

13.2 Data Usability Assessment

The HDR quality assurance officer will provide an independent review of the water quality 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 will be presented along with the data verification results in an appendix to the TER. The data usability assessment 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

- 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

14.0 Data Analysis Methods

14.1 Data Analysis Methods

14.1.1 Storm, Hydrologic, and Pollutant Information

Storm, hydrologic, and pollutant data will be compiled for each sampling event that occurred during the data collection and summarized into tables. This will include:

- Storm 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 flow rates
- Influent, effluent, and bypass average flow rates
- 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 sand filter media over a range of influent flow rates. In addition, the individual storm reports may also provide justification for why data has been included that does not meet TAPE requirements. Details regarding data that will be graphed is summarized in Section 14.2.

14.1.2 Statistical Comparisons of Pollutant Concentrations

A statistical comparison will be conducted to assess whether there was a statistically significant difference in the analytical results between the influent and effluent pollutant concentrations. This is expected to include evaluating whether the data was normally distributed using the Ryan-Joiner test (similar to Shapiro-Wilk test) (Helsel & Hirsch, 2002). Normality will be assumed if the tests produced a p-value greater than 0.05 (Ecology, 2008). If the data is normally distributed, a two-sample t-test was used to determine if there was a significant difference between the influent and effluent concentrations. If the data was non-normally distributed, a Wilcoxon rank sum test (a nonparametric analogue to the paired t-test) was used instead. The specific null hypothesis (H_o) and alternative hypothesis (H_a) evaluated are:

- H_o: Effluent pollutant concentration is equal to the influent concentration

- H_a: Effluent concentrations are less or greater than influent concentrations

The statistical comparison was based on a confidence level of 95% (α=0.05).

14.1.3 Calculation and Evaluation of Pollutant Reduction Efficiencies

The effectiveness of the BMP will be evaluated based on the average removal efficiency and mean concentration for each parameter over 12 qualifying rainfall events. This will include calculating the removal efficiency for each pollutant from each individual rainfall events using the equation below. The bootstrapping method will be used to compute the 95% confidence interval for the average removal efficiency from all rainfall events for each pollutant. The boot strapping method is the Ecology recommended method which assumes the dataset is non-normally distributed (Ecology, 2011). If analytical results provided by the laboratory included values that are non-detectable, the reporting limit for the respective pollutant will be used as defined by the standard testing method.

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

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

14.1.4 Water Quality Treatment Performance

The water quality data will be evaluated for meeting the Ecology performance goals for basic, dissolved metals, and oils treatment. The evaluation will include comparing the average removal efficiency at the 95% confidence interval and influent concentration from all rainfall events to the Ecology information noted in Table 14.1. The bootstrapping method will be used to compute the 95% confidence interval for the average removal efficiency from all rainfall events for each pollutant. If the removal efficiency is equal to or greater than the treatment performance criteria and if the average influent concentration falls within the range specified by Ecology, it will be concluded that the treatment performance criteria was met for pollutant of concern.

Table 14.1 Ecology Treatment Performance Goals

Performance Goal	Pollutant	Influent Concentration Range	Treatment Performance Criteria
Basic Treatment	Total Suspended Solids (TSS)	100-200 mg/L	80% Reduction
Dissolved Metals Treatment	Dissolved Copper (Cu)	5.0-20.0 µg/L	30% Reduction
	Dissolved Zinc (Zn)	20-300 µg/L	60% Reduction
Oil Treatment	NWTPH-Dx, visible sheen	Total petroleum hydrocarbons (TPH) > 10 mg/L	1) No ongoing/recurring visible sheen in effluent 2) Daily average effluent TPH concentration < 10 mg/L 3) Max. effluent TPH concentration of 15mg/L for a discrete sample

14.1.5 Infiltration Evaluation

The change in infiltration will be evaluated using the results from the modified falling head testing and using the influent and effluent flow rate measured by the data logger during storm events.

The SOP for the modified falling head test is described in section 8.1.8. The infiltration will be determined using the following equation.

$$f = \frac{depth\ of\ water\ at\ start\ of\ test\ (inches)}{time\ it\ takes\ water\ to\ \ completely\ infiltrate\ into\ media\ (hours)}$$

For rainfall events when the media is saturated, the infiltration rate may also be calculated as follows. The analysis should be repeated at each time interval data is recorded (5 minutes intervals) until the difference is less than 10% between three time intervals.

$$Q_{out} = fA$$

Where:

Q_{out} = effluent flow rate (cft/hr)
A = surface areas of sand filter sidewalk vault (20 sqft)
f = infiltration rate (in/hr)

The data collected will be graphed and a regression analysis will be used to establish a trend line of the rate of decline in the infiltration rate. Specifically, this data will be used (along with the sediment accumulation rate in Section 14.1.6) to identify when the field design infiltration rate (124 in/hr) may occur and subsequently identify when maintenance will need to occur to remove sediment and restore the infiltration rate.

The saturated hydraulic conductivity can be calculated from infiltration rate measurements when the depth of ponding above the sand filter media is known. For example, when the ponding depth is 18-inch (height of bypass) the gradient (i) equals the depth of ponded water (36 inches) divided by the sand filter media depth (18 inches). Using Darcy's law ($f=Q/A=iK_{sat}$), the saturated hydraulic conductivity (for this example) is twice the measured infiltration rate.

14.1.6 Sediment Accumulation Rate

Sediment accumulation will be evaluated to determine the maintenance cycle for this BMP using sediment depth measurements, dry weight of samples collected, and results from the particle size distribution testing. The approach is outlined in this section.

<u>Particle Size Distribution</u>
The sediment accumulated in the sand filter vault over the testing period will also be evaluated. PSD measurements from samples collected post testing (from on top of and in the top, middle, and bottom layers of the sand filter media) will be graphed along with pre-testing PSD measurements. The graph will be similar to Figure 3.8 and used to compare changes in the PSD from the start to end of testing.

Sediment Mass

The mass of sediment loading on top of and within the sand filter media will be estimated using the dry weights determined as part of the PSD testing. The mass of sediment on top of the BMP will be estimated by multiplying the average of the three dry weights from each of the transects (12 sqin = 1 sqft) by 20 (surface area of the sand filter). The mass of sediment within the sand filter media will be estimated by determining the change in the mass retained particularly from the smaller sieves from the PSD testing pre and post testing and then calculating the change in the total mass in the BMP (from on top and within the BMP).

Sediment Accumulation Rate

The sediment accumulation rate will be calculated to predict when the infiltration rate will decline to the design infiltration rate based on the sediment accumulated on top of the sand media. This will be done two ways first using the depth measurements (to compare with lab testing described in Section 3) and then using mass loading.

1. The sediment accumulation rate will be calculated using the total sediment depth measured on top of the BMP (equation below). Then sediment accumulation (S_{AR}) vs the respective infiltration rate measured (when the sediment depth was measured) will be graphed. A regression analysis will be used to establish a trend line. The sediment accumulation rate will also be normalized to predict when maintenance will be required at locations where the contributing basin area is different than the test-site. This will include dividing the value below by the total contributing basin area at the test site.

$$S_{AR-Depth} = \frac{sediment\ depth\ (inches)}{total\ depth\ of\ precipitation\ since\ start\ of\ study\ (inches)}$$

2. The sediment accumulation rate will be calculated using the total mass of sediment accumulation within the BMP (equation below). Then sediment accumulation (S_{AR}) vs the respective infiltration rate measured (when the sediment depth was measured) will be graphed. The sediment accumulation rate will also be normalized to predict when maintenance will be required at locations where the contributing basin area is different than the test-site. This will include dividing the value below by the total contributing basin area at the test site.

$$S_{AR-Mass} = \frac{sediment\ mass\ (pounds)}{total\ depth\ of\ precipitation\ since\ start\ of\ study\ (inches)}$$

14.2 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 shown in Figures 14.1, 14.2, and Table 14.1 and briefly described below:

- Figure 14.1 - 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 (red dashed line) to illustrate the relationship to the influent and effluent average concentrations.

- Figure 14.2 - Log-Normal Graphs are line graphs of the removal efficiency (C_{eff}/C_{in}) for each sampling event. These graphs illustrate the trend in the treatment performance over the duration of the study.

- Table 14.2 – A summary of the water quality results will be included in a table. This will include the average influent and effluent concentrations, sample size, results from the hypothesis testing, and the removal efficiency corresponding to the 95% confidence interval.

- The results from infiltration testing will be graphed to illustrating any changes over time.

- A table summarizing all the values/parameters measured for each testing event (i.e., pollutant information, storm data, hydrologic data, infiltration rate, etc.)

- A hydrograph for each storm during a sampling event that includes time and precipitation depth as well as the influent and effluent flow rates and aliquots

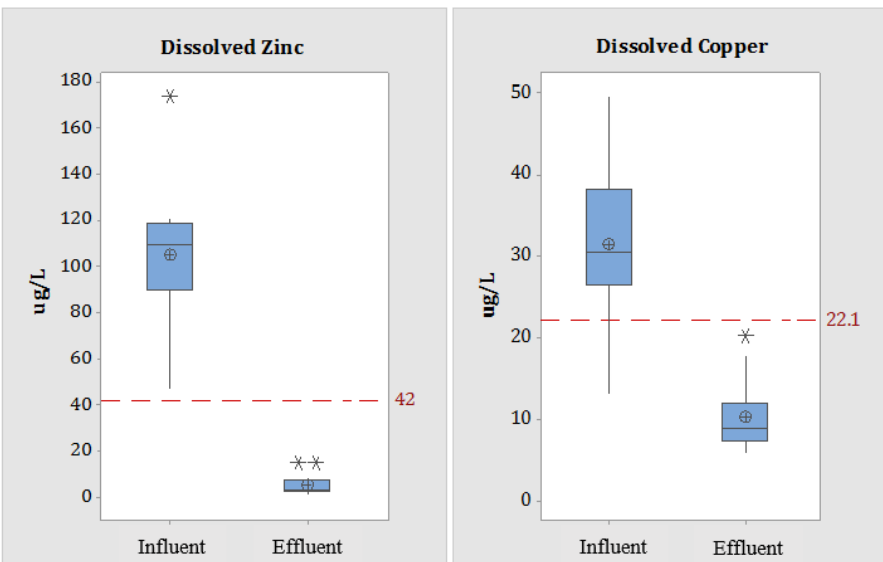

Figure 14.1 Example of Box Plots

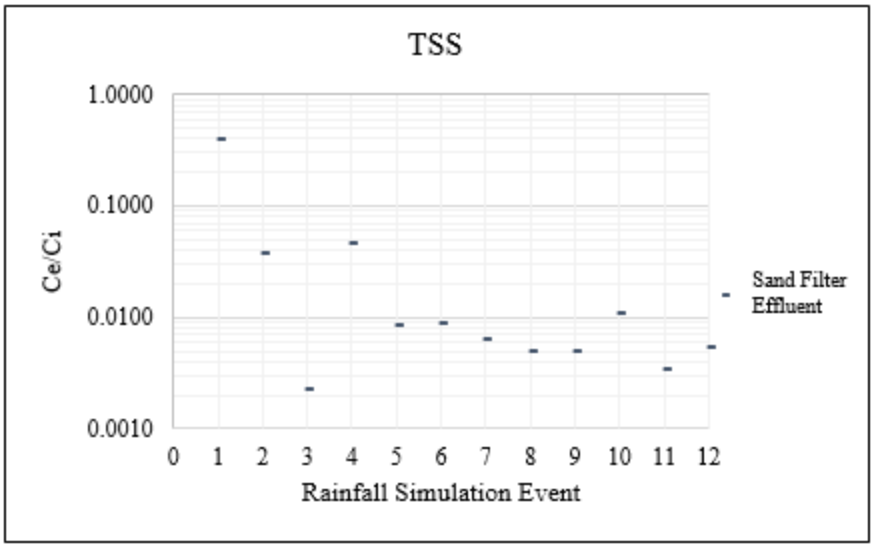

Figure 14.2 Example of Log-Normal Plot

Table 14.2 Example of Water Quality Results Summary

Column ID	Average Influent Concentration	Average Effluent Concentration	Sample Size (n)	Statistically Significant (Y/N)	95% CI Removal Efficiency	Performance Criteria	Pass or Fail
TSS	171	2.64	12	Y	92%	80%	Pass
Cu	31.57	10.42	12	Y	62%	30%	Pass
Zn	105.15	5.67	12	Y	94%	60%	Pass
TPH	7.4	8	12	N		10 mg/L; no visible sheen	Pass

**A summary of all required and screening parameters will be included in the final table*

15.0 Reporting

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

15.1 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.

- Annual Reports (Permit Section S8.B8) – the lead entity will develop the annual reports which will describe the interim results and status of the study
- Final Technical Report (Permit Section S8.B10) – the principal investigator will produce the final technical report which will summarize the results of the study and recommends future actions based on the study findings. Table 15.1 provides an outline of the final technical report. Since this study includes the goal of developing a new BMP, the final report will also be developed to meet the requirements specified in the Ecology TAPE Guidance Document section *Preparing a Technical Evaluation Report (TER)*, (Ecology, 2011).
- A Fact Sheet – a fact sheet (2-4 page) will develop that summarizes the key points of the study along with the study findings

Table 15.1 Proposed Effectiveness Study Report Content

Final Report Sections		Effectiveness Studies
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	✓
7.0	Discussion	✓
8.0	Conclusions	✓
9.0	Future Action Recommendations	✓
10.0	Appendices	✓
11.0	Third-Party Review[2]	✓

1. The Final Report will reference the noted sections in the approved QAPP (in lieu of rewriting the sections in the report). Any changes made in those sections of the study since the QAPP was approved will also be documented.
2. The principal investigator will convene a Board of External Reviewers (BER): three to five individuals (two of whom should be from Ecology) with technical skills necessary to provide a peer review of the TER. This is only required for studies with the goal of developing a new BMP.

15.2 Dissemination of Project Documents

The Final Technical Report will be shared with the participating agencies and will be posted to the Spokane County webpage (https://www.spokanecounty.org) along with a fact sheet about the study and study findings. The data collected over the duration of the study will be uploaded to the International BMP database. Additionally, a spreadsheet of all data collected, including rejected or un-useable data, will be sent to the municipal stormwater permit manager with the final report.

16.0 References

Abad, M., Noguera, P., Puchades, R., Maquieira, A., & Noguera, V. (2002). Physico-chemical and chemical properties of some coconut coir dusts for use as a peat substitute for containerised ornamental plants. *Bioresource technology*, *82*(3), 241-245.

Environmental Protection Agency. (2014). Best Practices for Continuous Monitoring of Temperature and Flow in Wadeable Streams. Washington, DC. Retrieved from: https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=NCEA&dirEntryId=280013&simpleSearch=0&showCriteria=2&searchAll=best+practices+for+continuous+monitoring&TIMSType=&dateBeginPublishedPresented=06%2F27%2F2008

Evans, M. R., Konduru, S., & Stamps, R. H. (1996). Source variation in physical and chemical properties of coconut coir dust. *HortScience*, *31*(6), 965-967.

Herrera Environmental Consultants. (2015) Analysis Of Bioretention Soil Media For Improved Nitrogen, Phosphorus And Copper Retention. Kitsap County.

Jeyaseeli, D. M., & Raj, S. P. (2010). Chemical characteristics of coir pith as a function of its particle size to be used as soilless medium. *The Ecoscan*, *4*(2&3), 163-169.

