Appendix 21 – Catch Basin Retrofit Device Replacement Proposal

Eastern Washington
Stormwater Effectiveness Studies

Detailed Study Design Proposal

Catch Basin Retrofit Device Placement

Study Classification:

☑ Structural BMP ☐ Operational BMP ☐ Education & Outreach

Study Objective(s):

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

June 30, 2017

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Proposal Publication Information

This Detailed Study Design Proposal (Proposal) will be stored and accessible to the public at the following weblink: Add Weblink where the Proposal can be accessed by the Public

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Signature Page - Proposal

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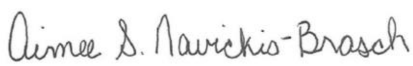

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This section will be completed for the QAPP.

List each party responsible for the contents of the QAPP and the project along with their project title, and organization. Each party must sign and date this page before the study proceeds to the implementation phase (i.e. conduct the study).

Distribution List – Proposal

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

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Distribution List - QAPP Only

During the QAPP development, this section should be updated to include a list of each party who will receive copies of the approved **QAPP** as well as any subsequent revisions along with their contact information. This may include those who is responsible for the QAPP development and project implementation including project managers, QA managers, representatives of other groups/agencies involved, field staff, etc.

1.0 Table of Contents

The TOC should be updated during the QAPP development and auto generated using a word processing program.

2.0 Executive Summary

This section will be completed for the QAPP.

3.0 Introduction and Background

3.1 Introduction to the Structural BMP

A spill control device is a standard catch basin that is constructed or retrofit with a hood, snout, downturned elbow or tee on the outlet pipe. These retrofits are used to retain a limited volume of pollutants that float on the water such as oil or antifreeze (Ecology, 2006, p. 21). The catch basin also retains gross solids that settle in the basin from rainfall events. Spill control devices are required upstream of Underground Injection Control (UIC) wells at locations where oil or other floatable chemical spills are likely during the span of a project, including high use sites (but excluding high vehicular traffic areas). High use sites include but are not limited to: vehicle maintenance facilities, fueling stations, roads in EWA with an average daily traffic (ADT) count equal to or greater than 30,000 vehicles, and commercial on-street parking areas in EWA with an ADT count equal to or greater than 7,500 (Ecology, 2006, p. 22). Examples of constructed or retrofit spill control separators are shown in Figures 3-1 to 3-4.

A spill control device receives stormwater from an incoming storm sewer pipe (Figure 3-2) or through a grate inlet (Figures 3-3 and 3-4). Stormwater in the catch basin then flows out through the spill control device (downturned elbow or tee) which is installed on the outlet pipe. During extreme events, and if a tee is used on the outlet pipe, stormwater may also flow out of the catch basin through the top of the tee functioning as an emergency overflow. (Ecology, 2006, p.30).

BMP Treatment Mechanisms

The spill control device limits the entry of sediment, oils and grease, and trash into the storm sewer system. Specifically, incoming stormwater velocities decrease in the catch basin, which allows gross solids and sediment to settle out in the sump. The downturned elbow or tee prevents floatable contaminants in the influent from flowing further downstream when the water level in the catch basin is above the opening of the retrofit device. The BMP therefore physically reduces the transport of pollutants to downstream catch basins. *Note: spill control devices do not provide full treatment of oils and solids rather they are only intended to temporarily retain the pollutants in the catch basin. Spill control devices are passive and must be cleaned-out for the pollutant to be removed (Ecology, 2004).*

BMP Design Criteria

No design guidance is provided for spill control devices in either the Eastern Washington Stormwater Management Manual (EWSWMM) or the Guidance for UIC Wells that Manage Stormwater Manual. Guidance for the installation of retrofit devices varies depending on the specific device, manufacturer and application. Storm sewer networks with catch basins that include these retrofits should be designed per the jurisdictions typical requirements for storm sewers. Additionally, storm sewer networks with spill control devices installed in the catch basins should be designed to maintain the typical water surface above the opening of the outlet to prevent floatable pollutants from entering the downstream storm sewer system.

Operation and Maintenance Requirements

To prevent buildup or transport of pollutants downstream, the catch basin and retrofit device should be inspected regularly for the purpose of detecting and cleaning any spills that may have been retained in the catch basin (Ecology, 2004, p.5-57, 5-59). The EWSWMM does not specify the maintenance or operation standards for spill control devices; however, the Manual does specify that facilities should be operated according to other manuals or documents approved by Ecology, or by local jurisdictions. The Washington State Department of Transportation (WSDOT) Highway Runoff Manual, a manual equivalent to the EWSWMM, includes provisions for spill cleanup, specifically they should be coordinated with the local water quality response agency (WSDOT, 2016, p.5-244). Typical cleanup or maintenance activities for the spill control device include periodic vacuum truck cleaning of the sump contents and occasional repair or replacement due to breakage or routine wear and tear.

