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Annual Report

Number	Permit Section	Question
1	S5.A.4.	Attach updated annual Stormwater Management Program Plan (SWMP Plan) or website address in the Comment field where it can be found. (S5.A.4.) **SWMP Plan 2020_1_03312020080808**
1.a	S5.A.4.	Cite website of SWMP if unable to attach **Not Applicable**
2	S9.C.6.	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.C.6. **Attachment 1 - NPDES Permit Ar_2_03312020080905**
3	S5.A.5.a.ii.	Tracked the estimated costs of implementation of each component of the SWMP. (S5.A.5.a.ii.) **Yes**
4	S5.A.6.b.	Coordinated among departments within the jurisdiction to eliminate barriers to permit compliance. (S5.A.6.b.) **Yes**
4a	S5.A.6.b.	Attach a written description of internal coordination mechanisms among departments within the jurisdiction to eliminate barriers to permit compliance. (Required to be submitted no later than March 31, 2021, S5.A.6.b.) **Attachment 2 - Internal Coordi_4a_03312020080905**
5	S5.B.1	Were elements of a regional program implemented to complete any part of your education and outreach program? (S5.B.1) **Yes**
5a	S5.B.1	If yes, list the elements, and the regional program **Elements of regional coordination are detailed further in Attachment 4 - Public Education and Outreach.**
6	S5.B.1.a.i.-iii.	Attach description of public education and outreach programs and stewardship activities conducted per S5.B.1.a.i.-iii. **Attachment 3 - Public Educatio_6_03312020080914**
7	S5.B.1.a.ii.	Which types of businesses were targeted per S.5.B.1.a.ii.? **Spokane County participates in the the Spokane/Kootenai Waste Directory, providing information to local business that generate hazardous waste on how to properly dispose of hazardous materials. Spokane County also consults with the Spokane Regional Health District and provides information on pollution prevention and source control practices. It is a priority this permit cycle to continue the partnership and expand on outreach programs.**

Number	Permit Section	Question
8	S5.B.1.b.	Used results of measuring the understanding and adoption of targeted behaviors among at least one audience in at least one subject area to direct education and outreach resources and evalueate changes in adoption of targeted behaviors. (Required no later than December 31, 2021, S5.B.1.b.) **Yes** Comment: Spokane County conducted a Stormwater Awareness Survey in 2011 and followed up in 2019. Results of the survey are provided in attachment 4. Spokane County will evaluate how to implement results of the survey into education and outreach programs.
9	S5.B.2.a.	Describe in Comments field 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.) **Spokane County solicits public comment on the SWMP Plan by advertising the comment period online at: https://www.spokanecounty.org/971/Water-Quality-NPDES-UIC-LID Spokane County also uses social media to announce the comment period.**
10	S5.B.2.b.	Posted the updated SWMP Plan and latest annual report on your website no later than May 31. **Yes**
10a	S5.B.2.b.	List the website address in Comments field. (S5.B.2.b.) **https://www.spokanecounty.org/971/Water-Quality-NPDES-UIC-LID**
11	S5.B.3.a.	Maintained a map of the MS4 that includes the requirements listed in S5.B.3.a. (Updated maps required no later than August 1, 2023) **Yes**
12	S5.B.3.a.i.	Attach a spreadsheet that lists the known outfalls and discharge points, including the outfalls' size and material(s). (Required to update no later than August 1, 2023, S5.B.3.a.i.) **Outfall Inventory_12_03242020103815**
13	S5.B.3.a.ix.	Developed an electronic format for map, with fully described mapping standards in accordance with S5.B.3.a.ix. (Required no later than August 1, 2021) **Yes**
14	S5.B.3.b.	Implemented an ordinance or other regulatory mechanism to effectively prohibit non-stormwater, illicit discharges as described in S5.B.3.b. **Yes**
15	S.5.B.3.b.vii.	Updated ordinance or regulatory mechanism to meet the requirements of this permit, if necessary. (Required no later than February 2, 2023, S.5.B.3.b.vii.) **Not Applicable**
16	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**
17	S5.B.3.c.	Implemented procedures for conducting illicit discharge investigations in accordance with S5.B.3.c. **Yes**

Number	Permit Section	Question
18	S5.B.3.c.iv.	Percentage of MS4 coverage area screened in reporting year per S5.B.3.c.iv. (Required to screen 12% on average each year, S5.B.3.c.iv.) **33**
18a	S5.B.3.c.iv.	Cite field screening techniques used to determine percent of MS4 screened. **Visual inspections are performed on county stormwater structures and logged in the GIS Stormwater Inspection Application. Percentage of MS4 screened is calculated based off of the number of structures inspected in 2019.**
18b	S5.B.3.c.iv.	Percentage of total MS4 screened from permit effective date through end of the reporting year. **33**
19	S5.B.3.c.v.	Describe how you publicized a hotline telephone number for public reporting of spills and other illicit discharges in the Comments field. (S5.B.3.c.v.) **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.**
20	S5.B.3.c.vi.	Implemented an ongoing illicit discharge training program for all municipal field staff per S5.B.3.c.vi. **Yes**
21	S5.B.3.c.vii.	Informed public employees, businesses, and the general public of hazards associated with illicit discharges and improper disposal of waste. Describe actions in Comments field. (S5.B.3.c.vii.) **IDDE education is included as part of Stormwater education curricula. Attachment 4 - Public Education includes a table of education activities performed in 2019. Additionally, the county follows up on discovered spills or requests for investigation and provides education to the offending party, if one can be identified.**
22	S5.B.3.d.	Implemented an ongoing program designed to address illicit discharges, including spills and illicit connections into the MS4 per S.5.B.3.d. **Yes**
23	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**
24	S5.B.3.f.	Attach a report with data describing the actions taken to investigate, characterize, trace and eliminate each illicit discharge found by or reported to the permittee. The submittal must include all of the applicable information and must follow the format and timelines described in Appendix 7. (S5.B.3.f.) **Attachment 4 - Illicit Dischar_24_03312020080933**
25	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. **Yes**
26	S5.B.4.a.i.-iv.	Adopted ordinance or other regulatory mechanism and enforcement procedures for construction site stormwater runoff control as described in S5.B.4.a.i.-iv. (Required no later than December 31, 2022)

Number	Permit Section	Question
		Yes
26a	S5.B.4.a.i.-iv.	Cite code reference. **Primarily enforced through County Code 9.14. See Section 2.3 of SWMP Plan - Legal Authority for additional relevant codes.**
27	S5.B.4.b.	Reviewed site plans for all new development and redevelopment projects as described in S5.B.4.b. **Yes**
27a	S5.B.4.b.i.	Number of site plans reviewed during the reporting period. (S5.B.4.b.i.) **60**
27b	S5.B.4.b.i.	The number of construction sites that provided their intent to apply for the “Erosivity Waiver” during the reporting period as described in S5.B.4.b.i. **Not Applicable**
27c	S5.B.4.b.i.	The number of complaints investigated about sites that have received an “Erosivity Waiver” . (S5.B.4.b.i.) **Not Applicable**
28	S5.B.4.	Implemented procedures for site inspection and enforcement of construction stormwater pollution control measures. (S5.B.4.) **Yes**
28a	S5.B.4.c.i.	Number of permitted construction sites inspected during the reporting period. (S5.B.4.c.i.) **131**
28b	S5.B.4.f.	Number of enforcement actions taken during the reporting period based on construction phase inspections at new development and redevelopment projects. (S5.B.4.f.) **12**
29	S5.B.4.d.	Trained the staff involved in permitting, plan review, field inspections, and enforcement for construction site runoff control. (S5.B.4.d.) **Yes**
30	S5.B.4.e.	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. Describe information provided in the Comments field. (S5.B.4.e.) **Yes**
30a	S5.B.4.e.	Describe information provided in the Comments field. (S5.B.4.e.) **Applicants receive information relevant to construction BMPs at the time of application. If any issues should arise during the construction period, a County inspector will provide technical assistance as well as proper enforcement procedures. Spokane County references the Spokane Regional Manual as the primary guidance document for stormwater management in the region. The County also allows BMPs in the SWMMEW for ESC requirements.**

Number	Permit Section	Question
31	S5.B.5.a.	Implemented ordinance or other regulatory mechanism and enforcement procedures to address post-construction stormwater controls runoff to the MS4 from new development and redevelopment as described in S5.B.5.a. **Yes**
32	S5.B.5.a.	Revised ordinance or other regulatory mechanism and enforcement procedures to address post-construction stormwater controls runoff to the MS4 from new development and redevelopment as described in S5.B.5.a. (Adopted no later than December 31, 2022) **Not Applicable**
33	S5.B.5.b.ii.(a)	Allowed non-structural preventive actions and source reduction approaches such as Low Impact Development (LID) techniques to be used. (S5.B.5.b.ii.(a)) **Yes**
34	S5.B.5.b.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. (S5.B.5.b.ii.(b)(2)) **Yes**
35	S5.B.5.d.	Inspected post-construction stormwater controls, including structural BMPs, at new development and redevelopment sites. (S5.B.5.d.) **Yes**
35a	S5.B.5.d.i.	Number of new and redeveloped sites inspected during installation of structural BMPs during the reporting period. (S5.B.5.d.i) **74**
35b	S5.B.5.d.i.	Number of new and redeveloped sites inspected upon final installation of BMPs or upon completion of the project during the reporting period. (S5.B.5.d.i.) **38**
36	S5.B.5.d.ii.	Inspected structural BMPs at least once every five years after final installation. (S5.B.5.d.ii.) **Yes**
36a	S5.B.5.d.ii.	Number of BMPs inspected during the reporting period. **3461**
37	S5.B.5.d.	Number of enforcement actions taken as a result of these inspections during the reporting period? (S5.B.5.d.) **8**
38	S5.B.5.e.	Trained the staff involved in permitting, plan review, inspection, and enforcement for post-construction stormwater control. (S5.B.5.e.) **Yes**
39	S5.B.5.f.	Provided information to design professionals about training available on how to comply with the requirements in Appendix 1 and apply the BMPs in the SWMMEW, or an equivalent document. (S5.B.5.f.) **Yes**

Number	Permit Section	Question
39a	S5.B.5.f.	Describe information provided and cite the manual used **Spokane County utilizes both the SWMMEW and SRSM as stormwater guidance manuals. Spokane County engineers and technicians regularly provide guidance to design professionals during the permit application and construction process. Guidance is typically given during scheduled meetings, walk-ins to the public works department, or over the phone.**
40	S5.B.6.a.	Reviewed and, if needed, updated Operations and Maintenance Plan. (Required no later than December 31, 2022, S5.B.6.a.) **Yes** Comment: O&M Plan has undergone review and will be updated by the required date.
41	S5.B.6.a.	Implemented the schedule of Operation and Maintenance activities for municipal operations. (S5.B.6.a.) **Yes**
42	S5.B.6.a.i.(f) and (g)	Have NPDES permit coverage for all applicable Permittee construction projects and industrial facilities. (S5.B.6.a.i.(f) and (g)) **Yes**
43	S5.B.6.a.i.(h)	Implemented a Stormwater Pollution Prevention Plan for all heavy equipment maintenance or storage yards, and material storage facilities owned or operated by the Permittee in areas subject to this Permit that are not required to have coverage under an NPDES permit that covers stormwater discharges associated with the activity. (S5.B.6.a.i.(h)) **Yes**
44	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**
44a	S5.B.6.a.ii.(a)	Number of facilities inspected during the reporting period. **3461**
45	S5.B.6.a.ii.(b)	Inspected municipally owned or operated catch basins and inlets every two years or used an alternative approach? (Required at least once every two years, S5.B.6.a.ii.(b)) **Yes**
45a	S5.B.6.a.ii.(b)	Number of known catch basins. **2953**
45b	S5.B.6.a.ii.(b)	Number of catch basins inspected during the reporting period. **809**
45c	S5.B.6.a.ii.(b)	Number of known catch basins cleaned during the reporting period. **690**
46	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**

Number	Permit Section	Question
47	S5.B.6.a.ii.(c)	Conducted spot checks of stormwater facilities after major storms. (S5.B.6.a.ii.(c)) **Yes**
48	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**
49	S7.A.	Complied with the Total Maximum Daily Load (TMDL)-specific requirements identified in Appendix 2. (S7.A.) **Yes**
50	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.) **Not Applicable**
51	S8.A.	Attach a summary of your participation in effectiveness study development and implementation during the reporting year. (S8.A.1. and S8.A.2.a.) **Attachment 5 - Effectiveness S_51_03312020081008**
56	S8.A.	Was the SWMP updated to include effectiveness study activities? (S8.A.2.f.) **Yes**
57	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**
58	G3.A.	Took appropriate action to correct or minimize the threat to human health, welfare, and/or the environment per G3.A. **Yes**
58a	G3.A.	Actions taken to correct or minimize the threat to human health, welfare, and/or the environment per G3.A. **See IDDE Attachment which details all reportable spills that occured in 2019 and the follow-up actions taken as a result of those spills.**
59	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.) **Yes**
60	G20.	Number of non-compliance notifications provided in reporting year. (G20.) **1**
60a	G20.	List permit conditions described in non-compliance notification(s) **Permit condition S5.B.2.b - Annual Report was not posted on website by May 31st. Permit coordinator requested submittal of a G20 on June 1, 2019. Annual Report was put on County website immediately after receiving notification - G20 was submitted on June 6.**
61	S4.F.1.	Notified Ecology within 30 days of becoming aware that a discharge from the Permittee's MS4 caused or contributed to a known or likely violation of water quality standards in

Number	Permit Section	Question
		the receiving water. (S4.F.1.) **Not Applicable**
62	S4.F.3.a.	If requested, submitted an Adaptive Management Response report in accordance with S4.F.3.a. **Not Applicable**
63	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_2_03312020080905	Attachment 1 - NPDES Permit Ar_2_03312020080905	.pdf	923350	1702830	wqwebportal
View	WAR046506_4a_03312020080905	Attachment 2 - Internal Coordi_4a_03312020080905	.pdf	923351	1702830	wqwebportal
View	WAR046506_6_03312020080914	Attachment 3 - Public Educatio_6_03312020080914	.pdf	923352	1702830	wqwebportal
View	WAR046506_24_03312020080933	Attachment 4 - Illicit Dischar_24_03312020080933	.pdf	923353	1702830	wqwebportal
View	WAR046506_51_03312020081008	Attachment 5 - Effectiveness S_51_03312020081008	.pdf	923356	1702830	wqwebportal
View	Submitted Copy of Record for Spokane County	Copy of Record SpokaneCounty Tuesday March 31 2020	.pdf	923369	1702830	wqwebportal
View	Submitted Cover Letter for Spokane County	Cover Letter SpokaneCounty Tuesday March 31 2020	.pdf	923370	1702830	wqwebportal
View	WAR046506_12_03242020103815	Outfall Inventory_12_03242020103815	.xlsx	911909	1702830	wqwebportal
View	WAR046506_1_03312020080808	SWMP Plan 2020_1_03312020080808	.pdf	923349	1702830	wqwebportal

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SPOKANE COUNTY
STORMWATER MANAGEMENT PROGRAM (SWMP) PLAN 2020

Eastern Washington Phase II Municipal Stormwater Permit

Permit WAR 04-6506

Permit Cycle – August 1, 2019, to July 31, 2024

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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 industrial sites and wastewater treatment plants. While these efforts have led to improved water quality, new efforts are now needed to address other sources of water pollution. Non-point urban stormwater runoff can contain harmful pollutants and, 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 urbanized municipalities with populations fewer than 100,000 people (where population density is greater than 1,000 persons per square mile), to develop a Stormwater Management Program addressing runoff that discharges to surface waters. The Washington Department of Ecology enforces federal environmental programs, regulating municipalities via Municipal Stormwater Permits through the National Pollution Discharge Elimination System (NPDES).

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 *Eastern Washington Phase II Municipal Stormwater Permit* (Permit), Permit No. WAR 04-6506, effective February 16, 2007. The Permit is renewed every five years, with the most recent version of the Permit taking effect on August 1, 2019 and expiring July 31, 2024. The Permit states, "All permittees shall develop and implement a *Stormwater Management Program* (SWMP) during the term of this Permit." The Permit authorizes stormwater discharges to surface waters. Drywells, legally referred to as Underground Injection Control (UIC) wells, are regulated under the State of Washington's Underground Injection Control Program. Drywells are addressed in this plan due to requirements pertaining to monitoring, maintenance, and spill response.

1.2 Purpose

The purpose of this SWMP Plan is to describe the County's programs and practices used to manage the Municipal Separate Storm Sewer System (MS4) and implement the requirements of the Permit. This Plan:

- is updated annually to describe upcoming permit year activities;
- describes on-going programs in-place to comply with Permit conditions;
- outlines staffing and funding responsibilities for permit programs; and
- applies to the 5-year duration of the current Permit cycle (expiring July 31, 2024)

Upkeep of this plan furthers the County's long-term commitment to reducing pollutants discharged to Waters of Washington State.

1.3 Authorization

This SWMP Plan was prepared by the Spokane County Stormwater Utility, a section within Public Works. 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 County to carry out the responsibilities of the Permit. Although the Stormwater Utility is the lead entity on Permit management, multiple County departments are necessary for permit implementation. Section 2 of this plan details internal coordination and program administration.

1.4 Area of Coverage

The permitted MS4 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 unincorporated urban growth areas associated with permitted 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 1 – 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.

Coordination with the municipalities of the City of Spokane and the City of Spokane Valley helps to 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 2 – Internal Coordination*.

1.5 Reporting Period

This Plan has been organized to provide background on Spokane County's Stormwater program, to outline the program goals for the 2020 calendar year, and to address questions listed in Permit *Appendix 3 – Annual Report questions for Cities, Towns, and Counties.*

This SWMP Plan applies to the 5-year effective period of the Permit, valid from August 1, 2019 to July 31, 2024. The Permit requires annual reports that are subject to the following reporting periods:

- Annual Report, Year 1 – January 1, 2019 to December 31, 2019
- Annual Report, Year 2 – January 1, 2020 to December 31, 2020
- Annual Report, Year 3 – January 1, 2021 to December 31, 2021
- Annual Report, Year 4 – January 1, 2022 to December 31, 2022
- Annual Report, Year 5 – January 1, 2023 to December 31, 2023

1.6 Stormwater Management Program Permit Requirements

There are six essential components of the SWMP. To the extent allowable under state and federal law, 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

SECTION 2 – STORMWATER MANAGEMENT PROGRAM ADMINISTRATION

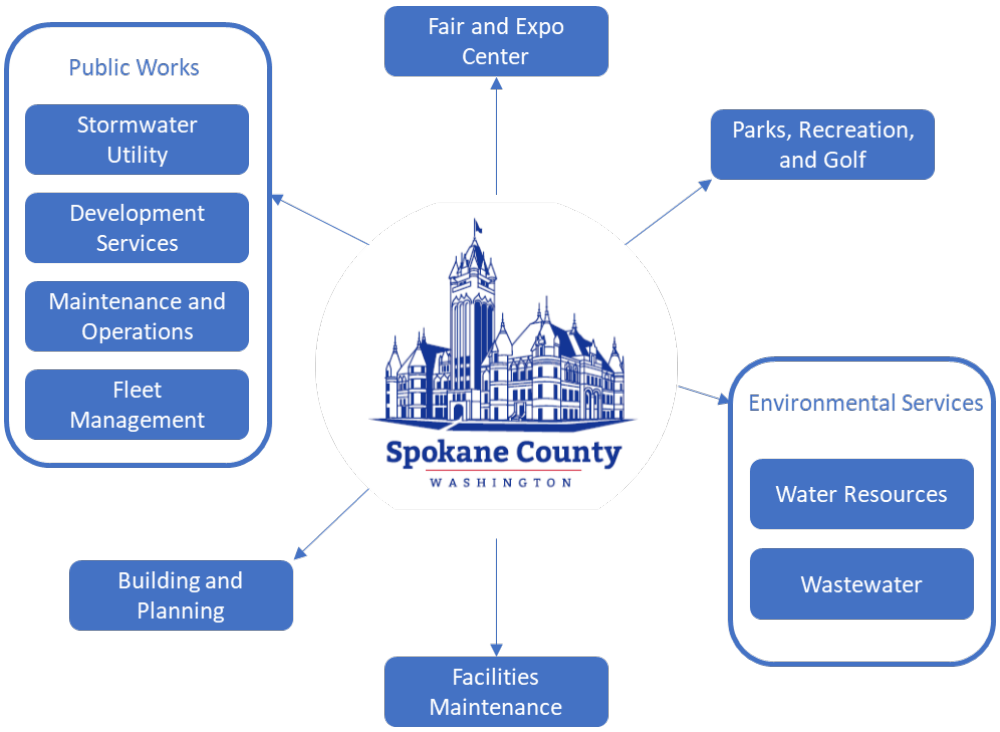
2.1 Introduction

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 which are calculated by quantifying impervious area 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 the West Plains. Each of the individual basin plans emphasizes protection of natural drainage features as the most cost-effective and environmentally conscious means of managing stormwater development.

Although the Stormwater Utility is the lead entity on addressing stormwater concerns within the unincorporated areas of Spokane County, multiple County departments perform essential activities to operate and maintain the Municipal Separate Storm Sewer System. *Attachment 2 – Internal Coordination* 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 has 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 included as part of the Spokane County Code of Ordinances[1] as stated in Chapter 9.14. The SRSM is considered by the Department of Ecology to meet design standard requirements of Appendix 1 of the Permit.

Spokane County Code of Ordinances, Title 9, Chapter 14 – Roads, Approach and Drainage in New Construction is the primary reference document for stormwater management standards for new construction. Amendments to chapter 9.14 were developed and approved in 2008 (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; and
- inspection and monitoring procedures necessary to determine compliance and enforce the prohibition of illicit discharges to the MS4.

Spokane County Code Title 8 includes various sections that addresses surface water protection, waste disposal, and illicit discharges within Spokane County. The chapter also addresses notice of violation, enforcement, and penalty. Relevant chapters include Chapter 8.03 – Sanitary Sewer, Chapter 8.26 – Litter and Discriminate Dumping, and Chapter 8.26.020 – Litter in General. Chapter 8.60.030 – Oil Sellers--Educational Responsibilities, requires sellers of lubricating oil to post educational materials describing: the importance of used oil recycling; how and where used oil may be recycled; and where reusable used oil containers are available for purchase.

Spokane County requires design plans to address flood control via Title 3, Buildings and Structures, Chapter 3.20 – Flood Damage Protection. This comprehensive flood control ordinance manages development within delineated floodplains in compliance with the National Flood Insurance Program.

2.4 Additional Required Legal Authority

Spokane County is required to evaluate legal authority following new legislation or executive action, such as new Permit requirements. If review of current regulations and ordinances identifies deficiencies in the ability to implement SWMP programs, a plan for addressing the deficiencies shall be developed. In 2020 Spokane County will evaluate new permit requirements, determine if ordinance changes are necessary, and implement changes as required. A specific example includes review of the SRSM and potential implementation of new BMPs included in the 2019 SWMMEW. Spokane County frequently coordinates with the City of Spokane and the City of Spokane Valley on regional policymaking.

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

2.5 Stormwater Utility Funding

As the lead entity on NPDES Permit implementation, the Stormwater Utility is the primary financer of NPDES related programs. The Stormwater Utility, a sub-department of Public Works, maintains a fund independent of the Public Works General Fund. Stormwater fees are collected throughout the Stormwater Service Area[2] to finance maintenance activities, design, construction, staff time, permit implementation, and other Utility programs. County Code chapter 9.70 – Charges for Stormwater Management and Benefits details the stormwater rate structure utilized by the County. Staffing and funding for each Stormwater Management Program element is further detailed in each chapter of this Plan.

Spokane County receives additional funding through grant programs offered by state and federal organizations. Ecology's Stormwater Capacity Grant assists municipalities in Permit implementation, providing $95,000 on a recurring two-year cycle. The current Capacity Grant period started October 2019 and ends March 2021. Additional grants include Washington State's Stormwater Funding Assistance Program (SFAP), which assists municipalities with large scale retrofit and construction projects. Ecology evaluates submitted project proposals via an application process, ranks submissions based on factors including perceived water quality benefit, and then distributes available funding following a negotiation period. Funding for this program is allocated by the Washington State legislature on a biennial basis.

2.6 Performance Standards and Training

Spokane County enforces guidelines set in two regional stormwater manuals: the Stormwater Management Manual for Eastern Washington (SWMMEW) and the Spokane Regional Stormwater Manual (SRSM). These manuals serve as the primary guidance documents for information pertaining to the design, operation, and maintenance of stormwater treatment and disposal structures. Training materials are developed following regulatory changes such as new Permit requirements or manual revisions.

In 2013, the Eastern Washington Low Impact Development (LID) Guidance Manual, now included in the SWMMEW was developed as a supplemental guidance for the design, construction, and maintenance of LID stormwater Best Management Practices (BMPs). Spokane County worked in conjunction with Eastern Washington municipalities, the Washington Stormwater Center, consultants, Ecology, and regional LID experts on the implementation of this manual.

Spokane County incorporates elements of the Highway Runoff Manual (HRM) into stormwater management, planning, and design. The HRM is a Washington State guidance manual that establishes minimum design and maintenance requirements for highways, highway maintenance facilities, parking lots, and related highway infrastructure.

[2] A map of the Stormwater Service Area is included in Attachment 1 – NPDES Permit Area Maps

SECTION 3 – PUBLIC EDUCATION AND OUTREACH

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 general 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.

Pictured: Spokane County Water Resources employee Toni Taylor with the Aqua Duck, a local mascot promoting aquifer water quality

3.2 Public Education and Outreach Program Elements

Spokane County's Water Resources department is the lead entity on educating the general public about stormwater and regional water quality. The Stormwater Utility helps coordinate education activities 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).
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, public service announcements, or commercials for targeted messages and audiences.

d) **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.

e) **Website:** The County will continue to enhance, maintain, and update the existing Spokane County Stormwater Utility[3] website to provide information to the public on stormwater topics.

f) **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.

g) **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). The County is pursing collaboration with the Spokane Regional Health Department (SRHD) on the EnviroCertified program, a pollution prevention program aimed at recognizing environmentally responsible businesses.

h) **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.

i) **Technical Education for Engineers, Contractors, and Developers:** The County provides educational materials to developers as part of the application and permitting process. Inspectors educate site operators on regulatory requirements and guidance on which BMPs may be effective. Comments offered to developers as part of the application process include reference to guidance documents and educational materials to assist with stormwater design. Spokane County is coordinating with the City of Spokane and the City of Spokane Valley to update guidance documents, such as the SRSM, to provide consistent regional guidance to developers throughout the greater Spokane region.

j) **Illicit Discharge Program:** The County responds to spills and provides information to businesses and the public about illicit discharges. Materials developed by the SRHD are provided to encourage proper management and disposal of toxic materials.

k) **Stormwater Facilities:** The County will continue to construct and maintain interpretive signage at regional stormwater facilities and demonstration swales to educate citizens about 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.

l) **HOA Education Campaign:** In 2020 the County is beginning a campaign to improve communication with HOAs on stormwater maintenance responsibilities. An initial

[3] https://www.spokanecounty.org/918/Stormwater-Utility

communication letter will include general information about the plat-mandated maintenance responsibilities, as well as an offer to present site-specific information at an HOA meeting. If the presentation offer is accepted, the County will send Stormwater Utility employees to an HOA meeting to distribute Operations and Maintenance plans to HOA members and ask for their participation in a citizen science initiative to provide inspection records back to the County to assist with Post-Construction permit requirements.

3.3 2020 Education Programs and Goals

Spokane County is pursuing new education opportunities in 2020.

- Spokane County Water Resources has received preliminary sketches from education consultant KidZibits for the fabrication of new interactive educational materials for the Water Resources Center.
- In 2020 the County has partnered with Mead School District to provide education to every 6th grader about the aquifer, watershed, and water use. This will consist of four days of educational activities in March and April.
- Revisions to the Spokane Valley-Rathdrum Prairie Aquifer Atlas have been planned for 2020.
- The Stormwater Utility will be updating educational resources (brochures, website) based on the results of the Stormwater Awareness Survey.
- The Stormwater Utility is sending out a communication letter to inform contractors of increased attention on construction inspections. The letter details construction resources, ordinances, and guidelines to assist contractors in pollution prevention.

3.4 2019 Stormwater Survey

In 2019 a follow-up to the 2011 Spokane County Stormwater Awareness Survey was conducted; surveys were distributed to the same households polled in 2011 for consistency. The survey addresses questions of water quality, causes of water pollution, knowledge about storm water runoff, sources of information on stormwater issues, and willingness of participants to take specific actions to reduce water pollution. The survey results will aid in developing appropriate education and outreach activities that help protect water resources within the unincorporated urban areas of Spokane County. Additionally, the information gathered can provide a baseline for evaluating program effectiveness, as required by Permit Section S5.B.1.b. A report of the findings is included in Attachment 3 of this Plan.

3.5 Staffing, Funding, and Training for Program Elements

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 to achieve regional goals.

3.6 Permit Requirements

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. Objectives as required by the permit include:

S5.B.1.b	Each Permittee shall measure the understanding and adoption of targeted behaviors for one of the target audiences in one subject area by December 31, 2021.
S5.B.1	Implement a Public Education and Outreach program targeted either locally or regionally to reach target audiences.
S5.B.1.a.i	Educate the General Public - Importance of protecting waters of the state, impacts from stormwater pollution, individual actions that can be taken, and methods for reducing stormwater pollution.
S5.B.1.a.ii	Educate Businesses - Information on illicit discharges: what they are, how to prevent, best waste practices, and the use and storage of hazardous chemicals.
S5.B.1.a.iii	Educate Engineers, developers - Information about technical standards, low impact development (LID), municipal codes and requirements, and stormwater BMPs.

SECTION 4 – PUBLIC INVOLVEMENT AND PARTICIPATION

4.1 Introduction

This section describes the public involvement and participation activities used to meet the municipal permit requirements for such a program (S5.B.2).

Spokane County has, under the State's Growth Management Act, adopted the *Public Participation Program Guidelines* (PPPG) which outline procedures to ensure opportunities for public participation in land use decisions. The County uses the PPPG[4] to ensure ongoing opportunities for public involvement and participation in the development of stormwater code.

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) Requests for Investigation (RFIs): Citizens can directly contact Spokane County to report stormwater related concerns. Every call or comment received is investigated by a Spokane County employee and subsequently prioritized in terms of monitoring, maintenance, and potential design.
b) **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 are conducted according to State and local public participation and noticing guidelines. Examples include the SEPA (State Environmental Policy Act) process, the GMA (Growth Management Act) and the NPDES Permit renewal process.
c) **Hearing Examiner**: The Spokane County Hearing Examiner conducts public hearings on various land use applications, land use determination appeals submitted by Public Works Departments, and certain other quasi-judicial matters. Stormwater and drainage comments pertaining to review of design standards are frequently received at this time.

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

d) **Website**: In addition to maintaining and updating the website content, the County provides an online comment form[5] where the public can share feedback and/or submit questions regarding the Stormwater Utility's programs.
e) **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.
f) **SWMP Plan and Annual Report[6]:** The SWMP Plan and Annual Report is made available for review and/or download on the Spokane County webpage; public comment is heavily encouraged.

4.4 Staffing, Funding, and Training

Funding and staffing for the public participation program is led by the Stormwater Utility and Environmental Programs departments within Public Works. Public Works, Environmental Services, and the County's general fund also contribute towards public involvement programs.

4.5 Permit Requirements

The Public Involvement and Participation permit requirements are outlined below:

S5.B.2.a	Implement a program or policy directive to create opportunities for the public to provide input during the decision-making processes of the SWMP, including the development and adoption of ordinances and regulatory mechanisms.
S5.B.2.b	Post Annual Report and SWMP on your website no later than May 31st each year.

[5] https://www.spokanecounty.org/FormCenter/Engineering-Roads-14/Contact-Stormwater-Utility-61
[6] 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) Maintain a Geographic Information Systems (GIS) map of the permitted and non-permitted 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 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.

Unincorporated Spokane County has developed without an extensive centralized storm sewer network; most runoff is directed to localized infiltration structures such as swales or drywells for disposal. The County manages eight outfall locations on various waterbodies including the Spokane River, the Little Spokane River, Deadman Creek, and Little Deep Creek. Management of the County's MS4 requires inspecting these isolated systems and various outfalls for evidence of illicit connection or illicit discharge.

In 2010 Spokane County issued the IDDE Guidance Manual to provide personnel direction on how to conduct field assessment activities on high-priority waterbodies. The practices and principles outlined in this plan include locating, assessing, characterizing, tracing, and eliminating illicit discharges at outfalls.

5.2 Illicit Discharge Data and Mapping

Spokane County maintains a 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 stormwater

mapping data is based on surveys and fieldwork conducted regularly within the Stormwater Service Area since the Stormwater Utility's formation in 1992.

Spokane County's MS4 is comprised of roads with ditches, catch basins, culverts, curbs, bridge drains, swales, retention/detention ponds, drywells, and piping systems that direct stormwater into groundwater and surface waterbodies such as a DNR stream, river, wetland, pond, lake, etc. GIS basemaps were developed using stormwater data collected 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.

5.3 Visual Inspection Program Elements

Visual inspections are conducted on a regular basis by Stormwater Utility staff to identify the structural integrity of stormwater structures, maintenance needs, presence of any illicit connections, 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 4 – Illicit Discharge Detection and Elimination* provides more detail on visual inspection methods.

Each year, technicians and seasonal crews inspect roughly 50% of County facilities; in 2019 alone, County staff inspected 3461 of the County's storm structures. 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.

Members of the Spokane County Road Maintenance department are 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.

5.4 Spill Prevention and Response Program

Hazardous spill prevention and response 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. Spokane County provides field staff with spill kits and training for the immediate protection of surface waters or stormwater structures that may be impacted by a spill. 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.

5.5 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 Stormwater Utility website[7]
d) Calls to Spokane Regional Health District – (509) 314-1500
e) Calls directly to the Department of Ecology spill hotline – (800) 258-5990

5.6 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 Regional Solid Waste System-member jurisdictions. The Spokane County Comprehensive Solid Waste Management Plan[8] guides the solid waste decisions and activities of the System. The Regional Solid Waste Management System includes establishment of the Solid Waste Advisory Committee[9] (SWAC), a regional collaborative policy-making committee involved in waste management.

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 3 – Public Education and Outreach*.

5.7 Staffing, Funding, and Training

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 funds from Spokane County's general budget 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 visualize sources of stormwater pollution. MS4 mapping exercises, such as the 2018 Little Spokane outfall identification project, act as valuable field assessment activities, and provide hands on experience with GPS equipment, GIS, and investigation procedures. 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, skill certifications, and the attendance of educational seminars, webinars, and conferences. *Attachment 4 – Illicit Discharge Detection and Elimination*, provides more details on elements of the IDDE program.