Meerow, A. (1994). *Growth of Two Subtropical Ornamentals Using Coir (Coconut Pith) as a Peat Substitute*. HortScience, 29(12):1484-1486.

Minton, G. (2012). *Stormwater Treatment* (3rd ed.). Seattle, WA: Resource Planning Associates.

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at the following link: https://websoilsurvey.sc.egov.usda.gov/. Accessed April 30, 2018.

Spokane County, City of Spokane, and Spokane Valley. (2008). Spokane Regional Stormwater Manual (SRSM). Spokane, Washington. Available online at the following link: https://www.spokanecounty.org/DocumentCenter/View/1640/Spokane-Regional-Stormwater-Manual-PDF

Washington State Department of Ecology (Ecology). (2004). *Eastern Washington Stormwater Management Manual.* Retrieved from: https://fortress.wa.gov/ecy/publications/documents/0410076.pdf

Washington State Department of Ecology (Ecology). (2006). *Guidance for UIC Wells that Manage Stormwater.* Olympia: Washington State Department of Ecology, Water Quality Program. Retrieved from https://fortress.wa.gov/ecy/publications/documents/0510067.pdf

Washington State Department of Ecology (Ecology). (2011). Technical Guidance Manual for Evaluating Emerging Stormwater Treatment Technologies: Technology Assessment Protocol – Ecology (TAPE). Olympia: Washington State Department of Ecology, Water

Quality Program. Retrieved from https://fortress.wa.gov/ecy/publications/summarypages/1110061.html

Washington State Department of Ecology (2014). Eastern Washington Phase II Municipal Stormwater Permit. Olympia, Washington. Retrieved from: https://ecology.wa.gov/Regulations-Permits/Permits-certifications/Stormwater-general-permits/Municipal-stormwater-general-permits/Eastern-Washington-Phase-II-Municipal-Stormwat-(1)

Washington State Department of Transportation (2006). Regional Precipitation-Frequency Analysis and Spatial Mapping of Precipitation for 24-Hour and 2-Hour Durations in Eastern Washington. Olympia, Washington.

Eastern Washington
Stormwater Effectiveness Studies

Detailed Study Design Proposal

Bioretention Soil Media Thickness Study

Study Classification: Structural BMP

Study Objective(s):

- ☑ Evaluate Effectiveness
- ☑ Compare Effectiveness
- ☑ Develop Modified BMP

September 28th, 2018

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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 Spokane County's website: https://www.spokanecounty.org/918/Stormwater-Utility. For questions regarding either document, please contact Matt Zarecor by email MZarecor@spokanecounty.org or phone (509) 477-7255.

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Document History

This document was developed following the Eastern Washington (EWA) Detailed Study Design Proposal and Quality Assurance Project Plan Template for Structural Best Management Practices (BMPs). A copy of the template is located on the City of Spokane Valley's website at the following web link: http://www.spokanevalley.org/content/6836/6896/6914/8301/10121/default.aspx

A Detailed Study Design Proposal (Proposal) was submitted to Ecology on June 30, 2017 and Ecology approved the Proposal via email to Spokane County on November 8th, 2017. Appendix A contains a copy of the email along with Ecology's comments on the Proposal. Appendix B contains a summary of HDR's responses to Ecology's comments including how the comments were incorporated into the Quality Assurance Project Plan (QAPP).

The study goal described in this QAPP has changed since the Proposal was approved by Ecology. Specifically, the Proposal goal was to evaluate the treatment performance of a bioretention cell that contains vegetation compared to a bioretention cell without vegetation. Both cells would have contained either the bioretention soil media (BSM) that is under development in western Washington (WWA) or the 60:40 BSM that is currently approved by Ecology. Whereas the goal of the study defined in this QAPP is to evaluate the treatment performance of a bioretention cell that contains 12-inches of the 60:40 BSM compared to a cell that contains 18-inches of the same BSM. Both study ideas were identified by the Eastern Washington Stormwater Permittees during earlier phases of the Effectiveness Studies and both studies were ranked as one of the top 14 top studies (with the same score) on the list submitted to Ecology on June 30, 2016. (Reference the weblink at the top of this page for more details about the history of the EWA Effectiveness Studies).

The study QAPP was submitted to Ecology on May 8, 2018 for their review and comment. Ecology provided their comments on the QAPP to Spokane County on August 23, 2018. Appendix C contain a copy of Ecology's QAPP approval letter and a summary of Ecology's comments along with HDR's responses to the comments including how the comments were incorporated into the final QAPP document. The final QAPP was submitted to Ecology on September 28, 2018.

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2.0 Executive Summary

Current bioretention research suggests that TSS and dissolved metals removal typically occurs in the top 6-inches of the bioretention soil media (BSM) mix. Additionally, studies have indicated that the BSM leaches nutrients and that the higher the content of compost the higher the concentration of nutrients leaching from the media. Because of these findings, there is an interest in reducing the BSM depth from the 18-inches required by Ecology to a 12-inch depth. The goal of this study is to develop a modified bioretention BMP that uses the existing 60:40 bioretention mix to a minimum depth of 12 inches (rather than the current required 18-inch depth) for providing treatment of TSS and dissolved Cu and Zn. Evaluation of the modified BMP will be based upon:

- Pollutant removal efficiency of the 60:40 BSM mix at a depth of 18-inches compared to 12-inches.
- Change in the infiltration rate and saturated hydraulic conductivity of each cell over the duration of the study
- Achievement of treatment performance goals for basic (TSS) and metals (dissolved Cu and Zn) by comparing study results to the Technology Assessment Protocol Ecology (TAPE) treatment performance goals

The goals for this study will be achieved by conducting field testing two bioretention cells with 18-inch and 12-inch depths of BSM. The field testing will involve using automated equipment to collect data at a site at Gonzaga University 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 12 qualifying storm events over two wet seasons starting in 2018. If the evaluation objectives can be met, the results from this study will be used to justify the development of a modified BMP that can be used on future projects, and subsequently lower the cost of bioretention construction.

3.0 Introduction and Background

3.1 Introduction to the Structural BMP

Bioretention cells are a common structural stormwater best management practice (BMP) in Spokane County (Figure 3.1). 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) (Figure 3.2). Treated stormwater then infiltrates into the existing soils beneath the bioretention cell or is collected in an underdrain and conveyed to a storm drain network.

Figure 3.1. Example of a Bioretention area in the City of Spokane

The BSM mix specified in the Eastern Washington (EWA) LID Manual is composed of 60% sand and 40% compost by volume. This mix is approved by Ecology to provide runoff treatment for total suspended solids (TSS) and dissolved metals, copper (Cu) and zinc (Zn), to the level specified in the EWA Phase II NPDES MS4 Permit (Ecology, 2014). The primary treatment mechanisms responsible for reducing pollutants include sedimentation, as particles settle on the surface of the BMP; filtration, as runoff infiltrates into the BSM mix and particulates become physically trapped in the media pore spaces; and sorption, of dissolved metals onto the surface of organic materials amended into the BSM mix.

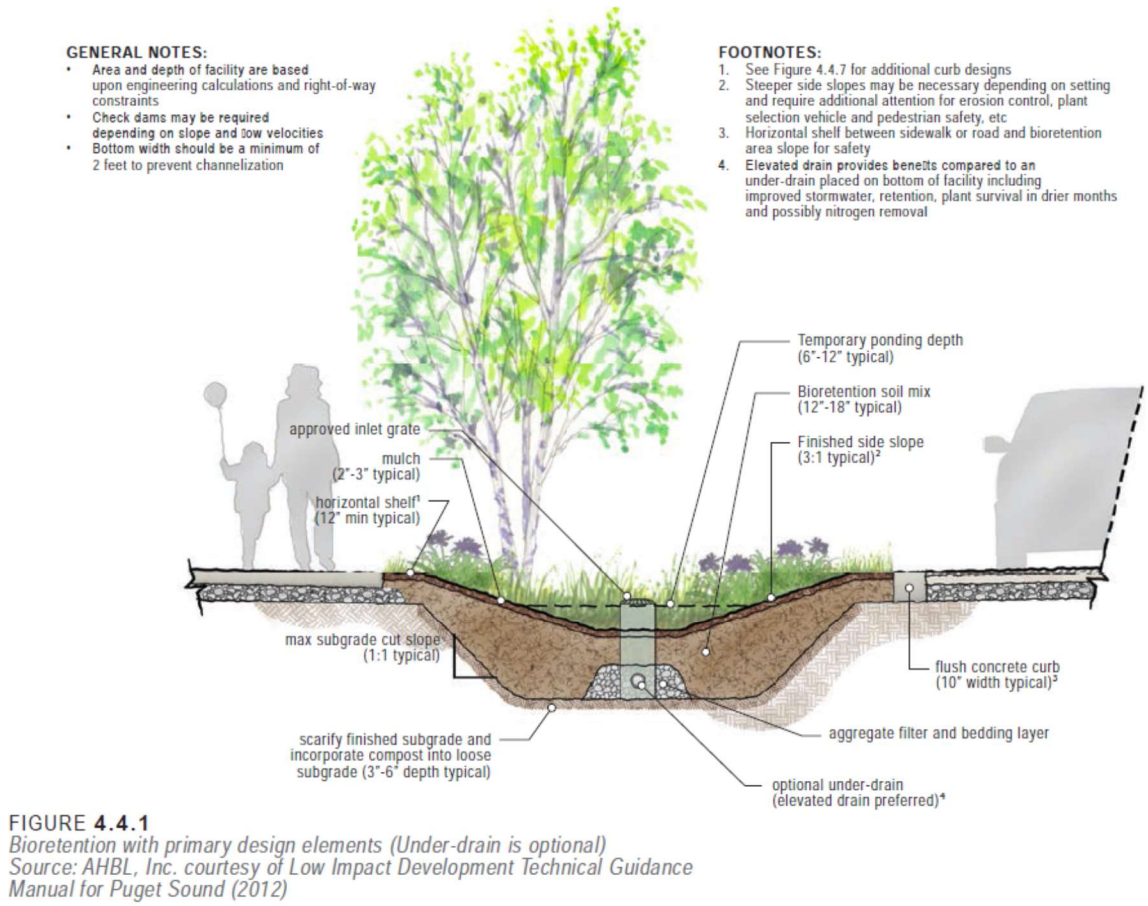

FIGURE **4.4.1**
Bioretention with primary design elements (Under-drain is optional)
Source: AHBL, Inc. courtesy of Low Impact Development Technical Guidance Manual for Puget Sound (2012)

Figure 3.2. Typical bioretention cell design (AHBL & HDR, 2013)

3.2 Background and Problem Description

The test-site for the proposed effectiveness study is located on the campus of Gonzaga University. The site was constructed in 2014 for the purpose of conducting bioretention soil media stormwater effectiveness studies. The study described in this QAPP specifically focuses on evaluating the effectiveness of a bioretention cell that contains a 12-inch depth of the 60:40 BSM mix compared to a cell that contains 18-inches of the 60:40 BSM. The effectiveness is based on the treatment performance of the different depths for reducing concentrations of TSS and dissolved metals (Cu and Zn). The 18-inch depth was selected because it is the minimum required by Ecology for bioretention cells. The study was proposed because a thinner depth mix would reduce costs associated with constructing bioretention cells. Furthermore, bioretention research suggests that TSS and dissolved metals removal typically occurs in the top 6-inches of the BSM mix. These findings support the theory that a 12-inch depth of BSM is sufficient when TSS and dissolved metals are the target pollutant (Hatt, 2008; Hunt & Lord, 2006; Davis, 2001).

Research conducted on the 60:40 mix in western Washington indicates that the media is leaching nutrients (Ecology, 2013; Ecology, 2016). Research has also demonstrated a relationship between the quantity of organic matter (i.e. compost) and nutrient leaching. Specifically, the higher the content of compost the higher the concentration of nutrients leaching from the media (Erickson et al., 2007; Minnesota Pollution Control Agency, 2014). As such reducing the depth of the BSM

from the Ecology required 18-inch depth to the modified 12-inch depth is expected to reduce the quantity of nutrients leaching from the media.

3.3 Results of Prior Studies

The test site proposed for this study is located on the campus of Gonzaga University and consists of two bioretention cells located immediately adjacent to each other (Reference sections 4.2, 7.1, and 7.2 for a detailed description of the test site). Each cell contains the same type and configuration of the 60:40 BSM, except one cells contains a 12-inch thick BSM layer and the other contains an 18-inch BSM layer. Since construction in 2014, civil engineering students from Gonzaga University have been collecting water quality samples at the test site. Between 2015 and 2017, flow weighted composite samples (influent and effluent) were collected using a fire hose or synthetic stormwater to simulate rainfall events. In the fall of 2017 automated samplers were installed at the test-site allowing the students to collect flow weighted samples during natural rainfall events.

Results from all three years of data collection (n=10) are included in Appendix K. Specifically, plots of the pollutant reduction ratio (effluent concentration C_e divided by the influent concentration C_i) for TSS, dissolved metals (Cu and Zn), total phosphorus (TP), and nitrate-nitrite (NO3-NO2) are included. Some trends observed in the data include:

- The TSS and Cu pollutant reduction trend appears to improve with time
- Nutrient leaching (phosphorus and nitrate-nitrites) appears to declines with time

Data collected during the natural rainfall events is summarized in Table 3.1. There was a total of three storm events monitored (n=3) and for each event one influent and two effluent samples (one from the 12-inch cell and one from the 18-inch cell) were collected. Each storm event met the conditions for qualifying rainfall events defined in the Technology Assessment Protocol Ecology (TAPE) (Ecology, 2011) except for two events in which the rainfall depth was lower (0.07- and 0.08-inches) than the minimum 0.15-inches. In addition, the influent concentration for each parameter during each event was within range defined by TAPE.

The data was analyzed by conducting a statistical comparison of the pollutant concentrations and by calculating the average percent removal for each parameter ((Ci-Ce)/Ci*100%). The differences between the influent and effluent concentrations were compared, along with the difference between the effluent concentrations from each cell, to determine whether there is a significant difference in the data sets using a two sample t-test. Because of the very small sample size, p-values of both moderately significance ($p \leq 0.1$) and high statistical significance (≤ 0.05) were considered. As noted in table 3.1 there is a moderate to high significance between the influent and effluent concentrations for all parameters except for nitrate-nitrite. In addition, the difference between the effluent concentrations from the two cells is insignificant for all parameters. These results suggest that the BSM is reducing pollutant concentrations of TSS and dissolved metals (Cu and Zn) and that the depth of the BSM (12-inch compared to 18-inch) does not significantly influence the treatment performance for these parameters. These results also suggest that both the 12-inch and 18-inch cells can meet the Ecology treatment performance goals defined in TAPE (Table 14.1) for TSS and dissolved Cu. While neither cell met the treatment performance goals for

dissolved Zn, the sample size is very small (n=3) and more data (minimum n=12) is needed to more accurately assess whether the performance goals can be achieved.