Figure 3-1. Spill control device: a standard catch basin with a retrofit (tee) on the outlet pipe

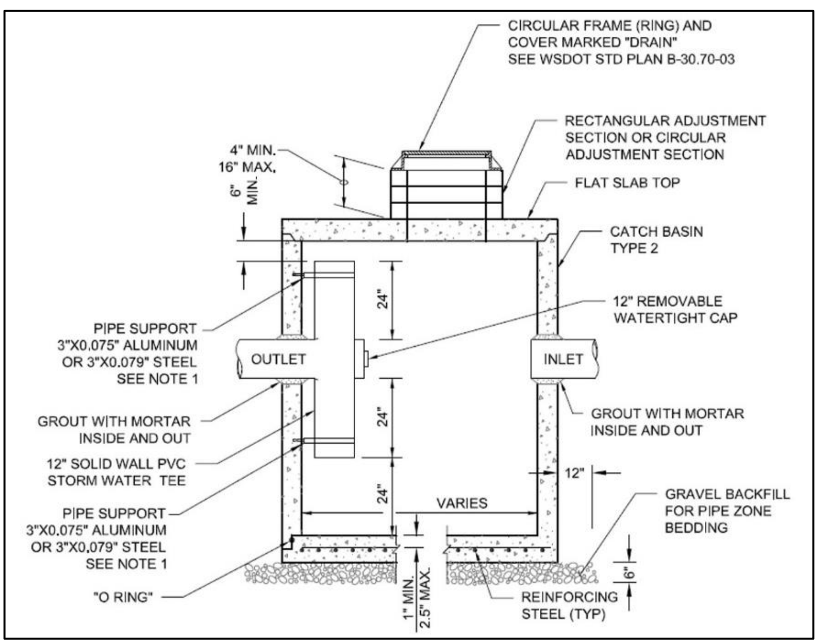

Figure 3-2. Examples of Tee Retrofit (Ecology, 2006, p.22).