[7] https://www.spokanecounty.org/formcenter/Public-Works-14/Contact-Stormwater-Utility-61
[8] https://www.spokanecounty.org/2032/Spokane-County-ComprehensiveSolid-Waste-
[9] https://www.spokanecounty.org/2558/Solid-Waste-Advisory-Committee-SWAC

5.8 Permit Requirements

Specific Illicit Discharge Detection and Elimination permit requirements are outlined below:

S5.B.3.b.vii	Prohibit via ordinance or other regulatory mechanism, non-stormwater discharges to MS4. Define allowable discharges or conditionally allowable discharges. Authorize enforcement actions including on private property. Revise regulatory mechanism if necessary by Feb 2, 2023.
S5.B.3.f	Keep records of activities and submit data in the annual report following guidance in Appendix 7. Implement by March 31, 2020.
S5.B.3.a	Maintain a map of MS4 including: known outfalls, discharge points, receiving waters, ground discharges, stormwater facilities, connections to MS4.
S5.B.3.b.vi	Implement IDDE compliance that includes informal compliance actions such as education and technical assistance, as well as the enforcement provisions. Must include a) SWMMEW BMPs, and b) Maintenance standards.
S5.B.3.c	Implement a program to detect and identify illicit discharges/connections to the MS4.
S5.B.3.c.i	Implement procedures for investigating or field screening the MS4 to identify potential sources.
S5.B.3.c.ii	Implement procedures for locating priority areas likely to have illicit discharges. Evaluate land uses, documented areas with IDDE complaints, areas with material storage that has the potential to spill.
S5.B.3.c.iii	Field assess outfalls, discharge points, and stormwater facilities that serve priority areas to detect illicit connections/discharges during dry weather.
S5.B.3.c.iv	Field assess 12% on average of the MS4 within the coverage area each year to verify outfall and discharge point locations to detect illicit discharges. Track total percentage.
S5.B.3.c.vi	Train field staff on how to identify and respond to illicit discharges/connections including reporting, responding, and follow-up if necessary. Document and record trainings.
S5.B.3.c.vii	Inform public employees/businesses/general public of hazards associated with illicit discharges and improper waste disposal.
S5.B.3.d.i	Implement procedures for characterizing illicit discharges and any threat they pose to public safety or the environment.
S5.B.3.d.ii	Implement procedures for tracing the source of an illicit discharge including visual inspections, opening manholes, using detection equipment, collecting samples.
S5.B.3.d.iii	Implement procedures for eliminating the discharge, notifying appropriate authorities and property owner (if applicable). Provide technical assistance, follow-up inspections, and compliance strategy (including enforcement).
S5.B.3.d	Implement ongoing program to address illicit discharges and connections to the MS4.
S5.B.3.e	Train responsible staff on how to identify, investigate, cleanup, report, etc. illicit discharges/connections. Document and record trainings.
S5.B.3.a.v	Document connections to the MS4 authorized or approved after August 1, 2019.
S5.B.3.a.viii	Provide maps and mapping info to Ecology upon request.

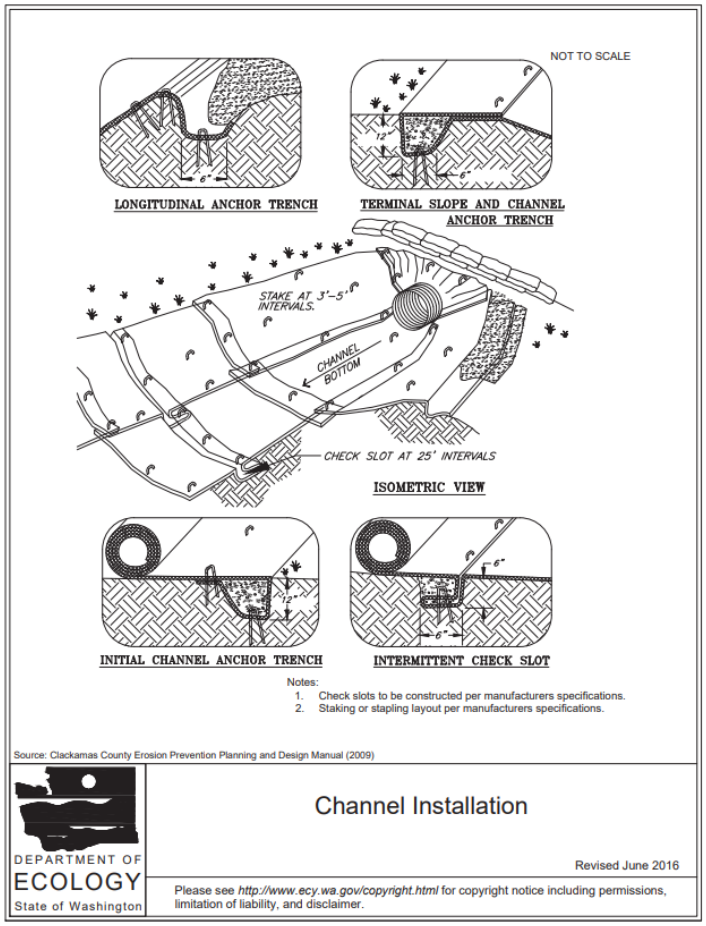
S5.B.3.c.v	Maintain a public hotline for reporting of spills and other illicit discharges.
S5.B.3.d.iv.b	Investigate complaints, reports, monitoring info that indicates a potential illicit discharge within 7 days.
S5.B.3.d.iv.c	Initiate an investigation of any report or discovery of a suspected illicit connection to determine nature of connection within 21 days.
S5.B.3.d.iv.d	Upon confirmation of an illicit connection, use a procedural compliance strategy to document the effort to eliminate the illicit connection within 6 months.

SECTION 6 – CONSTRUCTION SITE STORMWATER RUNOFF CONTROL

6.1 Introduction

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

2020 program elements include activities intended to provide guidance to public and private groups in Spokane County regarding appropriate construction practices, as well as supporting Ecology in implementing state construction permitting programs. The Stormwater Utility is pursuing improvements to inspection procedures, internal permitting programs, and enforcement actions.



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

6.2 NPDES Construction Stormwater Permit

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, however some applicants still do not pursue the coverage they need. The Stormwater Utility is reviewing educational materials that are provided by Building and Planning during the construction application process to determine if language includes reference to Construction SW General Permit requirements. The County is determining how to effectively implement proof of Construction SW General Permit application prior to issuance of County construction permits.

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.

The SWMMEW and the Permit each received updates in 2019; necessitated review of the SRSM. The County coordinated effort with the City of Spokane and the City of Spokane Valley to review the SRSM to new regulatory standards. In 2020, the Department of Ecology confirmed that the SRSM meets regulatory requirements as detailed in Appendix 1 of the Permit. The Spokane Region will continue to review the SRSM and consider if any updates are necessary to further align the manual with regulatory requirements.

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 Certified Erosion and Sediment Control Lead (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 Education for Construction Activities

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.

Coordination occurs between the Department of Ecology and Spokane County regarding enforcement of erosion and sediment controls at construction sites. County and State field inspectors meet with contractors at construction sites to review existing controls and convey ESC/BMP requirements to sites lacking proper controls. Pre-visit communication and post-visit follow-up is essential to effectively educate and regulate construction projects. County departments involved with permitting and inspections keep record of relevant documentation. Trainings are made available to employees whose primary job responsibilities are heavily focused on design, implementation, and project management of construction projects.

6.7 Internal Training

In 2019 the Stormwater Utility focused effort on updating inspection procedures to meet new and existing permit requirements. The Construction Erosion and Sediment Control Enforcement procedure includes enforcement strategies, timelines, specific references to County Code, and instructions on when to contact relevant Ecology personnel. This procedure serves as an internal education document and assists the County in enforcing ESC concerns in a consistent and timely manner. Additionally, the County provides CESCL training to engineers and technicians on staff whose responsibilities include management or inspection of construction sites. CESCL is an Ecology approved training program that provides education and up-to-date methods of reducing or preventing contaminated runoff from leaving construction sites. *Attachment 3 – Public Education and Outreach* provides more detail on the CESCL program. Spokane County employees who design, manage, and implement County construction projects receive additional training on pollution prevention BMPs and training specific to the various departments' operations and functions. Refresher/recertification training is provided to County staff as requested or needed.

6.8 Permit Requirements

The "Construction Stormwater Management" permit requirements are outlined as follows:

S5.B.4	Implement and enforce a program to reduce stormwater pollutants from construction activities (public or private) disturbing one acre or more, or part of a larger development.
S5.B.4.b	Implement procedures for site plan review which incorporates water quality considerations.
S5.B.4.b.i	Review construction SWPPPs prior to clearing and construction pursuant to Core Element 2.
S5.B.4.c	Implement procedures for site inspection and enforcement of construction pollution control measures.
S5.B.4.c.i	Inspect prior to clearing and grading if high risk is identified, and during construction to verify proper installation/maintenance of ESC controls. Compliance determined by achieving 80% inspection rate.
S5.B.4.d	Train staff responsible for plan review, site visits, inspections, and enforcement. Document and maintain records of training.
S5.B.4.e	Provide info to construction site operators about ESC and BMP training.
S5.B.4.f	Keep records of all projects, site plan review, inspections, enforcement actions, trainings, correspondence.
S5.B.4.a	Review ordinance or other regulatory mechanism that requires ESC and other construction pollution controls. Must adapt ordinance compliant to this section no later than December 31, 2022.

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

7.1 Introduction

Permanent stormwater control structures are managed under Permit section S5.B.5, which requires design, plan review, construction inspection, and on-going maintenance as part of the SWMP. 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 the Spokane area.

Pictured: A Sand Filter Vault in Spokane County, an example of a Post-Construction Stormwater BMP

Both the SWMMEW and the Permit received updates in 2019, which necessitated review of the SRSM. The County coordinated effort with the City of Spokane and the City of Spokane Valley to review the SRSM to new regulatory standards. In 2020, the Department of Ecology confirmed that the SRSM meets regulatory requirements as detailed in Appendix 1 of the Permit. The Spokane Region will continue to review the SRSM and consider if any updates are necessary to further align manual with regulatory requirements.

7.2 Post-Construction General Requirements and Site Inspection Elements

Spokane County enforces Post-Construction stormwater activities through the authority provided in the Chapter 9.14 of the County Code of Ordinances. Chapter 9.14 includes the SRSM via reference, thus requiring proper design and maintenance of permanent stormwater control and treatment structures. Chapter 9.14 details the regulatory authority and enforcement measures granted to the County in instances of non-compliance.

For structures not owned/operated by Spokane County, maintenance and monitoring responsibilities are delegated to responsible parties, whether it be an individual or a Homeowners Association (HOA). Finalized plats contain language detailing maintenance tasks for a completed project and, if applicable, to whom responsibility has been delegated. Supplemental enforcement programs, like the County's swale bond program, ensure that swales are built and maintained according to submitted plans. Inspectors determine if swales have been impacted by

construction activities, and then schedule a flood test to ensure that infiltrative capacity meets design criteria. The swale bond is released if no standing water is left in the swale after 72 hours.

Stormwater structures maintained by Spokane County are added to the GIS mapping system and inspected every two years. Items referred to as Drainage Accounts or Regional Facilities are often Post-Construction BMPs maintained by the County and funded via the collection of special stormwater fees. Chapter 8 of this Plan discusses Operations and Maintenance activities in more detail.

7.3 External Education and Training Elements of Post-Construction

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

7.4 Staffing, Funding, and Training for Program Elements

The various Spokane County departments involved in compliance with the Permit 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 the 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. At a minimum, county personnel not immediately responsible for stormwater tasks are made aware of common stormwater issues and how to reach Stormwater Utility staff.

7.5 Permit Requirements

The "Post-Construction Stormwater Management for New and Redevelopment" permit requirements are outlined as follows:

S5.B.5	Implement and enforce a program for and private projects with stormwater runoff from new and redevelopment projects that would impact the permittee's MS4.
S5.B.5.c	Implement procedures for site plan review that incorporates water quality impacts. Plans must contain SWPPPs.
S5.B.5.d	Implement procedures for site inspection and enforcement of post-construction stormwater controls.
S5.B.5.d.i	Inspect structural BMP at least once during installation and upon final installation or upon completion of the project.
S5.B.5.d.ii	Inspect structural BMPs at least once every 5 years after final install, or more frequently if deemed necessary.
S5.B.5.d.iii	If an inspection is performed and problems are identified, permittee shall require and confirm that necessary practices are performed as soon as possible. SWMMEW contains recommended operating standards.
S5.B.5.e	Provide adequate training for all staff involved in permitting, planning, review, inspection, and enforcement.
S5.B.5.f	Provide info to design professionals about training available on how to comply with the requirements of Appendix 1 and apply SWMMEW BMPs
S5.B.5.g	Keep records of all projects disturbing one acre or more for 5 years or until project is complete. O&M and site plans shall be kept indefinitely. Keep records of any information that was distributed to design professionals.
S5.B.5.a	Implement an ordinance that requires post-construction stormwater controls at new development and redevelopment project. Implement before December 31, 2022.

SECTION 8 – OPERATIONS AND MAINTENANCE

8.1 Introduction

The Operations and Maintenance program is an essential shared responsibility between Spokane County departments. The Maintenance and Operations department of Public Works is the primary entity responsible for maintaining county road infrastructure. Although primarily addressing stormwater infrastructure, the Permit identifies minimum performance measures for the operation and maintenance of all publicly owned facilities. 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

The Stormwater Utility coordinates with the following County departments: Maintenance and Operations; Environmental Services; Facilities Maintenance; Parks, Recreation, and Golf; Fair and Expo; Human Resources; and Sherriff. The Stormwater Utility maintains a Stormwater Operations and Maintenance Plan[10], as required by the Permit, to address activities performed at County facilities. The Permit and SWMMEW received updates in 2019, prompting the Stormwater Utility to begin reviewing the O&M Plan for updates. The Stormwater Utility will work on O&M Plan revisions throughout 2020.

8.2 Stormwater Facilities and Conveyance Systems

Stormwater treatment and flow control BMPs within the permit boundary are inspected at least every two years as required by the Permit. In 2020 Spokane County will hire temporary summer workers from May to October to collect data related to maintenance benchmarks. This data is collected via the County's Stormwater Inspection and Maintenance web application which allows field crews to input data while inspecting County structures, scheduling maintenance activities, and reporting details of maintenance activities. Data is then analyzed in GIS software to prioritize and schedule maintenance activities. This application is now fully incorporated into inspection procedures and will be crucial to 2020 inspections. Each year technicians and seasonal crews inspect and collect data on nearly 50% of the facilities within the County's MS4. In 2019 alone, County staff inspected 3461 of the County's storm structures.

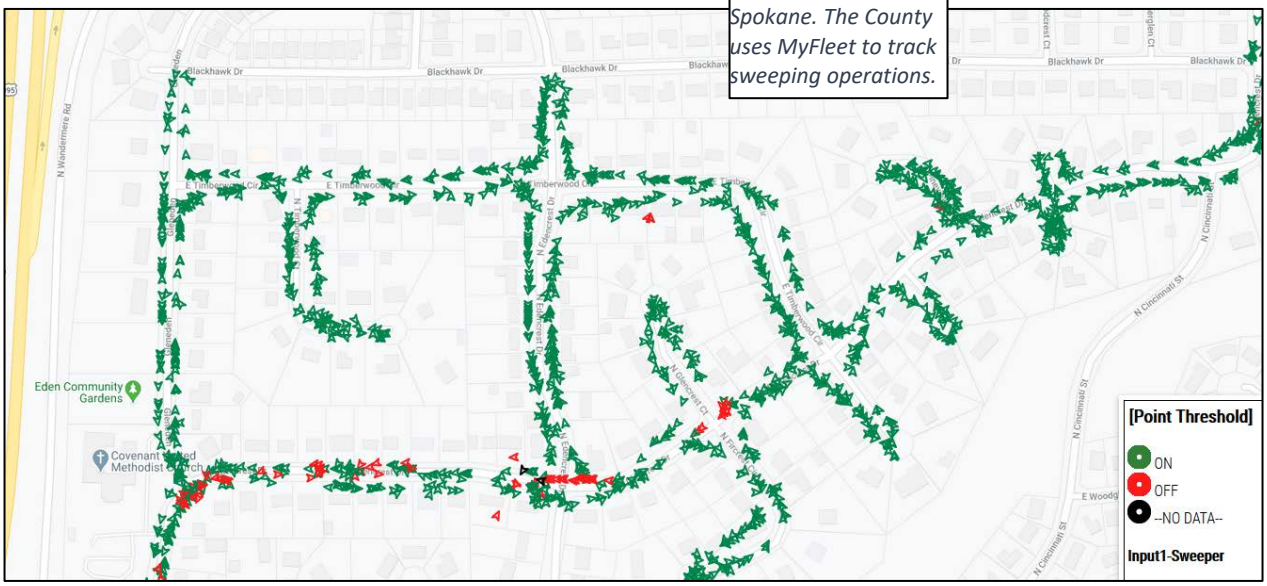
[10] https://www.spokanecounty.org/DocumentCenter/View/1715/Spokane-County-Stormwater-OM-Plan-PDF?bidId=

Routine inspection helps to develop adequate maintenance frequencies for catch basins, drywells, pipe connections, and culverts. The Stormwater Utility regularly consults with the Maintenance Department and Public Works Information Technology on procedures for tracking and reporting stormwater facility maintenance activities. 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. *Attachment 4 – Illicit Discharge Detection and Elimination* includes actions taken to prevent illicit discharges and connections, which includes maintaining various maps of the MS4.

The Stormwater Utility works in conjunction with County Road Maintenance crews to update the inventory of these facilities and implement preventative maintenance activities. Vactor trucks collect contaminated material that has accumulated in stormwater facilities and deposit the resulting slurry at the Regional Decant Facility for water treatment and later material disposal. In 2020 the County will continue the successful vactor program, dedicating two maintenance staff members to the operation of one vactor truck from May-October. Inspectors can flag and prioritize structures that need immediate maintenance, to which the vactor crew can respond immediately depending on availability.

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. The 1400 miles of paved County streets are cleaned on a priority basis, while County parking lots are swept twice per year (spring and fall). In 2019, the County reported 1200 miles of sweeper operation, roughly equivalent to 600 miles of swept roadway. In 2020 the County plans to maintain the current rate of street sweeper activity, which prioritizes high ADT roadways, and roads which receive winter sanding/salting operations. Spokane County tracks sweeping activities using GPS mapping tools.

Pictured: An example of 2019 MyFleet street sweeper data collected in North Spokane. The County uses MyFleet to track sweeping operations.



Pictured Left: Spokane County Street Sweeper in operation.

Pictured Right: Spokane County maintenance crew using a vactor truck to clean a catch basin.

8.3. Material Storage, Heavy Equipment Storage, Maintenance Areas, and Vehicle Fleets

The Stormwater Utility reviews operations and maintenance activities to encourage environmentally responsible practices. Spokane County has developed SWPPPs for required facilities, as required by Permit section S5.B.6. SWPPPs are site specific stormwater plans that act as living documents providing employees with guidance on stormwater regulations and requirements. With the release of the 2019 Permit, Spokane County has modified facility SWPPPs to meet new guidelines.

Staff are trained on the additional requirements regarding pollution prevention and good housekeeping practices at vehicle and heavy equipment maintenance shops. SWPPPs directly reference BMPs and pollution prevention guidance provided in the SWMMEW. For example, facilities without adequate vehicle wash stations wash equipment off-site at contracted wash stations.

In 2015/2016, Spokane County Public Works 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. To date 4 of the 6 maintenance shops have been constructed, including the Denison, Eden, Craig, and Old Corral Shops.

8.4 Municipal Buildings, Parks, and Open Space

Municipal buildings, parks, golf courses, and natural areas all require maintenance which, if improperly managed, could result in adverse environmental impact. Application of chemicals such as cleaners, fertilizers, herbicides, pesticides, and deicers can impact runoff and enter

downstream receiving waters. When performed improperly, maintenance activities such as washing 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 management to protect water resources. The Spokane County Stormwater Operations and Maintenance plan details specific sources of pollution and the operational BMPs to prevent pollution.

Training is provided to employees as needed regarding pollution prevention practices such as good housekeeping. In 2020 the Stormwater Utility plans on increasing coordination with Facilities Maintenance and Parks and Recreation staff by rolling out site SWPPPs and providing resources to improve pollution prevention practices.

8.5 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.

8.6 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. Waste generated from the cleaning of catch basins, drywells, swales, conveyance systems, and other stormwater facilities are transported 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. The County is working on improvements to the Decant Facility in 2020 to preserve the lifespan of the treatment swale on site.

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 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.

8.7 Construction Projects

The County is responsible for the construction of new roads and improvements to existing roads, including selection, installation, and retrofit of stormwater BMPs. The Stormwater Utility works with the Public Works Construction department and Environmental Programs 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 structure within County right-of-way.

Spokane County continues to comply with applicable standards for pollution prevention control measures related to construction activities. The local and regional stormwater manuals detail engineering design standards which include implementation of effective construction stormwater BMPs. 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 part of a larger development exceeding one acre, that have the potential to impact surface waters of the state via stormwater runoff. These permits: require the submittal of stormwater pollution prevention plans; require implementation of sediment, erosion, and pollution prevention measures; and are subject to inspection and enforcement by Ecology.

8.8 Flood Management Projects

The Environmental Programs Department is the lead entity on floodplain management in Spokane County. Responsibilities include review of plans, implementation of local, state, and federal floodplain management requirements, and enforcement. Uncontrolled construction within a floodplain, improper design, and lack of floodplain maintenance lead to water quality problems that can otherwise be avoided with proper floodplain management. Coordination occurs between Spokane County's Environmental Programs Department and permitting entities, such as the Army Corps of Engineers, to prevent human activities from significantly and adversely affecting the environment.

8.9 Staffing, Funding, and Training for Program Elements

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.

8.10 Permit Requirements

The "Operations and Maintenance" permit requirements are outlined in the following table:

S5.B.6	Implement an Operations and Maintenance program that includes a training component and has the goal of preventing/reducing pollutant runoff from Municipal operations.
S5.B.6.a.i.a	Maintain Stormwater Collection and Conveyance systems including cleaning, inspection, disposal of waste, and recordkeeping.
S5.B.6.a.i.b	Maintain roads, highways, and parking lots including cleaning, deicing, snow disposal areas, material storage areas, all season BMPs to reduce road and parking lot debris and other pollutants.
S5.B.6.a.i.c	Maintain vehicle Fleets including storage, washing, maintenance, repair, and fueling of vehicles.
S5.B.6.a.i.d	Maintain municipal buildings including cleaning, washing, painting, and other maintenance.
S5.B.6.a.i.e	Maintain parks and open space including fertilizer application, pesticide/herbicide application, pet waste BMPs, ESC, landscaping and vegetation disposal, trash management, and building cleaning BMPs.
S5.B.6.a.i.f	Public construction projects shall comply with requirements applied to private projects. All construction projects owned by the permittee needing a NPDES construction permit shall have one and meet Appendix 1 requirements.
S5.B.6.a.i.g	All facilities owned/operated by the permittee that need an Industrial NPDES permit shall have one.
S5.B.6.a.i.h	Material Storage, heavy equipment storage, and maintenance areas shall possess a SWPPP which includes a drainage/discharge/pollutant site map, inventory of materials/equip on site, inventory of activities, spill plan, and description of BMPs on site including maintenance details.
S5.B.6.a.i.i	Assess water quality impacts in the design of all new flood management projects associated w/ the MS4.
S5.B.6.a.i.j	Maintain other facilities not specifically mentioned in this section that would reasonably be expected to discharge contaminated runoff.
S5.B.6.a.ii	Include a schedule of inspections and requirements for recordkeeping
S5.B.6.a.ii.a	Every two years, inspect a minimum of 95% of all known stormwater treatment and flow control facilities. Inspect problem facilities more frequently.
S5.B.6.a.ii.b	Inspect all catch basins and inlets every two years. Clean catch basins as needed. Use alternative catch basin inspection schedules if applicable (see details in S5.B.6.a.ii.b 1&2).
S5.B.6.b	Provide training to employees who have primary construction, operations, or maintenance job functions likely to impact stormwater quality.
S5.B.6.a	Implement an O&M Plan and update no later than December 31, 2022. BMPs shall reduce pollutants to MEP, AKART. BMPs shall be at least as protective as those in SWMMEW and must control the following sources.
S5.B.6.a.ii.c	Spot check treatment and flow control facilities for potential damage following a 10-year or greater storm, and repair as soon as practicable.

SECTION 9 – TOTAL MAXIMUM DAILY LOAD REQUIREMENTS

9.1 Total Maximum Daily Loads (TMDLs)

This section details the implementation of Permit special provision S7 – Compliance with Total Maximum Daily Load Requirements. 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 and still safely meet water quality standards. TMDLs describe the type, amount, and sources of water pollution in a 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.

9.2 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 inspection and maintenance of storm drainage facilities within road rights-of-way, and County-owned properties, to reduce pollutant-loading impacts on surface waterbodies. Spokane County shall continue monitoring outfall locations for evidence of illicit discharges and illicit connections, as these structures have immediate potential to impact surface water quality should any problems occur.

Spokane County is not included in Appendix 2 of the current Permit. Permit section S7.B states that “For applicable TMDLs not listed in Appendix 2, compliance with this permit shall constitute compliance with those TMDLs.” The County will continue regular monitoring activities for known outfalls, as well as continue monitoring for unknown outfalls on applicable water bodies.

9.3 Staffing, Funding, and Training for Program Elements

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.

9.4 Permit Requirements

The “Total Maximum Daily Load” permit requirements are outlined below:

S7.A	Comply with any applicable requirements identified in Appendix 2. Include status and activities in Annual Report.
S7.B	For applicable TMDLs not listed in Appendix 2, overall compliance with this permit shall constitute compliance with those TMDLs.

SECTION 10 – STORMWATER MANAGEMENT PROGRAM EFFECTIVENESS STUDIES

10.1 Introduction

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.

Effectiveness studies may address topics including changing public behavior, decreasing inputs of target pollutants to the environment, compliance with NPDES Permit requirements, and developing new technologies, such as BMPs, that can be utilized by permittees.

Pictured: Sand Filter Sidewalk Vault BMP Effectiveness Study site

10.2 Planning and Development

Most permitted cities and counties within Central and Eastern Washington participate in a working group, known as the Eastern Washington Stormwater Group (EWSG), to collaborate on NPDES program elements. In 2013, the EWSG began discussing how to cooperatively develop and implement studies to test the effectiveness of SWMP components. In 2013 the City of Spokane Valley was awarded two grants from Ecology for the period of 2013-2017 to lead coordination of Permittees in meeting this program component. The group selected eight studies relevant to stormwater management activities currently implemented, or of interest to, member jurisdictions. Key documents compiled to date are published on the City of Spokane Valley's website[11].

Spokane County acts as lead entity on two of the eight active studies. Attachment 5 – Effectiveness Studies contains a summary of study activities conducted in 2019, as required by the permit, and activities planned for 2020. Attachment 5 contains further background on the selection of current effectiveness studies, as well as the up-to-date Quality Assurance Project Plans (QAPPs) for each Spokane County study.

10.3 Staffing, Funding, and Training for Program Elements

Spokane County collaborates with Eastern Washington Stormwater Group (EWSG) members to ensure successful implementation of this section of the SWMP. The current versions of each Study Design Proposal are provided in *Attachment 5 – 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.

[11] https://www.spokanevalley.org/content/6836/6896/6914/8301/10121/default.aspx

10.4 Priorities and Measurable Goals

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

S8.A.1	Continue to participate in implementation of the eight Ecology-approved studies that were selected pursuant to Section S8.B in the 2014 Permit.
S8.A.2	Coordinate with other Permittees in your Urban Area to plan and begin an additional SWMP effectiveness study. Must be either a lead entity, funding provider, or contribute staff time to be considered a participant. Submit a brief description of the study with a list of project participants and associated roles to Ecology by June 30, 2021.
S8.A.2.c	Submit a detailed study design proposal to Ecology on or before September 30, 2022.
S8.A.2.d	Submit a completed QAPP on or before July 31, 2023.
S8.A.2.e	Begin to conduct the study on or before December 1, 2023.
S8.A.2.f	Include effectiveness study activities in the updated SWMP.
S8.B.1	Lead Entities shall follow reporting requirements and timelines in the approved QAPP for the study.
S8.B.1.a	Enter all applicable data collected during the study into Ecology's EIM database. Submit non-applicable data in the Annual Report.
S8.B.1.b	Publish a final report with the results and recommended future actions within 60 days of completing the study.
S8.B.1.c	Produce a fact sheet summarizing the findings and recommendations within 90 days of completing the study.

Appendix 1

Definitions and Acronyms from the NPDES Permit

DEFINITIONS AND ACRONYMS

NOTE: All references to Appendix 1 within these definitions refer to Permit Appendix 1

"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.

"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.

"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.

"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, 331251 *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.

"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.

"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.

"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.

"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.

"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.

"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.

"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 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.

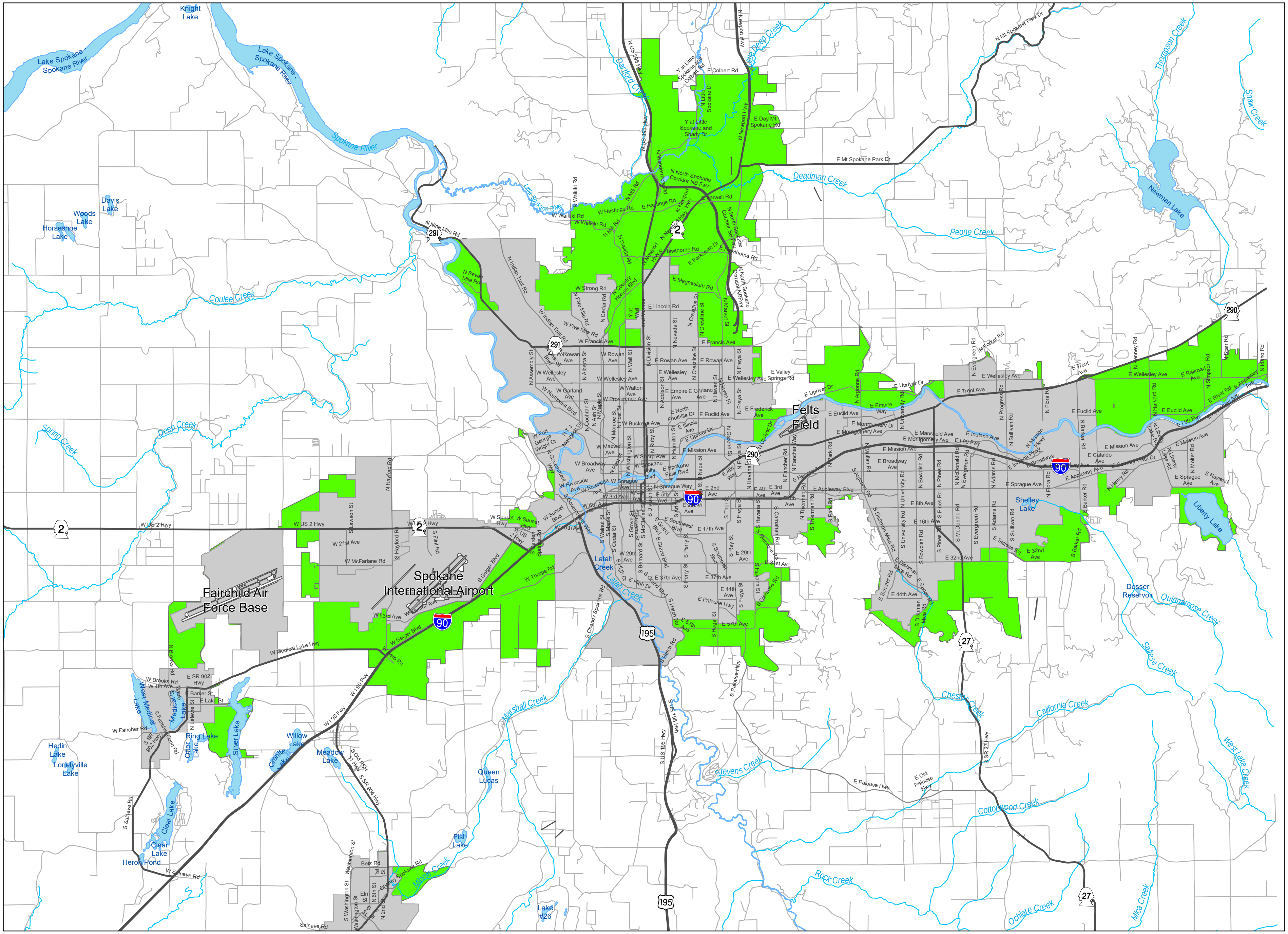
"Waters of the state" includes those waters as defined as "waters of the United States" in 40 CFR 122.2 within the geographic boundaries of Washington State and "waters of the state" as defined in Chapter 90.48 RCW which includes: lakes, rivers, ponds, streams, inland waters, underground waters, salt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

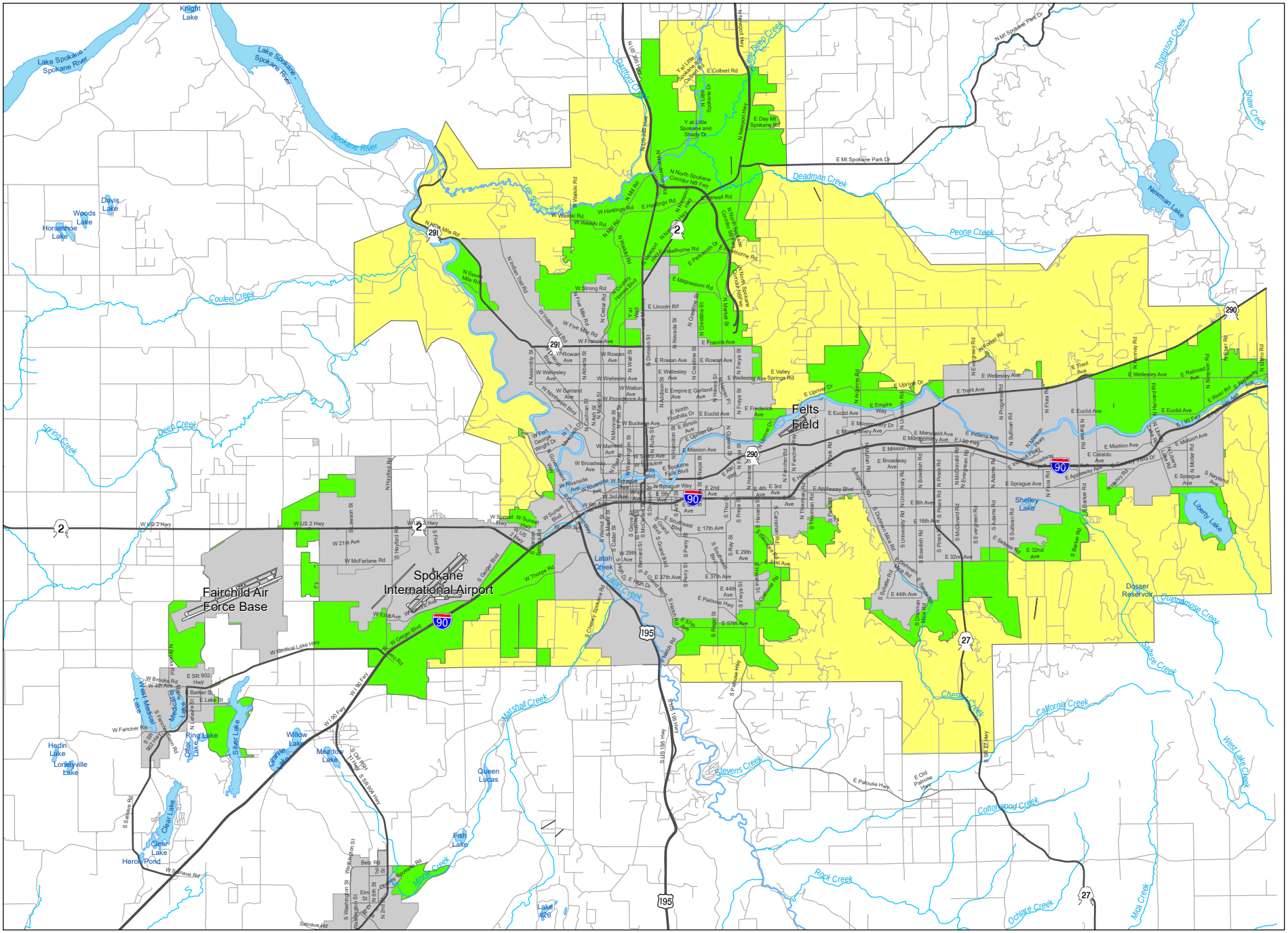
Attachment 1

NPDES Permit Area Maps

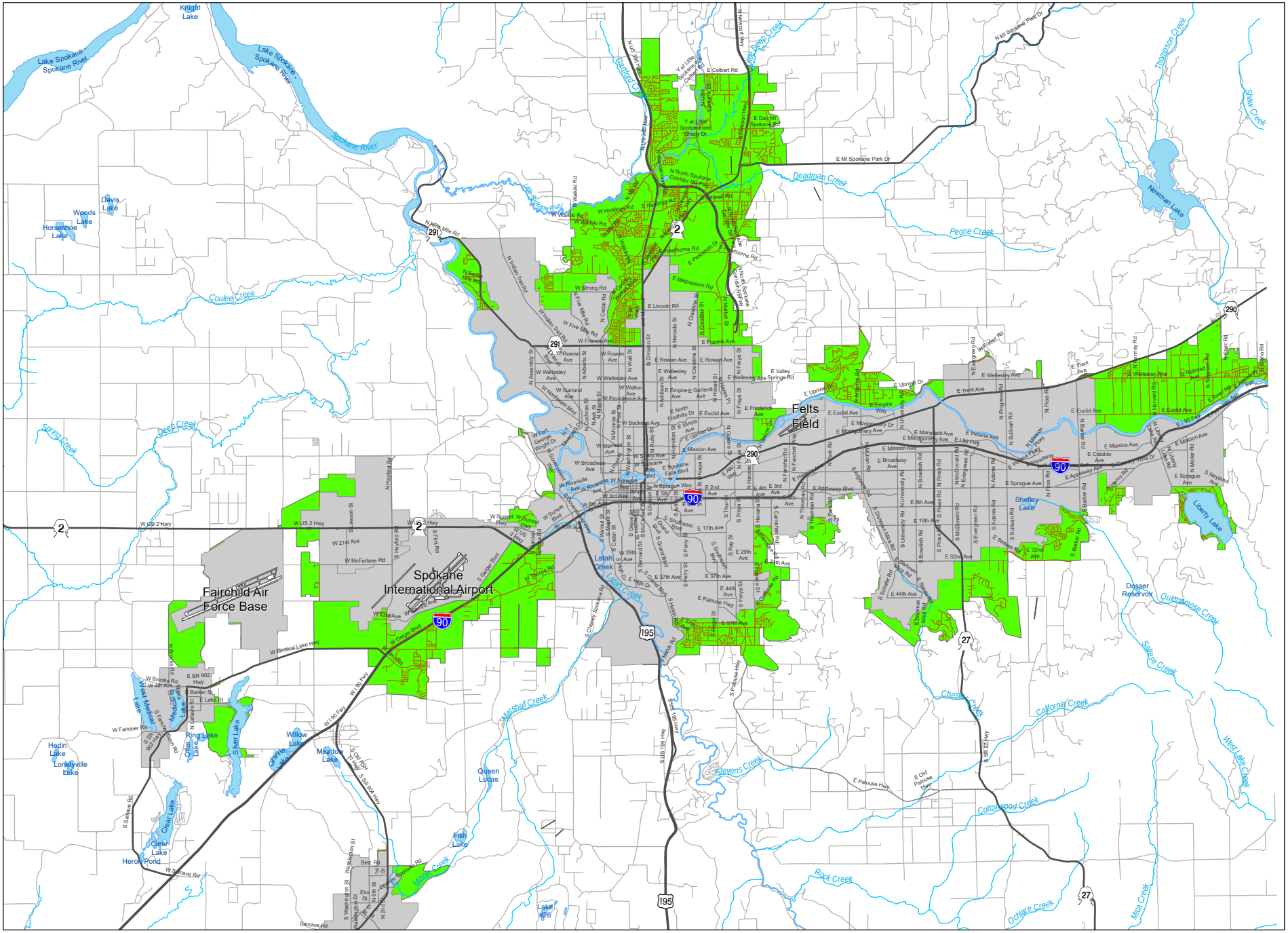


SPOKANE COUNTY NPDES PHASE II PERMIT AREA

NPDES Boundary
Incorporated Cities
Water Bodies
Freeway
Highway
Major Arterial
Minor Arterial
N



SPOKANE COUNTY STORMWATER SERVICE AREA



NPDES PHASE II COUNTY MAINTAINED ROADS

Roads In NPDES (358 mi.)