Table 3.1 Summary of Results from Water Quality Monitoring this Year (n=3)

Target Pollutant	Cell Effluent	Average (mg/L)		Normal Distribution (Y/N)	Percent Removal	p-value	Statistically Significant? (Y/M/N)	Ecology Treatment Goals Met
		Influent[2]	Effluent					
TSS	12-inch	26	2	Yes	92.3%	0.091	Moderately	✓
	18-inch		3	Yes	86.8%	0.103	Moderately	✓
	12-inch vs 18-inch					0.270	No	
Cu[1]	12-inch	0.0052	0.0023	Yes	47.5%	0.086	Moderately	✓
	18-inch		0.0018	Yes	59.5%	0.049	Yes	✓
	12-inch vs 18-inch					0.189	No	
Zn[1]	12-inch	0.040	0.022	Yes	43%	0.053	Moderately	×
	18-inch		0.020	Yes	48%	0.080	Moderately	×
	12-inch vs 18-inch					0.448	No	
TP	12-inch	0.072	0.297	Yes	-344%	0.049	Yes	×
	18-inch		0.304	Yes	-359%	0.048	Yes	×
	12-inch vs 18-inch					0.152	No	
NO_3-NO_2	12-inch	0.163	0.138	Yes	10.2%	0.423	No	N/A
	18-inch		0.181	Yes	-15.8%	0.638	No	N/A
	12-inch vs 18-inch					0.204	No	

1. The values reported for Cu and Zn represented the dissolved fraction of each parameter.
2. Influent concentrations were within the TAPE limits for all samples except TP samples and two Cu samples (0.004 mg/L) which was slightly below the TAPE influent limit (0.005 mg/L).

3.4 Regulatory Requirements

The Eastern Washington Phase II Municipal Stormwater Permit issued to the Spokane County by the Washington State Department of Ecology (Ecology) requires the Stormwater Management Program Effectiveness Studies. Specifically, *each city and county permittee listed in the permit shall collaborate with other permittees to select, propose, develop, and conduct Ecology-approved studies to assess, on a regional or sub-regional basis, effectiveness of permit-required stormwater management program activities and best management practices*. Spokane County proposes to serve as the lead entity for the following effectiveness study: Bioretention Soil Media Thickness Study. Section S5.B.5 of the permit (Ecology, 2012) is specifically addressed by this investigation.

- S5.B.5 requires permittees to implement and enforce a program to address post construction stormwater runoff to the municipal separate storm sewer systems (MS4) from new development and redevelopment projects.

4.0 Project Overview

4.1 Study Goal

The goal of this study is to develop a modified bioretention BMP that uses the existing 60:40 bioretention mix to a depth of 12-inches (rather than the current required 18-inch depth) for providing treatment of TSS and dissolved Cu and Zn. The results of this study will be used to justify approval of the 12-inch BSM as on future projects where treatment of pollutants regulated under Ecology's treatment performance criteria (i.e. basic and dissolved metals) is required per the NPDES Municipal Stormwater Permit (Ecology, 2011).

4.2 Study Description and Objectives:

The goal of this study will be accomplished through field monitoring and sampling following the modified TAPE process summarized in the Eastern Washington Effectiveness Study QAPP Template for Structural BMPs. The test-site is located at Gonzaga University which consists of a dual-cell bioretention area that contains 18-inches and 12-inches of the 60:40 mix in each cell (Figure 4.1). An automated monitoring system is installed at the test-site which collects flow weighted composite samples, rainfall depth, and flow rate (influent and effluent). 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 3 composite flow weighted water quality samples for each rainfall event (one influent and two effluent) as well as 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). Samples of the BSM mix were collected when the site was constructed and will be submitted to an Ecology certified lab for analysis to characterize the physiochemical properties. Testing is expected to occur over two wet seasons.

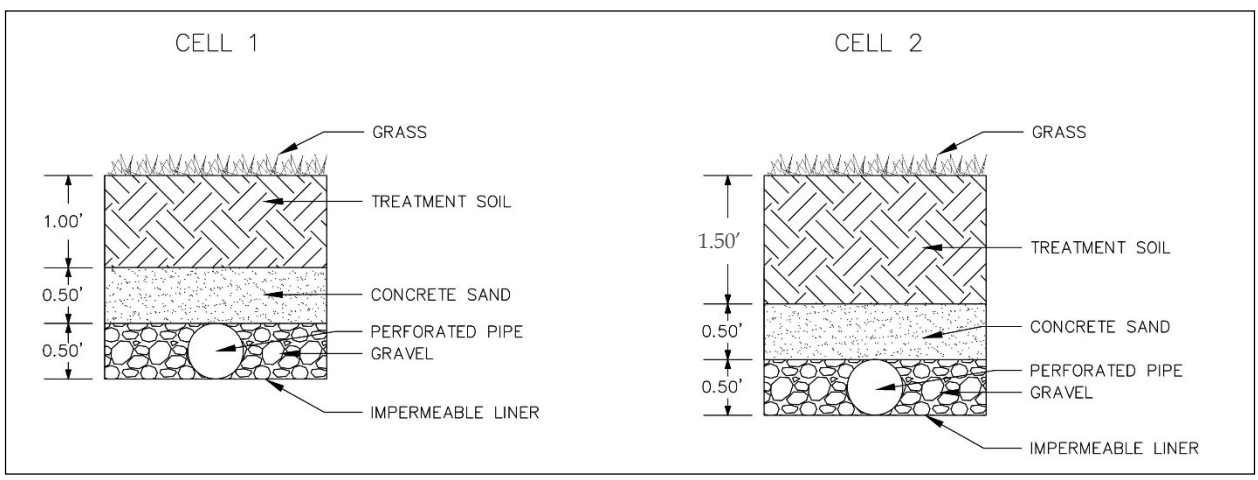

Figure 4.1 Cross Section of the Bioretention Cells: 12-inch BSM (cell 1) and 18-inch BSM (cell 2)

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

- Determine the pollutant removal efficiency of the 60:40 BSM mix at a depth of 18-inches compared to 12-inches

- Determine the change in the infiltration rate and saturated hydraulic conductivity of each cell over the duration of the study
- Determine whether the treatment performance goals were achieved for basic (TSS) and dissolved metals (Cu and Zn) by comparing study results to TAPE treatment goals
- Summarize the study results into a final report and submit the report to Ecology for approval of the modified BMP

4.3 Study Location

The test-site location is in the City of Spokane on the campus of Gonzaga University. Specifically, it is located south of the Rudolf Fitness Center, east of Luger Soccer Field, and north of the Law School. An aerial photograph of the test-site is shown in Figure 4.2. The contributing basin area is 0.42 acres of a paved parking lot and 0.08 acres from sidewalks and the access road to the parking lot. The basin area is delineated in Figure 4.3.

Figure 4.2 Aerial View of Test-Site Location

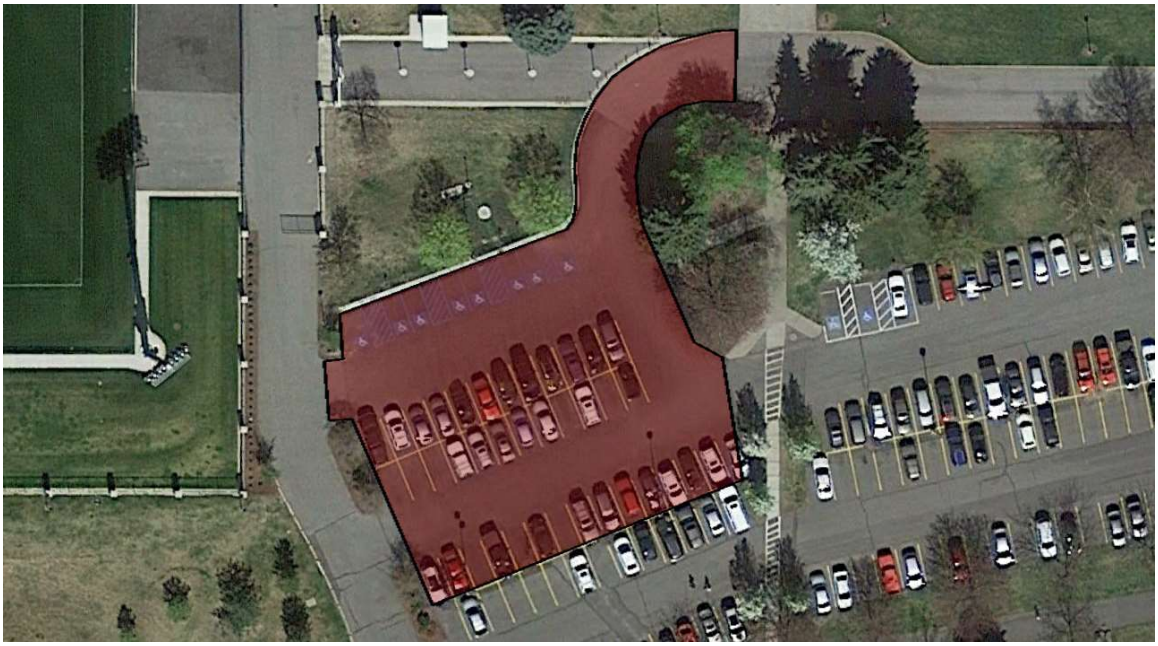

Figure 4.3 Contributing Basin Area

4.4 Data Needed to Meet Objectives

The data needed to complete this study is summarized in Tables 4.1. The water quality parameters to be tested to demonstrate that the BMP meets performance goals are summarized in Table 4.2.

Table 4.1 Data Needed to Meet Objectives

Data Type	How Data Will Be Collected	Purpose
BSM media physiochemical properties	Samples of the BSM material collected during construction will be sent to the lab for analysis	Identify physiochemical properties of the media
Precipitation	A rain gauge connected (via cable) to the data logger at the test site; data downloaded from 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 4.2)	Auto-samplers collect composite flow weighted samples when triggered by the data logger	Quantify parameters influent & effluent concentrations; assess media depth effectiveness
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	Collect pH, temperature measurements from small amount of composite sample	Quantify influent & effluent pH; verify sample is at or below 6°C for laboratory analysis
Saturated hydraulic conductivity	Falling head test (See Section 8.1.8 for SOP)	Calculate BSM infiltration rate

Table 4.2 Summary of Water Quality Testing (per TAPE requirements)

Performance Goal	Required Parameters	Required Screening Parameters
Basic	TSS	PSD, pH, TP, orthophosphate, hardness, total and dissolved Cu and Zn
Dissolved metals	TSS, hardness, total and dissolved Cu and Zn	PSD, pH, TP, orthophosphate

4.5 Tasks Required to Conduct Study

Tasks required to conduct the study include:

- **Experimental Design – Task Complete**
  - Develop Detailed Study Design Proposal
    - Submit Proposal to Ecology for review and approval; respond to comments
  - Develop and apply for GROSS Grant funding
    - Submit Grant to Ecology for review and scoring
- **Monitoring Equipment – Task Complete**
  - Design, select, and order monitoring equipment
  - Install equipment at the test-site
  - Develop and provide monitoring equipment training for the sampling staff
  - Develop standard operating procedures (SOPs) for operating, maintaining, and calibrating equipment
- **Quality Assurance Project Plan (QAPP) – Task Complete**
  - Develop QAPP (this document) and respond to Ecology Proposal comments
    - Submit QAPP to Ecology and advisory panel for review; respond to comments
- **Advisory Review Panel**
  - Convene an advisory review panel to provide a peer review of the QAPP and technical evaluation report (required for studies with the goal of developing a modified BMP)
- **Technical Advisory Group (TAG) Meetings**
  - Schedule 4 meetings with TAG for the purpose of discussing the project status, upcoming tasks, and soliciting input from the TAG on the study documents
- **Prepare for Data Collection:**
  - Program and install monitoring equipment
  - BSM material testing
  - Maintain bioretention cells including cleaning catch basins upstream of cells at the test-site
- **Data Collection and Analysis:**
  - Test BSM media
  - Track and select storms (daily)
  - 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 12 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, influent, and effluent flow rate), analyze data
  - Conduct falling head testing twice a year
  - Develop and manage a database that contains all the collected data
- **Develop Technical Reports:**
  - Develop annual reports
  - Develop technical evaluation report (TER)
  - Develop study fact sheet
  - Submit TER to Ecology and advisory panel for review; request approval for bioretention area with 12-inch BSM to be functionally equivalent to bioretention area with18-inch BSM

4.6 Potential Constraints

Potential constraints are conditions that may impact the project schedule, budget, or scope. The potential constraints identified in this section, 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.

4.2 Summary of Potential Constraints and Mitigation Approaches

Potential Constraint	Mitigation Approach
Spills: oil or other chemicals	Large spills could impact the BMP treatment performance; 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
Insufficient qualifying rainfall events	Extend monitoring period or collect data from lower depth (<0.15-inches) rainfall events
Campus facilities using fertilizer at test-site	Educate campus facilities about the study and adjust their maintenance practices
Campus facilities placing landscaping waste near the test-site	Educate campus facilities about the study and adjust their maintenance practices
Monitoring equipment malfunctions	Frequent inspection of equipment and review system output variables after each storm for any anomalies. If problems are encounters, equipment will be fixed promptly.

5.0 Organization and Schedule

The purpose of this section is to describe who is responsible for completing the tasks, when the tasks will be completed, and how the study will be funded.

5.1 Key Project Team Members: Roles and Responsibilities

Table 5.1 Key Project Team Members: Roles and Responsibilities

Name & Organization	Role	Contact Information
Matt Zarecor Spokane County	Lead Entity	509.477.7255 mzarecor@spokanecounty.org
Bill Galle Spokane County	Lead Entity TAG Member[6]	509.477.7261 bgalle@spokanecounty.org
Ethan Murnin Spokane County	Lead Entity[1] TAG Member[6]	509.477.7420 emurnin@spokanecounty.org
Ryan Cochran Spokane County	Lead Entity TAG Member[6]	509.477.7413 rdcochran@spokanecounty.org
David Haws Yakima County	Participating Entity TAG Member[6]	509.574.2277 David.Haws@co.yakima.wa.us
Chad Philips City of Spokane Valley	Participating Entity TAG Member[6]	509.720.5013 cphillips@spokanevalley.org
Seth Walker Walla Walla County	Participating Entity TAG Member[6]	509-524-2715 swalker@wwcountyroads.com
Rob Buchert City of Pullman	Participating Entity TAG Member[6,9]	509-338-3314 rob.buchert@pullman-wa.gov
Randy Meloy, City of Yakima	Participating Entity TAG Member[6]	509.576.6606 Randy.Meloy@yakimawa.gov
Bill Aukett City of Moses Lake	Participating Entity TAG Member[6]	509.764.3792 baukett@cityofml.com
Brian Olle, City of Pasco	Participating Entity TAG Member[6]	509.545.3445 olleb@pasco-wa.gov
Brandi Lubliner Ecology	Ecology Reviewer[11]	360.407.7221 abst461@ecy.wa.gov
Adriane Borgias Ecology	Ecology Reviewer[11]	509.329.3515 abor461@ecy.wa.gov
Doug Howie Ecology	Ecology Reviewer[11]	360.407.6444 doho461@ecy.wa.gov
Kathy Sattler Anatek Laboratories	Laboratory Manager[5]	509-838-3999 technical@anateklabs.com
Stephen Burchett Budinger & Associates	Laboratory Manager[5]	509-535-8841 tballard@budingerinc.com
Aimee Navickis-Brasch HDR, Inc.	Principal Investigator[2]	(509)343-8515 aimee.navickis-brasch@hdrinc.com
Taylor Hoffman-Ballard HDR, Inc.	Researcher[3] Sampling Staff[4,8]	509.343.8477 taylor.hoffman-ballard@hdrinc.com
Gonzaga University Civil Engineering Students	Sampling Staff[4,8]	Changes each academic year. *See notes about sampling staff[4] below.*

1.