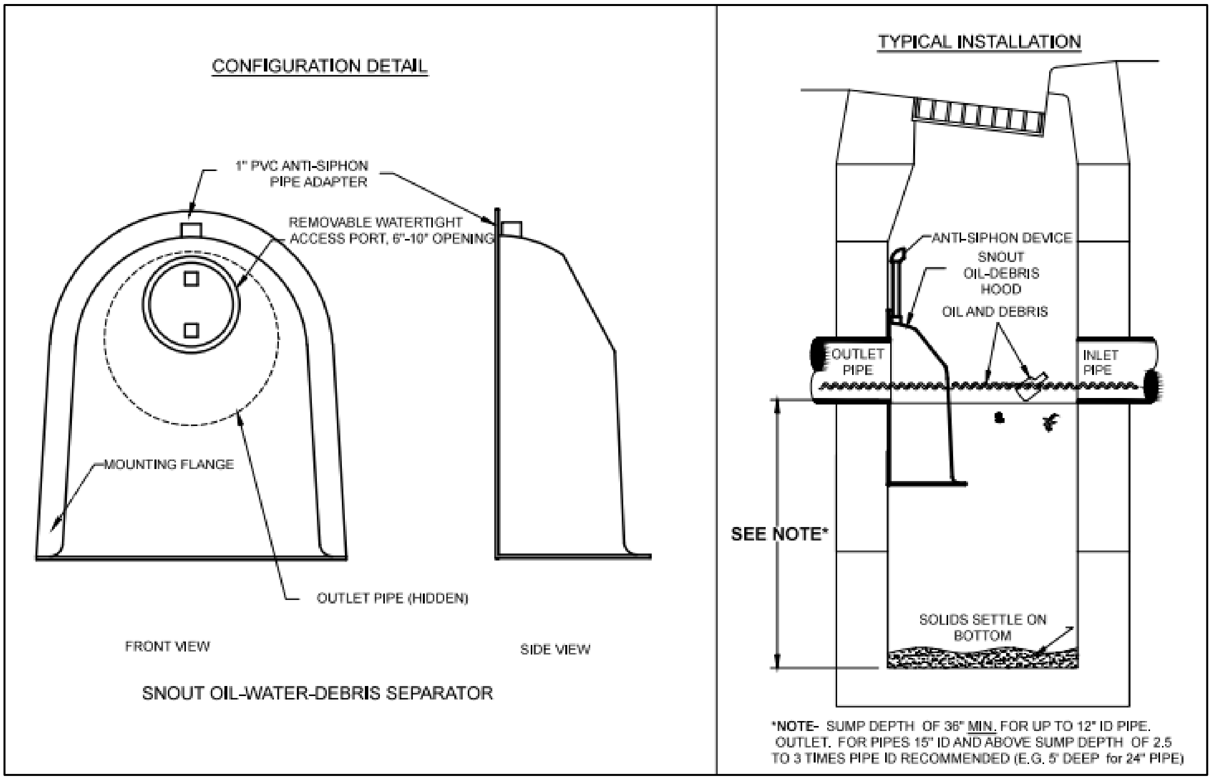

Figure 3-3. Example of Snout Separator (Best Management Products, www.bmpinc.com).

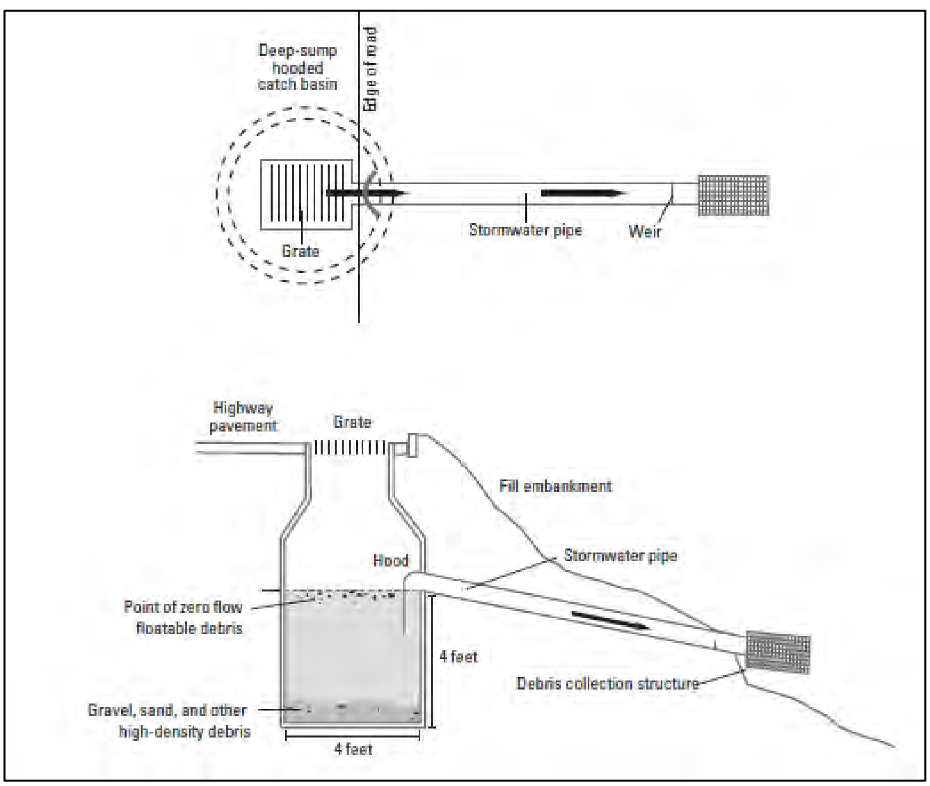

Figure 3-4. Example of Hood Separator (Smith, 2010)

3.2 Problem Description

Retrofits installed in catch basins are reported to cause difficulties for routine maintenance and cleaning, especially in smaller catch basins. This is due to the lack of space for the vacuum hose to access the bottom of the catch basin sump. As a result, the devices are sometimes removed and may not be reinstalled correctly, or at all. Worse, the retrofit may be removed prior to cleaning out the catch basin allowing the trapped floating oils and solids to be transported downstream negating the original intent of the device.

The current practice is to install a retrofit device in each catch basin within a storm sewer network that discharges to a UIC. Given the access difficulties in smaller catch basins with these devices installed, this study proposes a modified approach that maybe more effective. The modified approach would only install the retrofit device in a single larger catch basin that is located at the most downstream end of a storm sewer network. This study will help determine how retrofits can be applied most effectively in a storm sewer system to maximize their benefit and minimize maintenance burdens, and provide more cost-effective treatment (e.g., dollars per pound of gross solids and oils removed, $/lb.).