NPDES Boundary

Incorporated Cities

Water Bodies

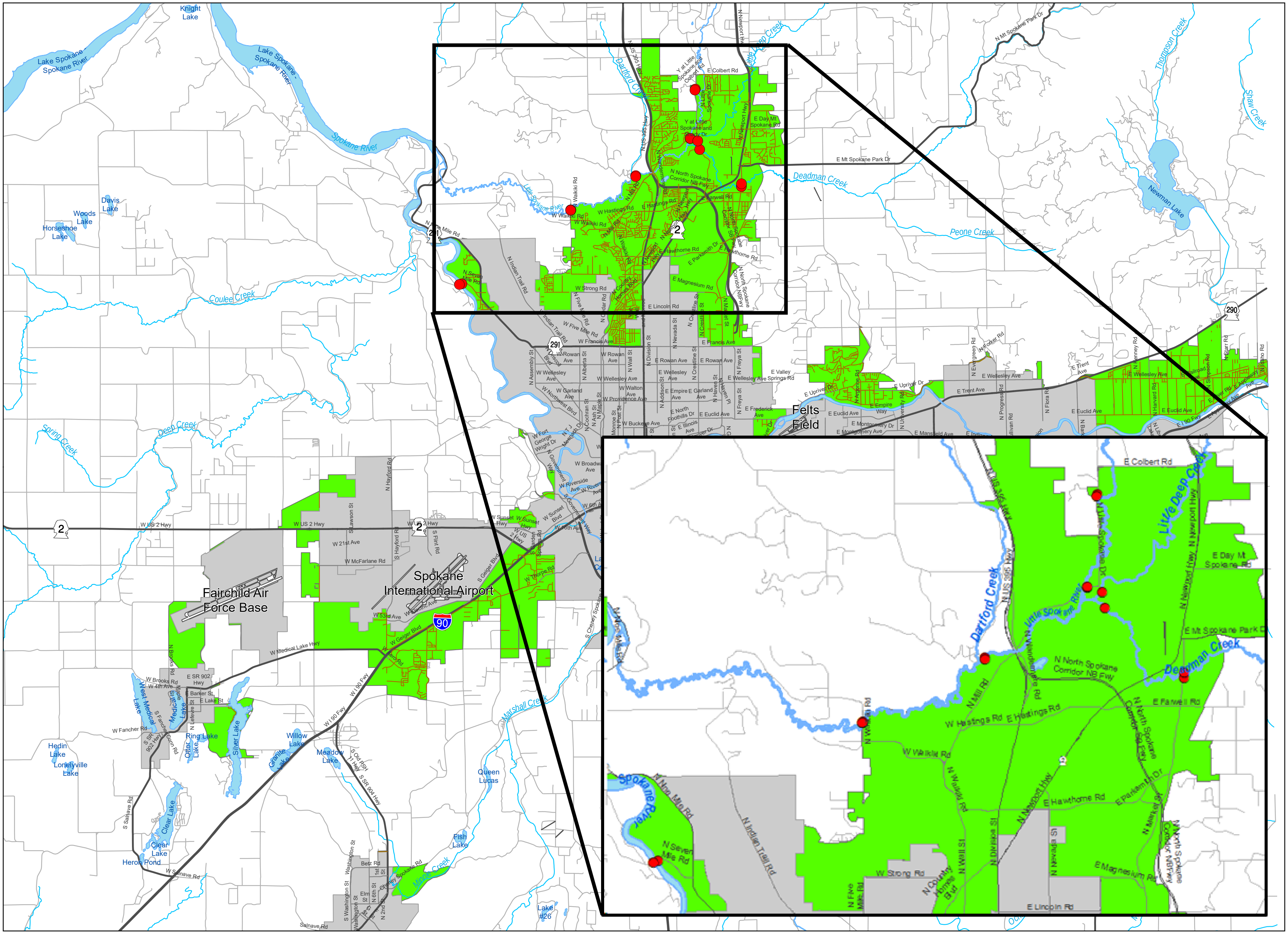
Freeway

Highway

Major Arterial

Minor Arterial

N



SPOKANE COUNTY NPDES PHASE II OUTFALLS

Outfalls	NPDES Boundary
Water Bodies	Freeway
Major Arterial	Incorporated Cities
Roads In NPDES (358 mi.)	Highway
Minor Arterial	

N

Spokane County PUBLIC WORKS

Attachment 2

Internal Coordination

Internal Coordination

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 2019. Successful coordination is critical to remove barriers between County departments, promote understanding of the NPDES Permit, and facilitate Permit compliance.

2. County Department Involvement

The Spokane County Stormwater Utility leads NPDES program development, staying current with new permit requirements, identifying training needs, and ensuring that mechanisms for tracking and coordination are in place. Stormwater Utility staff also have primary responsibility enforcing municipal stormwater regulations. The following is a list of divisions and departments in the County 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
- Information Technology

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
- Appropriate use and storage of chemicals outdoors
- Hazardous materials disposal
- Vehicle maintenance

3.2. Public Involvement and Participation

The Stormwater Utility provides the public the ability to participate in decision-making processes involving the development and implementation of 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. 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 establishing an ongoing process that identifies and eliminates sources of stormwater pollution.

The County provides opportunities for IDDE training for staff that conduct field-related activities. Employees are trained on how 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, when applicable, the local Spill Response Team with the Department of Ecology.

3.4 Construction and Post-Construction

The responsibility for enforcing runoff controls from construction sites is shared by Public Works and Building and Planning. Development Services is the primary entity responsible for reviewing 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.

The County is always looking for ways to improve plan review, permitting, and inspection processes. Inspections are conducted to review ESC requirements and departments must coordinate to track records of all inspections, violations, and enforcement activities. SmartGov, a browser-based application for municipal operations, is being increasingly used by the county to manage various aspects of the permitting process. SmartGov is an internal tracking and planning tool that can facilitate interdepartmental coordination throughout permitting processes.

3.5 Operations and Maintenance

The Public Works Maintenance Department performs upkeep of County storm drainage infrastructure, which includes catch basins, drywells, pipes, open channels, swales, and regional retention/detention facilities. Spokane County Stormwater Utility staff meet permit requirements by inspecting stormwater treatment and flow control facilities and referring concerns, cleaning, and/or repair needs to the Maintenance Department to direct prioritization of required maintenance activities. Public Works IT maintains a Geographic Information Systems (GIS) database of storm structures and their status (i.e. needs inspection, requires maintenance, no action necessary). The GIS database is an invaluable tool for interdepartmental coordination

Stormwater Utility employees inspect stormwater facilities during and after major storm events to ensure systems are functioning properly. A monitoring list, referred to as the Rain List, prioritizes sites needing inspection during and after stormwater events. All records of inspections and maintenance activities are kept in accordance with the Permit.

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 various County departments to collect data relevant to SWMP planning and reporting.

Attachment 3

Public Education and Outreach

Public Education and Outreach

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 the Public Involvement and Participation programs, describing the educational materials utilized to implement these programs in the calendar year 2019.

2. Program Focus

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

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

- Educate citizens on and encourage public reporting of illicit discharges. The reporting is accomplished using a countywide hotline telephone number.
- Convey information about stormwater pollutants, Spokane County environmental permitting, water quality issues, and BMPs. Provide opportunities for public comment and feedback regarding the Spokane County stormwater programs.
- Educate residents about stormwater structures and what they can do to protect local infrastructure.
- Provide educational materials and presentations to children on stormwater pollution issues;
- Broaden the sense of public responsibility by providing opportunities for citizens to actively participate in activities and events, such as storm drain stenciling and swale planting days.
- Follow public notification protocol. Seek input from the public on the SWMP Plan through meetings or other means.
- Educate construction site operators, contractors, and engineers on the importance of construction BMPs to reduce pollutants in runoff from construction sites.
- Educate the public on proper waste management, including the availability and locations of facilities for disposal or drop-off of household hazardous wastes, chemicals, grass clippings, leaf litter, animal wastes, oils, etc.

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

The Spokane County Water Resources Department, in cooperation with the Stormwater Utility, continues to conduct public education based on the water quality needs of our region. For a full list of activities conducted in 2019, see *Appendix A – Public Education and Outreach Activities.*

3.1. Spokane County Water Resource Center

Learning events for all ages are held at the Water Resource Center (WRC) throughout the year. The 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, and interactive water cycle quizzes on two iPads. Portable activities include a stream table, the EnviroScape watershed model, Stormwater Plinko, stormwater pollution jars, and the "What Should You Flush" activity, where students shake containers filled with water and "flushable" items to observe how much it breaks down.
- **Conference Room –** The indoor conference room provides tables and chairs for hosting meetings of 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

In 2019 Spokane County Water Resources, the Stormwater Utility, Spokane County Regional Solid Waste System, staffed a joint space at the Spokane County Interstate Fair from September 6-15, 2019. Over the span of ten days, hundreds of youth and adults learned about storm drains and the aquifer, in addition to such things as solid and hazardous waste recycling. The items for distribution included Storm Drain Dan (a local stormwater mascot) activity books, Aquifer Atlases, pencils, and various brochures on pollution prevention.

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 2019 the Stormwater Utility and Spokane County Water Resources continued its participation in an environmental program for 5th graders. During the months of April and May, more than 1,100 students and teachers from the Central Valley School District learned about watersheds, the water cycle, stormwater pollution, stewardship regarding

their storm drains, and drinking water protection. Each day, about 50 students worked their way through four (4) stations. The first station focused on the aquifer and water quality/stormwater. The second station 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 and students were tested on what they had learned.

- **Combination Tours –** In 2019 collaborative efforts with the City of Spokane resulted in combination tours offered to teachers and their classrooms. These tours allow a class experiences at two water resources facilities (The Upriver Hydroelectric Dam and the Spokane County Water Resources Center) to get a better understanding of the importance of water to everyday life. The topic of stormwater is addressed at both facilities, offering different perspectives on the important role runoff plays in water quality and quantity.
- **Spokane Public Schools Summer Program –** The County participates in two different programs, Summer Express and Go Forth. Summer Express, which is a daycare program for incoming 1st through 7th graders, were able to visit the Water Resources Center to learn about wastewater treatment, stormwater, water quality, and Spokane watersheds. The County taught the same curriculum at Go Forth, which is a supplemental enrichment program offered to students needing additional support before entering 4th grade.
- **Rain Barrel Program[1] –** 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 were held in 2019 with a total attendance of 114 people. The purpose of the program is to encourage the public to act to help manage stormwater, conserve water resources, and contribute to 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, 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 [2]–** Spokane County Stormwater Utility continues to partner with the EnviroKids Club, a regionally-cooperative environmental education program for K-6 students. When students join the Club, they receive quarterly newsletters in the mail which tackle a wide variety of environmental subjects, including water quality issues. The students 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.

[1] http://sccd.org/departments/education/rain-barrel-program
[2] https://sites.google.com/site/spokaneenvirokids/home

3.4. Educational Tools

Spokane County uses novel 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 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 groundwater.
- **Stream Table –** The Spokane County Water Resources Department purchased a stream table for use at educational events held at 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 about 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 Mismatch 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 match 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 Stormwater Utility 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 –** The Storm Drain Shell Game was created for use at various community events, including Earth Day and Unity in the Community. In this game, three mini storm drains – two 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 has proven 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, this 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 2019 at various community events, and classes or meetings held at the Water Resource Center. The Atlas can also be accessed online via the County's Water Resources webpage[3] or the Spokane Aquifer Joint Board website[4].

3.5. Public Education and Outreach Campaigns

- **Got waste? Put it in the right place![5] –** The local non-profit 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, children and adults are now more aware of differences between garbage, recyclables, and hazardous waste. This program is heavily advertised by information provided via brochure, online, and through regulatory guidance programs such SRHD's EnviroCertified program.
- **Don't Drip & Drive –** In cooperation with the City of Spokane, Spokane County helped co-launch the Puget Sound STORM [6]group's marketing campaign, "Don't Drip & Drive,"[7] to residents in the greater-Spokane region. Maintenance shops throughout the City, Valley, and County continue to offer discounted car maintenance services to customers through the Don't Drip and Drive program. The County disseminates information to residents on several occasions, such as the Spokane County Fair.
- **Residential Pool Mailings –** In 2019 the Stormwater Utility continued the practice of surveying homes with outdoor swimming pools. Swimming pools are a major contributor of pollutants such as chlorine entering the MS4. Residents with pools received educational mailings detailing 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.
- **Save Our Swales "SOS" Doorhangers –** County field crews leave homeowners who have swales near their property "SOS" doorhangers to encourage maintenance of bioinfiltration swales. The County gave out around 35 doorhangers in 2019 to residents who owned swales that may need maintenance.

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

During the Development Review and/or the Site Plan Review processes, including on-site inspections, Public Works staff provides Erosion and Sediment Control (ESC) guidance to contractors and developers. The Stormwater Utility provides CESCL certification to staff who

[3] https://www.spokanecounty.org/1227/SVRP-Aquifer-Home
[4] http://www.spokaneaquifer.org/2015-aquifer-atlas/mobile/index.html
[5] https://spokaneriver.net/wastedirectory/
[6] http://pugetsoundstorm.weebly.com
[7] https://fixcarleaks.org/

interact with construction operators and are expected to enforce the County's ESC ordinances, local, state, and federal regulations.

The Stormwater Utility provides a calendar, which displays the dates of – and hyperlinks to – all Certified Erosion and Sediment Control Lead (CESCL) trainings and recertification courses within the State of Washington. Contractors and/or developers can access the calendar via the County's Stormwater webpage[8].

The County's Building and Planning Department also includes relevant flyers[9] 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[10]

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.

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

Appendix A

Public Education and Outreach Activities

Spokane County Water Resources & Stormwater Utility

2019 Education & Outreach and Public Involvement & Participation Tracking

Date	Staff	Organization or Event	Audience	Topic or Purpose	Outreach Category	Youth Estimate	Adult Estimate	Total
1/10/2019	Taylor	Mead High School STEM Night	HS	Water Quality, Water Knowledge (Jeopardy), Stormwater	Off-site	80	15	95
1/25/2019	Taylor, Neil, Feiten	Christian Homeschool Group	Elementary, MS	Watershed, Wastewater, Stormwater	WRC	50	20	70
1/31/2019	Neil	Sunrise Elem. - Science Fair	Elementary	Watershed, Wastewater, Stormwater	Off-site	40	20	60
2/7/2019	Neil	Holmes Elem. - Science Night	Elementary	Watershed, Wastewater, Stormwater	Off-site	40	20	60
2/21/2019	Boese	McDonald Elem. - Science Fair	Elementary	Watershed, Wastewater, Stormwater	Off-site	40	20	60
2/26/2019	Taylor	Pasadena Park Elem. - Science Night	Elementary	Watershed, Wastewater, Stormwater	Off-site	40	20	60
2/28/2019	Neil	Otis Orchards - Science Extravaganza	Elementary	Watershed, Wastewater, Stormwater	Off-site	40	20	60
3/5/2019	Neil	Moran Prairie Elem. - STEAM Night	Elementary	Watershed, Wastewater, Stormwater	Off-site	40	20	60
3/7/2019	Neil, Feiten, Zimmer	Balboa Elementary	Elementary	Watershed, Wastewater, Stormwater	WRC	56	5	61
3/8/2019	Neil, Taylor	South Pines SPACE - 1st grade	Elementary	Watershed, Wastewater, Stormwater	WRC	18	6	24
3/14/2019	Neil	Trentwood Elem. Science Night	Elementary	Watershed, Wastewater, Stormwater	Off-site	40	20	60
3/18/2019	Neil	Evergreen Elem. Science Night	Elementary	Watershed, Wastewater, Stormwater	Off-site	40	20	60
3/20/2019	Boese	Mullan Road Elementary Science Night	Elementary	Watershed, Wastewater, Stormwater	Off-site	50	20	70
3/23/2019	Taylor	WVOLC H20 Heroes	Elementary, MS, Adu	Stormwater	Off-site	20	10	30
3/28/2019	Taylor, Neil	Hutton Elem. After School Express	Elementary	Watershed, Virtual Water, Stormwater	Off-site	35	2	37
4/1/2019	Boese, Neil	EnviroKids @ Shadle Park Library	Elementary	Water Quality, Stormwater	Off-site	35	20	55
4/4/2019	Boese, Neil	EnviroKids @ South Hill Library	Elementary	Water Quality, Stormwater	Off-site	35	20	55
4/5/2019	Taylor, Neil	Palisades Christian Academy	Elementary	Water Cycle, Wastewater, Stormwater	WRC	20	3	23
4/15/2019	Selcho	Rain Barrel Workshop - SCCD	Adult	Stormwater	Off-site	0	22	22
4/19/2019	Taylor, Neil	COMBO SWAP - Trent Elem. 4th grade	Elementary	Water Cycle, Wastewater, Stormwater, Virtual Water	WRC	60	6	66
4/19/2019	Boese, Feiten	CVSD - South Pines 5th grade	Elementary	Environmental Outdoor Ed - watershed, stormwater	Off-site	48	8	56
4/23/2019	Taylor	Classical Christian Academy	Elementary	Watershed, Stormwater, Wastewater, Groundwater	WRC	15	3	18
4/22/2019	Boese	CVSD - Riverbend 5th grade	Elementary	Environmental Outdoor Ed - watershed, stormwater	Off-site	48	8	56
4/23/2019	Boese, Feiten	CVSD - Ponderosa 5th grade	Elementary	Environmental Outdoor Ed - watershed, stormwater	Off-site	48	8	56
4/24/2019	Taylor, Neil, Zimmer	Wilson Elementary - 2nd grade	Elementary	Water Cycle, Wastewater, Stormwater, Conservation	WRC	50	4	54
4/24/2019	Taylor	Orchard Center Family STEM Night	Elementary	Wastewater, Stormwater	Off-site	60	30	90
4/24/2019	Boese, Feiten	CVSD - Broadway 5th grade	Elementary	Environmental Outdoor Ed - watershed, stormwater	Off-site	48	8	56
4/26/2019	Boese, Feiten	CVSD - Greenacres 5th grade	Elementary	Environmental Outdoor Ed - watershed, stormwater	Off-site	48	8	56
4/29/2019	Boese	CVSD - Sunrise 5th grade	Elementary	Environmental Outdoor Ed - watershed, stormwater	Off-site	48	8	56
4/30/2019	Boese, Feiten	CVSD - Ponderosa 5th grade	Elementary	Environmental Outdoor Ed - watershed, stormwater	Off-site	48	8	56
5/1/2019	Boese, Neil	CVSD - Adams 5th grade	Elementary	Environmental Outdoor Ed - watershed, stormwater	Off-site	48	8	56
5/3/2019	Boese, Feiten	CVSD - Sunrise 5th grade	Elementary	Environmental Outdoor Ed - watershed, stormwater	Off-site	48	8	56
5/6/2019	Boese, Neil	CVSD - Liberty Lake 5th grade	Elementary	Environmental Outdoor Ed - watershed, stormwater	Off-site	48	8	56
5/7/2019	Neil, Feiten	CVSD - Opportunity 5th grade	Elementary	Environmental Outdoor Ed - watershed, stormwater	Off-site	48	8	56
5/8/2019	Neil, Feiten	CVSD - Liberty Lake 5th grade	Elementary	Environmental Outdoor Ed - watershed, stormwater	Off-site	48	8	56
5/8/2019	Selcho	Rain Barrel Workshop - SCCD	Adult	Stormwater	Off-site	0	25	25
5/10/2019	Boese, Neil	CVSD - Liberty Lake 5th grade	Elementary	Environmental Outdoor Ed - watershed, stormwater	Off-site	48	8	56
5/14/2019	Boese, Feiten	CVSD - Chester 5th grade	Elementary	Environmental Outdoor Ed - watershed, stormwater	Off-site	48	8	56
5/15/2019	Boese, Taylor	CVSD - Chester 5th grade	Elementary	Environmental Outdoor Ed - watershed, stormwater	Off-site	48	8	56
5/15/2019	Taylor, Feiten	Pride Prep 6th grade	Elementary	NPS Pollution, Aquifer Model, Virtual Water, Stormwater	WRC	25	2	27
5/20/2019	Taylor, Neil, Brattebo	Summit School 3rd grade	Elementary	Water Cycle, Wastewater, Stormwater, Watershed	WRC	50	4	54
5/20/2019	Boese, Feiten	CVSD - McDonald 5th grade	Elementary	Environmental Outdoor Ed - watershed, stormwater	Off-site	48	8	56
5/21/2019	Boese, Neil	CVSD - Liberty Lake 5th grade	Elementary	Environmental Outdoor Ed - watershed, stormwater	Off-site	48	8	56
5/22/2019	Boese, Neil	CVSD - Greenacres 5th grade	Elementary	Environmental Outdoor Ed - watershed, stormwater	Off-site	48	8	56
5/28/2019	Boese, Goff	CVSD - Broadway/Adams 5th grade	Elementary	Environmental Outdoor Ed - watershed, stormwater	Off-site	48	8	56
5/28/2019	Taylor, Neil, Feiten	Combo Swap w/dam - SIA 3rd grade	Elementary	Water Cycle, Stormwater, Watershed	WRC	48	4	52
5/29/2019	Boese, Feiten	CVSD - University/SVLA 5th grade	Elementary	Environmental Outdoor Ed - watershed, stormwater	Off-site	48	8	56
5/29/2019	Neil	Otis Orchards 3rd Grade - classroom visit	Elementary	Environmental Outdoor Ed - aquifer, stormwater	Off-site	75	3	78

Date	Staff	Organization or Event	Audience	Topic or Purpose	Outreach Category	Youth Estimate	Adult Estimate	Total
5/30/2019	Neil, Taylor	Franklin Elem. Trout Release Day	Elementary	Environmental Outdoor Ed - aquifer, stormwater	Off-site	110	12	122
5/30/2019	Boese, Goff	Mead - Shilo Hills 5th grade	Elementary	Environmental Outdoor Ed - aquifer, stormwater	Off-site	90	5	95
5/31/2019	Boese	Mead - Midway 5th grade	Elementary	Environmental Outdoor Ed - aquifer, stormwater	Off-site	90	5	95
6/3/2019	Taylor, Goff, Feiten	Combo Swap w/WTE Moran Prairie 3rd grd	Elementary	Watershed, Aquifer, Wastewater, Stormwater	WRC	100	8	108
6/4/2019	Taylor, Neil, Goff	Opportunity 3rd grade	Elementary	Watershed, Wastewater, Stormwater, Water Cycle	WRC	60	6	66
6/4/2019	Boese,	Mead - Meadow Ridge	Elementary	Environmental Outdoor Ed - aquifer, stormwater	Off-site	90	5	95
6/5/2019	Boese, Taylor	Mead - Brentwood 5th grade	Elementary	Environmental Outdoor Ed - aquifer, stormwater	Off-site	90	5	95
6/6/2019	Boese, Goff	Mead - Evergreen 5th grade	Elementary	Environmental Outdoor Ed - aquifer, stormwater	Off-site	90	5	95
6/8/2019	Goff	Neighbor Days at Felts Field	Adult, Elementary	River, Aquifer, Wastewater, Stormwater	Off-site	350	150	500
6/10/2019	Boese, Feiten	Mead - Farwell 5th grade	Elementary	Environmental Outdoor Ed - aquifer, stormwater	Off-site	90	5	95
6/11/2019	Boese, WVOLC	Mead - Colbert 5th grade	Elementary	Environmental Outdoor Ed - aquifer, stormwater	Off-site	90	5	95
6/27/2019	Selcho	Rain Barrel Workshop - SCCD	Adult	Stormwater	Off-site	0	22	22
7/2/2019	Taylor	Home School Pre-School Group	Adult, Pre-K	Wastewater, Stormwater, Water Cycle	WRC	9	6	15
7/10/2019	Boese, Goff, Neil	SPS Go Fourth - Grant	Elementary	Stormwater, Watershed	Off-site	40	3	43
7/11/2019	Boese, Neil	SPS Go Fourth - Grant	Elementary	Stormwater, Watershed	Off-site	40	3	43
7/15/2019	Goff, Neil	SPS - Summer Express	Elementary	Wastewater, Stormwater, Conservation	WRC	30	2	32
7/17/2019	Boese, Goff	SPS Go Fourth - Regal	Elementary	Stormwater, Watershed	Off-site	55	3	58
7/19/2019	Goff, Neil	SPS - Summer Express	Elementary	Wastewater, Stormwater, Conservation	WRC	30	2	32
7/24/2019	Goff, Neil	Small Wonders Childcare	Elementary	Watershed, Water Cycle, Stormwater	WRC	28	4	32
7/25/2019	Goff, Taylor	Adventure Land Daycare	Elementary	Watershed, Water Cycle, Stormwater	WRC	30	5	35
7/29/2019	Boese, Goff, Neil	SPS - Summer Express	Elementary	Wastewater, Stormwater, Conservation	WRC	30	2	32
7/30/2019	Selcho	Rain Barrel Workshop - SCCD	Adult	Stormwater	Off-site	0	23	23
7/31/2019	Boese, Goff	SPS Go Fourth - Finch	Elementary	Stormwater, Watershed	Off-site	55	3	58
8/12/2019	Goff, Neil	SPS - Summer Express	Elementary	Wastewater, Stormwater, Conservation	WRC	30	2	32
9/6/2019	ES Staff	Spokane County Interstate Fair	All Ages	Aquifer, stormwater, wastewater	Off-site	0	0	0
9/21/2019	Taylor, Sherrer	Valleyfest	All Ages	Aquifer, stormwater, wastewater	Off-site	200	70	270
9/24/2019	Selcho	Rain Barrel Workshop - SCCD	Adult	Stormwater	Off-site	0	22	22
10/16/2019	Taylor	St. George's - Jim Tuck's 7th grade	MS	Wastewater, Stormwater	Off-site	24	1	25
10/21/2019	Goff, Sherrer	Hamblen Elementary Science Night	Elementary	Wastewater, Stormwater, Water Quality	Off-site	60	30	90
10/26/2019	Goff, Sherrer	Fall Leaf Festival & Compost Fair	All Ages	Stormwater	Off-site	60	100	160
10/28/2019	Sherrer	Prairie View Elementary STEM Night	Elementary	Wastewater, Stormwater, Water Quality	Off-site	60	30	90
11/12/2019	Goff, Sherrer, Feiten, Taylor	COMBO TOUR: Midway 5th grade	Elementary	Wastewater, Stormwater, Drinking Water, Aquifer	WRC	120	8	128
11/4/2019	Goff, Sherrer	HUB 360 After School Program	Elementary	Bioaccumulation, Water Quality	Off-site	9	1	10
11/5/2019	Goff, Sherrer	HUB 360 After School Program	Elementary	Bioaccumulation, Water Quality	Off-site	12	1	13
11/6/2019	Goff, Sherrer	HUB 360 After School Program	Elementary	Bioaccumulation, Water Quality	Off-site	5	1	6
11/7/2019	Goff	HUB 360 After School Program	Elementary	Bioaccumulation, Water Quality	Off-site	18	1	19
11/19/2019	Taylor, Goff, Sherrer	COMBO TOUR: Venture HS - C d'Alene	HS	Wastewater, Stormwater	WRC	24	2	26
11/21/2019	Taylor	St. George's - Rick Petrini's 4th grade	Elementary	Water Quality, Wastewater, Stormwater	Off-site	18	1	19
12/9/2019	Goff, Taylor, Sherrer	Libby Center - 1st grade	Elementary	Water Cycle, Watershed, Wastewater, Stormwater	WRC	25	3	28
12/9/2019	Goff, Taylor, Sherrer	Libby Center - 1st grade	Elementary	Water Cycle, Watershed, Wastewater, Stormwater	WRC	25	3	28
12/23/2019	Goff, Taylor, Sherrer	YMCA Spokane Valley - K-6	Elementary	Water Cycle, Watershed, Wastewater, Stormwater	WRC	55	4	59
					89	**4404**	**1113**	**5517**

Appendix B

Results and Analysis of the 2019 Stormwater Awareness Survey

Spokane County
Stormwater Awareness Survey

September 2019

SPOKANE COUNTY

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Introduction

The Washington State Department of Ecology issued the NPDES General Permit for Stormwater Discharges from Municipal Separate Stormwater Sewer Systems (MS4s) for Eastern Washington in 2007. Municipalities regulated under this permit are required to meet six minimum control measures, one of which is to provide opportunities for the public to play an active role in the development and implementation of their respective stormwater management program. According to the Environmental Protection Agency (EPA), conducting an Attitude Survey is one of many ways MS4s can involve the public in their stormwater program. See: http://cfpub.epa.gov/npdes/stormwater/menuofbmps.

The Spokane County Stormwater Utility (SWU) initiated this survey to gather public input and background knowledge of stormwater issues within the Spokane County Stormwater Service Area (SWSA). The survey results will aid in developing appropriate education and outreach activities that help protect water resources within the unincorporated urban areas of Spokane County. Additionally, the information gathered can provide a baseline for evaluating program effectiveness.

The survey addresses questions of water quality, causes of water pollution, knowledge about storm water runoff, sources of information on stormwater issues, and willingness of participants to take specific actions to reduce water pollution.

The Survey

An attitude survey was mailed to 809 random residential mailing addresses with in Spokane County's SWSA in 2010; the identical survey was mailed to the same addresses in April 2019 with responses accepted through June 2019. The 809 households received the survey packet consisting of a copy of the questionnaire, a pre-addressed postage-paid envelope, and a cover letter describing the questionnaire and stating how the information would be used. All respondents were assured of confidentiality.

Out of 809 surveys sent, 209 households returned surveys, 183 through the mail and 26 electronically; only 2 of those were largely incomplete. The response rate was 26% (209/809). The sample size of 209 yields data that has a statistical reliability of ± 5.8 percentage points at the 95% confidence level. This means that 95 out of 100 times, the results of this survey should differ by no more than 5.8 percent, in either direction, from what would have been obtained by interviewing all households within Spokane County's Stormwater Service Area (SWSA).

The Report

A summary of the findings immediately follows this section. The tabulations and associated charts are reported in the *Detailed Responses* section, beginning on page 7. Refer to the *Table of Contents* on page 3 for a detailed breakdown of the entire report.

Results

Your Perceptions of Local Water Resources

The first set of questions in the survey was designed to gauge respondents' perception and understanding of water quality. When asked to rate the overall quality of local lakes, rivers, and streams in their community, 62% of respondents responded positively with a *good* or *very good*, while only 6.2% of respondents rated water quality as *poor* or *very poor*.

Respondents were also asked to rate the significance of eleven separate sources of pollution. *Stormwater runoff from streets* and *Discharges from industry* equally rank as the perceived greatest water quality threats (71%). *Lawn fertilizers and pesticides* also ranked as a significant source of pollution (68%), as do the *improper disposal of household hazardous wastes* (67%) and *motor oil and antifreeze* (65%). In a follow up question, these items were identified in the same order as the *greatest contributors* to water quality problems in and around the community.