1. Lead Entity Project Manager – Responsible for ensuring the study is conducted as described in this QAPP. The Project Manager is the primary point of contact for the lead entity.
2. Principal Investigator – Responsible for developing an Ecology approved Proposal and QAPP. Serves as the primary point of contact for the laboratory manager, the project manager, sampling staff, the auditor, the TAG Members, the Advisory Review Panel and the students. Responsible for conducting the study as defined in the Ecology approved QAPP. Responsible for submitting the study documents to Ecology including the Proposal, QAPP, and Final Technical Report. 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.
3. Researcher - Responsible for assisting the Principal Investigator.
4. Sampling Staff – 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. *Each year a team of three 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.*
5. 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 6.0); 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.
6. Technical Advisory Group (TAG) Member - The goal of the TAG is to provide insight, suggestions, and professional opinions to the Principal Investigator and Lead Entity throughout the study. The primary responsibilities of TAG members include: attending project meetings (by webinar or in person) and participating in the meeting discussion; review/comment on research materials (i.e. QAPP, data collected, data analyzed, final report, etc.) prior to submitting the documents to Ecology.
7. Technical Advisory Group (TAG) Lead – Responsible for organizing/scheduling meetings with the TAG members and distributing the project/meeting documents prior to the meeting. During meetings the TAG lead is responsible for ensuring that the TAG member's comments are heard and addressed as well as developing/distributing meeting notes of any actions items from the meeting.
8. Data Verifiers - Data verifiers will review the analyzed data and verify the analysis is correct and that the data being analyzed matches the data collected. *See Section 11.0 of this document.*
9. Financial Support – Responsible for providing the lead entity with some level of financial support toward the cost of the study.
10. Auditor - Responsible for conducting audits to verify the study conforms to the plan and procedures as defined in *Section 12.0* of this document. This may include: verifying staff collecting the data are trained and follow SOPs for data collection; verifying data management procedures are followed including reviewing data records to ensure they are consistent, correct and complete, with no errors or omissions; and traveling where the data is stored to review the data records compared to the QAPP Data Management Plan. Auditors will report their findings directly to the lead entity Principal Investigator and Lead Entity.
11. Ecology Reviewer – Responsible for reviewing and approving the study documents: the Proposal, QAPP, and Final Report.

5.2 Project Schedule

A task timeline based on monthly activities is shown in Table 5.2.

Table 5.2 Proposed Study Timeline

Task Name	2017			2018				2018	2019				2020			
	Q2: Apr-Jun	Q3: Jul-Sept	Q4: Oct-Dec	Q1: Jan-Mar	Q2: Apr-Jun	Q3: Jul-Sept		Q4: Oct-Dec	Q1: Jan-Mar	Q2: Apr-Jun	Q3: Jul-Sept	Q4: Oct-Dec	Q1: Jan-Mar	Q2: Apr-Jun	Q3: Jul-Sept	Q4: Oct-Dec
Experimental Design							Study will be implemented no later than 15 months after QAPP Approval[1]									
Proposal Development																
Ecology Proposal Review																
GROSS Grant - Develop & Apply																
Ecology Grant Review																
Monitoring Equipment																
Design, Select, & Order Equipment																
Equipment Installation																
Equipment Training																
Develop Equipment SOPs																
QAPP																
QAPP Development																
Ecology QAPP Review																
Respond to Ecology Comments																
Advisory Review Panel																
Convene Advisory Board																
Advisory QAPP Review																
Respond to QAPP Comments																
TAG Meetings								1	2			3		4		
Data Collection & Analysis																
Technical Reports																
Annual Reports																
Technical Evaluation Report (TER)																
Study Fact Sheet																
Ecology & Advisory Review																
Respond to TER Comments																

1. The schedule was developed assuming the maximum time specified (90 days) for the Ecology QAPP review period as defined in S8.B.6 of the NPDES permit (Ecology, 2014b).

Note: dark gray squares indicate task is complete and light gray squares indicate tasks not complete.

5.3 Budget and Funding Sources

Spokane County intends to pay for the study with financial contributions from participating entities.

Table 5.2: Study Budget

Task	Labor & Expenses	Equipment & Lab Fees	Total
Project Management	$17,000	$0	$17,000
Monitoring Equipment[1,4]	$24,100	$10,000	$34,100
QAPP Development[1]	$17,300	$0	$17,300
Data Collection and Analysis[2,3,6]	$31,800	$10,000	$41,800
Gonzaga Senior Design Fees[5]	$12,000	$0	$12,000
Reporting: Technical Evaluation Report[2]	$26,700	$0	$26,700
		Total	$148,900

1. The cost for developing the detailed study design proposal was paid for by the 2015-2017 Ecology GROSS Grant titled the *Eastern Washington Effectiveness Study Development Phases 2 & 3*.
2. The task budget includes hours for coordinating with Ecology, the advisory panel, and for managing the Technical Advisory Group (TAG).
3. Budget assumes Spokane County staff will maintain the test-site. The cost for this work is not included in the table.
4. The majority of the monitoring equipment described in the QAPP was purchased prior to the start of this study. This task includes the cost for purchasing replacement parts and consumable materials (such as tubing), installing equipment, and developing standard operating procedures (SOPs) for operating the equipment.
5. Task includes the cost to sponsor two senior design teams at Gonzaga University for two year ($6000 per year for a total of $12,000). The budget assumes senior design students will collect and process 8 samples as well as conduct K_{sat} testing. The remaining 4 samples will be collected and processed by the consultant.
6. Task includes the cost to maintain and calibrate the equipment, manage and analyze the data, conduct QC reviews and audits, and laboratory fees for water quality and BSM material testing.

6.0 Quality Objectives

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 study.

The purpose of a QAPP is to ensure that the data collected during the study 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 study is embedded throughout the QAPP and emphasizes how the data quality indicators (DQIs) and respective measurement performance criteria (MPCs) are addressed during the study.

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 study. 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 (Ecology, 2004):

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

Once established, 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. Table 6.1 first defines each DQI, then the approach for addressing DQIs and the respective MPCs for this study are described.

Reference Section 13.0 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.

Table 6.1 Summary of the Data Quality Indicators (DQIs) and Measurement Performance Criteria (MPC) for Structural BMP Studies

Precision DQIs for This Study	Precision MPCs for This Study
Precision – A measure of agreement among repeated measurements of the same property taken under identical or substantially similar conditions (EPA, 2006; Erickson, 2013; EPA, 2002). 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).	
Develop and consistently following SOPs for collecting samples and measuring data will reduce the potential of collecting imprecise data.	An audit (Section 12.0) 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 6.2.	If the results of the duplicate sampling meet the respective relative percent difference (RPD) for the parameters listed in Table 6.2, the results of the analytical testing will be considered acceptable. Reference Section 6.1.
Rain gauge and flow measurements will also be assessed.	If the flow measurements and rain gauge data meet the RPD defined in section 6.1, that data will be considered acceptable. Reference Section 6.1.
Bias DQIs for this Study	**Bias MPCs for This Study**
Bias – 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).	
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 8.0, per in manufacturer's specifications. An audit (Section 12.0) will be conducted to verify sampling staff are following the calibration procedures.
Lack of maintenance at the site can be a source of bias in sample values or measurements. For example, if ISCO tubing is not cleaned regularly, sediment, oils, etc. can accumulate in the tubing and affect sample results. For that reason, manufacturer's recommendations for maintenance frequency and procedures will be followed to reduce the potential for bias.	An audit (Section 12.0) will be conducted to verify that sampling staff are following the SOPs outlined in Section 8.0 (written to match manufacturer's specifications).

SOPs defined in Section 8.0 will be followed when collecting samples and measuring data to limit bias.	An audit (Section 12.0) will be conducted to verify that sampling staff are following the SOPs outlined in Section 8.0.
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 6.2. *Note: the percent recovery for matrix spikes is defined in section 6.2.*
Representativeness DQIs for This Study	**Representativeness MPCs for This Study**
Representativeness – 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).	
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 seen throughout the wet season.	Local stormwater hydrologic conditions are represented by conducting the study over two wet seasons and collecting data from a minimum of 12 qualifying storm events (described in Section 7.5).
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.	

Completeness DQIs for This Study	Completeness MPCs for This Study
Completeness - The amount of valid data needed to be obtained during the study to meet the project objectives (Ecology, 2004).	
A minimum of 12 qualifying rainfall events (Section 7.5) are required to be sampled for the duration of the study, per TAPE. Additionally, at least 10 aliquots and 75% of the hydrograph must be sampled during the 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 study.	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 11.0. 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 SOPs outlined in Section 8.0, to limit the possibility of missing or invalid data.	An audit (Section 12.0) will be conducted to verify that sampling staff are following the SOPs outlined in Section 8.0 (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 and Chain of Custody are located in the appendix of this document.
Comparability DQIs for This Study	**Comparability MPQs for This Study**
Comparability - 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.	
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 study area is defined in section 7.2: the process focused on having a test site that is representative of locations where a bioretention cell would be installed.
Define and consistently follow SOPs for sample collection and field measurements	SOPs were developed and will be consistently followed during this study

All data and sample collection will be conducted in accordance with the SOPs outlined in Section 8.0.	An audit (Section 12.0) will be conducted to verify that sampling staff are following the SOPs outlined in Section 8.0.
Standard testing methods will be used to analyze samples submitted to the lab.	Anatek, the laboratory proposed for water quality testing in this study, is certified by Ecology and will follow standard methods approved by the US Environmental Protection Agency (EPA) (APHA et al. 1992, 1998; US EPA 1983, 1984). The methods to be used are listed in Table 9.1. Deviations from methods will be noted on analytical reports.
Sensitivity DQIs for This Study	**Sensitivity MPQs for This Study**
Sensitivity - The capability of a method or instrument to discriminate between measurement responses representing different levels of the variable of interest (EPA, 2002).	
Analytical results for water quality samples will be reported if they are above the reporting limit.	Reporting limits for water quality parameters are listed in Table 9.1. Data reported as below the detection limit will be calculated 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 9.1.
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 G.

6.1 *Precision*

Water quality sample and measurement precision will be assessed using laboratory and field duplicates. Precision for laboratory and field duplicates will be ± 20 percent for all other water quality parameters. The exception is pH which has a RPD of ± 10 percent for field duplicates and there is no RPD for laboratory duplicates (Table 6.2). In all cases, the RPD of duplicate samples will be calculated using the following equation:

$$\text{RPD} = \frac{|C_1 - C_2|}{\bar{x}} \times 100\%$$

Where: RPD = relative percent difference
C_1 = concentration (or value) of original sample
C_2 = concentration (or value) of duplicate
$\bar{x}$ = mean of samples

Rain gauge and flow measurement precision will be assessed at the beginning and end of the study. The rain gage precision will be assessed by pouring a known quantity of water into the tipping bucket two times. Precision for the rain gage measurements will be ± 20 percent RPD. Precision for flow will be assessed by comparing repeated pressure measurements with a known depth of water over each of the respective pressure transducers. Precision for pressure transducer measurements will be ± 20 percent RPD.

6.2 *Bias*

Bias will be assessed based on analyses of method blanks, rinsate blanks matrix spikes, and control standards (Table 6.1). Method blank values will not exceed the reporting limit. Rinsate blank values will not exceed two times the reporting limit. The percent recovery of matrix spikes will be ± 25 percent for total phosphorus, ortho-phosphate, hardness, and total and dissolved metals. Duplicate matrix spikes will also be run on a portion of the samples. The laboratory control sample recovery will be ± 20 percent for total phosphorus, ortho-phosphate, hardness, and total and dissolved metals. Percent recovery (%R) for matrix spikes will be calculated using the following equation:

$$\%R_m = \frac{(X_s - X_o)}{C_s} \times 100\%$$

Where: $\%R$ = percent recovery
X_s = spike sample result
X_o = original sample amount
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:

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

Where: %R = percent recovery
M = measured value
T = true value

6.3 *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 Study is representative of an area which would preclude the use of a bioretention cell (see Section 7.2, Test-Site(s) Selection Process). Local stormwater hydrologic conditions are represented by conducting the study over two wet seasons and collecting data from a minimum of 12 storm sampling events. Qualifying storm events are described in Section 7.5. 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 6.2 Measurement Performance Criteria (MPC) for Water Quality and Sediment Data

Matrix	Parameter	Units	Method	Method Blank	Rinsate Blank	LCS Recovery (Percent)	MS Recovery (Percent)	MSD (RPD)	Field Duplicate (RPD)[1]	Laboratory Duplicate (RPD)
Water Quality	Total Suspended Solids (TSS)	mg/L	SM 2540D	<RL	<2X RL	80 - 120	N/A	NA	≤20%	≤20%
	Particle Size Distribution (PSD)	%	ASTM D3977-97[2]	NA	NA	NA	NA	NA	≤20%	≤20%
	pH	std. units	EPA 150.1	NA	NA	NA	NA	NA	≤10%	N/A
	Dissolved Copper (Cu)	µg/L	EPA 200.8 (ICP/MS) or SM 3125 (ICP/MS)	<RL	<2X RL	70 - 130	75-125	≤20% or ± 2 x RL	≤20%	≤20%
	Dissolved Zinc (Zn)	µg/L		<RL	<2X RL	70 - 130	75-125	≤20% or ± 2 x RL	≤20%	≤20%
	Total Copper (Cu)	µg/L		<RL	<2X RL	70 - 130	75-125	≤20% or ± 2 x RL	≤20%	≤20%
	Total Zinc (Zn)	µg/L		<RL	<2X RL	70 - 130	75-125	≤20% or ± 2 x RL	≤20%	≤20%
	Hardness as CaCO3	mg/L	SM 2340B (ICP)	<RL	<2X RL	70 - 130	75-125	≤20% or ± 2 x RL	≤20%	≤20%
	Ortho-phosphate (OP)	mg/L	SM 4500-P G	<RL	<2X RL	80 - 120	75-125	≤20% or ± 2 x RL	≤20%	≤20%
	Total Phosphorus (TP)	mg/L	SM 4500-P F	<RL	<2X RL	80 - 120	75-125	≤20% or ± 2 x RL	≤20%	≤20%

1. The relative percent difference will be less than or equal to the indicated percentage for values greater than 5 times the reporting limit, and ± 2 times the reporting limit for values less than or equal to 5 times the reporting limit.
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

7.0 Experimental Design

7.1 Study Design Overview

This is a paired study with two bioretention cells that were constructed immediately adjacent to each other at the test-site. Each cell contains the same type and configuration of BSM, except one cells contains a 12-inch thick BSM layer and the other contains an 18-inch BSM layer (Figure 4.1). The BSM in each cell was installed in the fall of 2014. The site also includes 2 catch basins, an influent sampling sump, a manhole (effluent sampling), and equipment storage vault (Figures 7.1 and 7.2). Runoff from a parking lot is collected in a catch basin inlet located on the south end of the cells, which overflows into a covered sump that contains the influent piping with the pressure transducer (PT). Runoff discharges into a second covered catch basin located between the cells (influent sampling). Runoff is distributed equally to each cell through stormdrains 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 PTs are located and samples are collected (Figure 7.2).