3.3 Results of Prior Studies

A few studies (Mullen, 2003; Smith, 2010) have reported the benefit of retrofit devices installed in catch basins for reducing the transport of solids and oils through the storm sewer system. The documented removal rates of solids varies widely, and range from about 30 to 80 percent (Smith, 2010), depending on the type and amount of material trapped in the catch basin. Both of the studies cited in this section performed a direct comparison between a catch basin with the retrofit device and a catch basin without the device. However, no studies were located that focused on the system-wide effectiveness: storm sewer systems with only one catch basins retrofitted. In addition, no studies were located that address the reported maintenance problems in small catch basins with retrofits installed and no studies were located from a semi-arid, western climate.

3.4 Regulatory Requirements

The *Guidance Manual for UIC Wells that Manage Stormwater* specifies that spill containment structures are located upstream of UIC wells where oil or other floatable chemical spills are likely during the span of a project, including high use sites (but excluding high vehicular traffic areas) (Ecology, 2006, p. 22). It is important to note that the spill control devices do not provide full treatment of oils and solids. The spill control devices are only able to temporarily retain the pollutants in the catch basin, and maintenance is required to ensure buildup of oils and solids does not occur. This study will evaluate the runoff treatment performance of spill control devices for retaining concentrations of oils and hydrocarbons as well as solids for reducing the transport of these pollutants downstream of the catch basin.

4.0 Project Overview

4.1 Study Goal

The goal of this study is to determine if spill control devices installed in multiple catch basins in a storm sewer network are as effective for removing pollutants as one spill control device installed at the most downstream end of a system prior to discharge to a UIC. Results from this study could assist MS4s in prioritizing where retrofits are used, inform catch basin design to facilitate compatibility and reasonable maintenance procedures, and optimize cost-effectiveness ($/lb.). The study may also provide key information that could be used (after the study is complete) to determine how catch basin retrofits can be used in combination with other management practices, such as source controls and sweeping, could achieve water quality goals such as 80% removal of solids.

4.2 Study Description and Objectives:

This study will evaluate oils and gross solids removal differences between two similarly sized and located catchments; one in which a retrofit is only installed at the most downstream location in the catchment (test) and one in which the same retrofit is installed at multiple locations within the catchment (control). The catchments to be compared will be located near one another, and each catchment selected will contain a storm sewer network with a series of connected catch basins that discharge to the same endpoint (Figure 7.1). The study will also document installation as well as operation and maintenance costs which will be used to assess cost effectiveness of the two catchment types. A more in-depth description of the study can be found later in this document (Section 7.1).

The study goals will be achieved by meeting the objectives:

- Determine the effectiveness (pollutant removal and cost) of one retrofit installed in a catch basin at the most downstream end of a storm sewer network
- Determine the effectiveness (pollutant removal and cost) of installing retrofits in each catch basin within a storm sewer network
- Determine which of the two approaches is more effective
- Based on the study findings, summarize recommendations for placement of retrofits in storm sewer networks that provide the greatest benefit in terms of pollutant removal and cost

4.3 Study Location

The study location has not been selected. The location will be determined by the lead entity with consultation from participating agencies. It is anticipated that the study will occur in an eastern Washington residential or commercial street or parking lot where two separate, similarly-sized catchments are located. Alternatively, the study may occur at a controlled test site where a catchment system would be constructed for the study. The controlled test site would likely be established in partnership with a university extension program (e.g. WSU).

4.4 Data Needed to Meet Objectives

Data anticipated for collection during this study includes:

- The quantity of gross solids in the catch basins
- The particle distribution of settleable solids in the catch basins
- The concentration of oil (and other hydrocarbon) from the catch basins and discharge from the most downstream catch basins
- Total suspended solids (TSS) and turbidity from the influent and effluent of each catch basins
- Flow rates of stormwater in the sewer system during storm events
- Capital and O&M costs associated with catch basin retrofits for several municipalities in EWA will also be compiled for the cost-effectiveness part of the evaluation.

Note: The specific sample size and intervals for sample collection will be defined in the QAPP, after the site is selected. Per the EWA Effectiveness Study QAPP Template for Structural BMPs (Appendix A) the minimum sample size defined for effectiveness studies is 12, collected from natural rainfall events.