Survey respondents demonstrate various understanding of what happens to stormwater after it leaves their property. Only fifteen percent (15%) of respondents recognize that stormwater in Spokane County infiltrates into the ground. Twenty-five percent 25% state that they are *not sure* where stormwater goes when it leaves their neighborhood. Sixteen percent (16%) of those surveyed incorrectly state that stormwater goes *to a sewage treatment facility*, while over half (54%) believes it goes to surface water in the form of a *detention pond* or *a stream, river, or lake*.

Your Activities

Respondents were asked to supply information about individual actions and practices that may impact water quality. Cumulatively, individual practices and actions have the potential to significantly impact local water quality both positively and negatively. If specific actions or practices having potentially negative impacts can be identified, public education and outreach programs targeting those actions can be effective tools for improving local water quality.

One significant way in which households can affect the quantity and quality of stormwater runoff is through domestic lawn care practices. Nearly 78% of survey respondents' grass-clipping disposal habits have a low negative impact on water quality, as they either *mulch or compost them*, or *throw them in the trash or in the yard waste bin*.

The same can not be said for the use of fertilizers and weed-killers. A small percentage (6.7%) of respondents *conduct a soil test to determine proper fertilizer application rates* for their lawn. Nearly 95% of respondents fertilize or apply herbicides to their lawns. A few respondents admit to applying fertilizers or herbicides monthly (3.8%). Sixty-four percent (64%) fertilize or apply herbicides two-to-three times a year. The practice that respondents are most "willing to do" to reduce water pollution, however, is *use a fertilizer with little or no parts phosphorus* (37%).

Respondents, for the most part, have vehicle maintenance practices that would be classified as environmentally sensitive. Nearly two-thirds *wash their cars at a commercial car washing facility*, while 82% *have their oil changed at a service center* on a regular basis. Respondents were also asked whether they would *wash their vehicles on the lawn* instead of the driveway if they knew it would help reduce water pollution, and 12% *already do*. Twenty-two percent of all respondents (22%) are *willing to do this*, but 38% declare *unwillingness* to do so.

The results regarding household hazardous waste disposal are very positive. Nearly 85% of respondents claim to take their paints, varnishes, household cleaners, and used motor oil to *a recycling center or toxic waste drop-off*. Only 1 respondent admits to improperly disposing of these items by *pouring them down the sink*. Notably, no one pours household hazardous wastes *in the street, down a storm drain, or on the ground*.

The survey also assesses how respondents handle pet waste. Forty percent (40%) of respondents indicate that they do not have a pet. Of the remaining survey participants, 73% *always* pick up their dog's waste, 15% *often* do so, and fewer than 10% pick up pet waste only occasionally (4% *sometimes*, 2% *rarely*, and 3% *never*). The survey does not ask how pet owners dispose of pet waste, and it is unknown if the method of disposal has as much impact on water quality as whether or not it gets picked up.

Finally, respondents were asked about their willingness to perform "green" practices if they knew those actions would help to reduce water pollution. Actions which a great number of respondents *already do* to help reduce water pollution are *have your oil changed at an automobile service center (82%)* and w*ash your car at a car wash (72%)*. While these practices may have positive results for water quality, it is uncertain if respondents were aware of that aspect or simply undertake these activities for convenience or other reasons.

Another practice that respondents *already do* to reduce water pollution is *direct rainspouts to the lawn rather than the driveway* (75%). Eighty-two (82%) of respondents either *already* or *would be willing* to *keep street gutters and storm drains clear*. A fair number of those surveyed would be *willing* to *conduct soil tests to determine fertilizer application rates for your lawn* or to *install a rain barrel to collect/intercept rain from downspouts* (31% for each).

Practices that respondents have the greatest resistance to doing (or *not willing to do*) are *wash the car on the lawn* (38%) and *stop using chemical fertilizers and weed killers completely* (32%).

Your Information Preferences

Nearly half of survey respondents are aware that efforts are made to improve water quality in the community, but are not familiar with specific details. Thirty-eight percent (38%) are generally familiar with water quality improvement efforts. The remaining 13% either described themselves as *very knowledgeable* (4.3%), *unaware* of any efforts (6.7%), or gave no response to the question (1.9%).

Based on survey responses, Spokane County would reach the greatest general audience by utilizing local newspapers and newsletters, electronic communication, and television. The breakdown of preferred methods of information distribution identified by respondents is: *community newsletters* (48%), *internet or email* (48%), *television* (37%) or *local newspaper* (32%). Fewer than 10% of respondents favor getting information through their *child's school* or *billboards*.

When it comes to implementing measures to address stormwater problems in their community, respondents believe that providing more *street sweeping* (72%) and *yard waste and leaf collection* (70%) would be the most effective means to do so. *Constructing more infiltration facilities* (63%) and *enforcing County erosion control and stormwater ordinances* (58%) followed closely behind.

Thirty percent (30%) of all respondents do not know who to contact when a stormwater problem arises in their area, while just half (49.8%) correctly state they should contact Spokane County.

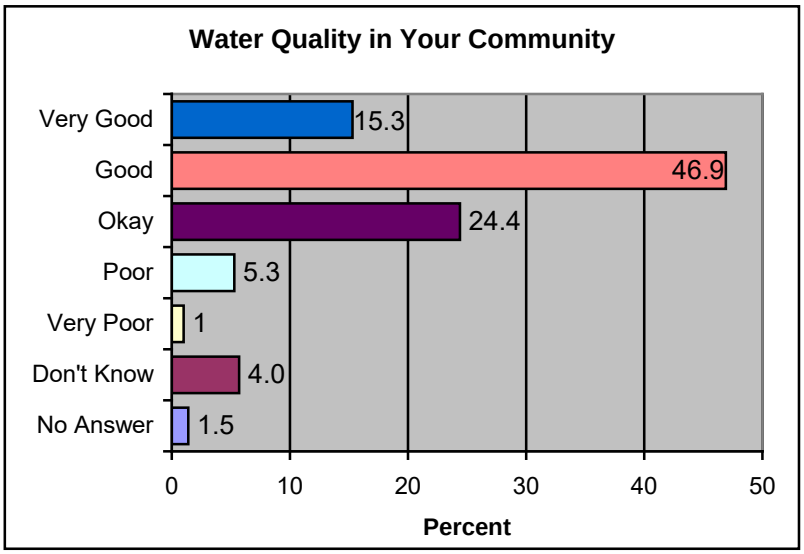
Detailed Responses

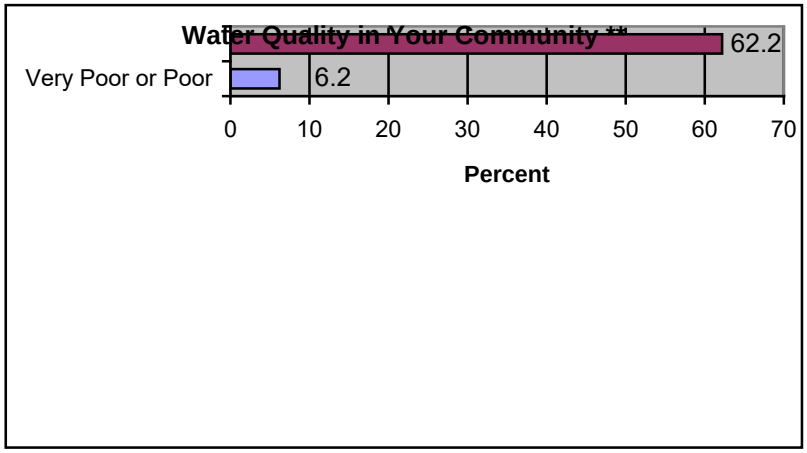
The following pages contain the detailed responses to the questionnaire. A complete copy of the survey questionnaire is included in Appendix A. The total number of respondents for each question is indicated by "n". Breakdowns of the responses are depicted as a percentage in the following graphs.

Your Perceptions of Local Water Resources

1. In general, how would you rate the water quality of the lakes, rivers, and streams located in and around your community and/or neighborhood?

Very Good	Good	Okay	Poor	Very poor	Don't know	No Answer	TOTAL
32	98	51	11	2	12	3	n = 209

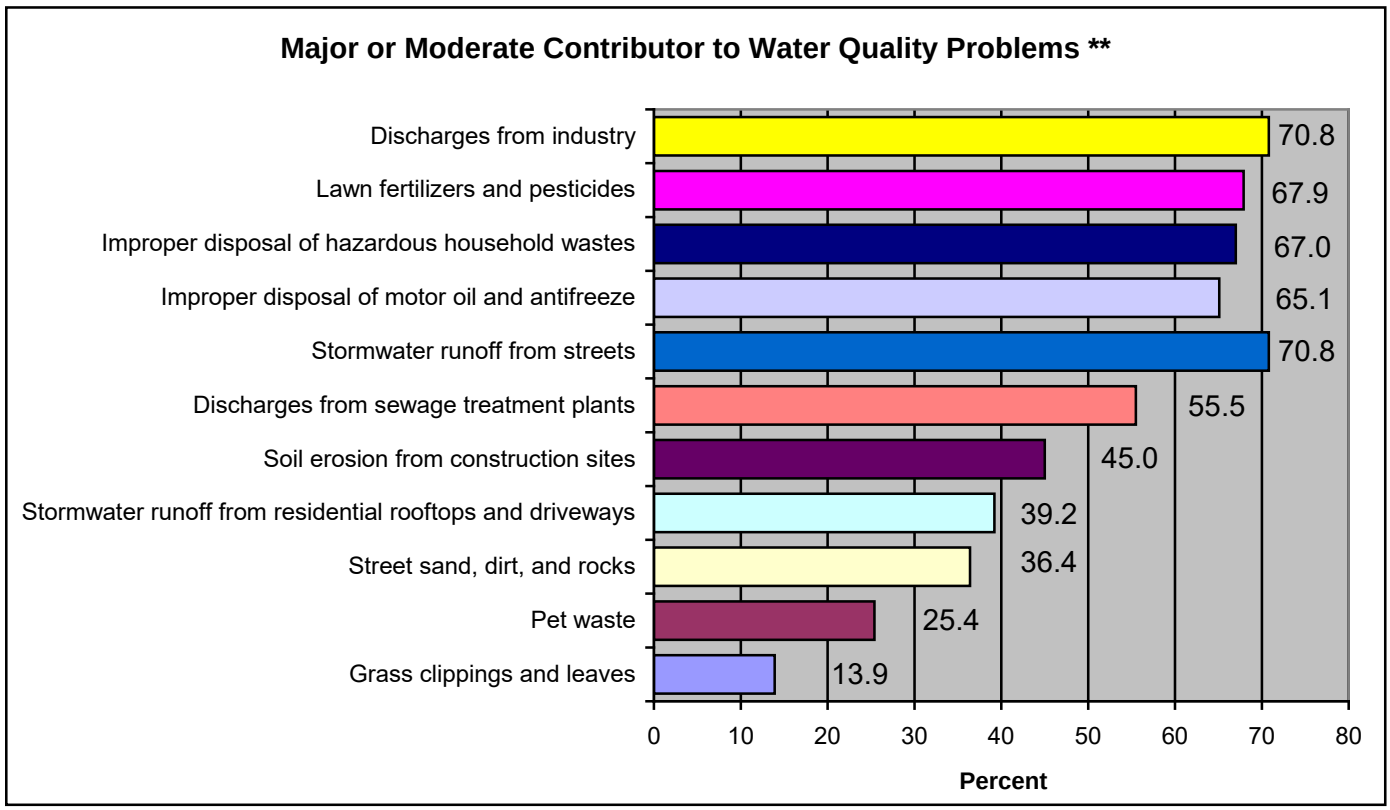




** This graph created by combining responses of
"Very Good" and "Good" or "Very Poor" and "Poor"

2. To what extent do you believe each of the following items contributes to water quality problems for the aquifer, and lakes, rivers, and streams in community?

	Major Contributor	Moderate Contributor	Minor Contributor	Does Not Contribute	Don't Know/ Not Sure	No Answer	TOTAL
Stormwater runoff from streets	71	77	43	5	10	3	**n = 209**
Stormwater runoff from residential rooftops and driveways	17	65	93	15	15	4	**n = 209**
Lawn fertilizers and pesticides	73	69	56	5	3	3	**n = 209**
Grass clippings and leaves	8	21	98	71	8	3	**n = 209**
Pet waste	18	35	97	40	15	4	**n = 209**
Street sand, dirt, and rocks	22	54	88	32	10	3	**n = 209**
Soil erosion from construction sites	35	59	84	14	14	3	**n = 209**
Discharges from industry	83	65	31	9	20	1	**n = 209**
Discharges from sewage treatment plants	57	59	51	10	29	3	**n = 209**
Improper disposal of motor oil and antifreeze	76	60	47	9	15	2	**n = 209**
Improper disposal of hazardous household wastes	82	58	44	9	14	2	**n = 209**



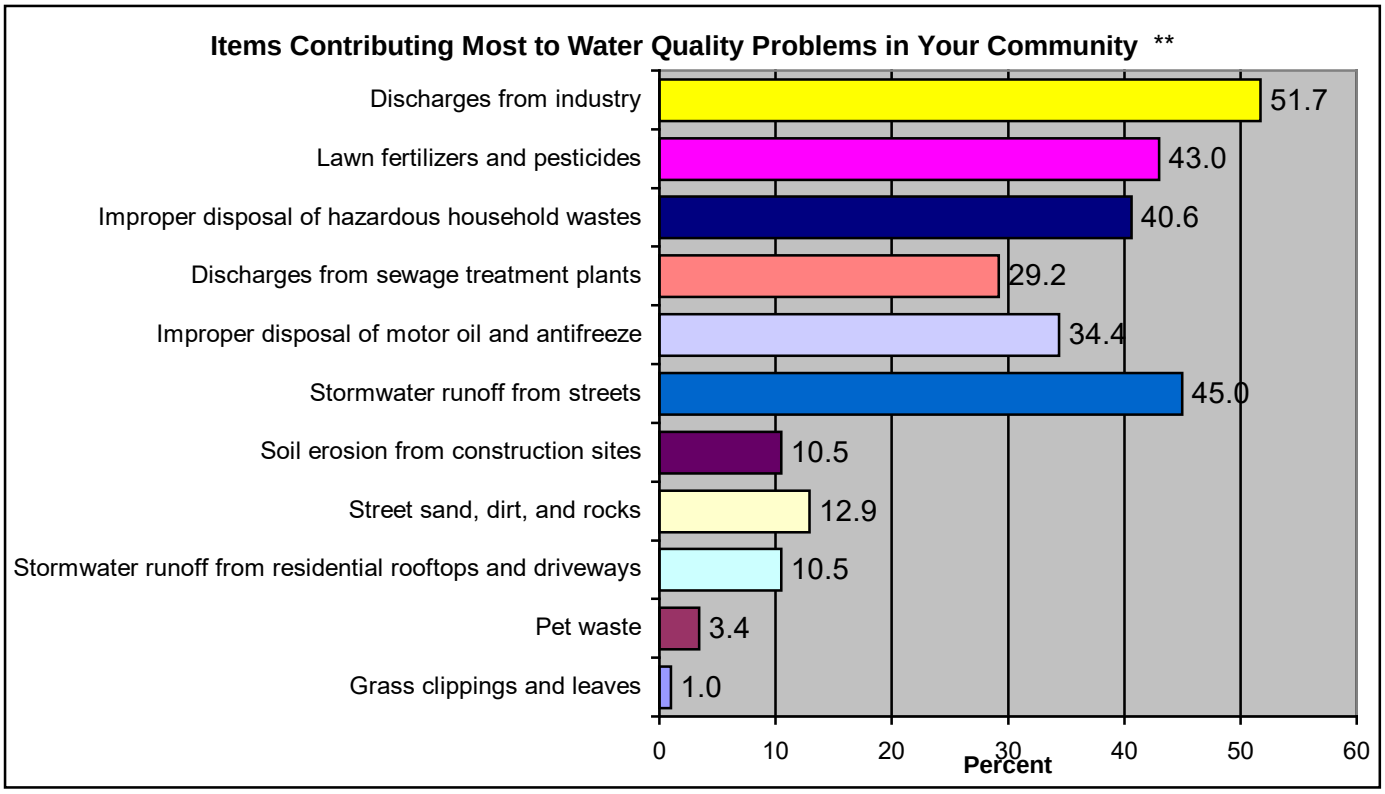
** This graph reflects the combined percentages of respondents identifying the issue as either a "Major contributor" or "Moderate contributor" to water quality problems

3. From the list of items in Question 2, enter the letters of the three items you feel contribute the most to water quality problems in and around your community. (n = 209)

Greatest Contributor _____ 2nd Greatest Contributor _____ 3rd Greatest Contributor _____

	Greatest Contributor	%	2nd Greatest Contributor	%	3rd Greatest Contributor	%	Combined TOTAL % **
Stormwater runoff from streets	58	27.8	17	8.1	19	9.1	**45.0**
Stormwater runoff from residential rooftops and driveways	0	0.0	12	5.7	10	4.8	**10.5**
Lawn fertilizers and pesticides	36	17.2	28	13.4	26	12.4	**43.0**
Grass clippings and leaves	0	0.0	1	0.5	1	0.5	**1.0**
Pet waste	0	0.0	5	2.4	2	1.0	**3.4**
Street sand, dirt, and rocks	5	2.4	10	4.8	12	5.7	**12.9**
Soil erosion from construction sites	4	1.9	7	3.3	11	5.3	**10.5**
Discharges from industry	46	22.0	34	16.3	28	13.4	**51.7**
Discharges from sewage treatment plants	14	6.7	27	12.9	20	9.6	**29.2**
Improper disposal of motor oil and antifreeze	13	6.2	31	14.8	28	13.4	**34.4**
Improper disposal of hazardous household wastes	21	10.0	27	12.9	37	17.7	**40.6**
No Answer	12	5.7	10	4.8	15	7.2	**17.7**
TOTAL	**n = 209**	**100**	**n = 209**	**100**	**n = 209**	**100**	**-**

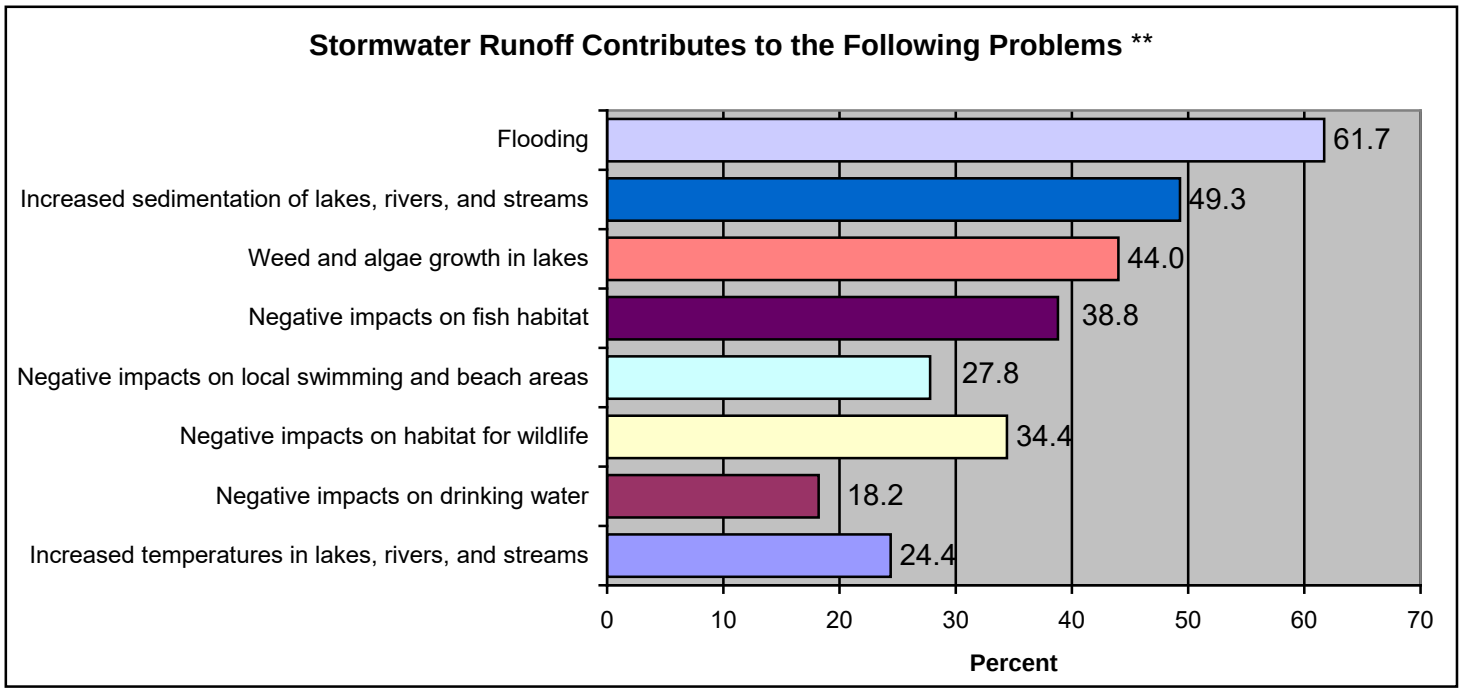
** Graphic results on following page



** Graph created by combining percentage responses to "Greatest," "2nd Greatest," and "3rd Greatest" categories

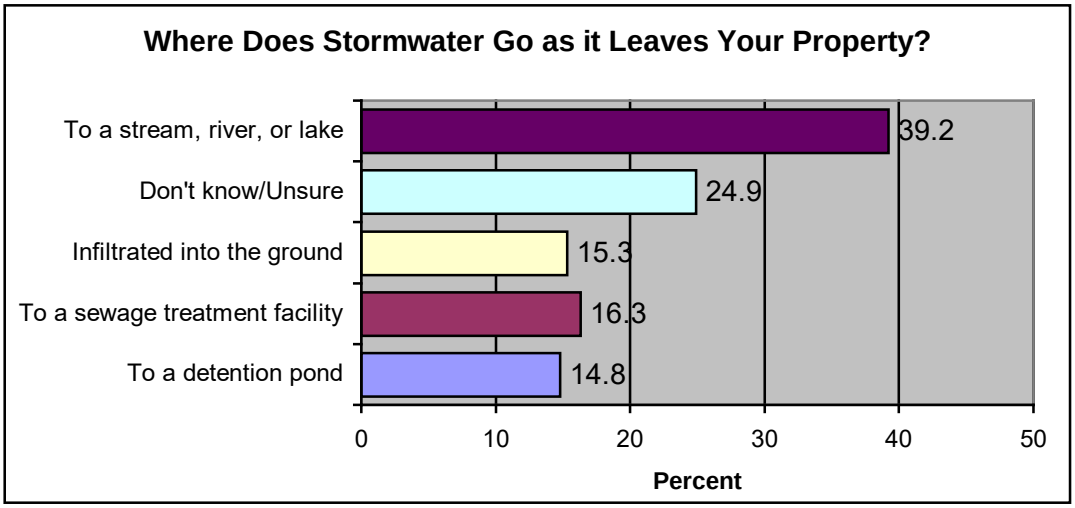
4. To the best of your knowledge, after it rains or when snow melts, to what extent does the resulting stormwater runoff contribute to the following problems in your community?

	Major Contributor	Moderate Contributor	Minor Contributor	Does Not Contribute	Don't Know/ Not Sure	No Answer	TOTAL
Negative impacts on drinking water	9	29	74	59	31	7	**n = 209**
Increased sedimentation of lakes, rivers, and streams	31	72	55	20	26	5	**n = 209**
Increased temperatures in lakes, rivers, and streams	11	40	61	53	40	4	**n = 209**
Weed and algae growth in lakes and rivers	36	56	53	22	35	7	**n = 209**
Flooding	60	69	39	22	14	5	**n = 209**
Negative impacts on fish habitat	27	54	61	29	33	5	**n = 209**
Negative impacts on habitat for wildlife	15	57	72	33	29	3	**n = 209**
Negative impacts on local swimming and beach areas	11	47	74	41	31	5	**n = 209**



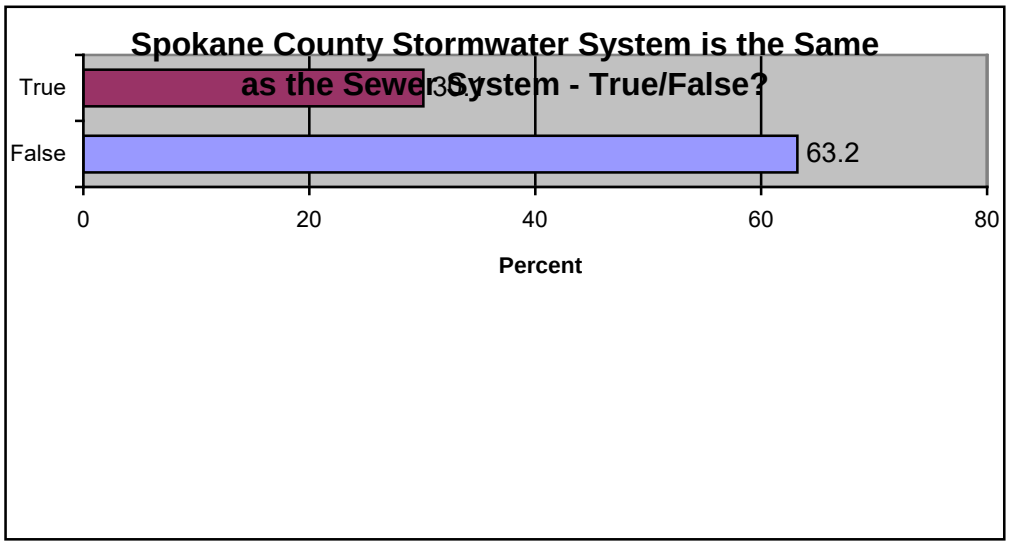
** Graph represents combined percentages of "Major contributor" and "Moderate contributor" responses

5. After it rains or when snow melts, where do you think the resulting stormwater runoff ends up after it leaves your property? (n = 209)



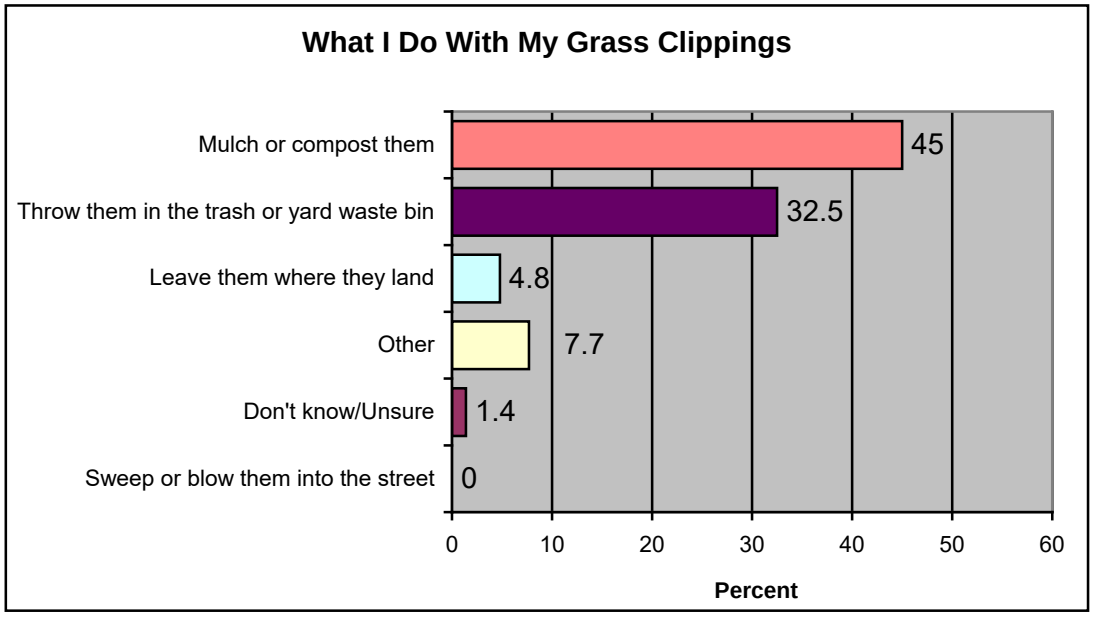
6. In Spokane County, storm drain systems and sewer systems are the same (in other words, stormwater that enters storm drains goes to a sewage treatment facility)?

True	False	No Answer	Total
63	132	14	n = 209

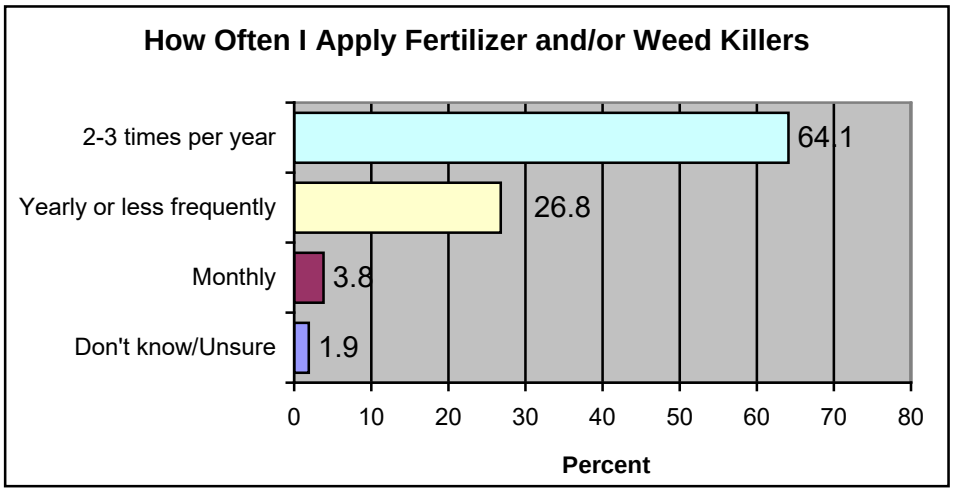


Your Activities

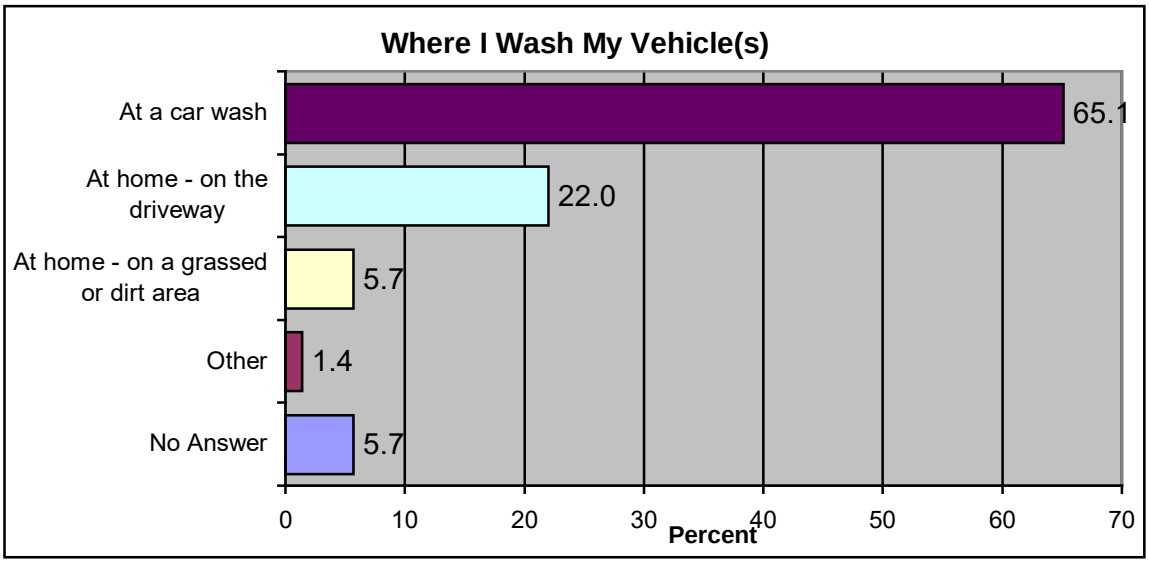
7. When you mow your lawn, what do you do with the grass clippings? (n = 209)



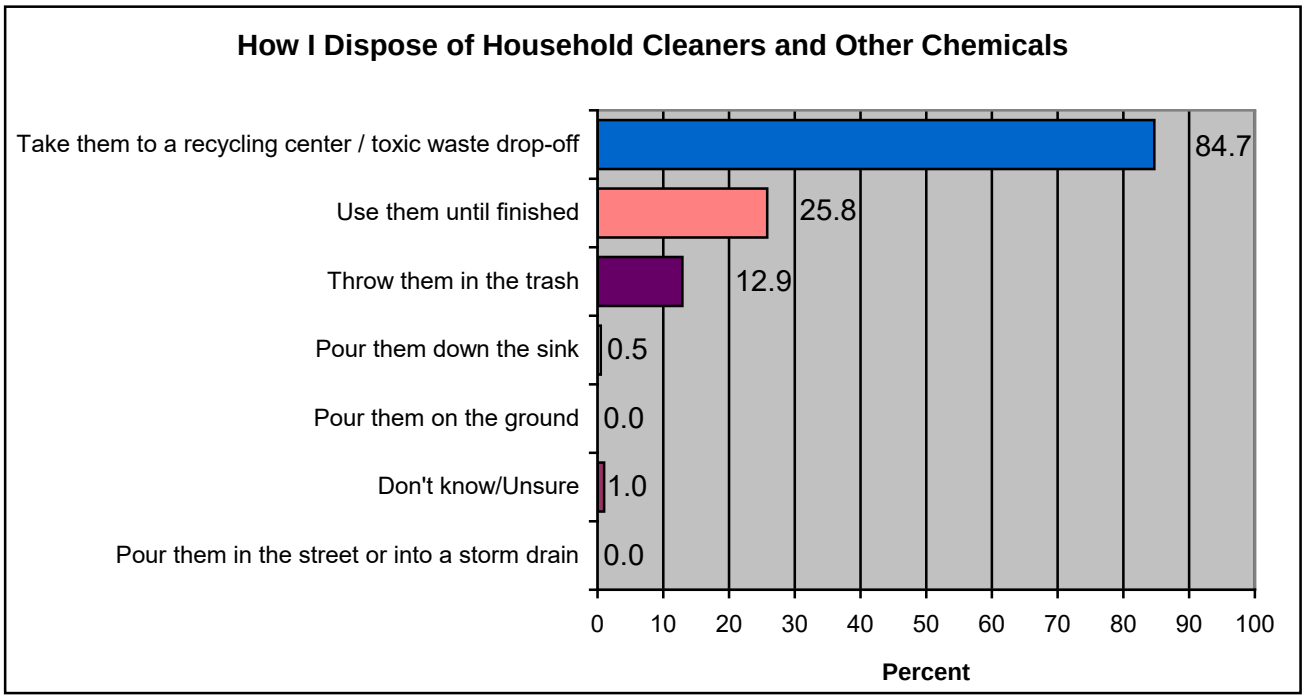
8. To your best knowledge, how often would you say you fertilize your lawn and/or apply weed killers? (n = 209)