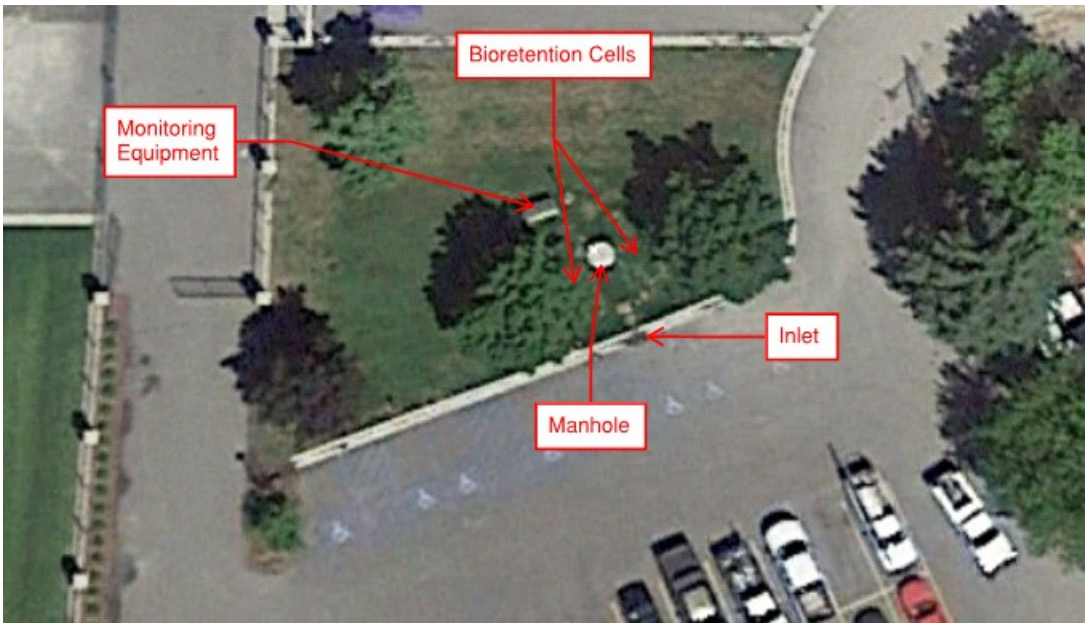

Figure 7.1 Aerial View of Test Site

Figure 7.2 Influent sampling sump (left), manhole-effluent sampling (middle), and weir (right)

Major components of the monitoring system are shown in Figure 7.2 and are defined below. The connections between these components and other instrumentation are shown in Figure 7.3.

- A rain gauge, adjacent to the monitoring vault, captures rainfall and relays precipitation data to the data logger
- Pressure transducers continuously measure flow upstream of the Thel-Mar weirs located in the influent and effluent pipes and transmit stage data to the data logger
- A data logger is located in the monitoring vault and triggers sampling at the automated samplers dependent on qualifying rainfall event criteria. For example, sample collection starts and ends when the storm start and end conditions occur (see Section 7.5).
- Three automated samplers stored inside the monitoring vault collect flow weighed composite samples from the influent pipe in the influent sampling sump (Figure 7.2) and from the effluent pipes in the manhole (Figure 7.2)

Composite samples from the influent and two effluent pipes will be collected from a minimum of 12 qualifying rainfall events (see Section 7.5 for details on qualifying events). Samples will be tested for the required parameters (each sampling event) and screening parameters (minimum 3 sampling events) in order to demonstrate treatment performance goals for basic and dissolved metals (Table 14.1). Testing is expected to occur over a minimum of 2 wet seasons.

Samples of the BSM, installed in the cells and stored since the test-site was constructed, will be submitted to the lab for analysis. The material physiochemical properties of the samples will be tested (at an Ecology certified lab) to verify that media meets the specification for the selected BSM mix. Section 7.9 provides more details on material testing.

Saturated hydraulic conductivity (K_{sat}) testing will occur twice per year using a falling head test. The cell will be filled using a fire hydrant and the rate of fall will be measured using yard sticks. The purpose of the K_{sat} testing is to monitor changes in the rate over the duration of the study. K_{sat} will also be measured using the effluent flow data as described in Section 14.0.

The focus of the study is to evaluate the influence of BSM depth on the runoff treatment performance of the cells. This will include statistically comparing the effluent concentrations from each cell to determine whether the treatment performance of the cell with a 12-inch BSM layer is significantly different than that of the cell with an 18-inch BSM layer for reducing TSS and dissolved metals (Cu and Zn). In addition the removal efficiency from the 12-inch BSM soil will be compared to the TAPE treatment goals to determine whether the 12-inch BSM cell achieved Ecology's treatment goals for basic and dissolved metals.

The final report will be submitted to Ecology at the end of the study and the annual reports will be included in Spokane County's annual stormwater report. For the pollutants in which the treatment goals are met, the final study report (TER) will be submitted to Ecology and the advisory review panel to request a '*functional equivalent*' designation for bioretention cells with 12-inches of BSM.

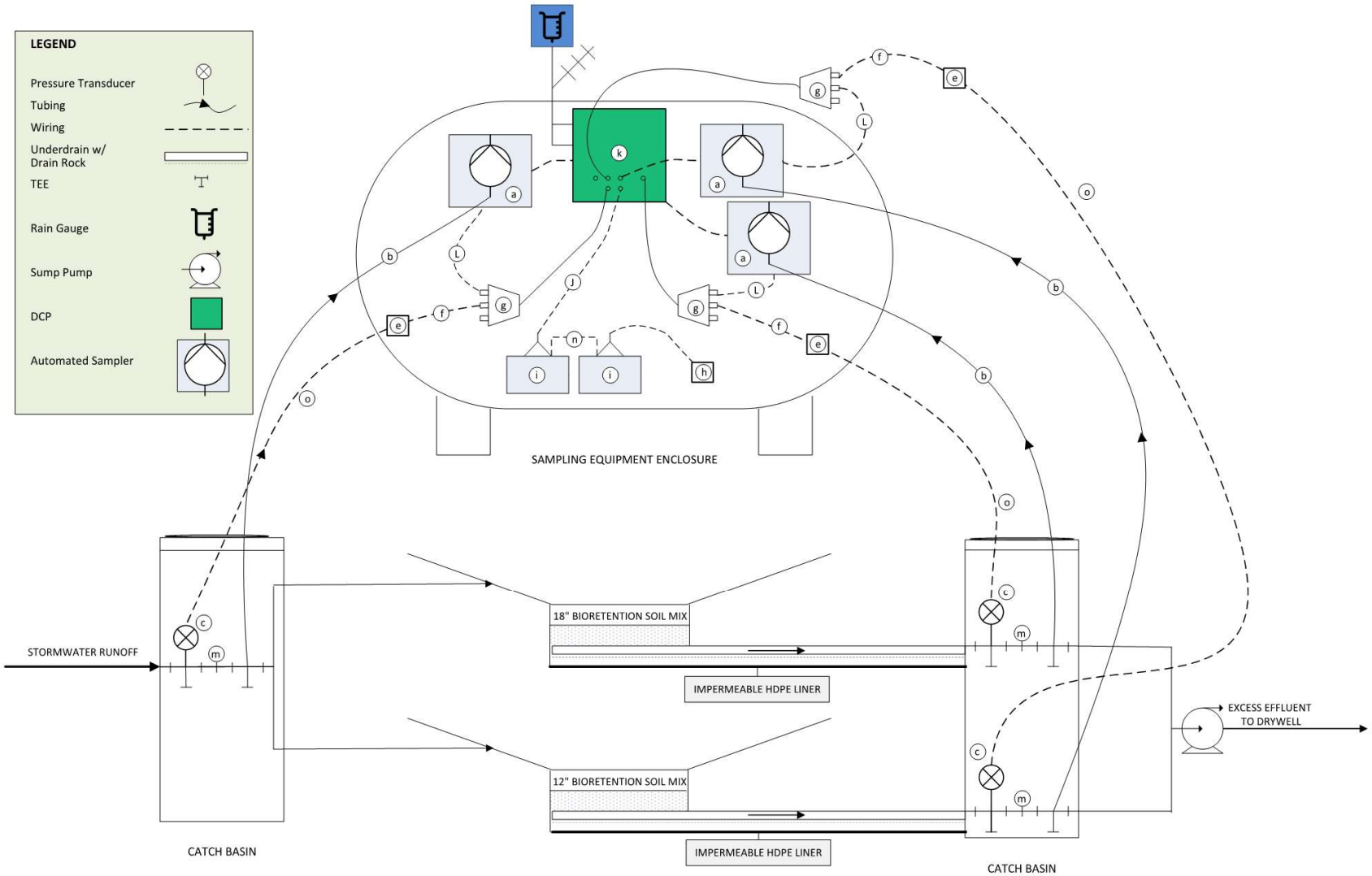

Figure 7.3 Process Diagram of Monitoring System

Table 7.1 Summary of Monitoring Equipment and Instrumentation

Symbol	Equipment 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 dessicant 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, SDI Connectors 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 samplers and data logger	2
j	Battery Cable, Dual 10A Fuse, F6 & H2, 8.5ft	Connects data logger and samplers 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	Volumetric Weir 6"	Used to measure influent and effluent flow rates	3
n	Cable, Two Batteries in Parallel	Connects two 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 presssure transducer to the datalogger. This cable terminates at the junction box (humidity absorber).	2

7.2 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. A copy of the construction plan sheets is located in Appendix E. This site 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, 2013). As such, it is 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 14.1).

7.3 The Structural BMP System Sizing

The bioretention cells were designed following the design guidance from the EWA LID Manual (AHBL & HDR, 2013) and the Ecology Stormwater Management Manual for Western Washington (Ecology, 2014). The following is a summary of the cell design methods, assumptions, and results. Table 7.2 provides a summary of the cell sizing and a copy of the BMP sizing calculation are located in Appendix D.

- Both cells are 7-feet wide by 18-feet long by 2.5-feet deep
- The cells were sized to contain the water quality event (6-month 24-hour event) to a depth of approximately 6-inches and contain runoff from the 25-year 24-hour storm with between 0.5- to 1-foot of freeboards above the max ponding depth
- A single event model was used to size the cells using the Type 1A rainfall distribution
- Rainfall depths: 6-month 24-hour (1”) and 25-year 24-hour (2.20”)
- The contributing basin area (0.50 AC) was modeled assuming half of the runoff from the contributing basin area is distributed to each cell (0.25 AC per cell)
- BSM Infiltration rate: 3-inches/hour
  Note: 3 inches/hour was calculated from the Ecology proposed 12 inches/hour using the correction factor appropriate for the size of the site (4).
- The bioretention cells were modeled assuming the BSM has a 40% porosity. As such the live storage volume is the bottom of the BSM (as opposed to the bottom of the cell or the top of the BSM)
- BSM depth: one of the cells was modeled with 18-inches of BSM (as defined in the Ecology approved design guidance) while the other cell was modeled with 12-inches of BSM

Table 7.2 Summary of Bioretention Cell Sizing

Biotention Cell ID	Event	Effluent Peak Q (cfs)	Live Storage Elevation[1] (ft)	Max Pond Depth[2] (ft)	Bottom of Pond Elevation[3] (ft)	Max Ponded Elevation[4] (ft)	Vol (cf)	Time to Empty (hr)
12-inch Cell	6m 24hr	0.0143	99.00	1.64	100.00	100.64	152.43	2.00
	25yr 24hr	0.0243		3.00		102.00	547.34	6.17
18-inch Cell	6m 24hr	0.0145	98.50	2.02	100.00	100.52	155.98	2.50
	25yr 24hr	0.0246		3.45		101.95	549.72	6.50

1. The live storage elevation represents the bottom of the BSM. This is because the BSM was modeled assuming a 40% porosity (AHBL & HDR, 2013).
2. The max ponding depth represents the ponding depth starting at the bottom of the BSM.
3. The bottom of pond elevation represents the top of the BSM or the bottom of the cell.
4. The max ponded elevation represents the ponding depth starting at the bottom of the cell (or the top of the BSM).

7.4 Type of Data Being Collected

Sampling process design has been developed based on monitoring requirements identified in the Eastern Washington NPDES Phase II Permit (Ecology, 2014) and in TAPE (Ecology, 2011). This section addresses the steps and processes taken to develop these monitoring sites and sampling strategies and to ensure the data collection and monitoring methods satisfy the requirements of TAPE and the permit. Table 7.3 provides a summary of the type of data that will be collected along with the frequency of data collection, sampling method, and the sampling location.

Table 7.3 Overview of Monitoring Variables

Parameters	Frequency	Sampling Method and sampling location
Rainfall	Continuous[1], year-round	Rain Gage, on-site
Stage (Discharge)	Continuous[1], year-round	PT: influent and effluent
Temperature	Continuous[1], year-round	PT: influent and effluent
Time	Continuous[1], year-round	PT: influent and effluent
TSS, Metals, Hardness	Storm events (min. of 12 events)	Composite with Autosampler, Influent and effluent
OP, TP, pH	Storm events (min. of 3 events)	Composite with Autosampler, Influent and effluent
PSD	Storm events (min. of 3 events)	Composite with Autosampler, influent
Saturated Hydraulic Conductivity	Twice per year (4 times total)	Falling head test; fill cells using fire hydrant, measure rate of fall with yard sticks; Calculate infiltration rate using average effluent flow rate
BSM materials	Once, prior to start of study	Grab Sample; BSM installed at the test site (stored since the cell was constructed) will be tested

1. Measured in 5-minute intervals when storms are monitored and 15-minute intervals during all other times.

The study is expected to last two wet seasons. Water quality samples will be collected during a minimum of 12 qualifying rainfall events (see Table 7.4 for definition of qualifying rainfall

events). This will include collecting flow weighted composite samples from the influent and the effluent. Composite samples collected will represent 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 (12 minimum samples) and screening parameters (three minimum samples) as defined in TAPE in order to demonstrate treatment performance goals for basic and dissolved metals.

The discharge flow rate for the influent and effluent are calculated by the data logger using stage values measured by the pressure transducers (PTs) combined with weir equations specific to the pipe diameter. Weirs are located downstream of the PT in the influent and effluent pipes. 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 (Rantz at al, 1982; USEPA, 2002c). However, weirs tend to be more influenced by debris than flumes (Church et al., 2003) and need to be carefully monitored and maintained. An equations for the weir was derived specifically for the size of weir (based on the pipe diameter) using depth and flow data provided by the manufacturer. The equation is programmed into the data logger logic and used to calculate the discharge flow rate at each time interval using the stage (feet) measured by the PTs. Flow over the weirs at the site (see Figure 7.2) is calculated from the following equations provided by the manufacturer for the 6-inch weirs (in the influent and effluent pipes):

6-inch Weir: $Q = 6085.1 \times (d_{PT})^{2.5756}$

Where:

Q=flow rate (liters per minute)

d_{PT}=depth measured at pressure transducer (feet)

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. Hydrographs and hyetographs will be created from the collected rain gage and discharge data to accurately compare and relate the two parameters.

7.5 Precipitation Monitoring

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

7.5.1 Storm Event Prediction

Sampling should be attempted for storms that are predicted to meet the storm event guidelines defined in TAPE (Ecology, 2011 p. 14). These events are referred to as 'qualifying rainfall events' in this document which have the characteristics defined in Table 7.4.