4.5 Tasks Required to Conduct Study

The tasks required to conduct the study will depend on the study location chosen. The tasks outlined in this section assume a site with small paired catchments (e.g. two sides of the same street or a large parking log) is selected. *This section should be updated when the QAPP is develop and the site is selected to include more specific details regarding the task that will be completed.*

- **Develop a Quality Assurance Project Plan**
  - Select a test-site and control-site location
- **Prepare for Data Collection**
  - Construct test-site and control-site (unless an existing site is located)
  - Install flow measurement devices in the storm sewer network
  - Install retrofit devices: in one catchment, each catch basin would contain a retrofit device; in the other, only the final oversized catch basin in the series would be retrofitted.
  - Clean-out the storm sewer network including the catch basin sumps prior to starting the study
- **Data Collection**
  - In each catch basins (both control and test), the quantity of gross solids (floatable and settleable) captured would be measured at specific intervals (e.g. every other month for a year) by removing and weighing the solids
  - Collect grab samples from each catch basin at a specific interval (e.g. every other month for a year) and test the sample for oils and hydrocarbons

- Collect grab samples of the stormwater discharges (from rainfall events) at the most downstream catch basins; test for oils and other hydrocarbons
- Collect grab samples from the influent and effluent of each catch basin during rainfall events; test for TSS and turbidity
- Measure the flow rate of the stormwater influent and effluent during rainfall events at the most downstream catch basin in the test-site and control-site
- Quantify the total amount of material removed from the test-site and control-site with the area normalized to account for differences in drainage area between the watersheds, and compared.
- Clean the catch basin sumps after each rainfall event in which samples are collected
- Collect and document the typical costs for retrofit installation and catch basin operation and maintenance. (This information will be used to perform the cost-effectiveness evaluation ($/lb removed))
- Input data into database and perform QA/QC of data collection records

- **Final Report**
  - Analyze the data
  - Summarize the study findings into a report including recommendations for the placement of retrofits and summary of cost analysis

Note: Similar tasks would be required to conduct if a controlled test site were selected. However, the runoff events at the site could be simulated and samples of influent and effluent could be obtained in a more controlled manner than sampling actual rainfall events.

4.6 Potential Constraints

This section describes conditions that may impact the project schedule, budget, or scope and the steps that will be taken to reduce the impact of these conditions. These conditions are summarized in Table 4.1 along with the mitigation approach.

Table 4.1 Summary of Potential Study Constraints and the Subsequent Mitigation Approach

Potential Constraints	Mitigation Approach
A key constraint of this study will be to locate comparable existing sites where the side-by-side comparison of a storm sewer system with connected catch basins versus a similar system with a single larger downstream catch basin	It may be more appropriate and successful for project partners to investigate proposed developments or redevelopments that provide opportunities to construct comparable study facilities. Another possibility is to establish a test site in partnership with a university extension or similar institution in the region.
Spills: oil or other chemicals	Spills could require the sewer system to be cleaned. This could interfere with the study results. The mitigation approach includes: weekly visual inspect catch basins; if spill occurs the catch basins will be cleaned and the incident will be noted in the data collection log.
Time of grab samples during rainfall events	Follow TAPE requirements for collecting grab samples (Ecology, 2011)

5.0 Organization and Schedule

5.1 Key Project Team Members: Roles and Responsibilities

Key Team Members	Role	Responsibility
Name Organization Phone Number Email	Lead Entity	Define
Name Organization Phone Number Email	Participating Entity	Define
Name Organization Phone Number Email	Partner Entity	Define
Name Organization Phone Number Email	Ecology Reviewer	Define
Name Organization Phone Number Email	Proposal Author	Define
Name Organization Phone Number Email	QAPP Author	Define
Name Organization Phone Number Email	Key Team Member Project Role	Define

5.2 Project Schedule

The project schedule cannot be defined in any detail at the time of this proposal. A suitable existing site has not been identified and the alternative approach related to a research test site in partnership with a university extension has not been arranged to date. When the site(s) location and needed facilities are identified and constructed or retrofit, it is expected that the field monitoring would extend for one or two years (if real world basins are used) and at least one year if a university extension research site is established.

5.3 Budget and Funding Sources

A very rough estimate of the hours required to conduct this study is included in the table below. A funding source for the study had not been determined at the time this Proposal was written.