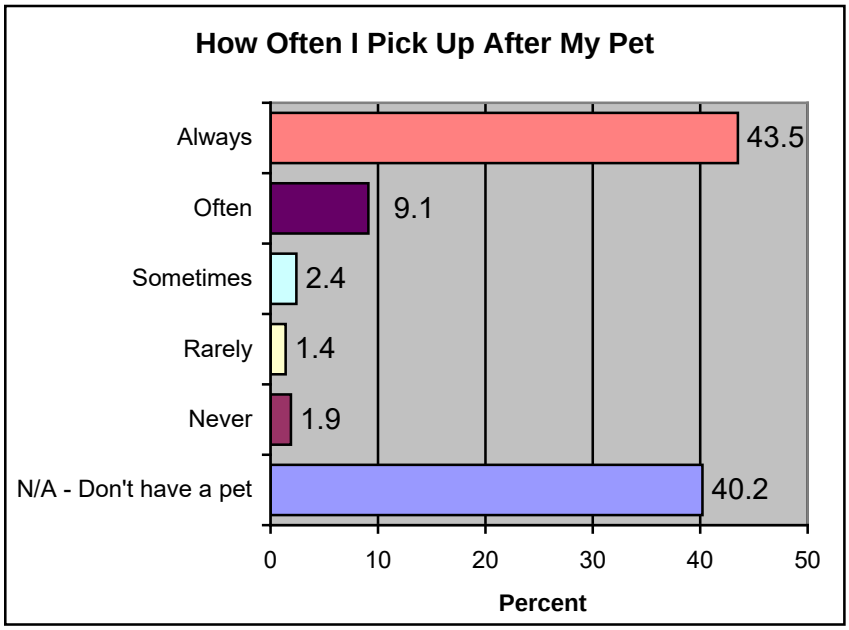
9. Where do you most often wash your vehicle(s)? (n = 209)

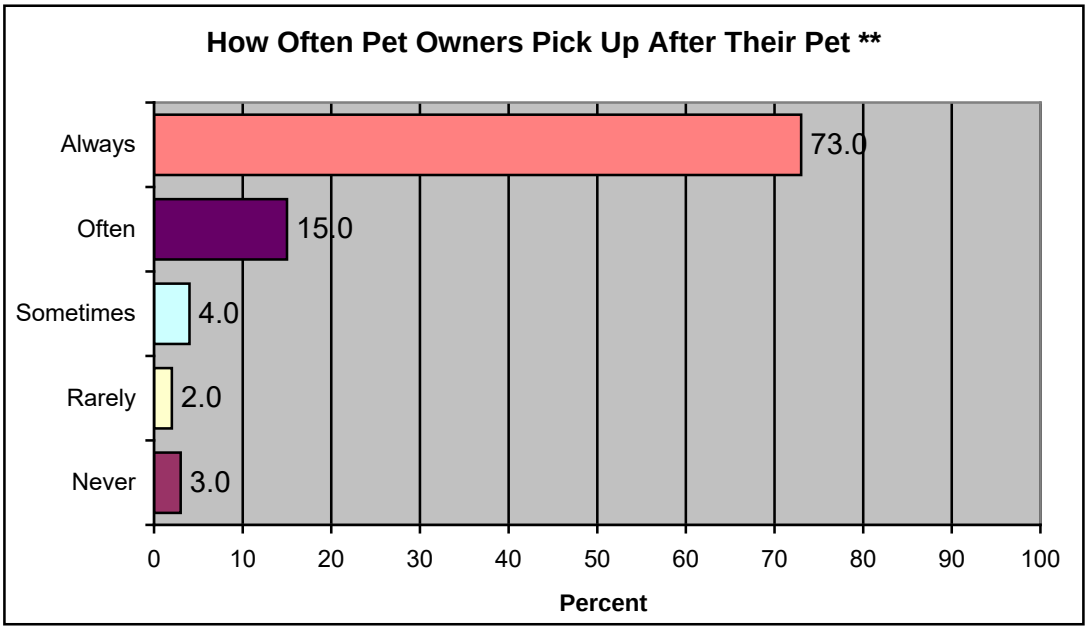


10. How do you dispose of products such as paints, varnishes, household cleaners, used motor oil, fertilizers, and/or pesticides? *Please select all that apply.* (n = 209)



11. How often do you pick up after your pet at home or while out walking? (n = 209)



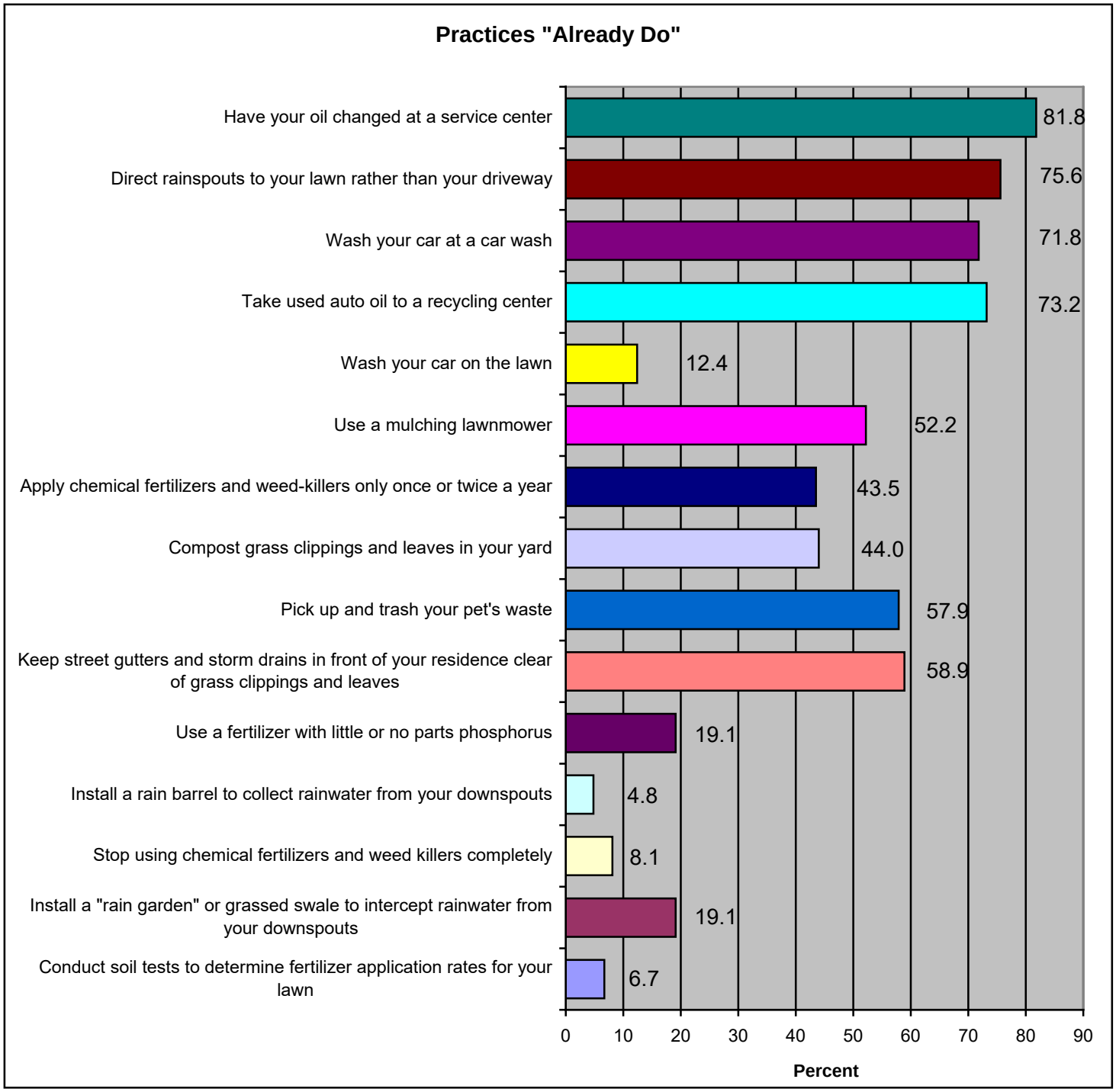


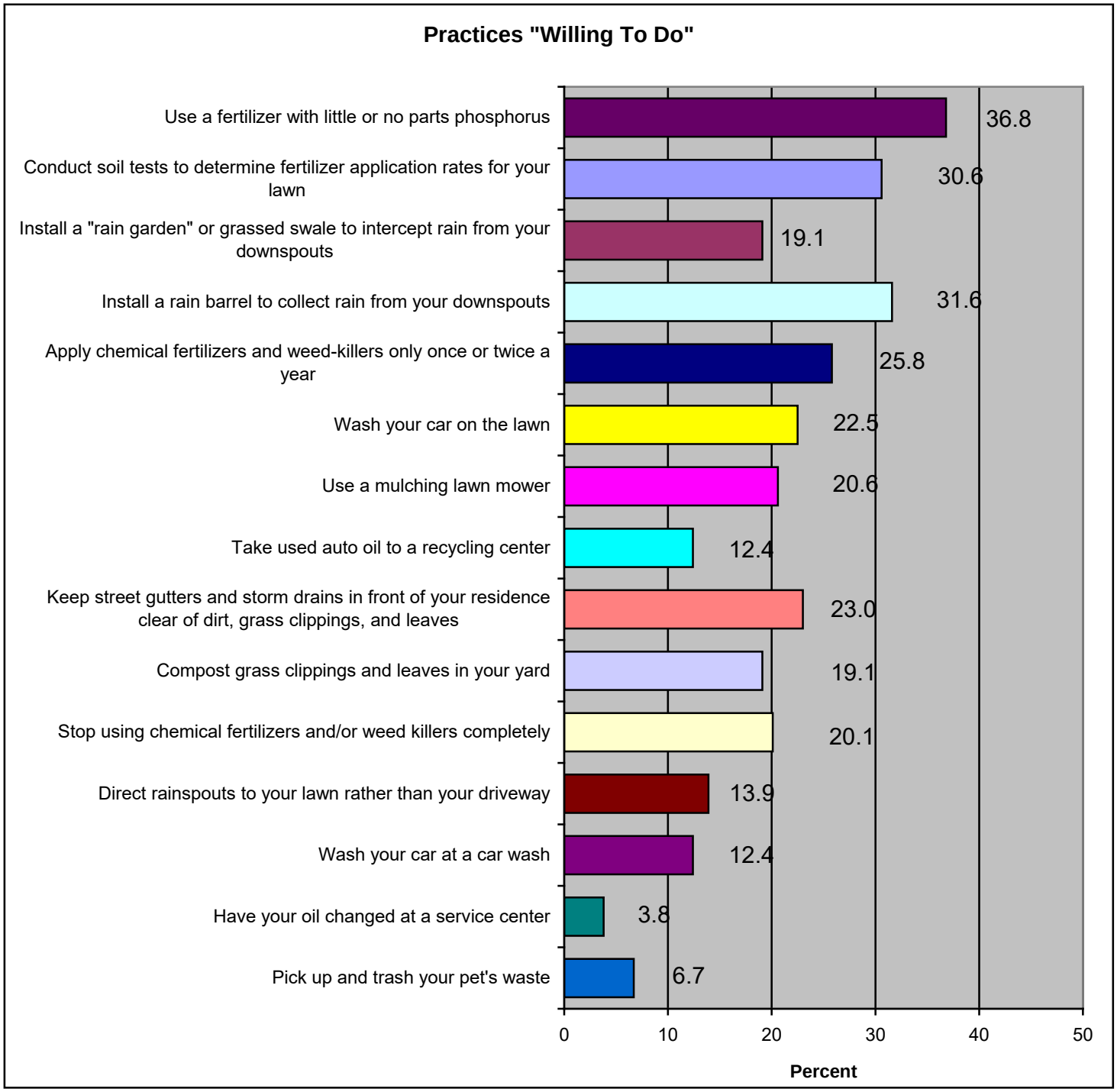
** Graph represents answers of the 125 respondents indicating probable pet ownership.

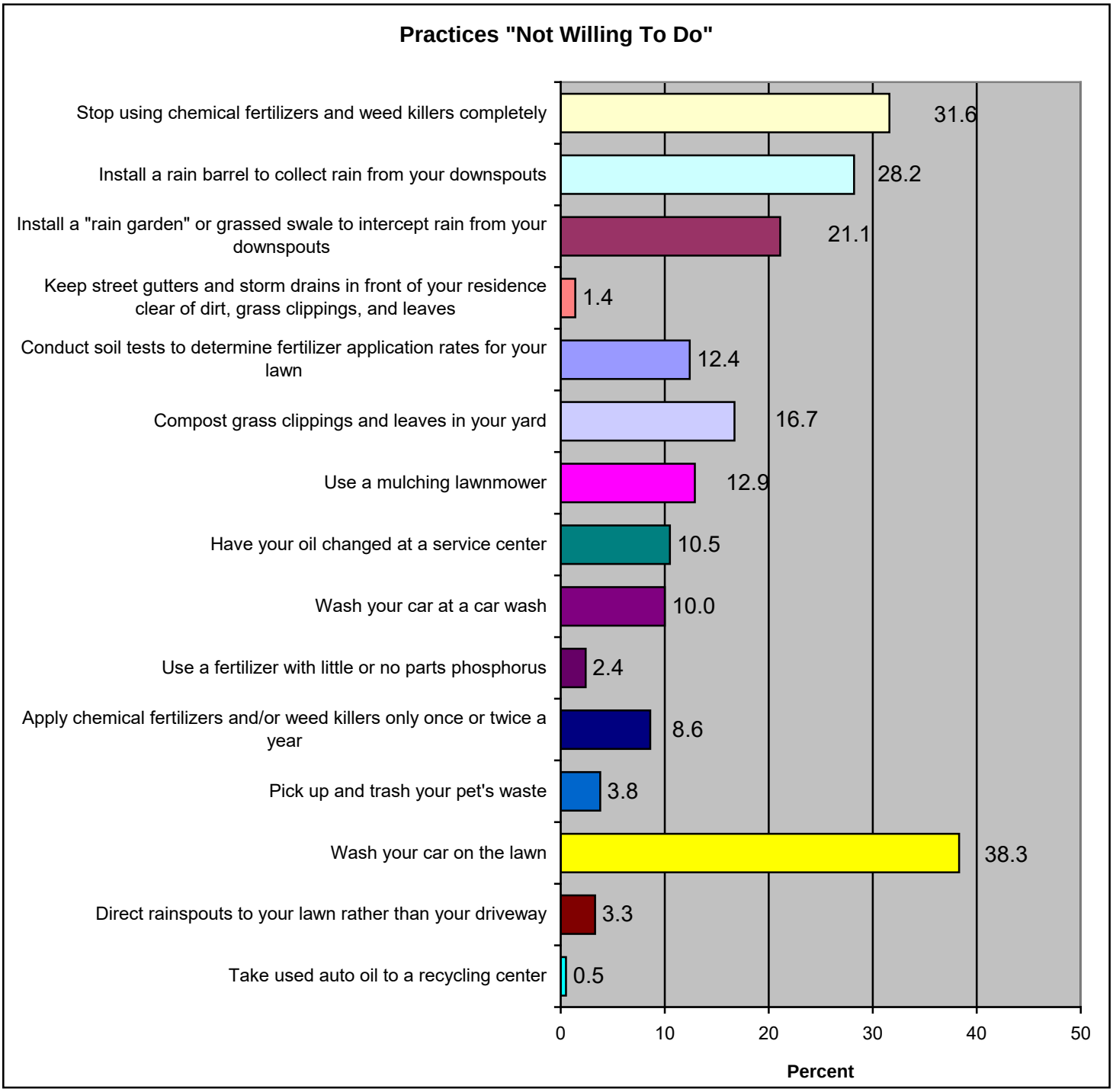
12. Which of the following practices would you do (or have done for you) on a regular basis if you knew that the action would help reduce water pollution?

	Already do this	Willing to do	Need more information	Not willing to do	Don't Know/ Not Sure	No Answer	TOTAL
Take used auto oil to a recycling center	153	26	4	1	9	16	**n = 209**
Have your oil changed at a service center	171	8	1	22	1	6	**n = 209**
Conduct soil tests to determine fertilizer application rates for your lawn	14	64	77	26	17	11	**n = 209**
Apply chemical fertilizers & weed-killers only once or twice per year	91	54	25	18	5	16	**n = 209**
Stop using chemical fertilizers and weed killers completely	17	42	68	66	7	9	**n = 209**
Use a fertilizer with little or no parts phosphorus	40	77	62	5	15	10	**n = 209**
Compost leaves and grass clippings in your yard	92	40	22	35	7	13	**n = 209**
Use a mulching lawnmower	109	43	10	27	6	14	**n = 209**
Direct rainspouts to your lawn rather than your driveway	158	29	6	7	4	5	**n = 209**
Install a rain barrel to collect rainwater from your downspouts	10	66	46	59	15	13	**n = 209**
Install a "rain garden" or grassed swale to intercept rainwater from your downspouts	40	40	58	44	14	13	**n = 209**
Keep street gutters in front of your residence clear of grass clippings and leaves	123	48	4	3	9	22	**n = 209**
Wash your car on your lawn	26	47	13	80	14	29	**n = 209**
Wash your car at a car wash	150	26	6	21	1	5	**n = 209**
Pick up and trash your pet's waste **	121	14	1	8	21	44	**n = 209**

** Twenty-one (21) respondents wrote in N/A or that they don't have a pet


Practices "Already Do"
Have your oil changed at a service center
81.8
Direct rainspouts to your lawn rather than your driveway
75.6
Wash your car at a car wash
71.8
Take used auto oil to a recycling center
73.2
Wash your car on the lawn
12.4
Use a mulching lawnmower
52.2
Apply chemical fertilizers and weed-killers only once or twice a year
43.5
Compost grass clippings and leaves in your yard
44.0
Pick up and trash your pet's waste
57.9
Keep street gutters and storm drains in front of your residence clear of grass clippings and leaves
58.9
Use a fertilizer with little or no parts phosphorus
19.1
Install a rain barrel to collect rainwater from your downspouts
4.8
Stop using chemical fertilizers and weed killers completely
8.1
Install a "rain garden" or grassed swale to intercept rainwater from your downspouts
19.1
Conduct soil tests to determine fertilizer application rates for your lawn
6.7
0
10
20
30
40
50
60
70
80
90
Percent

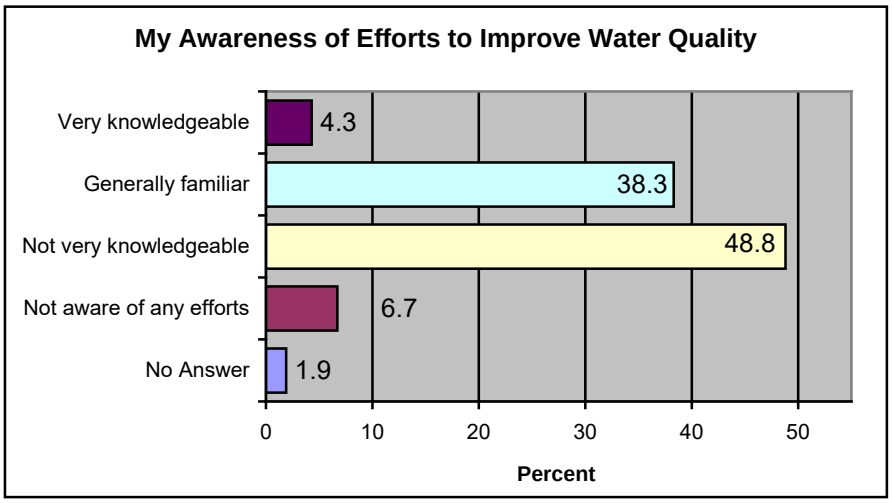

Practices "Willing To Do"
Use a fertilizer with little or no parts phosphorus
36.8
Conduct soil tests to determine fertilizer application rates for your lawn
30.6
Install a "rain garden" or grassed swale to intercept rain from your downspouts
19.1
Install a rain barrel to collect rain from your downspouts
31.6
Apply chemical fertilizers and weed-killers only once or twice a year
25.8
Wash your car on the lawn
22.5
Use a mulching lawn mower
20.6
Take used auto oil to a recycling center
12.4
Keep street gutters and storm drains in front of your residence clear of dirt, grass clippings, and leaves
23.0
Compost grass clippings and leaves in your yard
19.1
Stop using chemical fertilizers and/or weed killers completely
20.1
Direct rainspouts to your lawn rather than your driveway
13.9
Wash your car at a car wash
12.4
Have your oil changed at a service center
3.8
Pick up and trash your pet's waste
6.7
0
10
20
30
40
50
Percent


Practices "Not Willing To Do"
Stop using chemical fertilizers and weed killers completely
31.6
Install a rain barrel to collect rain from your downspouts
28.2
Install a "rain garden" or grassed swale to intercept rain from your downspouts
21.1
Keep street gutters and storm drains in front of your residence clear of dirt, grass clippings, and leaves
1.4
Conduct soil tests to determine fertilizer application rates for your lawn
12.4
Compost grass clippings and leaves in your yard
16.7
Use a mulching lawnmower
12.9
Have your oil changed at a service center
10.5
Wash your car at a car wash
10.0
Use a fertilizer with little or no parts phosphorus
2.4
Apply chemical fertilizers and/or weed killers only once or twice a year
8.6
Pick up and trash your pet's waste
3.8
Wash your car on the lawn
38.3
Direct rainspouts to your lawn rather than your driveway
3.3
Take used auto oil to a recycling center
0.5
0
10
20
30
40
50
Percent

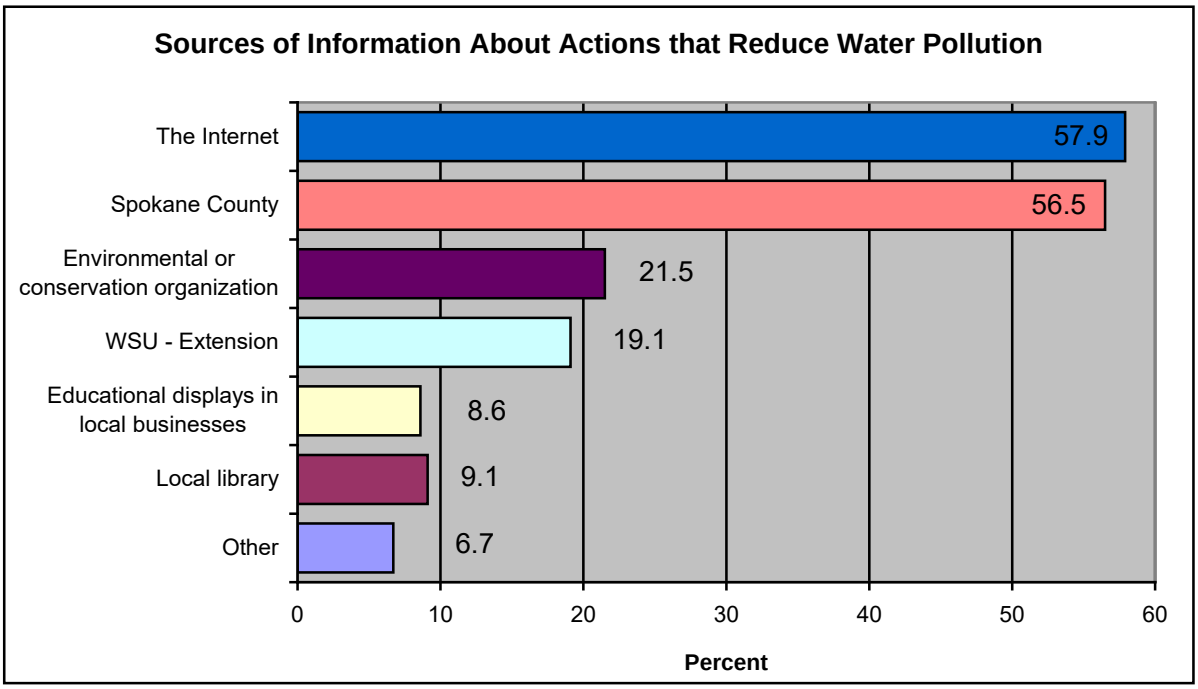
Your Information Preferences

14. Which of the following statements describes your awareness of efforts to improve water quality in your community?

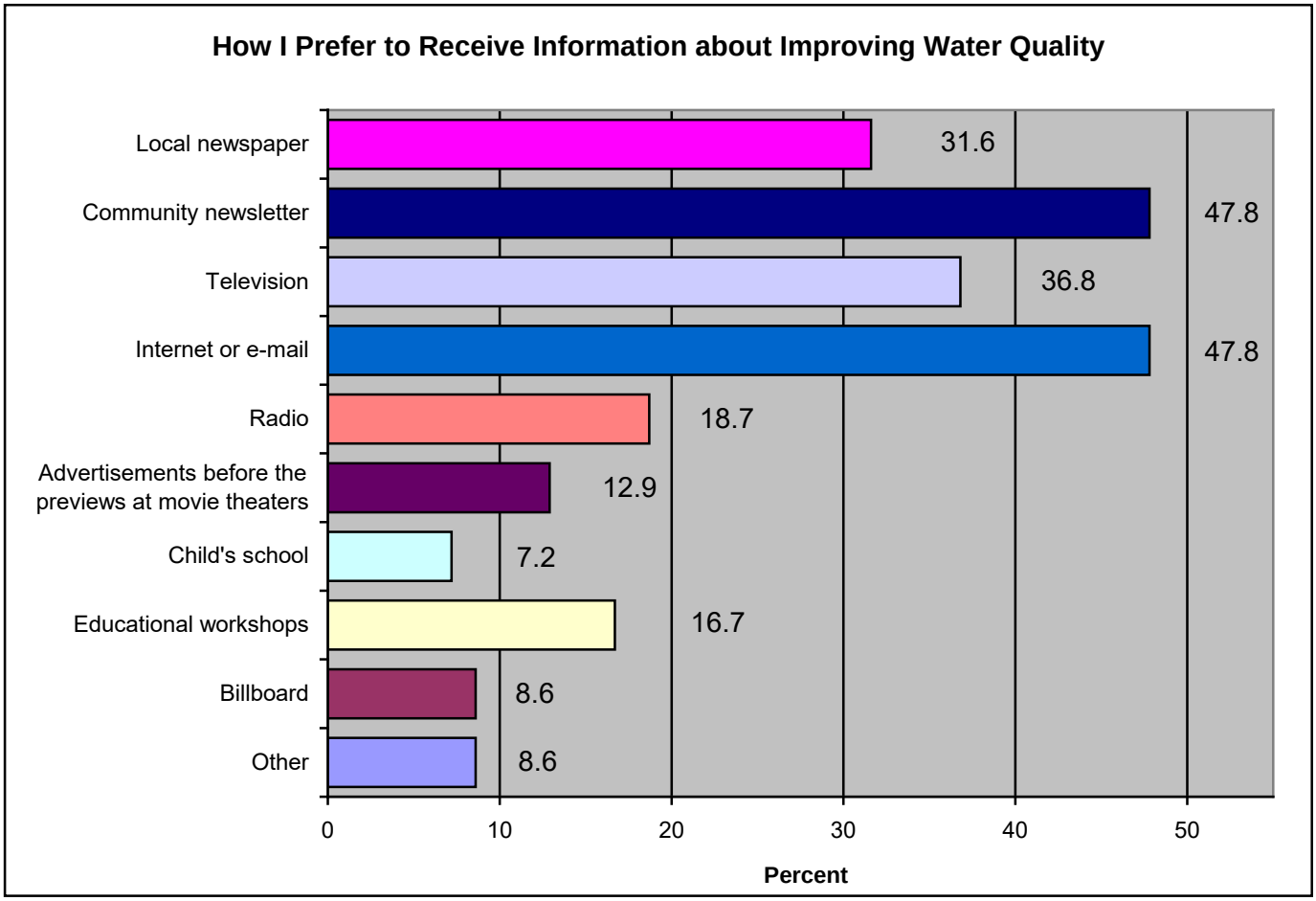
Very knowledgeable	Generally familiar	Not very knowledgeable	Not aware of any efforts	No Answer	TOTAL
9	80	102	14	4	n = 209



15. Which of the following sources would you most likely turn to for information about the practices listed in Question 12? *Please select all that apply.*

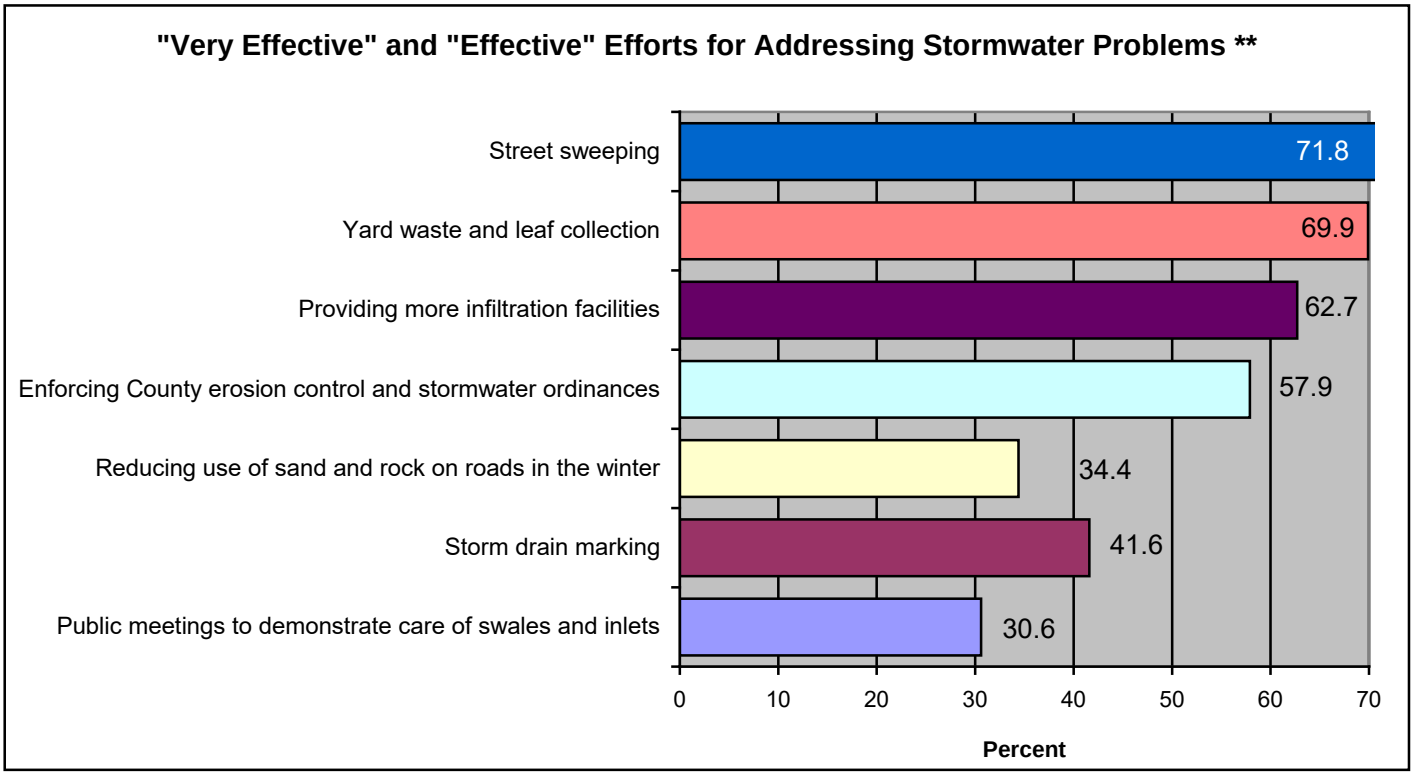


16. How would you prefer to receive information about activities that you can do to improve water quality in your community? *Please select all that apply.*

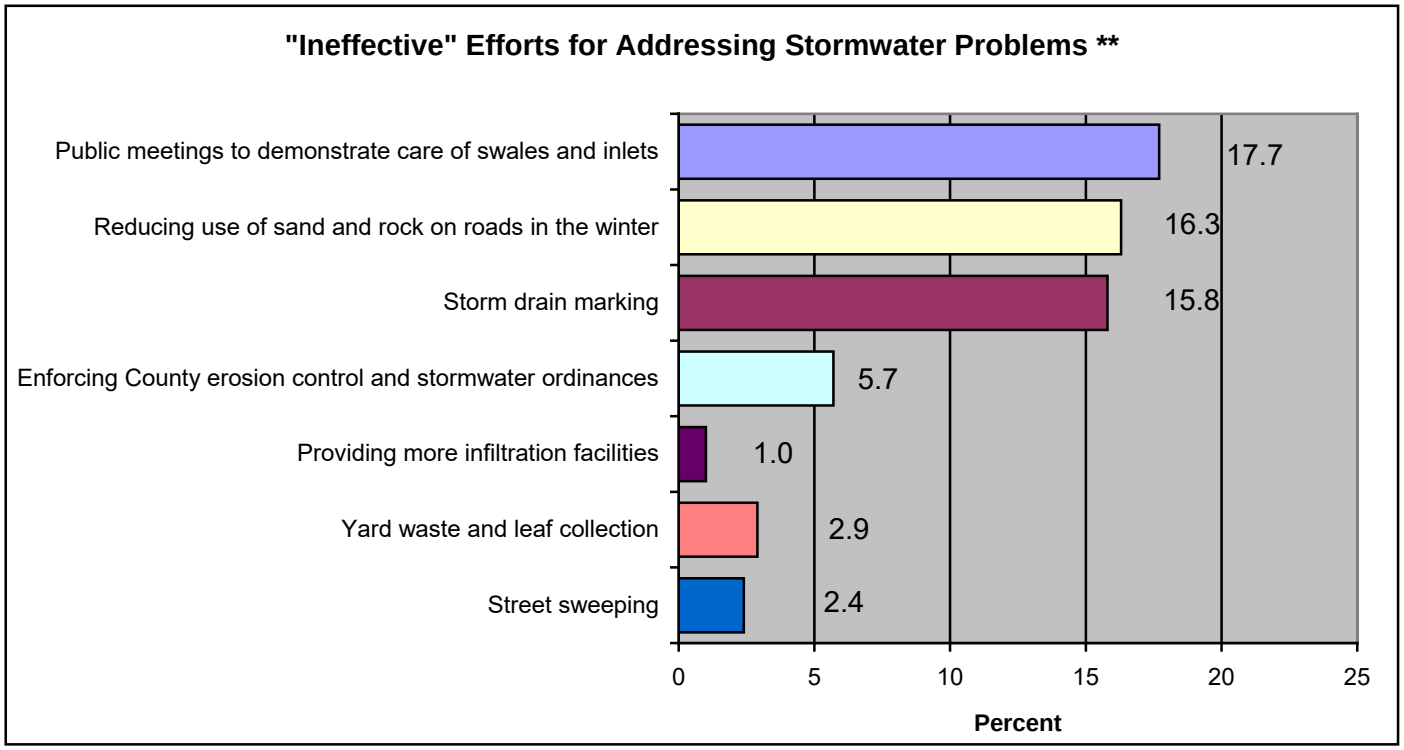


17. If implemented, how effective do you think the following types of efforts for addressing stormwater problems in your community would be?