Table 7.4 Storm Event Guidelines for TAPE Monitoring

Parameter	Definition	Guideline [1]
Minimum storm depth	Total rainfall amount during the storm event	0.15 inches
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 hour)	Range of rainfall intensities[2]

1. Will provide justification in the Technical Evaluation Report (TER) for storm event data that does not meet the storm event guidelines, but is included in the data analysis. Currently the data logger is programed to only collect samples during qualifying events.
2. To assess performance on an annual average basis and performance at the system's peak design rate, samples will be collected over a range of rainfall intensities.

The National Oceanic and Atmospheric Administration's (NOAA) National Weather Service, Spokane forecast office website will be monitored daily for storm forecasts. (http://graphical.weather.gov/sectors/otx.php). These observations will determine if a predicted storm will meet the qualifying event criteria in which sample collection will occur. The SOPs for selecting and tracking a storm are defined in Section 8.1.1.

7.5.2 Rainfall Measurements

Precipitation monitoring will be conducted to quantify rainfall during storm events and to measure the duration, intensity and distribution of rainfall throughout a discrete storm event. Precipitation will be monitored in 15 minute increments by the data logger. 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.

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 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. Rain gage placement followed the National Weather Service specifications (http://www.weather.gov/om/coop/standard.htm) for the site.

If a deviation from NWS specification are needed, a notation will be made regarding the alteration and included in the TER. Rain gages will be mounted to the antenna mast approximately 6-8 feet from the ground unless otherwise specified. The rain gage will be calibrated prior to installation and maintained in accordance with the manufacturers' specifications.

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. In order to determine when sampling crew need to deploy for sample collection, actual precipitation at a weather station approximately 0.75 miles southeast of the test site will be monitored during storm events (https://www.wunderground.com/personal-weather-station/dashboard?ID=MTPERR). During each station visit, 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 for each storm event or during the maintenance schedule.

7.6 Water Quality Sampling

Two methods will be used for water quality sampling depending on the parameter that will be tested: grab sampling and composite sampling. This section describes the methods for both. Figure 7.3 includes a process drawing of the monitoring system.

7.6.1 Grab Sampling

Grab samples are typically those collected manually in jars or measured in situ with a probe. For this study, only in situ measurements will be taken. pH and temperature are the required in situ measurements at the site. Both will be collected from a small amount of the composite sample in the autosampler for both influent and effluent. If grab samples are not collected or are missed during qualifying storm events, allowable non-qualifying sized storm events may be sampled to ensure statistical requirements are met. An allowable non-qualifying storm means that only the stormwater rainfall depth can be the reason the storm is non-qualifying. Samples collected from non-qualifying storms will be noted and flagged in the dataset.

7.6.2 Composite Sampling

TAPE specifies that stormwater runoff must be collected by in-situ flow-weighted composite sampling. Autosamplers such as an ISCO or a similar product will be used at each of the monitoring stations to collect stormwater samples during a qualifying storm event. Autosamplers are programmed to begin sampling at the predetermined rates required for the collection of at least 75 percent of the event hydrograph. Sample collection into autosampler bottles will be triggered by the characteristics of a 'qualifying rainfall event' as described in Section 7.5 and Appendix L. Specifically, the data logger is programmed to only trigger collection of samples by the autosampler when qualifying conditions occur. If conditions fall outside the limits of a qualifying event, the data logger is programmed to stop sampling. The characteristics (i.e., water temperature, rainfall, discharge, and time) are necessary to determine whether the antecedent criteria and rainfall criteria required by TAPE were met, stormwater runoff is occurring and the water is not frozen. Water temperature, rainfall, and discharge will be measured using external probes connected to the data logger. Time will be measured by the data logger itself. If these four thresholds are not met during the storm, samples will not be collected.

7.7 Saturated Hydraulic Conductivity Testing

The saturated hydraulic conductivity of the bioretention ponds will be measured twice a year using a falling head test. This will include filling the cells with water using a fire hose. Then measuring the rate of fall using yard sticks installed in the cells. The infiltration rate of the BSM will be calculated using following each qualifying storm event using the effluent flow rates and using effluent flow rates measured during the falling head test.

7.8 Influent Sediment Particle Size Distribution

Composite samples of sediment will be collected from the influent by the autosamplers at the site. The samples will be sent to the laboratory for determination of the particle size distribution (PSD).

7.9 BSM Material Testing

The BSM will be tested once prior to the start of data collection. BSM material installed in the bioretention cells when the cells were constructed has been stored in a sealed container. Samples will be collected from the container and submitted to the lab for analysis of the parameters described in Table 9.1.

The purpose of the testing is to verify that materials properties are consistent with the properties defined in the selected BSM specification. The testing anticipated for this study is summarized in Table 9.1. Please note: the compost component of the bioretention media was tested prior to installation and met Ecology requirements for the media.

8.0 Sampling Procedures

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

8.1 Standard Operating Procedures

Water quality samples will be collected in the field, following standard operating procedures (SOPs). The SOPs 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. All visits to the site should be conducted with a partner or multiple personnel. SOPs included in this section are:

- Storm Selection and Tracking
- Storm Monitoring Equipment Maintenance
- Preparing Stormwater Monitoring Equipment for Storm Sampling
- Stormwater Grab Sampling – Not Used for This QAPP
- Stormwater Sample Collection and Processing
- Monitoring Equipment Data Download
- Accumulated Sediment PSD Sample Collection– Not Used for This QAPP
- Falling Head Test

8.1.1 Storm Selection and Tracking

The purpose of this SOP is to define the procedures for selecting and tracking 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 H) to record the decision process, weather activity, and outcome of the event

Summary of procedures 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 7.5 of this document. Storm event probability will be tracked via the NOAA National Weather Service Spokane forecast office website at the following link: http://graphical.weather.gov/sectors/otx.php
- 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 (0.15-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 project manager 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 lab will be notified and equipment will be prepared in accordance with the procedures outlined in Section 8.1.3.
- Step 5: Prior to and during a storm event that is selected for sampling, actual precipitation will be monitored remotely via the nearest available weather station to the site through Weather Underground (weatherunderground.com), a website which presents forecast, actual, and historical weather data. The actual precipitation data presented on Weather Underground will be used to determine when sampling personnel will go to the site to collect composite samples.
  - The nearest available weather station (https://www.wunderground.com/personal-weather-station/dashboard?ID=MTPERR) is located approximately 0.75 miles southeast of the site.

8.1.2 Storm Monitoring Equipment Maintenance

The purpose of this SOP is to outline the steps required for maintaining stormwater sampling equipment at the test site. Maintenance of storm monitoring equipment will occur once in early fall, prior to the first monitoring event of the wet season, and monthly between monitoring events..

Equipment needed:

- Personal Protective Equipment (PPE) including: eye protection, gloves, high visibility vest, work boots, etc.
- Cordless drill and drill bits needed to open catch basin lids
- Periodic Maintenance Checklist Field Form (Appendix H)
- Wet-dry vacuum
- Soft brush

- Volt meter
- USB drive
- Screwdriver
- Replacement suction, head, and pump tubing
- Volumetric plastic beaker
- Adjustable wrench
- Telescopic mirror
- Torpedo level
- Flashlight
- Replacement battery
- Spare desiccant bags (for ISCO and PT)
- Electronic water level indicator (tapedown tool)
- Nitrile gloves
- Cellular phone

Summary of procedures for initial inspection of site conditions and monitoring equipment 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 (Field Form) in Appendix H.
- Step 2: Access the monitoring equipment vault, manhole, sump, and catch basins. Visually inspect pipes, cables, wiring, tubing, and monitoring equipment. Note any frayed wires or damaged equipment on the Periodic Maintenance Checklist Field Form. Contact principal investigator or project manager on how to proceed if damage is significant. *Note: When accessing the equipment in the manhole and catch basin, 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 or sediment are observed in pipes, tees, or weirs, clean pipes according to Steps 3 – 5 in Section 8.1.3. Then immediately replace the grate inlet.
- 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 Periodic Maintenance Checklist and reconnect power to the battery.
    - If battery voltage is not within the specified range, replace battery with the spare, fully charged 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 14, 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 three months, 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. Note any discrepancies and reset level of rain gage platform if needed. Replace cover on rain gage and plug rain gage back in to the data logger.

- Step 7: Inspect ISCO suction tubing, head tubing and pump tubing for wear. Note and describe condition on the Periodic Maintenance Checklist. 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.
- 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 Periodic Maintenance Checklist.
    - 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 Periodic Maintenance Checklist.
    - 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 Periodic Maintenance Checklist.
        - 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 PT humidity absorbing systems. Record the observed color on the Periodic Maintenance Checklist.
    - 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 on the Periodic Maintenance Checklist.
- 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 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: 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.
    - 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.

8.1.3 Preparing Stormwater Monitoring Equipment for Storm Sampling

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

Equipment:

- Cordless drill and drill bits needed to open catch basin lids
- Telescopic mirror
- Adjustable wrench
- Torpedo level
- Volt meter
- Flashlight
- Wet-dry vacuum
- Soft brush
- Water source or 5 gallon bucket (with lid) filled with tap water

- Cleaning solutions for tubing (10% HNO3 acid solution, liquinox soap solution) in 5-gallon buckets (one for each solution) with lids
- 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
- 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
- Clean, powder-free nitrile gloves
- Personal Protective Equipment (PPE) including: eye protection, gloves, high visibility vest, work boots, etc.
- Electronic water level indicator (tape down tool)
- Cellular phone
- Pre-Storm Event Maintenance Checklist, Chain of Custody Form

Summary of procedures to prepare monitoring equipment 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 monitoring equipment vault, manhole, sump, and catch basins. Start a visit report on the data logger according to Step 5 in Section 8.1.2. *Note: In accordance with "clean hands/dirty hands" procedures, one staff member will be designated to install new ISCO composite bottles in Step 16. This staff member may not handle other equipment during the site visit. Additionally, 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 equipment vault and catch basin, do not disturb pipes or pipe tees*.
- Step 4: Before starting to clean, collect a water surface elevation measurement from the reference point on the control tee. Record the measurement and reference elevation on the Pre-Storm Event Maintenance Checklist in the assigned space. Assign a + or – value to your reading if there is any uncertainty due to debris, blockage, etc. Subtract the measurement from the reference elevation to determine water surface elevation and record

the value on the form. Compare this value to the measurement collected by the data logger to identify any prior instrument drift.

- Step 5: 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.
- Step 6: Inspect the pump, suction, and head tubing for the ISCO. If kinks or bellies are observed in the tubing, replace the tubing. Clean any ISCO tubing that was not replaced as follows:
    - Triple rinse the tubing with 10% HNO3 acid solution, then wash the tubing with liquinox soap solution, and finally triple rinse the tubing with DI water.
- Step 7: Put on a new pair of clean nitrile gloves and obtain the sample bottles provided for the rinsate blank.
- Step 8: 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 9: Replace the cap on the sample bottle, taking care to not touch the inside of the cap.
- Step 10: Repeat Steps 8-9 for the 12" and 18" effluent autosamplers and associated rinsate blank bottles.
- Step 11: Once the rinsate bottles have been filled, place bottles in the cooler and fill out the Chain of Custody form for the rinsate samples.
- Step 12: 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 Pre-Storm Event Maintenance Checklist.
- Step 13: Inspect pressure transducers (PT) and mounts. If PTs and/or mounts are dirty, remove PT 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 14: 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 PT reading. The PT reading may take a few minutes to update.
- Step 15: Once the PT reading updates, verify using the data logger that the PT reading value is zero. Take another water surface elevation reading using the electronic water level indicator to verify the PT 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 or project manager of the drift as soon as possible.
- Step 16: 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 17: Add ice to the around the sample bottles after they are replaced to ensure the samples remain cold prior to pick up.
- Step 18: Make sure all tubing is connected properly, bulkhead caps are secured and that cables are properly attached.

- Step 19: Before leaving the site, set the data logger and ISCO autosampler mode to sample if the criteria for qualifying rainfall event (see Section 7.5) 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 20: Additionally, set the threshold on the data logger to tell the system when to trigger influent and effluent sampling.
    - The threshold is determined through the spreadsheet calculator described in Appendix L.
    - 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 value determined from the spreadsheet calculator in Appendix L is entered for both the influent and effluent thresholds.
- Step 21: Once all maintenance, cleaning, and calibration has been completed, end the visit report on the data logger (according to Step 14 in Section 8.1.2), close the monitoring equipment vault, manhole, sump, and catch basins, and secure as needed before leaving the site. Return rinsate samples and associated Chain of Custody to Anatek Laboratory in Spokane.
- Step 22: Upon returning to the HDR lab, obtain the pH meter and turn on the meter. Put on nitrile gloves and eye protection.
- Step 23: Inspect the electrode for cracks in the electrode stem or bulb. If scratches or cracks are present, the electrode must be replaced.
- Step 24: 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 25: 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 26: Inspect connectors and ensure they are clean and dry. Rinse off any deposits with deionized water.
- Step 27: 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 28: 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.
- Step 29: 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 30: 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 31: 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 32: Once the pH value is stable, confirm the reading and record on the Pre-Storm Event Maintenance Checklist.
- Step 33: 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 34: 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 35: 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.

8.1.4 Stormwater Grab Sampling – Not Used for This QAPP

8.1.5 Stormwater Sample Collection and Processing

The purpose of this SOP is to outline the steps required for pH measurement and sample collection and processing at the test site.

Equipment:

- Cordless drill and drill bits needed to open catch basin lids
- USB flash drive
- Electronic water level indicator (tape down tool)
- Cellular phone to enable communication between staff and project manager or principal investigator
- Flashlight
- Volt meter
- Torpedo level
- pH meter
- 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
- Chain of custody form (Appendix I), sample tag, Sample Collection Field Form (Appendix H)

Summary of procedures for preparation of stormwater sampling equipment prior to monitoring and sampling.

- 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 monitoring equipment vault, manhole, sump, and catch basins . Start a visit report on the data logger according to Step 5 in Section 8.1.2. *Note: In accordance with "clean hands/dirty hands" procedures, one staff member will be designated to handle sample bottles, collect samples, and package samples for the lab during a sampling event. This staff member may not handle other equipment during the sampling event. Additionally, 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 and return the bottles to the bag after collection of samples.* Step 4: Measure the water surface elevation using the electronic water level indicator. Note the current water surface elevation measurement on the field form.
- Step 5: Check the ISCO and data logger to verify that the ISCO has completed its sampling and/or 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 6: 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 (i.e., if the number of aliquots reported is 20, and very little to no water is present, there has been a malfunction).
- Step 7: Pour some of the 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.
- Step 8: Replace the lid on the composite jar with a lab-cleaned, solid lid.
- Step 9: Remove jar from the ISCO and place the composite sample into a plastic bag within the cooler for transport to the HDR lab.
- Step 10: Check the pH reading to see if it has stabilized. If it has, record the pH and temperature reading on the field form. If not, wait for the reading to stabilize before recording pH and temperature 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.
- Step 11: End the visit report (according to Step 14 in Section 8.1.2) after all samples have been collected and the ISCO indicates that the program has been reset.
- Step 12: When ready to leave the site, close the monitoring equipment vault, manhole, sump, and catch basins, and secure as needed before leaving the site.
- Step 13: Return to the HDR lab. Composite samples are transported to the HDR lab prior to Anatek to transfer composite samples in ISCO bottles to the laboratory-specified bottles listed in Table 8.1 and to filter samples for dissolved metals and ortho-phosphate analysis.