Task Name	Hours	Cost per Hour	Equipment	Work Performed by (Consultant, Lead Entity or Participating Entity)	Sub-Total
Project Management				Lead Entity	$9,000
QAPP Development[5]	160	$150		Consultant	$24,000
Data Collection Preparation[3]	60	$50 ($100)	$5,600	Lead Entity & Staff	$10,600
Data Collection[2]	460	$40		Lead Entity Staff & Crew	$18,400
Analytical testing[1]				Ecology Certified Laboratory	$11,000
Final Report[5]	240	$50-$150		Lead Entity, Consultant, and Participating Entities	$24,000
				Total[4]	$97,000

1. The cost for analytical testing includes TSS ($15), turbidity ($15), TPH ($60), and particle size distribution ($50). This cost estimate assumes the control and test site will have a combined total of 7 catch basins. The cost reported in the table assumes: TPH -72 samples (24 samples collected from the outlet of the most downstream catch basins from 12 rainfall events; 42 samples collected from each catch basin every other month for a year); 108 samples each of TSS and turbidity (collected from the influent and effluent at each catch basin for a total of 12 rainfall events). 42 particle size distribution tests (costs assume samples will be collected from each catch basin six times). 10% was added to the cost to account for duplicate samples which are typically part of the quality assurance plan.
2. Hours include cleaning the catch basins sumps (assume 7 catch basins total) and collecting data/samples from 12 rainfall events. The cost of a rain gauge is not included; assume rainfall data will be collected using the nearest rain gauge in the jurisdiction.
3. Hours are for the installation of retrofit devices, flow meters, and cleaning the catch basins prior to the start of the study. Automated flow meters are ~$800 each and should be installed by a certified installer (estimated at $100/hr) in the discharge pipe from each catch basin. Additional equipment such as automated samplers may also be required however these items are not included because the monitoring system design cannot be complete until the site is selected. If an automated sampling system is selected for the test site shown in Figure 7.1, the estimated cost is $100,000 (samples collected from each discharge); $60,000-$70,000 for equipment and $30,000 to $40,000 for programming and installation.
4. The cost to construct the site is not included in the total cost.

6.0 Quality Objectives – QAPP Only

This section will be completed for the QAPP.

7.0 Experimental Design

7.1 Study Design Overview

As mentioned previously, the tasks required to conduct the study are dependent on the study location chosen. Therefore, one of two study design approaches can be used to conduct the comparison of implementation of spill control devices through a catchment versus at the downstream end of a catchment. The first study design approach assumes the selection of a site with small paired catchments (e.g., two sides of the same street or large parking lots) for comparison and monitoring. Catchments in the small paired catchment would contain a storm sewer system with connected catch basins that discharge to the same endpoint. In one catchment, each catch basin would contain a retrofit device (control-site); in the other, only the most downstream catch basin in the series would be retrofitted (test-site). The downstream catch basin at the test-site would be oversized to allow for easier maintenance access. The total cumulative catch basin volume would be the same for each site, and the total impervious area draining to each site would also be the same.