	Very effective	Effective	Somewhat effective	Not effective	Don't know/ Not sure	No Answer	TOTAL
Storm drain marking	28	59	50	33	30	9	**n = 209**
Building more infiltration facilities	52	79	33	2	34	9	**n = 209**
Providing public meetings/courses to demonstrate the proper care of grassed swales and inlets	15	49	75	37	23	10	**n = 209**
Yard waste and leaf collection	77	69	38	6	12	7	**n = 209**
Street sweeping	75	75	28	5	18	8	**n = 209**
Reducing the use of sand and rocks on icy roads in the winter	21	51	60	34	33	10	**n = 209**
Enforcing County erosion control and stormwater ordinances	53	68	42	12	29	5	**n = 209**

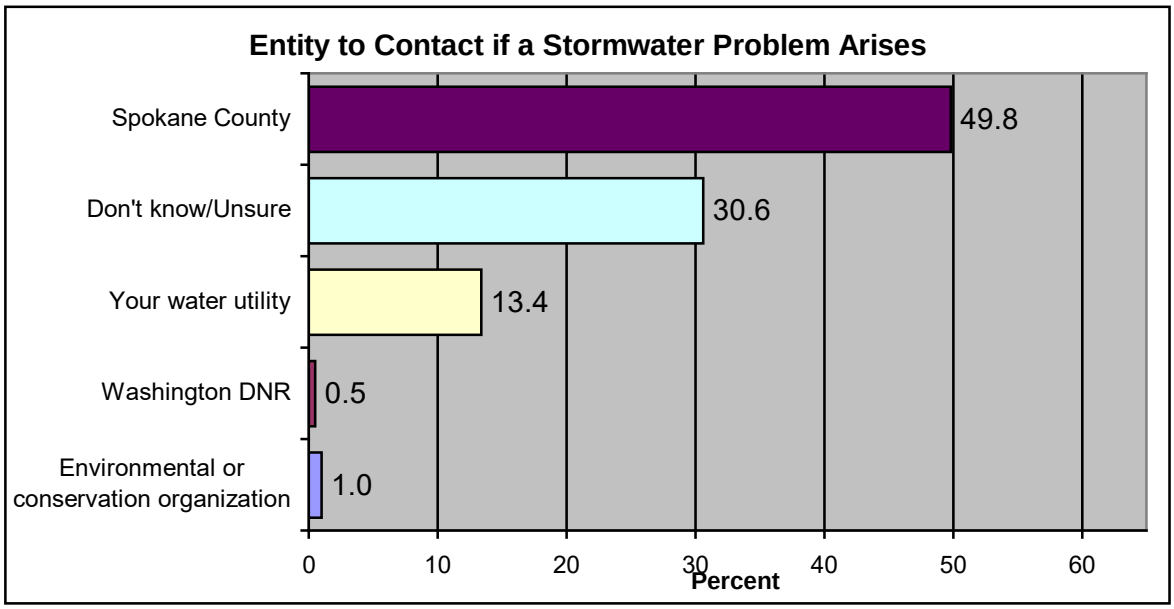


** Graph represents combined percentages of "Very Effective" and "Effective" responses



** Graph represents percentages of "Not effective" responses

18. In your opinion, which would be the most appropriate entity to contact if you became aware of a stormwater problem in your community?



Hand Written Responses and Additional Comments

5. After it rains or when snow melts, where do you think the resulting stormwater runoff ends up after it leaves your property? *Please select all that apply*. "Other" responses:

- Into the ground – we are rural
- Aquifer
- Into surrounding yard, acreage
- Catch basin
- Pasture
- In the ground
- Our own 6 acres
- Ground?
- Aquifer
- Ground filtration
- Swale
- Wasted
- Through natural ground filtration
- Ground
- Sides of roads/ditches in culverts
- I know it goes down a drain but I don't know where it ends up.
- Seasonal wetlands on my property & neighbors
- Overflowing/clogged storm drain
- Open land
- Aquifer
- Into the ground
- Deep road ditch filters out most negative impacts
- [I don't know where it goes] from <u>our</u> community
- Goes back in ground. We live on flat 10 acres
- Doesn't leave my property. 18" drain into the ground
- Ground filtration
- Wishing it would go into my well
- Water table underground
- Soaks into the ground
- Most is treated locally in swales. Some goes to streams, rivers, lake
- Runs off of property infiltrates into surrounding ground
- Our homeowners association has a 7.5 acre drainage area filled with cattails that handles run off from our neighborhood

7. When you mow your lawn, what do you do with the grass clippings? “Other” responses:

- Don’t mow – natural
- Yard waste pick up
- To dump facility in Elk
- Yard waste bin
- Lawn service
- Haul to waste transfer station
- Put in outdoor waste can
- Lawn crew removes them
- Waste to energy plant
- Cheney recycle plant
- Take to recycle
- Green bin
- Dispose at transfer station
- Recycle/clean green
- WM
- Collect & haul away
- Do not have a lawn
- Blow them into the lawn from sidewalk & driveway
- Feed them to livestock on my land
- Mulch into lawn

9. Where do you most often wash your vehicle(s)? “Other” responses:

- I don’t wash my car ☺ (my dad does at his home in Portland!)
- No car
- No soap or chemicals, just elbow grease!
- Rain
- Never wash
- 50/50 at home on the driveway & car wash

10. How do you dispose of products such as paints, varnishes, household cleaners, used motor oil, fertilizers, and/or pesticides? *Please select all that apply*. “Other” responses:

- Waste/Energy Plant or Fairchild Recycle/disposal
- Store paints & varnishes in crawl space
- Transfer Sta not open on wkdays (haz. Waste area)
- My husband takes motor oil to special disposal center
- Use professional to change oil w/disposal facility
- Motor oils burned in furnace
- Need to be open on weekdays to prevent wrongful disposal

13. If you have any concerns related to the practices listed on Page 4, please briefly describe them here:

- Would be nice if the county swept the residential streets after the winter to pick up sand spread during winter along curbs.
- We need to know where to dispose of pet waste. Currently it is pur in the regular garbage.
- We are on property. Does this change picking up pet waste?
- I don't want a government agency telling me how to fertilize or spray weeds.
- Not helpful that recycling center won't take all paint cans.
- I wish there were readily accessible collection sites for chemicals. I think most people don't want to be bothered with driving it to a waste site. We do, but most people either don't or can't.
- Please train personell in haz. wastes so motor oil can be dropped off during wk days – not just wkends. That makes it impractical to dispose of used oils & paints
- There are no rain water collection systems encouraged here such as in HI. We don't get high volumes of rain here but when had our gutters installed, there was no mention/education of "raingarden or barrels" provided. I would have been interested. Gutter & lawn care Co's should be required to provide some education to clients, even as little as a website or pamphlet.
- Some of my plants & bushes need phosphorus. My yard is surrounded by forested or grasslands.
- Composting correctly requires space we don't have, but that's the purpose of the green bin collection.
- I do my own vehicle maintenance and expect to continue to.
- How to set up [compost] collection? What fertilizers to use to kill weeds?
- Our lawn is maintained by a lawn service. Most of #12 is handled by them.
- I'm worried about the current administration lifting clean water regulations for our lakes & rivers.
- This survey needs to indicate rural small acreage vs housing development
- Need to outlaw fertilizing lawns
- We have a lawn fertilizing service, I don't have any idea what they use.
- I don't have space for a compost bin.
- I'd need to know "how" to take action; also, cost is a consideration.
- The county land fill will take hazardous materials such as oil, Fertilizers, ect. But are not open to the public 7 days a week. There is no reason they shouldn't be open 7 days a week to prevent wrongful disposal of hazardous material
- Are all lawn sprinkler systems required to have backflow preventers and is the installation inspected?
- Our lawn fertilizer probably leaches out or runs off enough to cause algae growth down stream. NaCl or MgCl2 in winter on streets is also a major pollutant to our street runoff.
- More water sent down the drain when the city cleans the streets with the water trucks or street sweeper.
- Make effort to keep storm drain(s) (not in front of my house) clear of [debris].

- Concerned about how fast weeds grow in driveway & yard to use weed killers less often.
- I leave fertilizers/weed killers to the discretion of the lawn care team. I also don't own a pet.
- Wash car on my lawn?? Really??
- Some of this is done in home developments
- Didn't think rain barrels were legal (looked into it when I moved here)
- I use organic fertilizer. Don't know of an effective weed killer though.
- It would be nice to have help with regard to mosquitoes in the drainage swale area. We have 100's of frogs in there, however, they can't keep up. When the health department warns about leaving water in buckets or hot tub covers, but we have acres that act as shallow ponds is seems silly.
- I'd love to get something in the mail pointing to a website with ideas/tips on how to do all of the above.

15. Which of the following sources would you most likely turn to for information about the practices listed on Page 4? *Please select all that apply.* "Other" responses:

- Newspaper
- Newspaper or flier in billing statement
- Mailings, commercials – the info needs to come to us.
- Read mailers
- Greenscape (now) or whatever commercial firm I'm using
- Liberty Lake Sewer & Water
- Spokane Environmental Services & Whitworth Water District
- Newspaper & businesses supporting river/lake clean up projects.
- Direct mailed info
- Mail flyer
- Pasadena Water Dist
- Anywhere!
- Newspaper or internet local news
- News
- Dept of Ecology

16. How would you prefer to receive information about activities that you can do to improve water quality in your community? *Please select all that apply.* "Other" responses:

- Letter
- Regular mail
- Mail to our house
- In monthly billing statements like Avista does.
- Mailing from County
- Utility Billing
- Mail flyers
- By US postal service
- Mail

- Local pros
- …pamphlet or other literature w/resources to click &/or read about all options under #12.
- Mailers
- Don't care
- Make public the specific quality levels of local waters in an easily accessed media like they do for air quality.
- Info sheets in water/utility bills

17h. If implemented, how effective do you think the following types of efforts for addressing stormwater problems in your community would be? "Other" responses:

- More education to public. No studs, no sand, no salt.
- Just getting educated on how to do it.
- Promote residential & agricultural use of non-chemical products
- Stop using magnesium chloride on the roads
- Educate people on how their actions are impacting clean water.
- No studded snow tires
- Collect water from run off, reserve water in collection, and purify, use later when its hot or drought
- Have readily available collection sites all over town.
- If all above info. in one, local, short class & resources provided to encourage use of, ex discounts for application/installation
- Free yard waste disposal
- Banning sale of weed killers
- Lower [Hold's] pond
- Do street sweeping 4x's/year
- Test water from our home faucets
- Somehow educate people that a problem even exists
- Enforcing pet clean up laws/ordinances
- Public [campaigns]
- Have street sweeping more than 2x a year
- Stop using chemicals on roads in winter

18. In your opinion, which would be the most appropriate entity to contact if you became aware of a stormwater problem in your community (for example, you see mud flowing into a storm drain)? *Please select ONLY ONE*. "Other" responses:

- Wastewater management dept. Stormwater utility 509-477-3600
- Simple education statement on water bill – ex IF you see (above) or an overflowing storm drain, call _____#.
- Leave the State out of Spokane county
- I.D. stormwater problems to the public first. Follow on with who to contact for resolution.
- Public Works
- Dept of Ecology

Additional Comments

Thanks for conducting this survey.

This survey seems super costly vs. the quality of the information you will get back. Educate people and incent them to make better choices. Charging a ridiculous price for a green barrel is not helpful. I do not understand why more incentives are not available for those trying to do what they can to protect the environment.

There is no stormwater problems in my neighborhood - When it rains hard we have mud puddles - the land where I live is flat! Its Morgan Acres Its County

In this area, we need [a] lot better info on the health of Spokane River & Long Lake. How safe is it to swim, eat fish, etc. I know they treat noxious milfoil w/Herbacide & would like to know more about when & times/dates to avoid & safety for swimming & consuming fish. [email address provided]

Appendix B

Focus on Fertilizers, Herbicides, and Pesticides

We compared how respondents believed lawn fertilizers, herbicides, and pesticides impacted local water quality versus their willingness to change their lawn fertilizer, herbicide, and pesticide application practices.

Notable aspects:

1) Of those who believe lawn fertilizers and pesticides are *major contributors* to water quality problems:

    - 45% *already* limit applications of chemical inputs to 1-2 times per year, and 27% are *willing to do* so.

    - 16% *already* use no chemical inputs, and 22% are *willing to do* so. Notably, 26% are *not willing to do* so.

    - 24% *already* use fertilizer with no or limited amounts of phosphorus, and 42% are *willing to do* so.

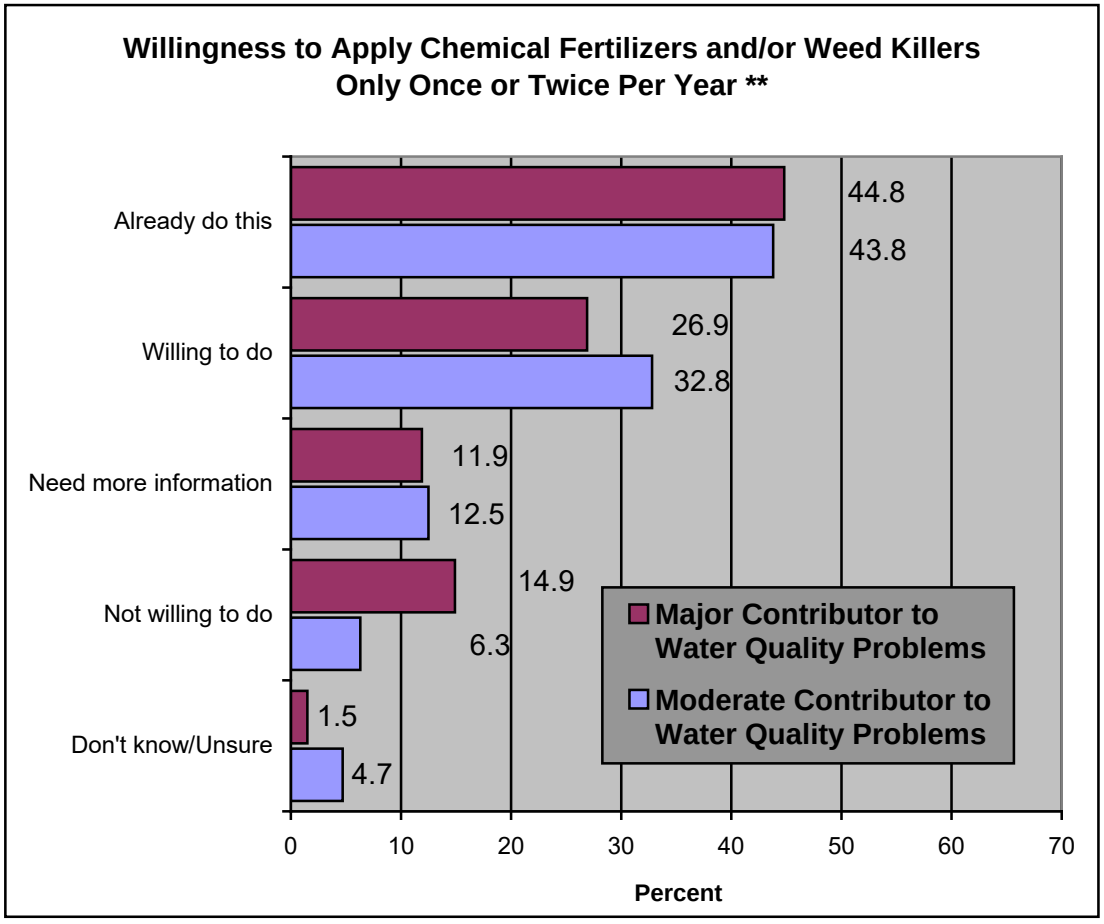
2) Of those who believe lawn fertilizers and pesticides are *moderate contributors* to water quality problems:

    - 44% *already* limit applications of chemical inputs to 1-2 times per year, and 33% are *willing to do* so.

    - 20% are *willing to do* use no chemical inputs, but none *already does* so.

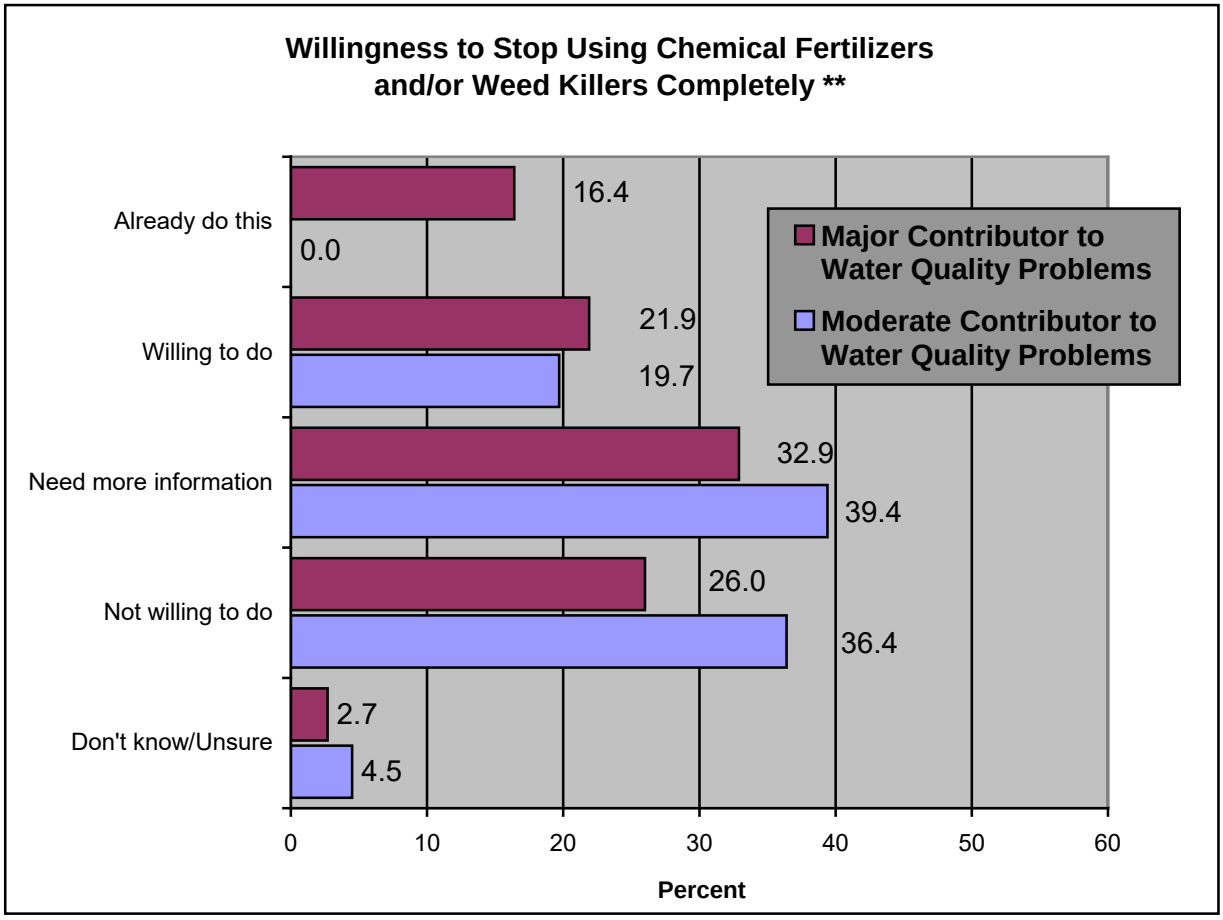
    - 14% *already* use fertilizer with no or limited amounts of phosphorus, and 42% are *willing to do* so.

		Willingness to apply chemical fertilizers and/or weed killers only once or twice per year (Q12.d)					
		Already do this	**Willing to do**	**Need more information**	**Not willing to do**	**Don't know / Not sure**	**TOTAL**
Belief that lawn fertilizers and pesticides contribute to water quality problems (Q2.c)	**Major contributor**	30	18	8	10	1	**n = 67**
	Moderate contributor	28	21	8	4	3	**n = 64**
	Minor contributor	27	13	6	4	1	**n = 51**
	Does not contribute	3	0	2	0	0	**n = 5**
	Don't know / Not sure	2	1	0	0	0	**n = 3**
						Total	**n = 190**



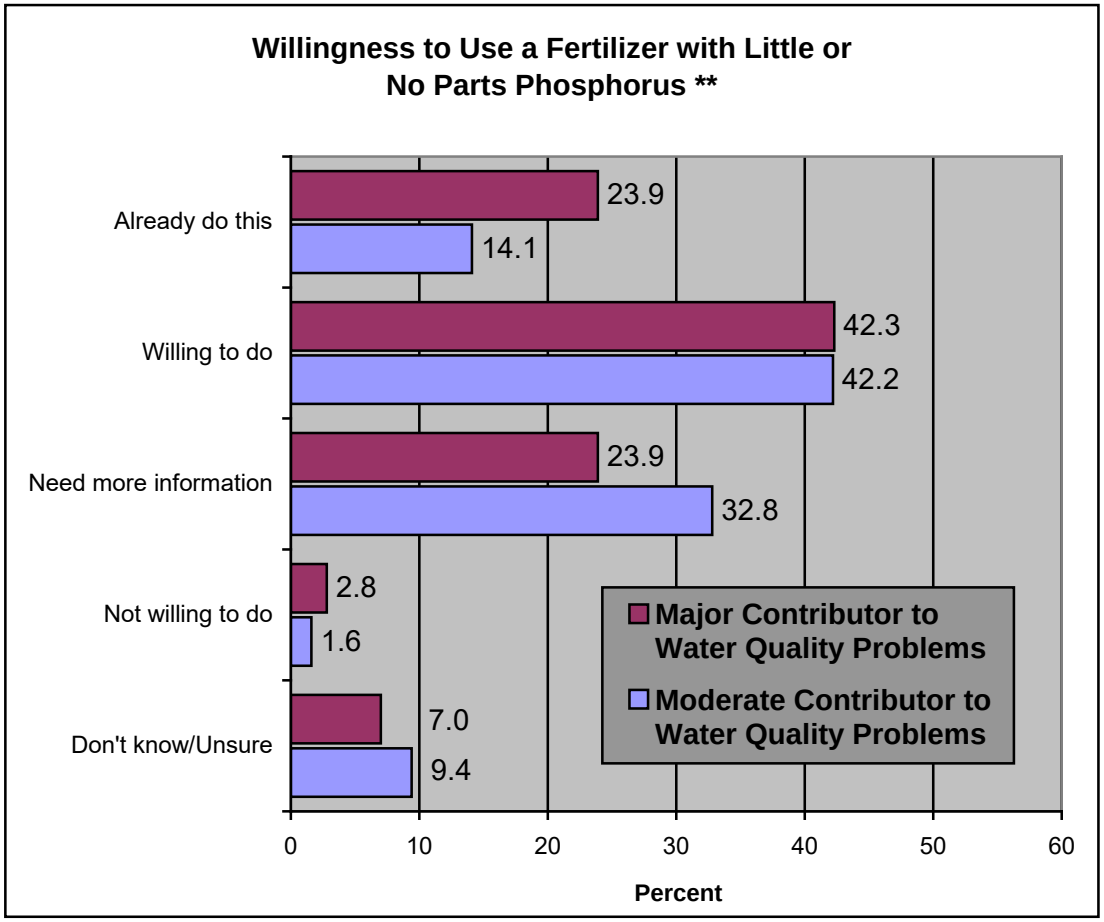
** Chart is a crosstabulation of respondents' belief that fertilizers and pesticides are major or moderate contributors to water quality problems and their willingness to limit fertilizer and pesticide applications to only once or twice per year

		Willingness to stop using chemical fertilizers and/or weed killers completely (Q12.e)					
		Already do this	**Willing to do**	**Need more information**	**Not willing to do**	**Don't know / Not sure**	**TOTAL**
Belief that lawn fertilizers and pesticides contribute to water quality problems (Q2.c)	**Major contributor**	12	16	24	19	2	**n = 73**
	Moderate contributor	0	13	26	24	3	**n = 66**
	Minor contributor	5	12	14	19	2	**n = 52**
	Does not contribute	0	0	3	2	0	**n = 5**
	Don't know / Not sure	0	1	0	2	0	**n = 3**
						Total	**n = 199**



** Chart is a crosstabulation of respondents' belief that fertilizers and pesticides are major or moderate contributors to water quality problems and their willingness to stop using chemical fertilizers and pesticides completely

		Willingness to use a fertilizer with little or no parts phosphorus (Q12.f)					
		Already do this	**Willing to do**	**Need more information**	**Not willing to do**	**Don't know / Not sure**	**TOTAL**
Belief that lawn fertilizers and pesticides contribute to water quality problems (Q2.c)	**Major contributor**	17	30	17	2	5	**n = 71**
	Moderate contributor	9	27	21	1	6	**n = 64**
	Minor contributor	11	17	19	2	4	**n = 53**
	Does not contribute	0	2	3	0	0	**n = 5**
	Don't know / Not sure	2	1	0	0	0	**n = 3**
						Total	**n = 196**



** Chart is a crosstabulation of respondents' belief that fertilizers and pesticides are major or moderate contributors to water quality problems and their willingness to use a fertilizer with little or no parts phosphorus

Appendix C

Focus on Motor Oil and Antifreeze

We compared how respondents believed the improper disposal of used motor oil impacted local water quality versus their willingness to change their motor oil and antifreeze disposal practices.

Notable aspects:

1) Of those who believe the improper disposal of motor oil and antifreeze is a *major contributor* to water quality problems:

    - 76% *already* take their used auto oil to a recycling center, and 18% are *willing to do* so.

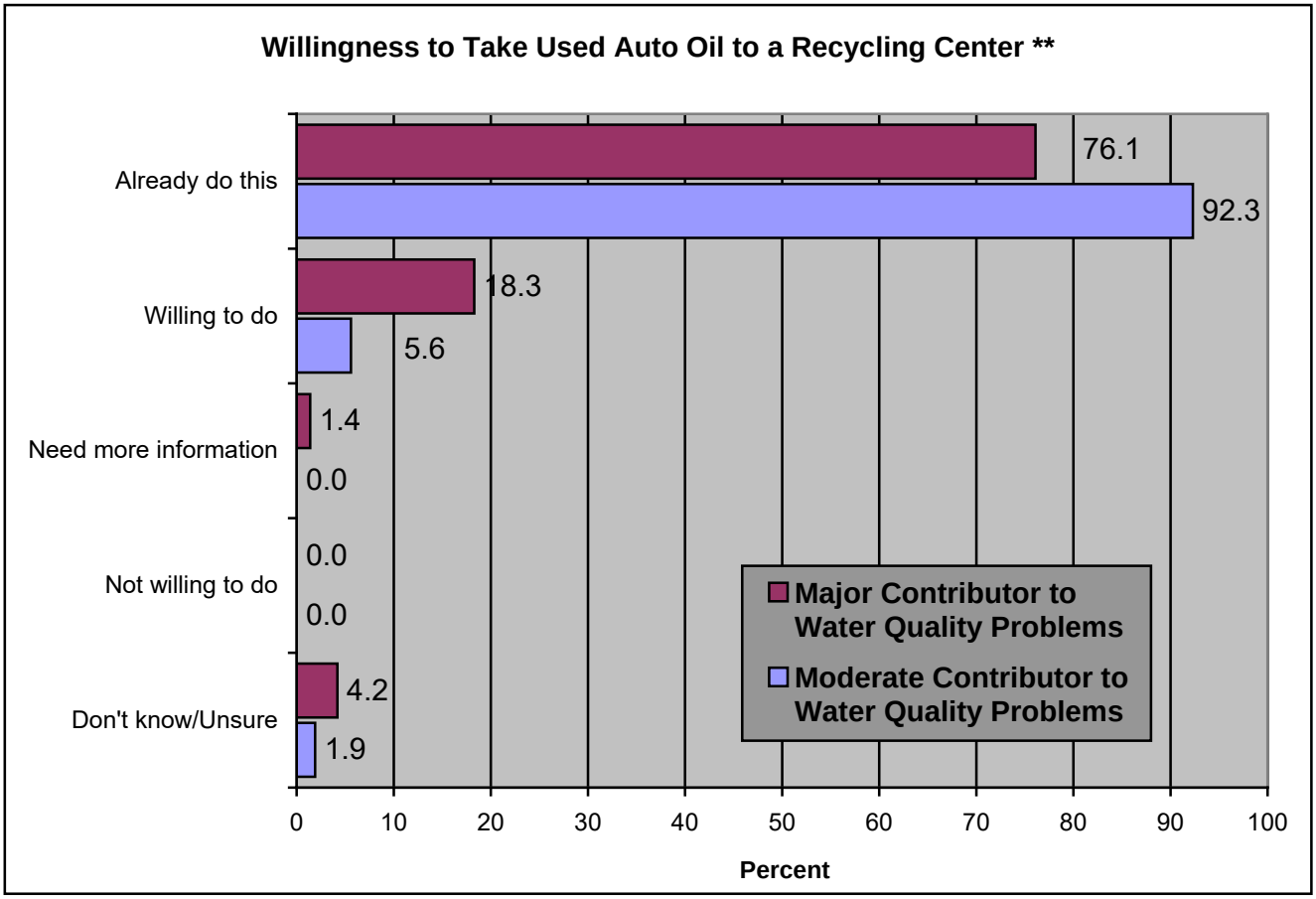
    - 82% *already* have their oil changed at a service center, and 4% are *willing to do* so.

2) Of those who believe the improper disposal of motor oil and antifreeze is a *moderate contributor* to water quality problems:

    - 92% *already* take their used auto oil to a recycling center, and 5.6% are *willing to do* so.

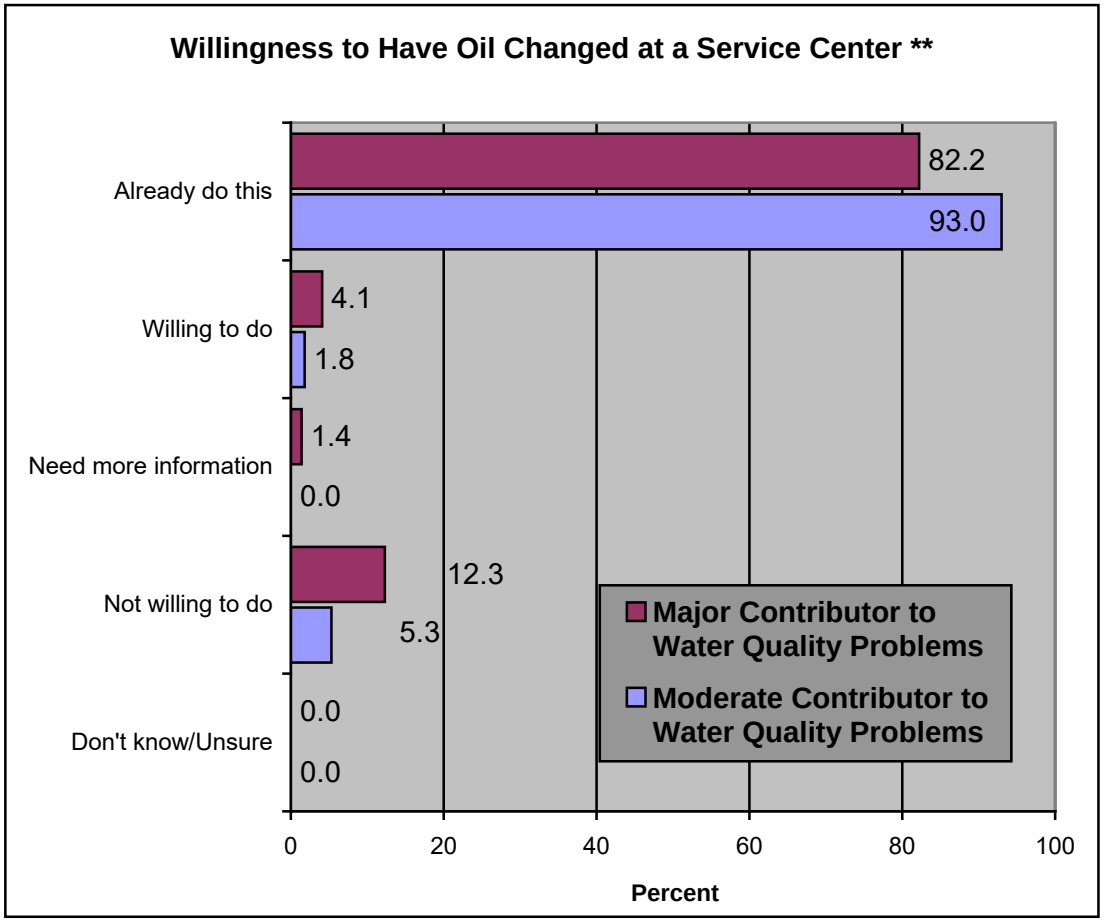
    - 93% *already* have their oil changed at a service center, and 2% are *willing to do* so.

		Willingness to take used auto oil to a recycling center (Q12.a)					
		Already do this	**Willing to do**	**Need more information**	**Not willing to do**	**Don't know / Not sure**	**TOTAL**
Belief that the improper disposal of motor oil and antifreeze contribute to water quality problems (Q2.j)	**Major contributor**	54	13	1	0	3	**n = 71**
	Moderate contributor	50	3	0	0	1	**n = 54**
	Minor contributor	32	7	3	1	3	**n = 46**
	Does not contribute	7	0	0	0	1	**n = 8**
	Don't know / Not sure	10	3	0	0	1	**n = 14**
						TOTAL	**n = 193**



** Chart is a crosstabulation of respondents' belief that the improper disposal of motor oil and antifreeze is a major or moderate contributor to water quality problems and their willingness to take their used auto oil to a recycling center

		Willingness to have oil changed at a service center (Q12.b)					
		Already do this	**Willing to do**	**Need more information**	**Not willing to do**	**Don't know / Not sure**	**TOTAL**
Belief that the improper disposal of motor oil and antifreeze contribute to water quality problems (Q2.j)	**Major contributor**	60	3	1	9	0	**n = 73**
	Moderate contributor	53	1	0	3	0	**n = 57**
	Minor contributor	36	4	0	7	0	**n = 47**
	Does not contribute	7	0	0	2	0	**n = 9**
	Don't know / Not sure	13	0	0	1	1	**n = 15**
						TOTAL	**n = 201**



** Chart is a crosstabulation of respondents' belief that the improper disposal of motor oil and antifreeze is a major or moderate contributor to water quality problems and their willingness to have their oil changed at a service station

Appendix D

Focus on Pet Waste

We compared what pet owners believe about the impact pet waste has on local water quality versus their willingness to pick up after their pet.