    - 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 14: Place the filled laboratory bottles in the plastic bags provided by the lab, and place the plastic bag(s) in the cooler.
- Step 15: Fill out the Chain of Custody for the samples according to the procedures outlined in Section 8.5. Measure the temperature in the cooler using the thermometer and record the temperature on the Chain of Custody form.
- Step 16: 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.

8.1.6 Monitoring Equipment Data Download

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

Equipment:

- Cordless drill and drill bits needed to open catch basin lids
- USB flash drive
- Cellular phone to enable communication between staff and principal investigator or project manager
- Flashlight
- Personal Protective Equipment (PPE) including but not limited to: high visibility vest, gloves, work boots, etc.
- Monitoring Equipment Data Download Field Form

Summary of procedures for download of data from 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 field form.
- Step 2: Open the monitoring equipment vault.
- Step 3: Insert USB flash drive 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 the monitoring vault.

8.1.7 Accumulated Sediment PSD Sample Collection– Not Used for This QAPP

8.1.8 Falling Head Test

The purpose of this SOP is to outline the steps required to perform a falling head test on the BSM in the bioretention cell.

Equipment needed:

- Tools necessary to access fire hydrant and hose
- Personal Protective Equipment (PPE) including but not limited to: high visibility vest, gloves, work boots, etc.
- At least 4 yard sticks
- Timer
- Falling Head Test Field Form (Appendix H)
- Fire hose

Summary of procedures 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: 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 (yard sticks will be used to verify that 12 inches has been reached). Allow time for the media to become saturated. If needed use the fire hose to fill the water level in the cells back up to just above 6-inches.
- Step 3: Once the water level reaches 6-inches and start the timer.
- Step 4: Recording the time for water to drop 1-inch on the Falling Head Field Test Form. Continue recording time until K_{sat} is stable which is defined as when the value does not change more than 10% for 3 intervals.
- Step 5: Close and secure the monitoring vault and manhole before leaving the site.

8.2 Containers, Preservation Methods, Holding Times

Clean sample bottles and associated preservatives will be provided by Anatek Laboratory and Budinger (PSD only) in Spokane, WA, according to Table 8.1. 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 8.1 Sample Containers, Preservative, and Holding Times

Matrix	Parameter	Method	Sample Container & Amount Required	Preservative	Pre-filtration Holding Time	Total Holding Time
Water Quality	pH	pH meter	NA	NA	NA	NA
	PSD, influent	Modified SSC: ASTM D3977-97	Plastic; 1L	NA	NA	NA
	Total Suspended Solids (TSS)	SM 2540D	Plastic; 125 mL	Cool, ≤ 6°C	NA	7 days
	Dissolved Metals (Cu, Zn)	EPA 200.8 (ICP/MS) or SM 3125 (ICP/MS)	Plastic; 125 mL	Cool, ≤ 6°C; filtration, 0.45 µm; HNO3 to pH < 2	12 hours	180 days
	Total Metals (Cu, Zn)		Plastic; 125 mL	Cool, ≤ 6°C; HNO3 to pH < 2	NA	180 days
	Hardness as CaCO3	SM 2340B (ICP)	Plastic; 500 mL	HNO3 pH < 2	NA	180 days
	Ortho-phosphate (OP)	SM 4500-P G	Plastic; 1 L	Cool, ≤6°C; filtration, 0.45 µm	12 hours	2 days
	Total Phosphorus (TP)	SM 4500-P F	Glass; 1 L	Cool, ≤ 6°C; H2SO4 to pH < 2	NA	28 days
Bioretention Soil Media	Cation Exchange Capacity	S-10.10	Plastic; 2 grams	Cool, ≤ 6°C	NA	NA
	Saturated Hydraulic Conductivity (K_{sat}) @ 85% compaction rate	Modified ASTM D2434 (Ecology, 2014a)	Plastic; 500 grams	Cool, ≤ 6°C	NA	NA
	Total Elements (Zn, Cu)	EPA 6020	Plastic; 20 grams	Cool, ≤ 6°C	NA	NA
	Organic Matter Content	ASTM D2974 or TMECC 5.07A	Plastic; 50 grams	Cool, ≤ 6°C	NA	NA
Aggregate -Specific	Particle Size Distribution for the following sieve sizes: 3/8", No. 4, No. 10, No. 40, No. 100, No. 200	ASTM D422	Plastic; 500 grams	Cool, ≤ 6°C	NA	NA

8.3 Equipment Decontamination

Equipment decontamination will follow procedures in SOP "Storm Monitoring Equipment Maintenance, Cleaning and Calibration". The following equipment will be decontaminated between sampling events:

- pH Meter
- ISCO Sample Bottles (laboratory)
- ISCO Sample Tubing
- Pressure transducers

8.4 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)

8.5 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:

- Name(s) of field personnel
- Date and time of sample collection
- Location of sample collection
- Printed names, signatures and contact information 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, samples will be immediately delivered to Anatek and/or Budinger in Spokane, WA. 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 HDR principal investigator or project manager. The sampling staff will record the date and time of sample deliveries for the project file. An example chain of custody form is in Appendix I.

8.6 Field Log Requirements

Field observations and measurements associated with a monitoring event will be recorded on the field forms (Appendix H). 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 equipment condition
- Samples collected (checklist)
- QC samples collected (checklist)
- Water temperature, pH, and oil sheen measurements/ observations
- Instrument calibration results
- Comments on activities or issues that may influence the quality of the data

9.0 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.

9.1 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 and discharge measurements will be collected during data download (from the data logger) at the test-site as described in Section 8.1.6. Composite samples will be collected according to the procedures in Section 8.1.5. The pH and water temperature measurements will be instantaneous measurements collected with a calibrated pH meter, as described in Section 8.1.5.

Field measurement quality will be evaluated in terms of bias and precision (See Section 6.2 and 6.1). Measurement bias will be measured and corrected by calibrating the rain gauge at the beginning and end of the study, checking the depth measurements of the PTs during each maintenance cycle, calibrating the pH meter prior to sampling events, and calibrating the ISCO quarterly. Detailed calibration procedures are in the Sections 8.1.2 and 8.1.3. Measurement precision will be evaluated for pH and water temperature by collecting duplicate measurements for at least 10% of all measurements.

9.2 Laboratory Procedures

Laboratory analytical procedures will follow methods approved by the US Environmental Protection Agency (EPA) (APHA et al. 1992, 1998; US EPA 1983, 1984). These 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 9.1. HDR 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 8.1 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, is certified by Ecology. SoilTest Farm Consultants, Inc. Laboratory (SoilTest) is the lab identified for soil analytical samples. PSD sample analysis will be performed by Budinger & Associates, Inc. (Budinger). These performance and system audits have verified the adequacy of the laboratory's standard operating procedures, which include preventive maintenance and data reduction procedures.

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

Table 9.1. Laboratory measurement methods.

Matrix	Parameter	Units	Method	Reporting Limits	Expected Range of Results	Minimum Number of Sample Events	Samples Per Event
Water Quality Stormwater	pH	units	EPA 150.1	0.2	6.5-8.0	12	3
	PSD, influent	%	ASTM D3977-97[1]	NA		3	1
	Total Suspended Solids (TSS)	mg/L	SM 2540D	1.0	20 - 500	12	3
	Dissolved Copper (Cu)	µg/L	EPA 200.8 (ICP/MS) or SM 3125 (ICP/MS)	0.1	0.1 - 20	12	3
	Dissolved Zinc (Zn)	µg/L		1.0	5 - 300	12	3
	Total Copper (Cu)	µg/L		0.1	0.1 - 40	12	3
	Total Zinc (Zn)	µg/L		5.0	5 - 600	12	3
	Hardness as CaCO3	mg/L	SM 2340B (ICP)	1.0	1 - 100	12	3
	Ortho-phosphate (OP)	mg/L	SM 4500-P G	0.01	0.01 - 0.5	3	3
	Total Phosphorus (TP)	mg/L	SM 4500-P F	0.01	0.01 - 0.5	3	3
Bioretention Soil Media	Cation Exchange Capacity	meq/100g	S-10.10	NA	Expected to meet specification	1	1
	Saturated Hydraulic Conductivity (K_{sat}) @ 85% compaction rate	ft/day	Modified ASTM D2434 (Ecology, 2014a)	NA		1	1
	Total Elements (Zn, Cu)	mg/kg	EPA 6020	5.0 (Zn); 0.1 (Cu)		1	1
	Organic Matter Content	Percent	ASTM D2974 or TMECC 5.07A	0.01		1	1
Aggregate -Specific	Particle Size Distribution for the following sieve sizes: 3/8”, No. 4, No. 10, No. 40, No. 100, No. 200	Percent	ASTM D422	NA		1	1

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)

9.3 Sample Preparation Methods

Ortho-phosphorus, dissolved, copper, and dissolved zinc require filtration and preservation prior to delivery to Anatek. HDR personnel will filter and preserve the samples which will be analyzed for those parameters according to the methods outlined in Section 8.1.5.

9.4 Special Method Requirements

Anatek, SoilTest, and Budinger do not require any special methods for the parameters to be analyzed during the study.

9.5 Lab(s) Accredited for Methods

Anatek laboratory is accredited by Ecology for the stormwater parameters collected for this study (Table 9.1) and participates in audits and inter-laboratory studies by Ecology and EPA. SoilTest will analyze the BSM parameters collected for this study and is also accredited by Ecology. Budinger is USACE accredited for materials testing in accordance with ASTM and WSDOT methods.

10.0 Quality Control

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

10.1 Field QC Required

Field quality control will be maintained by personnel training, SOP 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 (see Section 8.1.4 and 8.1.5) and measurement procedures, (see Section 9.0). Field staff will become familiar with all associated SOPs (Section 8.0) 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 or project manager. Completion of each element of training will be verified and documented by the principal investigator or project manager in a training completion log (Appendix H).

Equipment maintenance and calibration will ensure that the BMP, the sampling equipment, and the water quality meters are working properly. Equipment maintenance will occur once in early fall, prior to the first monitoring event of the wet season, and monthly between monitoring events. Calibration of the ISCO pumps will likely occur during equipment maintenance, according to the frequency specified by the manufacturer. Calibration of the remaining storm monitoring equipment, including the pH meter, will occur prior to field measurements, preferably on the day of a monitoring event. Details of equipment maintenance and calibration are provided in Sections 8.1.2 and 8.1.3 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 pH meter, pressure transducer, rain gage, 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 H). Recordkeeping procedures will be developed and consistently followed (see Section 11.0).

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 (see Table 6.2, Table 9.1 for reporting limits).

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 and sediment parameters (Table 10.1) and must meet the associated relative percent difference MPCs in Table 6.2. Field duplicates will also be collected for filter media variables.

10.2 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 (Table 10.1). MPCs associated with the quality control samples are in Table 6.1. 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.

10.3 Corrective Action

The auditor will notify the lead entity and principal investigator in writing (via email) within 2 business days if corrective actions is needed based on the audit findings. The lead entity and principal investigator are 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 in Appendix J) and included in the final report.

11.0 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.

11.1 Data Recording & Reporting Requirements

Field data will be recorded on standard field forms (Appendix H). The field form includes the date and time, data collectors name(s), sample identification, field measurements, field observations, a checklist of samples collected for laboratory analysis, and comment field. All field measurements will be entered manually into the project database (Microsoft Access) within 24 hours of sample collection. HDR's quality assurance lead for the project 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. HDR's quality assurance lead will qualify or reject field measurements based on field DQIs and associated MPCs (Section 6.0). All files will be archived for the duration of the study on an HDR server and transferred to Spokane County after completion of the study.

Laboratory results from Anatek, SoilTest, and Budinger will report the analytical 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. HDR's quality assurance 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 6.0). A new qualifier column will be created in each EDD that represents HDRs independent data verification and will include both field and laboratory qualifiers. HDR's quality assurance 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 Access on HDRs server up to one year following approval of the Technical Evaluation Report.

11.2 Electronic Transfer Requirements

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

11.3 Laboratory Data Package Requirements

Anatek will provide Level II data packages, corresponding to Stage 2A verification and validation checks (USEPA 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 (Tables 6.1 and 6.2)
- Frequency of QC samples
- Sample results are evaluated and qualified based on meeting holding times and sample-related QC results (Table 6.2)

11.4 Procedures for Missing Data

Missing data will be qualified as missing, and will have a qualifier code (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 also 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 DQI and MPC of 95% valid data collection.

11.5 Acceptance Criteria for Existing Data

No existing data will be used for this study.

11.6 Data Upload Procedures

Per section S8.B-9 of the MS4 permit, Spokane County will enter applicable data collected as part of the study into the International BMP database at the end of the study. Additionally, a spreadsheet of all data collected during the study should be sent to the municipal stormwater permit manager with the final report. This includes all the useable quality assured data used for the analysis and the rejected or un-useable data gathered as part of the study. Any rejected data should also be included, in a separate file or a different tab, along with a description of the reasons failure.

12.0 Audits

12.1 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 project manager or principal investigator. The technical system audits will be performed by a third party. The field audit will verify that field staff are following the SOPs for sample collection, all field data are being recorded, and equipment and instruments are being maintained and calibrated per manufacturer's requirements. Results from these audits will be documented in field audit worksheets (Appendix H) 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 (6.1) 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 H) that will be prepared for each batch of samples.
In the event that a potential QA issue is identified through these audits, HDR'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.

12.2 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.

13.0 Data Verification and Usability Assessment

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

- Water quality data
- Flow measurements
- Rainfall data

13.1 Data Verification

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. Data will be reviewed 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 validation reviews will be summarized in quality assurance worksheets (Appendix C) that are prepared for each sample batch. The HDR quality assurance officer 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.

13.2 Data Usability Assessment

The HDR quality assurance officer will provide an independent review of the water quality 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 will be presented along with the data verification results in an appendix to the TER. The data usability assessment 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

- 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

14.0 Data Analysis Methods

14.1 Data Analysis Methods

14.1.1 Storm, Hydrologic, and Pollutant Information

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

- Storm date
- Total storm precipitation depth
- Storm duration
- Storm average and peak precipitation intensity
- Storm antecedent dry period
- Total influent and effluent runoff volume
- Influent and effluent peak and average flow rates
- 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 BSM 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. Details about data that will be graphed is summarized in Section 14.2.

14.1.2 Statistical Comparisons of Pollutant Concentrations

A statistical comparison will be conducted to determine whether there was a significant difference in the analytical results between influent and effluent pollutant concentrations, and between the cell datasets. This is expected to include evaluating whether the data was normally distributed using the Ryan-Joiner test (similar to Shapiro-Wilk test) (Helsel & Hirsch, 2002). Normality will be assumed if the tests produced a p-value greater than 0.05 (Ecology, 2008). If the data is normally distributed, a two-sample t-test was used to determine if there was a significant difference between the data sets. If the data was non-normally distributed, a Wilcoxon rank sum test (a nonparametric analogue to the paired t-test) was used instead. The specific null hypothesis (H_o) and alternative hypothesis (H_a) were evaluated as defined below. The statistical comparison was based on a confidence level of 95% (α=0.05).

Statistical comparison for each parameter between the influent concentration and the effluent concentration for each cell.

- H_o: Effluent pollutant concentration is equal to the influent concentration
- H_a: Effluent concentrations are less or greater than influent concentrations

The treatment performance of the two cells will evaluated to determine if there is a significant differences between the 12-inch cell and the 18-inch cell.