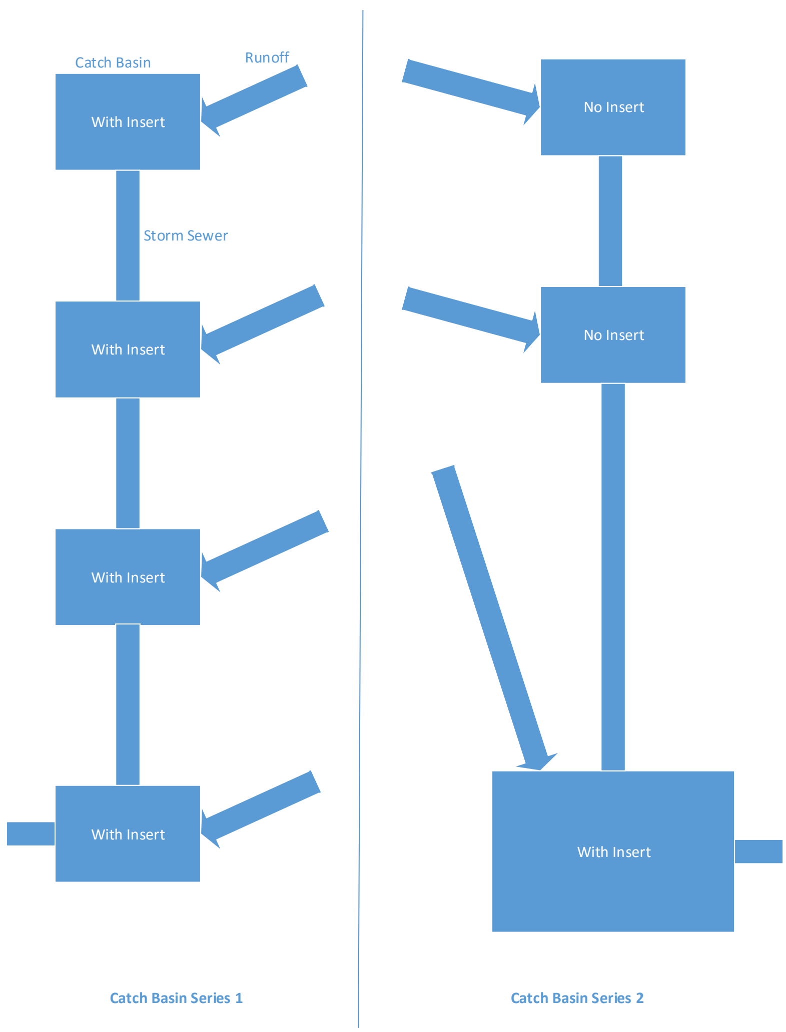

Figure 7.1 Schematic of Test-Site and Control-Site

Figure 7.1 is a schematic of the proposed control-site (left) with four catch basins each with a retrofit (tee, elbow, snout, etc.) installed on the outlet pipe and the test-site (right) with 3 catch basins and a retrofit only on the outlet pipe of the most downstream oversized catch basin. For comparability of the two storm sewer systems, the total cumulative catch basin volume would be the same along with the total impervious area draining to the test-site and control-site.

At specific intervals (e.g., monthly) the quantity of floatable and settleable gross solids will be measured in each of the catch basins in both test catchments. The floatable and settleable gross solids measured will be weighed, and the particle size of the settleable solids will also be determined. The total amount of material removed would be quantified for each system, with the area normalized to account for differences in drainage area between the watersheds, and compared. Depending on the site selected, the means of quantifying gross solids might vary (e.g., periodic manual removal and weighing of material collected, turbidity measured in runoff in and out of the catchment or basin, etc.). Figure 7.2 shows an example of manual collection and in Figure 7.3. a vacuum truck would be used to collect the solids.

Figure 7.2 Example of Manual Collection of Floatable Material

Figure 7.3 Example of vacuum truck empting the catch basin contents onto a tarp prior to processing the material

Capture of oils and other hydrocarbons in each catch basin would be measured by collecting grab samples periodically from the catch basin (e.g. once a month for a year). During 12 qualifying rainfall events as defined by Ecology in TAPE (Ecology, 2011), the following would be collected:

- Grab samples of the stormwater discharged from the outlet of the most downstream catch basin at both the test-site and control-site will be collected and tested for TPH
- Grab samples of stormwater samples from the influent and effluent of each catch basin will be collected and tested for TSS and turbidity.
- The discharge flow rates and the total event runoff volumes will be measured from the outlet of the most downstream catch basin at both the test-site and control-site
- Rainfall depth and duration will also be recorded continuously

Finally, the study will also document the typical installation costs, along with operation and maintenance costs, so that a cost-effectiveness evaluation can be included in the findings. The evaluation would compare the costs of the two catchments studied on a dollar per pound material removed ($/lb. removed) from the catch basins.

The alternative study design approach would involve establishing a more controlled test site, likely in partnership with a university extension program. Paired catchments like those described above could be established within the site, and runoff events could be simulated. Because the runoff events would be planned, measurements and sampling could be obtained at planned intervals and under controlled conditions. This may include collecting composite samples (instead of grab samples) for some of the analytical testing. The methods of obtaining the data at a controlled test site would therefore differ from those discussed earlier in this section, but the data obtained would be the same.

This section should be updated when the QAPP is developed and the site has been selected.

7.2 Test-Site(s) Selection Process

The site selection process will be different depending on which of the study locations and study design approaches identified in Section 7.1 is feasible. In general, both approaches will be established such that each catch basin treatment train (i.e., one with retrofits in multiple catch basins and the other with the retrofit only in the most downstream oversized catch basin) will have similar variables by design, including geographical area, land use classification, average daily traffic, accessibility to sites, soil conditions, influent pollutant concentrations, receiving waters, etc.

Access and other field crew safety considerations are common criteria when selecting a test site or sites and will certainly be important with the first study location alternative where the basins will be an active existing roadway or parking lot. The second alternative at a controlled site will have fewer safety considerations but will still be important.

7.3 The Structural BMP System Sizing

This section will be completed when the QAPP is developed and the site is selected.