Notable aspects:

1) Of those who believe pet waste is a *major contributor* to water quality problems:

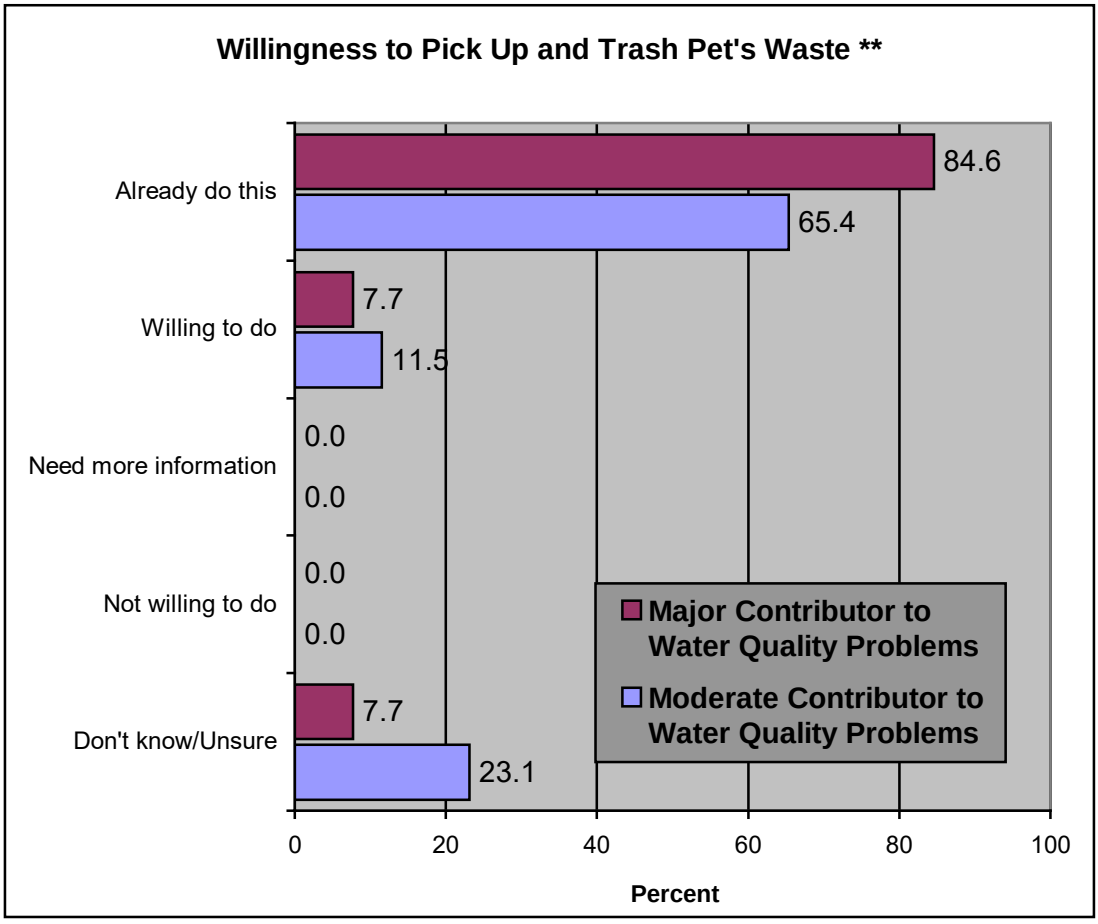
    - 85% *already* pick up and trash their pet's waste.

2) Of those who believe pet waste is a *moderate contributor* to water quality problems:

    - 65% *already* pick up and trash their pet's waste, and 11.5% are *willing to do* so.

3) 8 out of 164 respondents (5%) stated that they are unwilling to pick up after their pet at home or while out walking.

		Willingness to pick up and trash pet's waste (Q12.o) NOTE: 21 respondents indicated they do not have a pet					
		Already do this	**Willing to do**	**Need more information**	**Not willing to do**	**Don't know / Not sure**	**TOTAL**
Belief that pet waste contributes to water quality problems (Q2. e)	**Major contributor**	11	1	0	0	1	**n = 13**
	Moderate contributor	17	3	0	0	6	**n = 26**
	Minor contributor	55	8	0	5	11	**n = 79**
	Does not contribute	29	1	1	3	2	**n = 36**
	Don't know / Not sure	8	1	0	0	1	**n = 10**
						TOTAL	**n = 164**



** Chart is a crosstabulation of respondents' belief that pet waste is a major or moderate contributor to water quality problems and their willingness to pick up and trash their pet's waste

Appendix E

Focus on Car Washing

We compared information about where respondents most often wash their car and, for those times they wash at home, their willingness to wash their car on the lawn.

Notable aspects:

1) Of those who most often *wash their car on the driveway*:

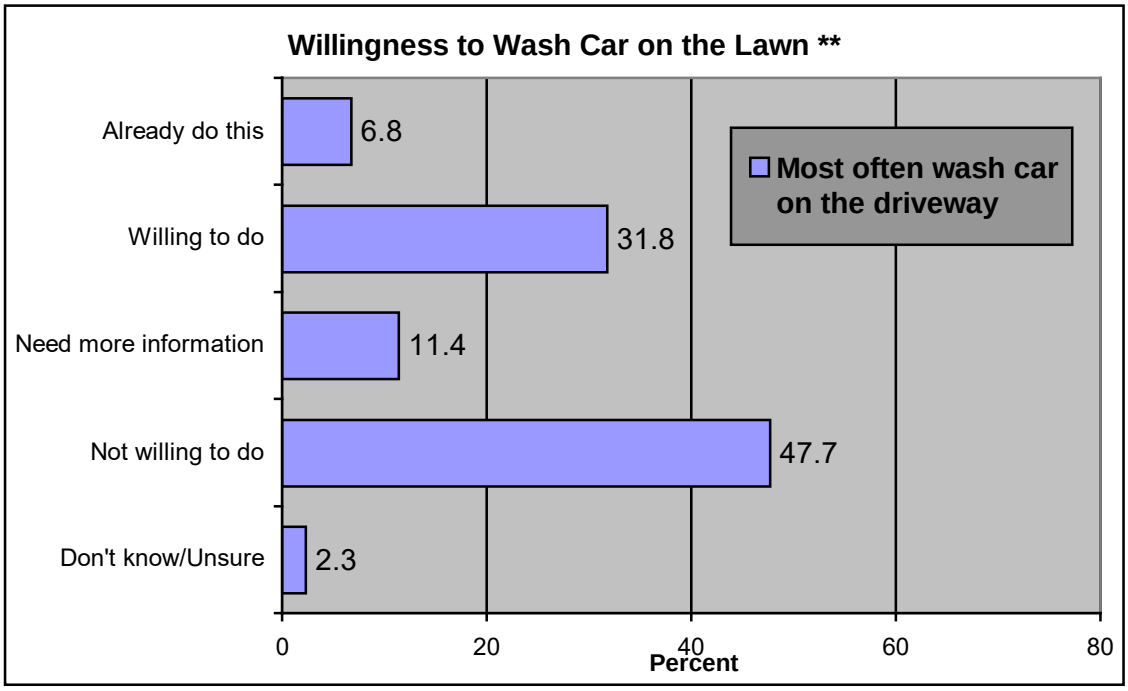
   - 7% say they also wash their car on the lawn
   - 32% say they are *willing to* wash their car on the lawn
   - 48% are *unwilling to* wash their car on the lawn

2) Of those who most often *wash their car on a grassed or dirt area*:

   - It can be reasonably concluded that at least 91% of these respondents wash their car on the lawn, while approximately 9% wash their car on a dirt area.

3) A total of 80 out of 180 respondents (44%) are *unwilling to* wash their car on the lawn rather than at a car wash, on a dirt area, or on the driveway.

		Willingness to wash your car on the lawn (Q12.m)					
		Already do this	**Willing to do**	**Need more information**	**Not willing to do**	**Don't know / Not sure**	**TOTAL**
Where vehicle is washed most often (Q9)	**At home – on the driveway**	3	14	5	21	1	**n = 44**
	At home – on a grassed or dirt area	11	1	0	0	0	**n = 12**
	At a car wash	9	31	8	54	12	**n = 114**
	Other	0	1	0	0	0	**n = 1**
						TOTAL	**n = 171**



** Chart is a crosstabulation of those respondents who most often wash their vehicle on the driveway and their willingness to wash their car on the lawn

Attachment 4

Illicit Discharge Detection and Elimination

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 ordinances, 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 inspection of all structures, which is crucial to the identification of potential illicit discharges.
- Discharge of Unauthorized Waters Ordinance – The Spokane County Code of Ordinances includes enforcement protocol in the event of unlawful non-stormwater discharge. 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 connections to the MS4 is by thoroughly inspecting individual stormwater structures such as catch basins, swales, drywells, ditches, treatment BMPs, and outfalls. 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 that 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 where the MS4 has potential to outfall to waters of the state. Outfalls often accompany structures 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.

One previously unidentified outfall was discovered in 2019. The Shady Slope bridge located over Little Deep Creek has the potential to drain into the creek via a discrete fissure at the shoulders of the bridge. This outfall was identified during an outfall survey inspection.

3.2. Stormwater BMP Inspections

In 2019, Spokane County inspected over 3400 individual structures, including drywells, swales, culverts, catch basins, outfalls, and detention/retention ponds. Spokane County staff are trained on how to look for possible illicit connections and 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 discovered during a structural inspection, investigative action is initiated through the County's Request for Investigation (RFI) process and tracked in the IDDE Database.

3.3. Incidental Discovery

Municipal staff are trained to 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 receive 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

In some instances, monitoring of rain list sites often results in small works or capital projects for issues deemed high priority. Other issues are remediated by maintenance activities such as vactor cleaning or pipe cleaning.

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 of 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.

Table 1 - IDDE Database Summary for 2019

Discharge/ Investigation Type	Location	Material	Date of Report or Discovery	Report Received by?	Date of Investigation	Code Enforcement Action?	Date Investigation Terminated	Notes
Erosion/Sediment	Geiger Blvd Infrastructure Improvement Area	Soil	1/22/2019	Hotline	1/24/2019	N/A	1/24/19	IDDE Hotline call from Shannon Adams, DOE, re soils eroding into wetland from Geiger infrastructure installation. Staff met w/Shannon (ECY) on 1/24/19 to walk the site and try to determine who is responsible for mitigation. Additional ESC BMPs determined necessary.
Illicit Dumping/Discharge	Country Homes Blvd and Warn Way	Drum filled with oil.	5/13/2019	Personal observation	5/13/2019	No responsible party identified	5/15/2019	S. Saunders observed a drum in median swale while performing inspections. Noticed the drum was leaking and notified ECY, National Response Center. R Cochran and K Calderon excavated and disposed of impacted soils. Dist. 1 Maintenance properly disposed of recovered barrel.
Illicit Discharge	vicinity of 2404 E 59th Ct	oil	6/26/2019	RFI	6/28/2019	No – internal	6/28/2019	S Saunders made site visit and observed a thin line of oil running continuing along road. No reasonable remedy to clean up the oil was evident. District staff were notified, equipment was flagged out and repaired. 7/2/19 notified that equipment in question is in the shop for repairs.
Potential Illicit Discharge	Columbia Dr and Woodview	Paint	7/8/2019	RFI	7/8/2019	none	7/8/2019	K Calderon made site visit and cleaned up to best of ability. Material determined to be dry, non-soluble, non-hazardous, latex based paint. Notified Maint. District.
Illicit Connection	906 W Weile Ave - Wall	Water	7/16/2019	Inspection following locate ticket	7/16/2019	N/A	8/8/2019	Water discovered flowing into catch basin a full day after rain event. Follow up inspection on 7/31/19 identified discharge was still occurring. Hypothesized that water originated via damaged Whitworth Water District #2 line. Notified WWD same day to alert of potential damage. Follow-up confirmed Whitworth repaired line. No further discharge was observed.
Illicit Discharge	12024 N Denver - Forest Glen 2nd	Pool Water	7/28/2019	Hotline	7/29/2019	Letter sent 7/29/19	7/29/2019	8/19/19 - Caller reported neighbor at 12024 N Denver is draining pool water to roadway. Water is running downhill, flooding a yard and swale, overtopping drywell in swale. Pool brochure sent to home owner. Will pursue enforcement if problem recurs.
Illicit Discharge	Argonne Ln, S to Upriver Dr	Oil	9/13/2019	RFI	9/13/2019	No responsible party identified	9/13/2019	8/13/19 Call received, K Calderon dispatched to spill location. Calderon observed and called ECY to report spill. ECY determined that spill remediation was impractical once oil had absorbed into asphalt. M Zarecor visited site and confirmed no cleanup actions would be effective.

Table 2 – Known Outfalls on Applicable TMDL Waterbodies

No.	Name	Lat	Long	Waterbody	Discharge Desc.	Priority	Notes
1a/1b	Seven Mile Bridge	47.740917	-117.518802	Spokane River	Vegetated Setback	LOW	a) CB to pipe and b) vegetated ditch outlet to river
2(a-d)	Waikiki Bridge Drains	47.769879	-117.453806	Little Spokane River	Direct	LOW	4 Bridge drains
3	Shady Slope and Leona Bridges	47.793578	-117.376959	Deadman Creek	Direct shoulder runoff	LOW	Vegetated discrete fissure
4a/4b	Little Spokane Drive Bridge Drains	47.798284	-117.382474	Little Spokane River	Direct	LOW	2 Bridge drains
5a/5b	Market St at Deadman Creek	47.779922	-117.352313	Deadman Creek	Setback	a) MEDIUM and b) LOW	a) culvert and ditch, b) CB to pipe
6a/6b	Riverview and Little Spokane	47.817335	-117.37952	Little Spokane River	Setback	LOW	2 Culverts from road ditch to wetland to river
7a/7b	Dartford Bridge	47.783422	-117.415120	Little Spokane River	Direct	a) LOW and b) MEDIUM	a) Culvert and b) CB to pipe, outlets downslope
8	Shady Slope at Little Deep Creek	47.797222	-117.378056	Little Deep Creek	Direct shoulder runoff	LOW	Vegetated discrete fissure, approach culvert SE of bridge

Attachment 5

Effectiveness Studies

1. Introduction

This document is provided to answer annual report question 51: "Attach a summary of your participation in effectiveness study development and implementation during the reporting year (S8.A.1 and S8.A.2)". The following sections detail the actions performed in 2019 to continue the completion of Effectiveness Studies for which Spokane County is the lead entity. Section 4 details the selection and implementation process utilized by Spokane County and the Eastern Washington Phase II Permittees to select the current effectiveness studies. The current Quality Assurance Project Plans (QAPPs) for these studies is include as an attachment to this document.

2. Sand Filter Sidewalk Vault BMP

Constructing BMPs at sites with space constraints presents a challenge for jurisdictions; thus Spokane County is pursuing the development of a BMP that can be retrofit into these built areas. The sand filter sidewalk vault is a variation of the basic sand filter vault BMP defined in Ecology's SWMMEW. The goal of this study is to evaluate the effectiveness of the proposed BMP. The following objectives are defined for this effectiveness study:

- Define the BMP design and maintenance guidance.
- Determine the pollutant removal efficiency of the BMP by measuring and comparing the pollutant concentrations of influent and effluent.
- Verify the maintenance cycle using results of the 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.

Spokane County is partnered with Osborn Consulting for the execution of this study. A summary of 2019 actions are as follows:

- Due to flooding events in spring, significant maintenance was required to clean the vault, replace the sump pump, and replace electrical connections for the sampler data logger.
- Seven samples were collected during 2019.
- Three samples met all the criteria for a qualifying event.
- Two samples were just short of the qualifying precipitation event of 0.15" The precipitation depth of 0.15" is challenging to meet due to most storms resulting in 0.1" to 0.12" of precipitation.
- One sample missed the criteria for minimum number of samples (10) required due to automatic sampler shut off – ambient temperature fell below 2° C.

Spokane County anticipates that Ecology will accept sampling data for the 3 non-qualifying events. The following table represents the sand media that was sampled in 2019. Table 2 on the following page presents results from the collected events. Sampling will continue during 2020 and may continue beyond that dependent on number of qualifying samples collected.

Table 1: Sand Filter WQ Data

Parameter	Units	9/18/2019		10/19/2019		10/21/2019		11/19/2019		12/7/2019		1/6/2020		1/28/2020	
		Influent EMC	Effluent EMC	Influent EMC	Effluent EMC	Influent EMC	Effluent EMC	Influent EMC	Effluent EMC	Influent EMC	Effluent EMC	Influent EMC	Effluent EMC	Influent EMC	Effluent EMC
Copper	mg/L	0.0170	0.0073	0.0395	0.0132	0.0182	0.0064	0.0203	0.0119	0.0995	0.0067	0.0509	0.0202	0.0225	0.0119
Dissolved Copper	mg/L	0.0054	0.0052	0.0067	0.0066	0.0061	0.0034	0.0038	0.0036	0.0092	0.0061	0.0058	0.0066	0.0052	0.0043
Zinc	mg/L	0.0979	0.0234	0.0776	0.0412	0.1050	0.0234	0.1340	0.0603	0.0851	0.0470	0.4000	0.1380	0.1420	0.0625
Dissolved Zinc	mg/L	0.0759	0.0457	0.0286	0.0191	0.0384	0.0133	0.0218	0.0047	0.0741	0.0317	0.0621	0.0446	0.0222	0.0197
Hardness	mg/L	17.50	21.00	29.50	28.00	21.50	20.50	22.50	26.00	40.00	42.00			34.50	25.50
TSS	mg/L	216	29	100	39	76	16	92	48	64	36	560	124	360	33
Total P	mg/L	0.3450	0.1040					0.3080	0.1900						
PO4/P	mg/L	0.0465	0.0300					0.0463	0.0616	0.1780	0.1410				
pH	-	6.73	6.95	6.63	6.30	7.00	7.11								
Lube Oil	mg/L	0.6050	ND	1.2400	1.1100	1.8300	0.4030	1.3400	0.6610			ND	ND	ND	ND
Diesel	mg/L	ND	ND	0.4760	0.3310	ND	ND	0.2710	0.2360	ND	ND	ND	ND	ND	ND

Table 2: Coarse Sand – Sample Results

Parameter	Units	Concentration
CEC	meq/100g	2.3
pH		7.9
Total-N	%	0.024
Total-C	%	0.36
C:N		14.8
Calcium	mg/kg	8553
Copper	mg/kg	13.4
Magnesium	mg/kg	6813
Zinc	mg/kg	36.2

3. Bioretention Soil Media Thickness Study

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 itself leaches nutrients and that the higher the content of compost, the higher the concentration of nutrients leached from the media. Because of these findings, Spokane County is pursuing reducing the BSM depth from 18 inches to 12 inches. The goal of this study is to develop a modified bioretention BMP that uses the existing 60:40 sand to compost ratio BSM mix to a minimum of 12 inches to provide for the treatment of TSS, dissolved copper, and dissolved zinc.

Evaluation of this study is dependent on:

- A comparison between the pollutant removal efficiency of 60:40 BSM mix at a depth of 18 inches and 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.

Spokane County is partnering with Osborn Consulting and Gonzaga University for the completion of this study. Engineering students from Gonzaga perform tasks associated with this study as part of their Senior Design curriculum. Sampling for this study began in 2018. A summary of 2019 actions are as follows:

- Eight samples were collected and analyzed in 2019.
- Multiple samples were lost in 2019 due to temperature, student availability, flooding events, and maintenance.
- Three events met all qualifying criteria
- For two events, one of the samplers was unable to collect resulting in an incomplete data set.
- One event measured slightly below the qualifying precipitation depth (0.15”), it was 0.12” The County is optimistic this event will still be accepted
- For two events, less than 75% of the hydrograph was collected for the effluent samples. These events may still be accepted since the storm event ended before the pond had completely infiltrated.

Sampling will continue into 2020 and potentially longer, based on the total number of samples collected. With the Gonzaga school year lasting from Fall 2019 through Spring 2020, a new student group will be selected to continue the project forward in Fall 2020. Osborn Consulting will conduct sampling during the time when students are unavailable.

Table 3: BSM Study Data for 2019

Parameter	Units	1/18/2019	7/24/2019	9/30/2019	11/21/2019	12/7/2019	12/20/2019	1/28/2020	1/30/2020
TSS-IN	mg/L	8	78	68	22	16	14	11	10
TSS-12	mg/L	1	12		1	3	5	1.5	1
TSS-18	mg/L	5	34	50		8	6	3.5	3.5
CuD-IN	mg/L	0.00406	0.00676	0.00133		0.00306	0.00215	0.00373	0.00118
CuD-12	mg/L	0.00142	0.00608		0.00324	0.00255	ND	0.0084	0.00648
CuD-18	mg/L	0.00146	0.00515	0.00469		0.00361	0.00127	0.0067	0.00463
CuT-IN	mg/L	0.00451	0.00885	0.0033		0.00353	0.00365	0.00369	0.00414
CuT-12	mg/L	0.00139	0.0064		0.00338	0.00315	0.0011	0.00835	0.00762
CuT-18	mg/L	0.00148	0.00533	0.0051		0.00386	0.00164	0.00685	0.00682
ZnD-IN	mg/L	0.0291	0.0565	0.0599		0.024	0.0279	0.0192	0.00804
ZnD-12	mg/L	0.0134	0.0074		0.0134	0.0115	0.0091	0.0192	0.00649
ZnD-18	mg/L	0.0146	0.0102	0.094		0.0133	0.00842	0.0176	0.00483
ZnT-IN	mg/L	0.0146	0.0565	0.0403		0.0246	0.0236	0.0217	0.0198
ZnT-12	mg/L	0.00832	0.0139		0.0125	0.00298	0.0013	0.00888	0.00776
ZnT-18	mg/L	0.0125	0.00852	0.0181		0.00504	0.00384	0.0057	0.00644
TP-12	mg/L		0.886		0.416	0.505	0.409	0.945	0.911
TP-18	mg/L		1.28	0.793		0.576	0.496	0.516	0.572
PO4/P-IN	mg/L			0.0991	0.0901	0.122	0.113	0.052	0.115
PO4/P-12	mg/L				0.349	0.354	0.215	0.738	0.776
PO4/P-18	mg/L			0.7		0.454	0.283	0.445	0.404
NO3-IN	mg/L					0.188	0.1	0.42	0.1
NO3-12	mg/L				15.6	0.305	0.11	0.683	0.228
NO3-18	mg/L					0.602	0.201	1	0.134
TN-IN	mg/L					ND	1.18	0.92	0.657
TN-12	mg/L					ND	ND	1.483	1.093
TN-18	mg/L					0.602	ND	1.5	1.018
Diesel-IN	mg/L			ND		ND	ND	ND	ND
Diesel-12	mg/L					ND	ND	ND	ND
Diesel-18	mg/L			ND		ND	ND	ND	ND
Gasoline-IN	mg/L							ND	ND
Gasoline-12	mg/L							ND	ND
Gasoline-18	mg/L							ND	ND
Lube Oil-IN	mg/L			ND		ND	ND	ND	ND
Lube Oil-12	mg/L					ND	ND	ND	ND
Lube Oil-18	mg/L			ND		ND	ND	ND	ND
Hardness-IN	mg/L		52	18		14.5	153	20	15
Hardness-12	mg/L		218		104	101	292	52	48.5
Hardness-18	mg/L		244	145		148	315	59	51

4.1. 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.

4.2. 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.

Table 2 summarizes the ranked studies, lead entities, and secondary Permittees that will participate in each effectiveness study. The official ranked list of effectiveness study ideas[1] is published on the City of Spokane Valley's website.

4.3. 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 Sidewalk Vault BMP* Study, and the *Bioretention Soil Media Thickness Study*. Information on these studies and the actions taken in 2019 can be found in the SWMP Plan. QAPPs for these studies are included as an appendix at the end of this document. Lastly, a report outlining the steps taken[2] by the EWSG and consultants to develop the QAPP templates and eight Proposals is published on the City of Spokane Valley's website.

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

Table 4: 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 delivery 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. The survey will question Permittees about different models of BMP ownership and responsibility for continued maintenance of BMPs.
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	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)

	Material Removal		affecting the amount of material removed by each sweeping event (a surrogate for sediment deposition rate).
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.
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 was 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.

Table 5: 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	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

Appendix 1

Quality Assurance Project Plans

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.

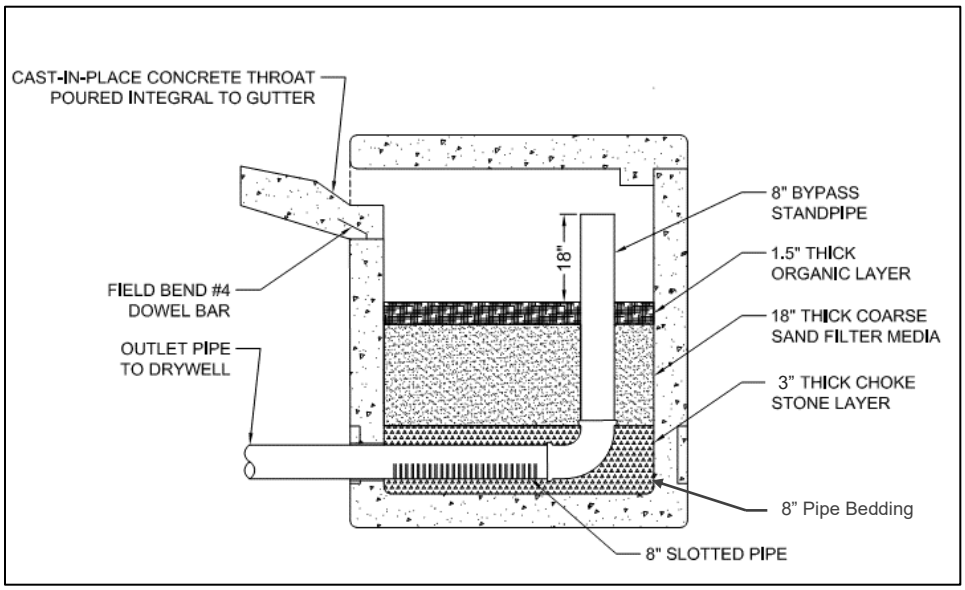

Figure 3.1 Cross Section of Sand Filter in Sidewalk Vault

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.

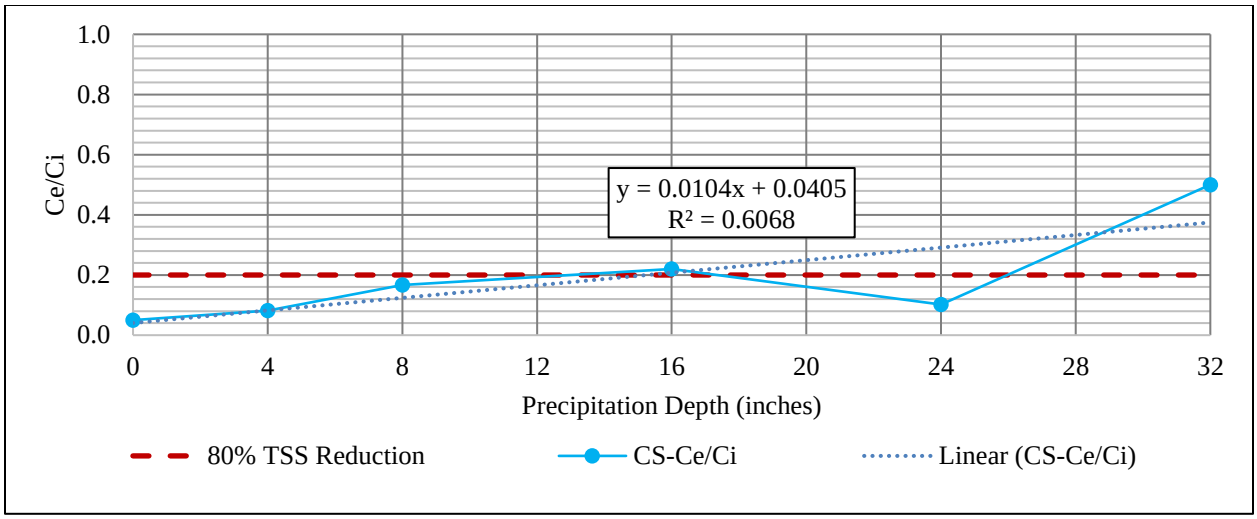

Figure 3.3 TSS Reduction Ratio (Ce/Ci) vs. Precipitation Depth (SIL-CO-SIL® 106 only)

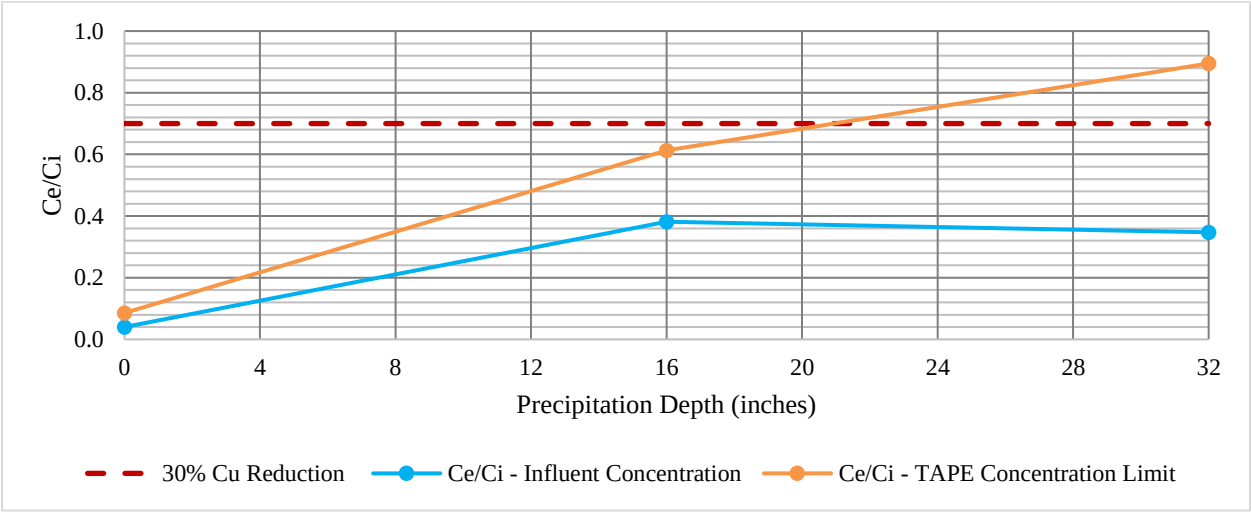

Figure 3.4 Dissolved Cu Reduction Ratio (Ce/Ci) vs. Precipitation Depth

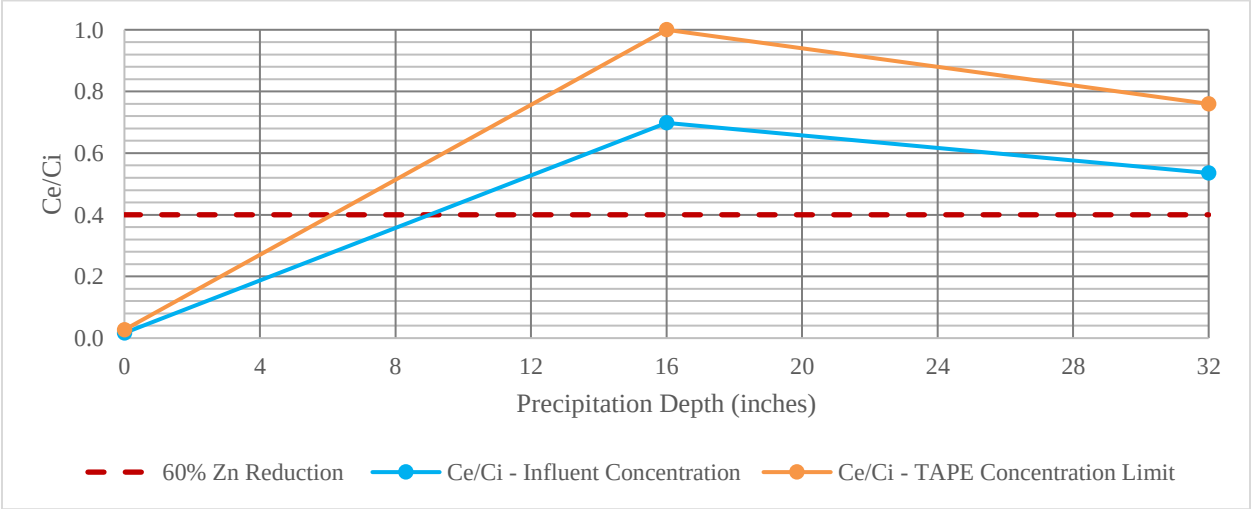

Figure 3.5 Dissolved Zn Reduction Ratio (Ce/Ci) vs. Precipitation Depth

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.

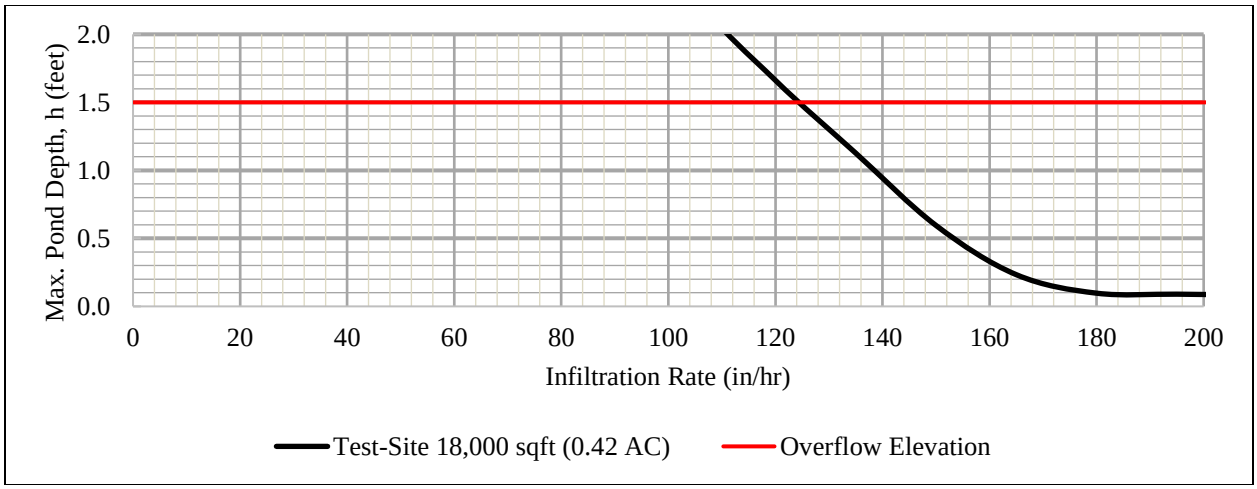

Figure 3.6 Design Infiltration Rate Based on Results from Single Event Modeling

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.