Statistical comparison for each parameter between the effluent concentration of the 12-inch cell and the effluent concentration of 18-inch cell.

- H_o: Effluent concentration from the 12-inch cell are equal to the effluent concentrations of the 18-inch cell
- H_a: Effluent concentrations from the 12-inch are less or greater than effluent concentrations of the 18-inch cell

14.1.3 Calculation and Evaluation of Pollutant Reduction Efficiencies

The effectiveness of the BMP will be evaluated based on the average removal efficiency and mean concentration for each parameter over at least the 12 qualifying rainfall events. This will include calculating the removal efficiency for each pollutant from each individual rainfall events using the equation below. Then the bootstrapping method will used to compute the average removal efficiency from all rainfall events for each pollutant. The boot strapping method is the Ecology recommended method which assumes the dataset is non-normally distributed (Ecology, 2011). 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 14.1, upper concentration limit will be used to calculate the pollutant reduction.

$$\Delta C = 100x\frac{C_{in}-C_{eff}}{C_{in}}$$

Where:

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

14.1.4 Water Quality Treatment Performance

The water quality data will be evaluated against the Ecology performance goals for basic and dissolved metals (Zn and Cu). This includes comparing the average removal efficiency at the lower 95% confidence interval and influent concentration from all rainfall events to the Ecology information noted in Table 14.1. If the removal efficiency is equal to or greater than the treatment performance criteria and if the average influent concentration falls within the range specified by Ecology, the conclusion will be made that the treatment performance criteria was met for pollutant of concern.

Table 14.1 Ecology Treatment Performance Goals

Performance Goal	Pollutant	Influent Concentration Range	Treatment Performance Criteria
Basic Treatment	Total Suspended Solids (TSS)	100-200 mg/L	80% Reduction
Dissolved Metals Treatment	Dissolved Copper (Cu)	5.0-20.0 µg/L	30% Reduction
	Dissolved Zinc (Zn)	20-300 µg/L	60% Reduction

14.1.5 Saturated Hydraulic Conductivity (Ksat) Measurements

The change in saturated conductivity will be evaluated using the results from the falling head testing described in section 8.1.8. The K_{sat} will be determined using the following equation.

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

H_1 = initial ponded water depth above the top of the cell (inches)
H_2 = final ponded water depth above the top of the cell for time interval (inches)
ΔTime = time interval for water to fall from Ho to Hi (seconds)
L = depth of BSM (inches)
A_1 = cell surface area at H1 (sqft)
A_2 = cell surface area at H2 (sqft)
L = depth of BSM (inches)

The infiltration rate may also be calculated using the effluent flow rate record by the data during the falling head test. Specifically, by calculating the average flow rate. The analysis should be repeated at each time interval data is recorded (5 minutes intervals) until the difference is less than 5% between three time intervals.

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

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)

The data collected will analyzed in a spreadsheet using standard statistical techniques. Specifically descriptive statistics (mean, minimum, maximum, and standard deviation) will be computed for all of K_{sat} measurements from each cell (see Table 14.2 for an example). The mean and standard deviation will also be graphed to illustrate the K_{sat} performance over study (see Figure 14.1 for an example).

Table 14.2 Saturated Hydraulic Conductivity (K_{sat}) Statistics for Study Duration

Cell Identification		K_{sat} (in/hr)			
	Total Number of Tests	Mean	Standard Deviation	Minimum	Maximum
12-inch Cell	4	2.4	0.5	2.0	2.8
18-inch Cell	4	2.0	0.7	1.5	2.5

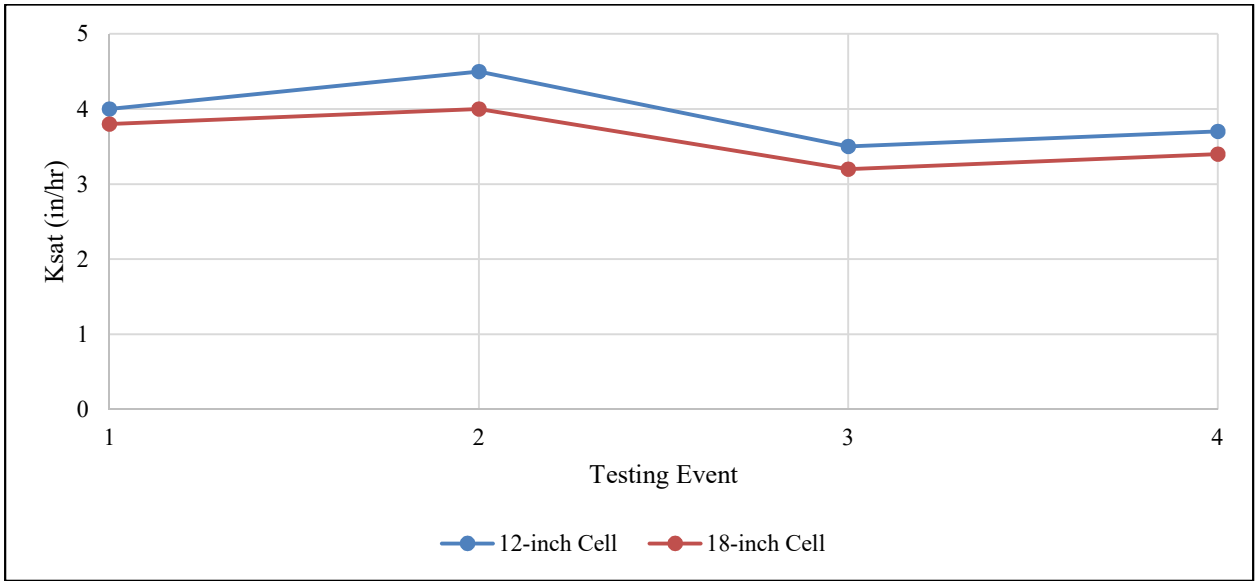

Figure 14.1 Summary of Mean and Standard Deviation K_{sat} Measurements for Each Testing Event

14.2 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., pollutant information, 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
- Figure 14.2 - 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 (red dashed line) to illustrate the relationship to the influent and effluent average concentrations.
- Figure 14.3 - 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.

- Table 14.3 – a summary of the water quality results will be include in a table. This will include the average influent and effluent concentrations, sample size, results from the hypothesis testing, and the removal efficiency corresponding to the 95% confidence interval.

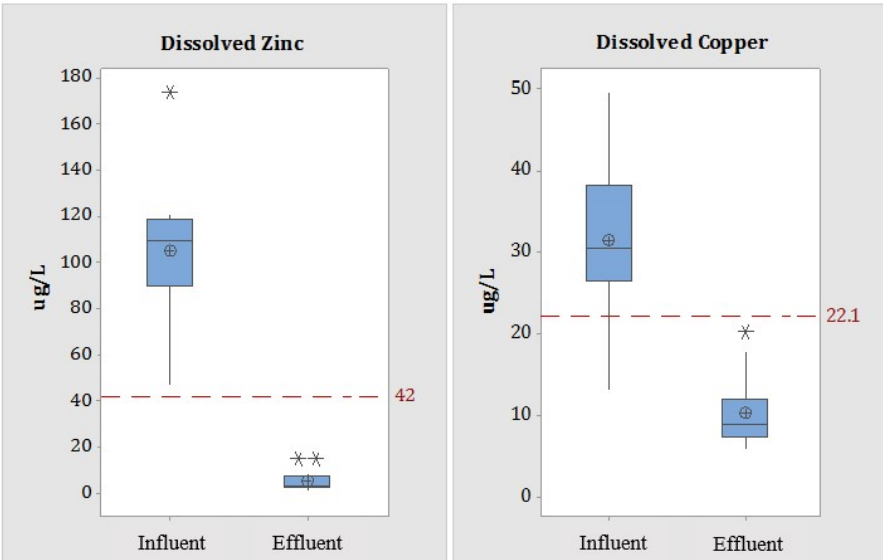

Figure 14.2 Example of Box Plots

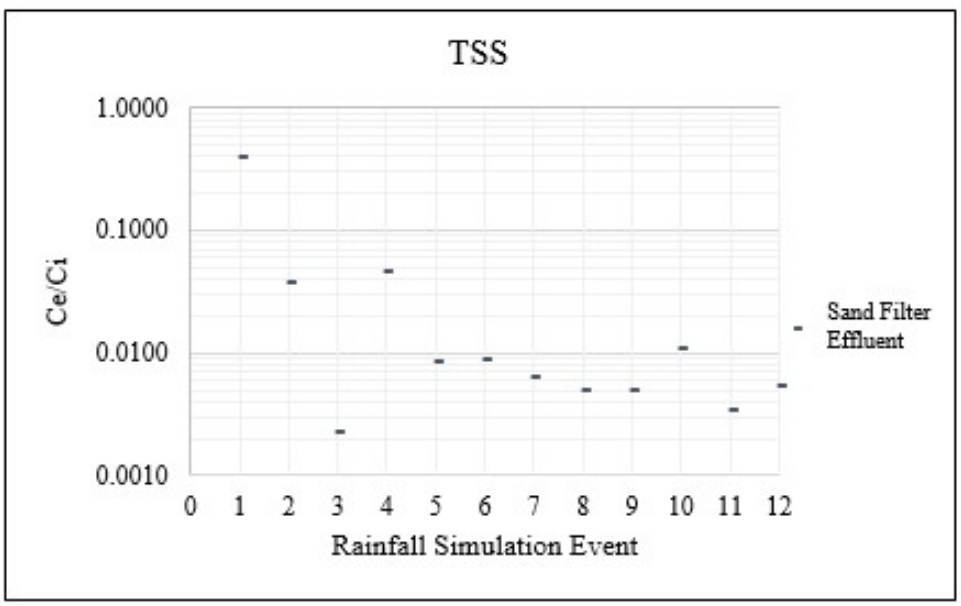

Figure 14.3 Example of Log-Normal Graphs line graphs: the removal efficiency (C_{eff}/C_{in})

Table 14.3 Summary of Water Quality Results (Example)

Column ID	Average Influent Concentration	Average Effluent Concentration	Sample Size (n)	Statistically Significant (Y/N)	95% CI Removal Efficiency	Ecology Performance Criteria	Pass Or Fail
TSS (mg/L)							
Cell 1	171.0	2.640	12	Y	92.0%	80%	Pass
Cell 2	126.4	2.390	12	Y	89.3%	80%	Pass

15.0 Reporting

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

15.1 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.

- Annual Reports (Permit Section S8.B8) – the lead entity will develop the annual reports which will describe the interim results and status of the study
- Final Technical Report (Permit Section S8.B10) – the principal investigator will produce the final technical report which will summarize the results of the study and recommends future actions based on the study findings. Table 15.1 provides an outline of the final technical report. Since this study includes the goal of developing a modified BMP, the final report will also be developed to meet the requirements specified in the Ecology TAPE Guidance Document section *Preparing a Technical Evaluation Report (TER),* (Ecology, 2011).
- A Fact Sheet – a fact sheet (2-4 page) will develop by Gonzaga Civil Engineering students that summarizes the key points and findings of the study each year. A copy of the 2017-2018 project fact sheet is located in Appendix F.

Table 15.1 Proposed Effectiveness Study Report Content

Final Report Sections		Effectiveness Studies
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	✓
7.0	Discussion	✓
8.0	Conclusions	✓
9.0	Future Action Recommendations	✓
10.0	Appendices	✓
11.0	Third-Party Review[2]	✓

1. The Final Report will reference the noted sections in the approved QAPP (in lieu of rewriting the sections in the report). Any changes made in those sections of the study since the QAPP was approved will also be documented.
2. The principal investigator will convene an advisory review panel: three to five individuals (two of whom should be from Ecology) with technical skills necessary to provide a peer review of the TER. This is only required for studies with the goal of developing a modified BMP.

15.2 Dissemination of Project Documents

The Final Technical Report will be shared with the participating agencies and will be posted to the Spokane County webpage along with a video fact sheet about the study and study findings. https://www.spokanecounty.org

16.0 References

AHBL and HDR, *Eastern Washington Low Impact Development Guidance Manual*. 2013, Washington State Department of Ecology: Puyallup, WA.

Barrett, M. E., Limouzin, M., & Lawler, D. F. (2013). Effects of media and plant selection on biofiltration performance. Journal of Environmental Engineering (United States), 139(4), 462-470. DOI: 10.1061

Davis, A.P., et al., Laboratory study of biological retention for urban stormwater management. Water Environment Research, 2001: p. 5-14.

Erickson, A. J., Gulliver, J. S., & Weiss, P. T. (2007). Enhanced sand Filtration for Storm Water Phosphorus Removal. *Journal of Environmental Engineering, 133*(5), 485-497.Hatt, B.E., Hydraulic and Pollutant Removal Performance of Fine Media Stormwater Filtration Systems. Environmental Science and Technology, 2008: p. 2535-2541.

Helsel, D.R., Hirsch, R.M., Statistical Methods in Water Resources, Chapter A3, in Techniques of Water-Resources Investigations of the United States Geological Survey. 2002, USGS.

Henderson, C.F.K. 2009. The Chemical and Biological Mechanisms of Nutrient Removal from Stormwater in Bioretention Systems. Thesis. Griffith School of Engineering, Griffith University.

Hunt, W.F. and W.G. Lord, *Bioretention performance, design, construction, and maintenance*. 2006: NC Cooperative Extension Service.

Li, H. and A.P. Davis, *Urban particle capture in bioretention media. I: Laboratory and field studies.* Journal of Environmental Engineering, 2008. **134**(6): p. 409-418.

Kadlec, R. H., & Wallace, S. (2008). *Treatment wetlands*. CRC press.

Minnesota Pollution Control Agency. (2014). Design Criteria for Bioretention. Minnesota Stormwater Manual, Layered Systems. Retrieved from http://stormwater.pca.state.mn.us/index.php/Design_criteria_for_bioretention

Technical Guidance Manual for Evaluationg Emerging Stormwater Treatment Technologies. 2011, Washington State Department of Ecology: Olympia.

Washington State Department of Ecology (Ecology). (2008). Guidance for Evaluating Emerging Stormwater Treatment Technologies, DRAFT. Olympia. Washington.

Washington State Department of Ecology (Ecology). (2011). Technical Guidance Manual for Evaluating Emerging Stormwater Treatment Technologies - Technology Assessment Protocol – Ecology (TAPE). Olympia. Washington.

Washington State Department of Ecology. (2013). Focus on Bioretention Monitoring. Olympia, WA

Washington State Department of Ecology (Ecology). (2014a). Stormwater Management Manual for Western Washington. Olympia. Washington.

Washington State Department of Ecology (2014b). Eastern Washington Phase II Municipal Stormwater Permit. Olympia, Washington. Retrieved from:

https://ecology.wa.gov/Regulations-Permits/Permits-certifications/Stormwater-general-permits/Municipal-stormwater-general-permits/Eastern-Washington-Phase-II-Municipal-Stormwat-(1)

Washington State Department of Ecology (Ecology). (2016). Status Update on Bioretention Soil Media. Olympia, WA. Retrieved from: https://fortress.wa.gov/ecy/publications/documents/1310017.pdf

Washington State Department of Ecology (Ecology). (2108). DRAFT Stormwater Management Manual for Eastern Washington. Table 5.4.8 Sizing Methods and Assumptions for Bioretention. Olympia, WA. Retrieved from: https://fortress.wa.gov/ecy/ezshare/wq/permits/EWAStormwaterManual.pdf