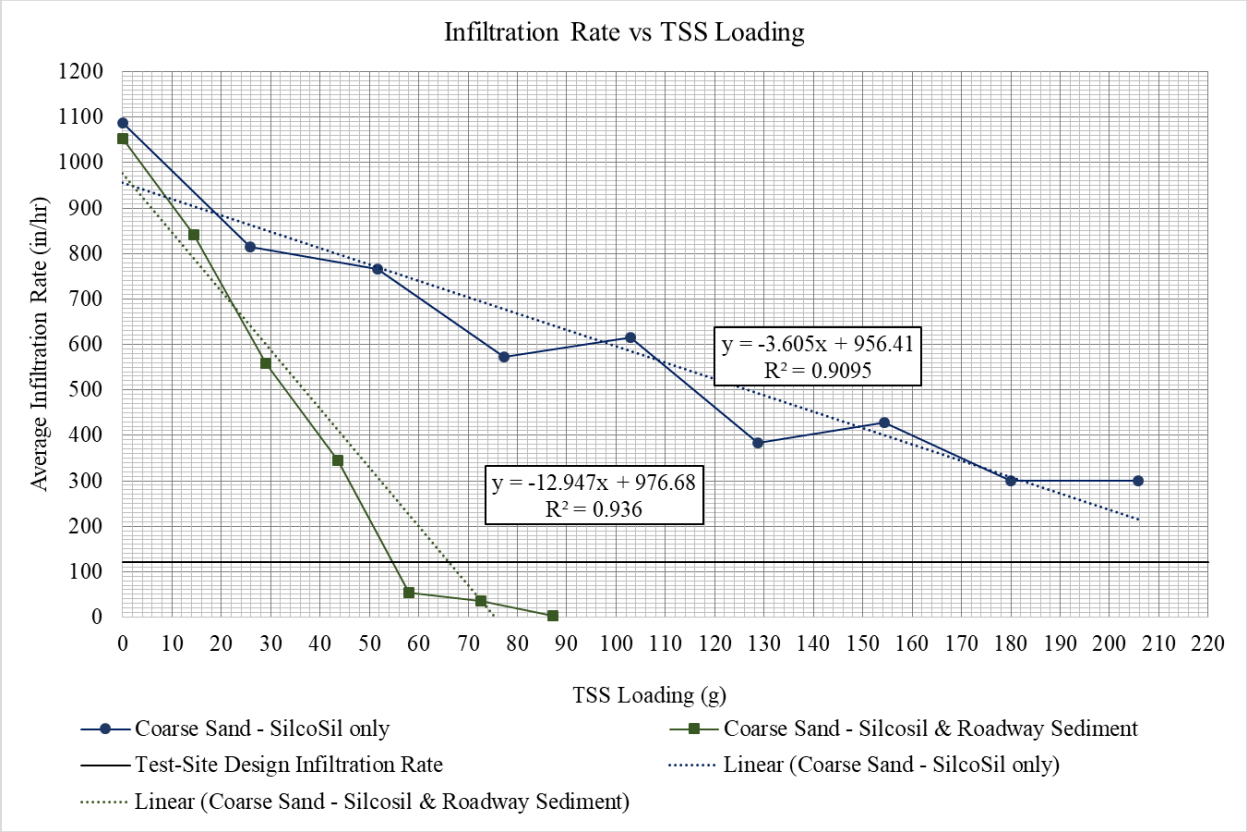

Figure 3.7 Results from Falling Head Testing

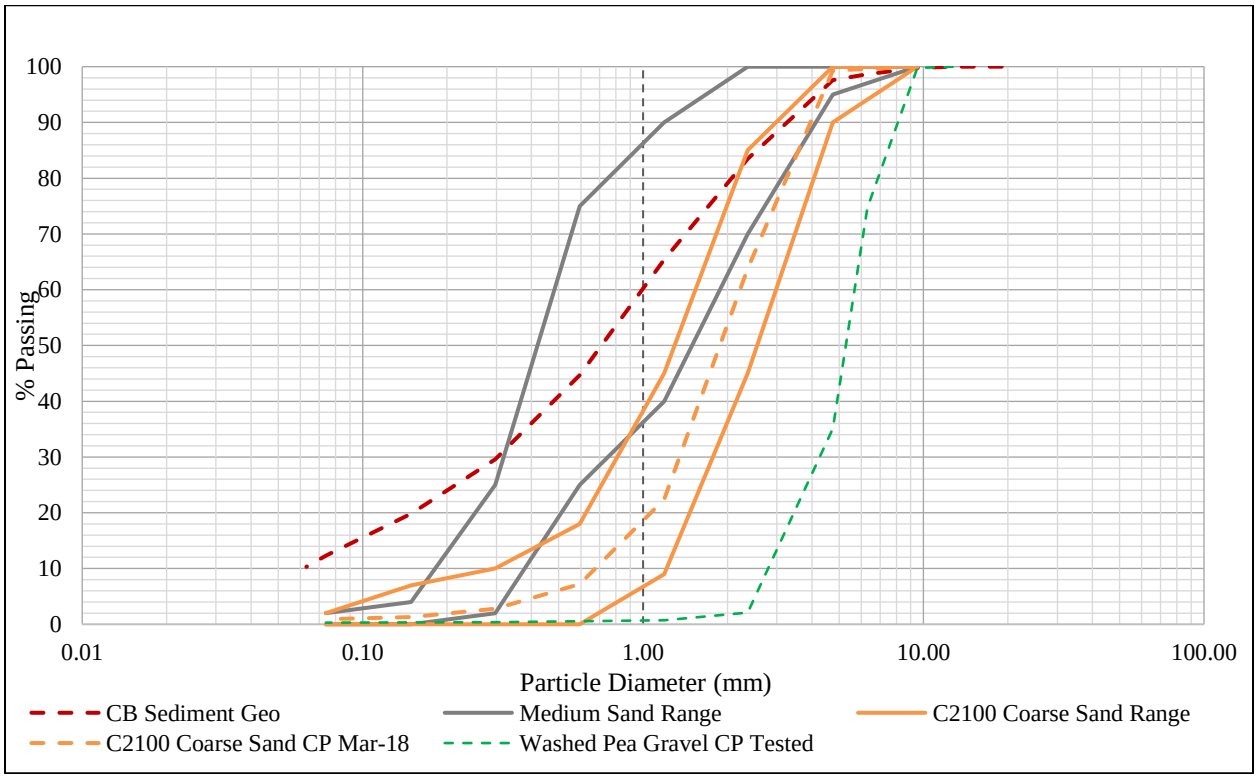

Figure 3.8 Comparison of Gradations: Medium Sand, Coarse Sand, and Roadway (CB) Sediment

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).

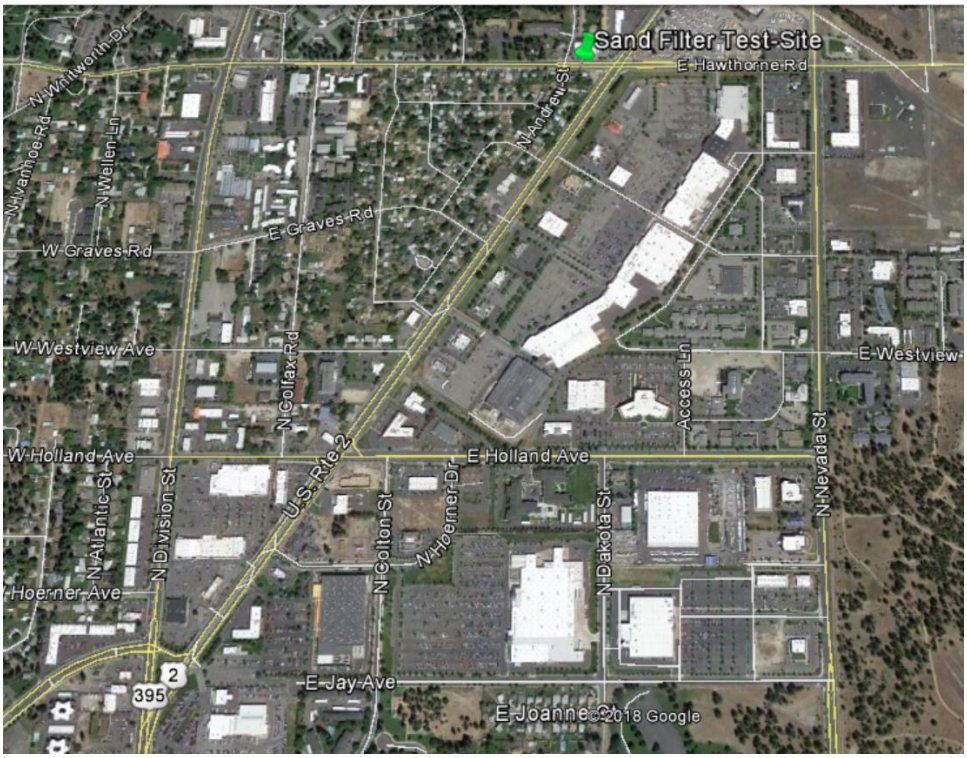

Figure 4.1 Test-Site Area Map

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
Nigel Pickering WSU	TAG Member[6]	509.335.8624 nigel.pickering@wsu.edu
Doug Howie Ecology	Ecology Reviewer[11]	360.407.6444 doho461@ecy.wa.gov
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
Stephen Burchett Budinger & Associates	Environmental Engineer Principal[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
Jeff Price HDR, Inc.	Sampling Staff[4,8]	509.343.8475 jeff.price@hdrinc.com

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

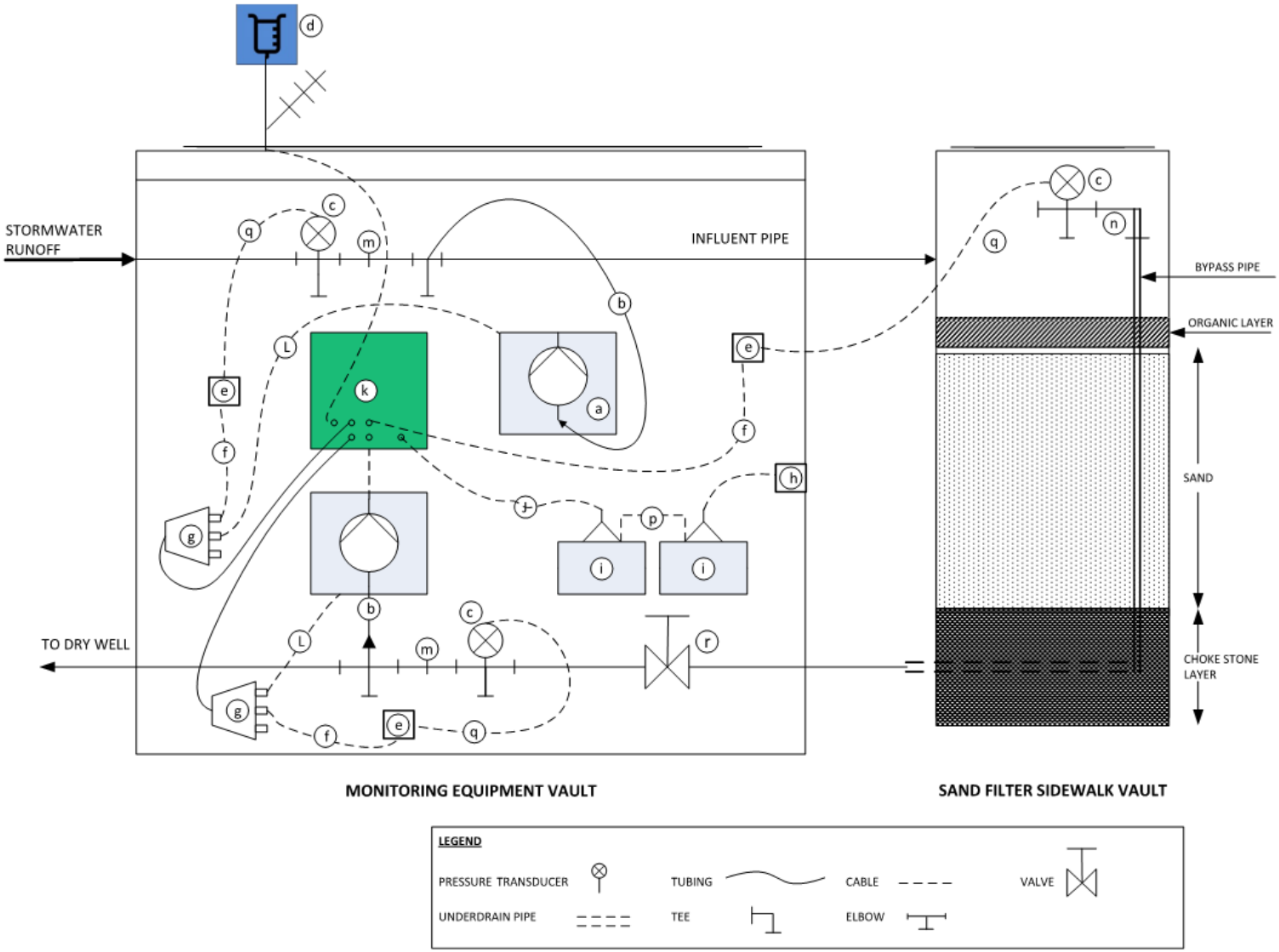

Figure 7.2 Water Quality Monitoring System Process Drawing: Cross-Section View

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

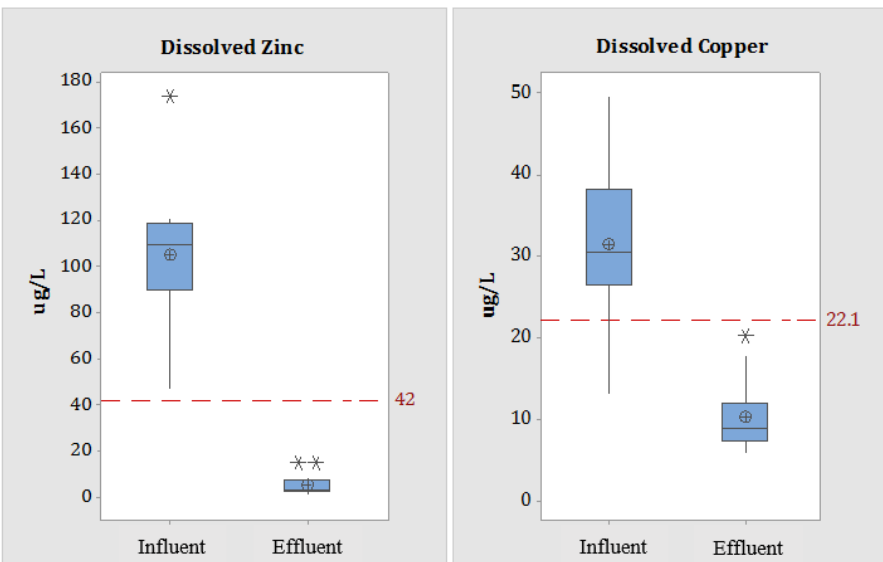

Figure 14.1 Example of Box Plots

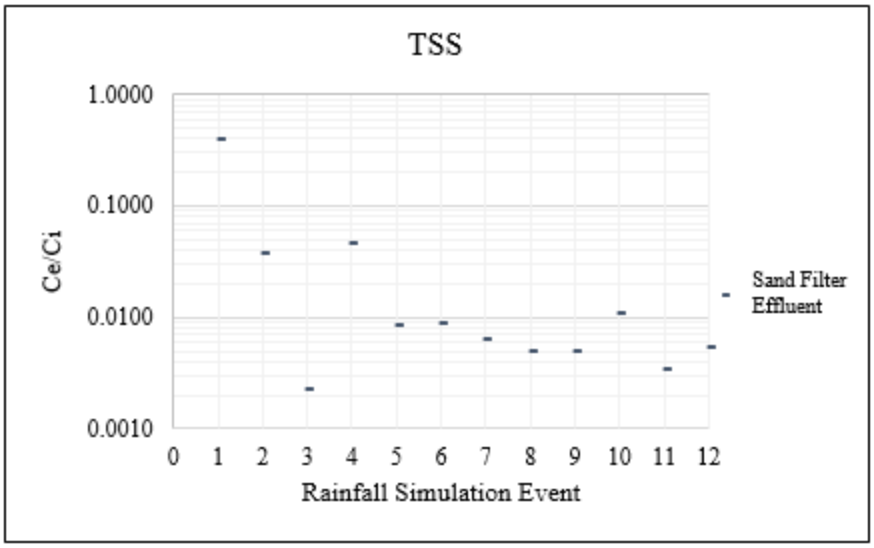

Figure 14.2 Example of Log-Normal Plot

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

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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

Prepared For:

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SPOKANE COUNTY

HDR

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.

Signature Page

Approved by:

Ethan D Murnin Date 5/8/2018

Ethan Murnin, Lead Entity, Spokane County

Aimee S. Navickis-Brasch Date 5/8/2018

Aimee Navickis-Brasch, Primary Author, HDR, Inc.

Kathy Sattler Date 5-8-18

Kathy Sattler, Anatek Laboratories Laboratory Project Manager

Stephen Burchett Date

Stephen Burchett, Budinger and Associates, Environmental Engineer Principal

Date

Adriane Borgias, Ecology, Water Quality Project Manager

Date

Doug Howie, Ecology, Reviewer Structural and Operational BMP Studies

Date

Brandi Lubliner, Ecology, Reviewer Monitoring System Designs

Distribution List

This section includes the distribution list for each party who will receive an Ecology approved copy of the QAPP.

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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.

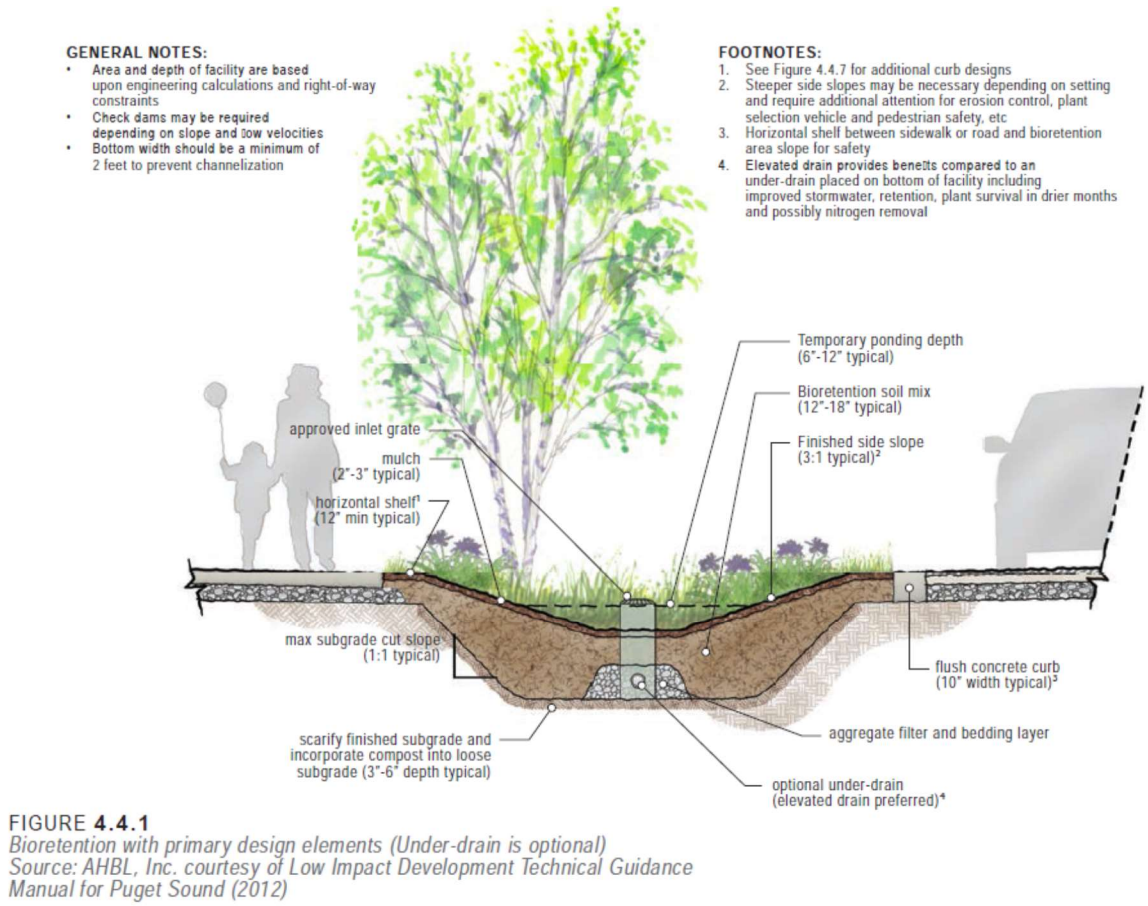

FIGURE **4.4.1**
Bioretention with primary design elements (Under-drain is optional)
Source: AHBL, Inc. courtesy of Low Impact Development Technical Guidance Manual for Puget Sound (2012)

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.

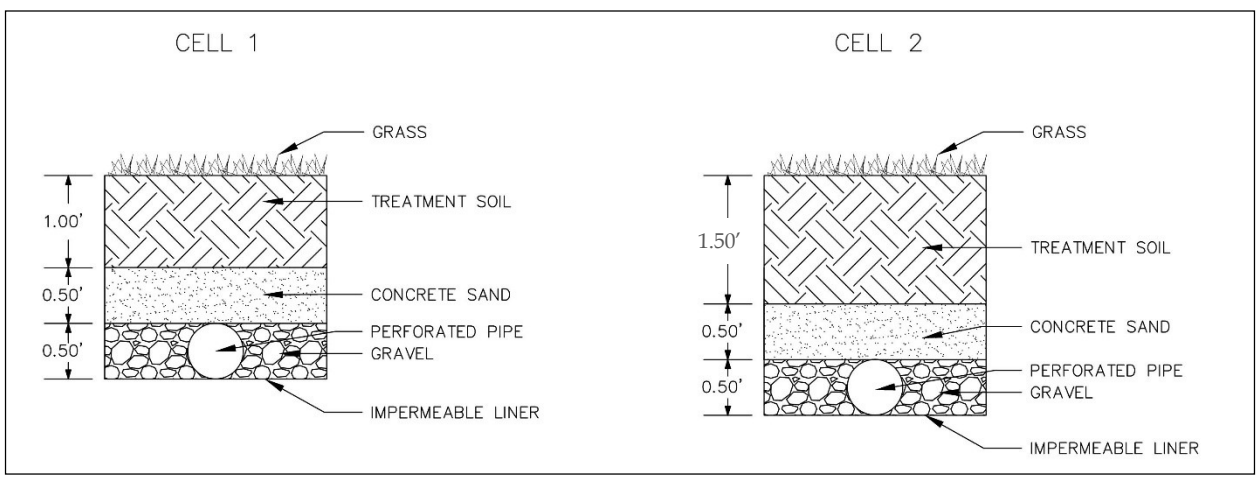

Figure 4.1 Cross Section of the Bioretention Cells: 12-inch BSM (cell 1) and 18-inch BSM (cell 2)

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

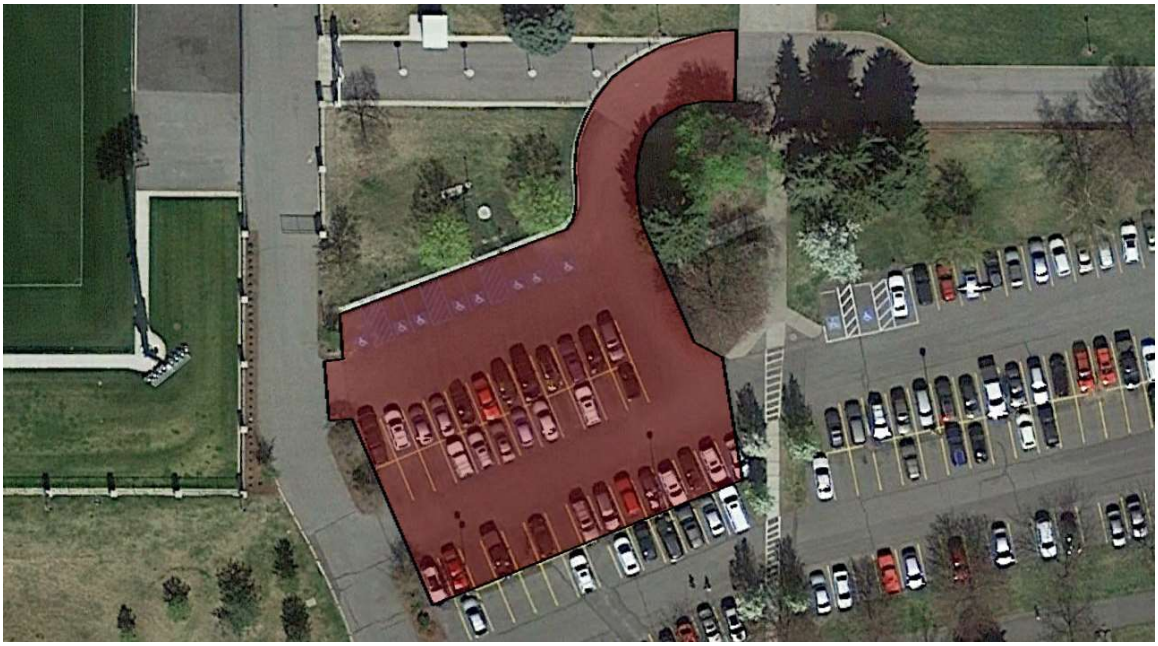

Figure 4.3 Contributing Basin Area

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
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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
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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).

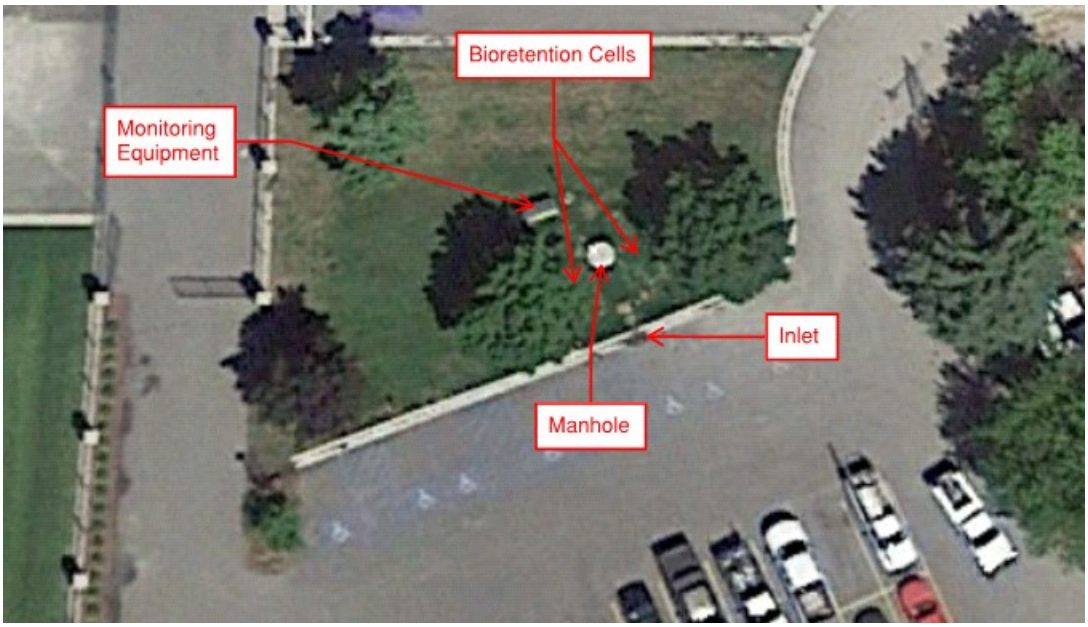

Figure 7.1 Aerial View of Test Site

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.

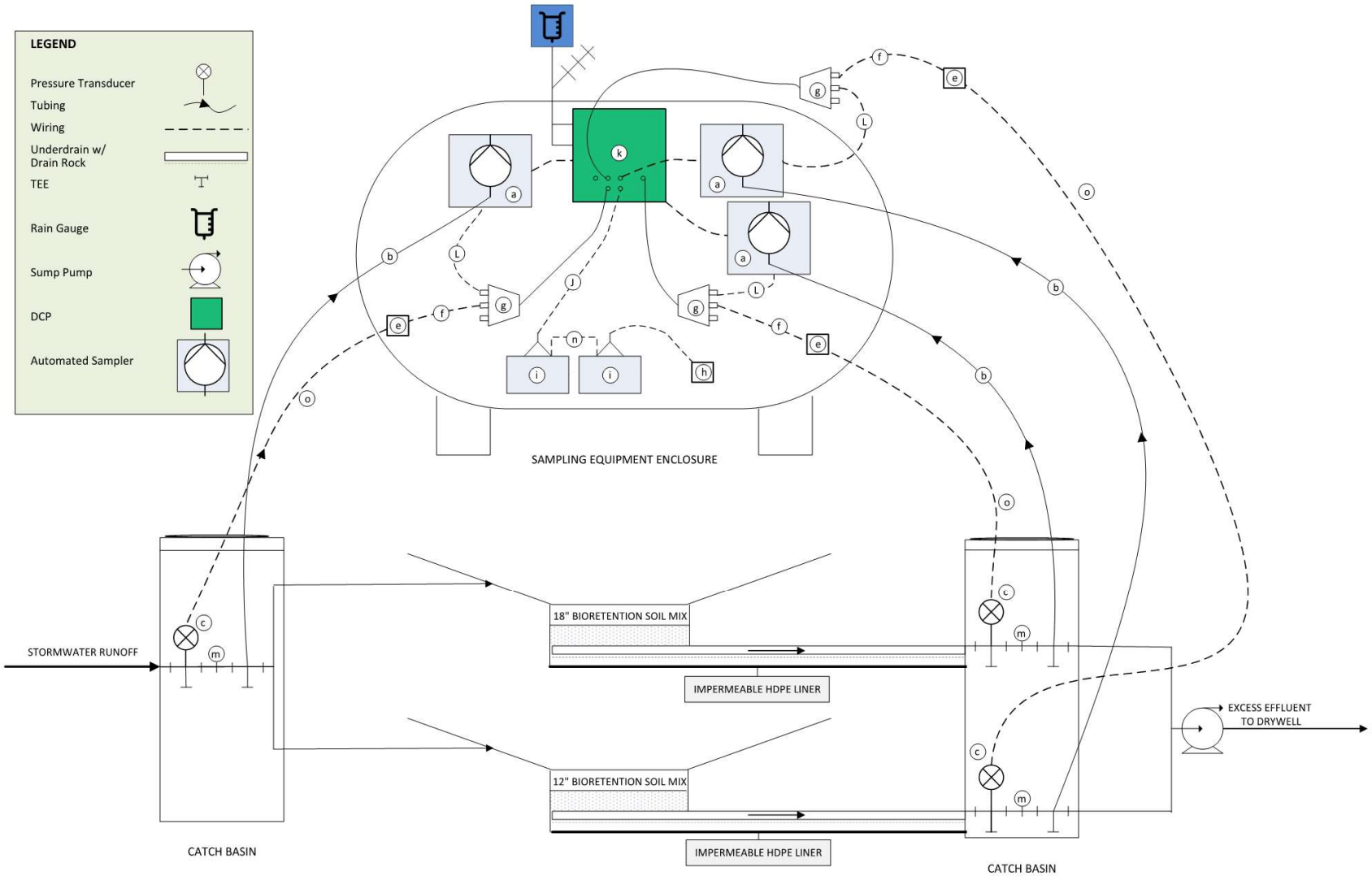

Figure 7.3 Process Diagram of Monitoring System

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

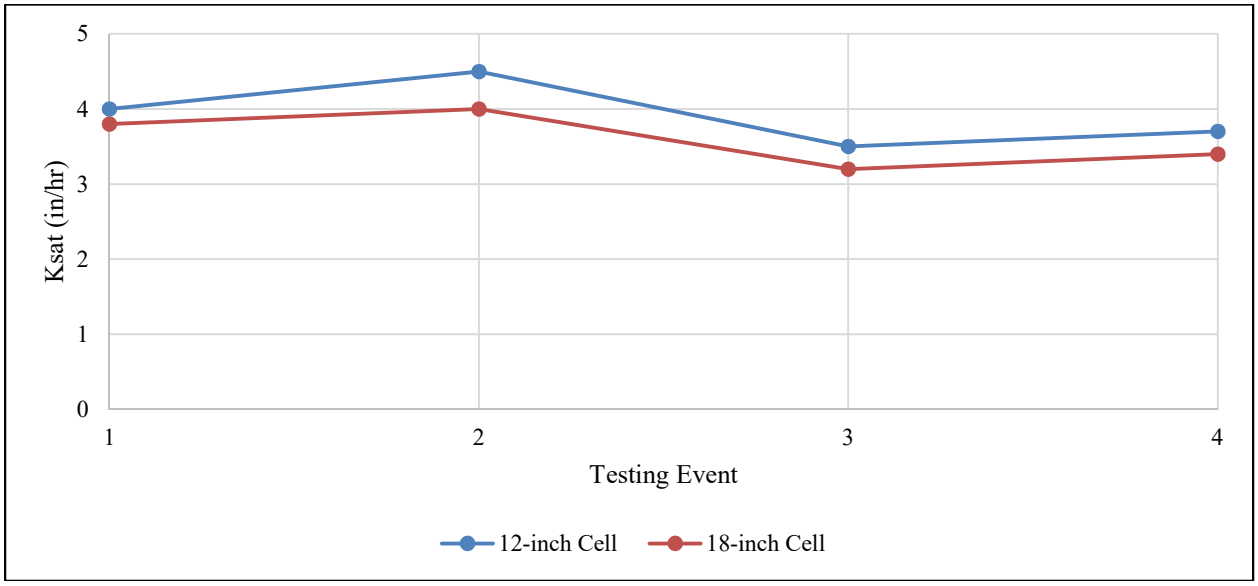

Figure 14.1 Summary of Mean and Standard Deviation K_{sat} Measurements for Each Testing Event

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.

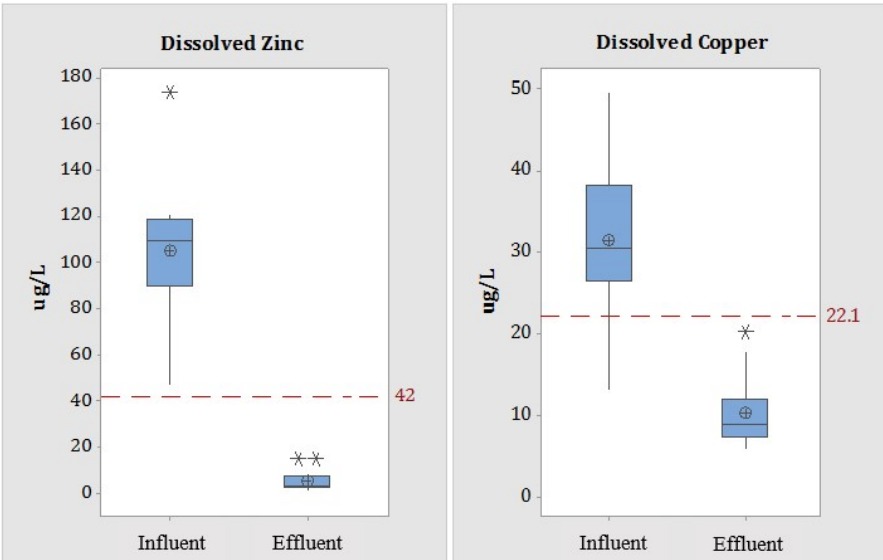

Figure 14.2 Example of Box Plots

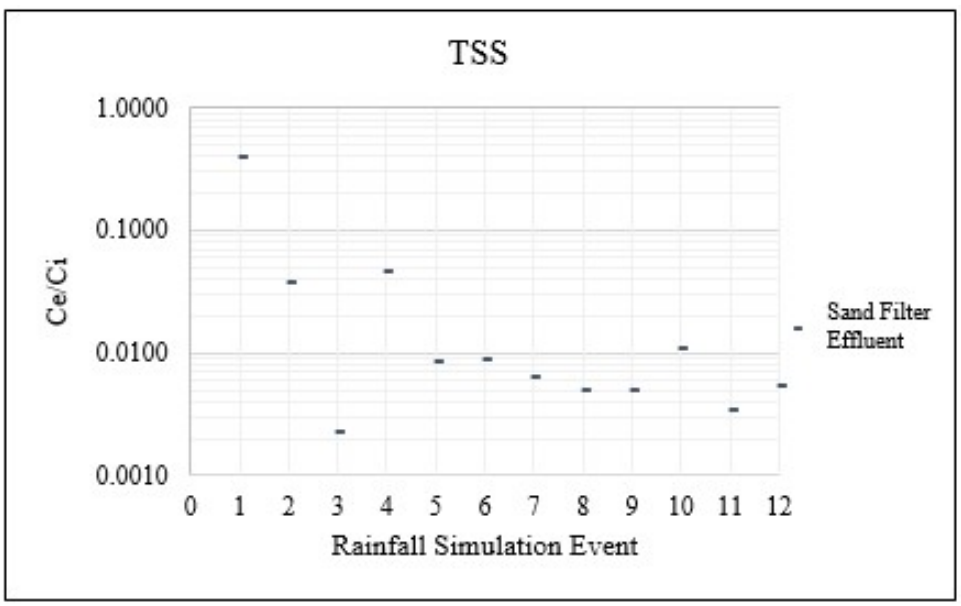

Figure 14.3 Example of Log-Normal Graphs line graphs: the removal efficiency (C_{eff}/C_{in})

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

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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