General Sizing Information: Guidance for the installation of retrofit devices varies depending on the specific device, manufacturer and application. Storm sewer networks with catch basins that include these retrofits should be designed per the jurisdictions typical requirements for storm sewers. Additionally, storm sewer networks with spill control devices installed in the catch basins should be designed to maintain the typical water surface above the opening of the outlet to prevent floatable pollutants from entering the downstream storm sewer system.

7.4 Type of Data Being Collected

This section will be updated following site selection.

Table 7.1: Summary of data being collected.

Data Type	**Purpose**	**Frequency**	**Sample Method**
Measure gross solids: weight of each material and PSD[1] of solids	Quantify the floatable and settleable material in each catch basin	Every other month	Grab Sample
TPH[2] (grab samples)	Quantify oils and hydrocarbons in each catch basin and at the outlet of the most downstream catch basins; compare test and control site	Every other month (each catch basin); during rainfall events (each downstream catch basin)	Grab Sample
Flow Rate and Volume	Quantify the catch basin discharge flow rate and volume; compare test and control site	Continuous, during rainfall events	Level Data Logger[1]
Rainfall	Identify when rainfall events will/have occurred and for timing of sample collection; Comparability of paired sites	Continuous, year-round	Rain Gauge (regional or installed at sites)
Construction, Operations, & Maintenance Cost for catch basins with retrofits	Determine cost per pound of pollutant removed; compare cost effectiveness of control and test sites	One time; collect records from lead entity	N/A

1. The equipment selected for this study will depend on the test selected. Assuming the paired test site is selected, a level data logger could be installed inside the catch basin to measure depth which could be converted to flow rates. The following provides an example of this type of equipment: http://www.onsetcomp.com/products/data-loggers/mx2001

Flow Monitoring

A Water Level Sensor (similar to the HOBO MX2001) will be utilized to collect gage data in the catch basins. The equipment consists of two parts: the water level sensor, which remains submerged in water in the sump located in the catch basin, and the top-end unit, which transmits the data via Bluetooth technology. The logger and sensor are connected by a cable.

Data recording via telemetry is recommended so that the logger does not need to be removed to download data. With this approach, data can be offloaded using Bluetooth. Measurements will be taken continuously at intervals of 15 minutes or less throughout the rainfall event. Installation should be provided by a certified installer. Typically the logger is housed in a stilling well made out of PVC piping (cross drilled to allow water to easily flow through) in the catch basin. The sensor should be located such that it will submerged in water throughout the data collection process.

7.5 Precipitation Monitoring

Precipitation monitoring consists of two parts: storm event prediction and rainfall measurements. This section describes the methods for both. *At the time this proposal was written, the experimental design had not been finalized as such some of the information included may not apply. The information included applies to sites that use composite sampling, collect data from natural rainfall events, and install at rain gauge at the site.*

Storm Event Prediction

Sampling will 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 Proposal which have the following characteristics:

- A minimum of 0.15-inch depth
- Storm start (antecedent dry-period): 6 hours minimum with less than 0.04-inches of rainfall
- Storm end (post storm dry period): 6 hours minimum with less than 0.04-inches of rainfall
- Minimum storm duration: 1-hour

The National Oceanic and Atmospheric Administration's (NOAA) National Weather Service, Spokane forecast office website should 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.

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 will use a 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. Rain gages must 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 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.

If a deviation from NWS specification is needed, 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 and will be broadcast hourly via telemetry to remotely identify on-site weather characteristics and determine when sampling crew need to deploy for sample collection. During each station visit, the rain gages 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

At the time this proposal was written, the experimental design could not be completed until the study location was determined. Grad samples will be collected with either site location. Composite sampling may also be used and has been included for that reason.

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 typically those collected manually in jars or measured in situ with a probe. For oil control BMPs NWTPH-Dx, pH, temperature, and visible sheen are required grab samples. If oil control is desired, NWTPH-Dx grabs will be collected by hand, visible sheen will be noted by observation. pH and temperature will be measured using a probe.

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 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 a four-step threshold system. Four thresholds (water temperature, rainfall, discharge and time) are necessary to determine whether the antecedent criteria and rainfall criteria was 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. Each monitoring station will be equipped with an autosampler and a 2.5-gallon glass bottle for sample containment.

7.7 Sediment Sampling

This section will be completed following site selection.

8.0 Sampling Procedures – QAPP Only

This section will be completed for the QAPP.

8.1 Standard Operating Procedures

This section will be completed for the QAPP.

8.2 Containers, Preservation Methods, Holding Times

This section will be completed for the QAPP.

8.3 Equipment Decontamination

This section will be completed for the QAPP.

8.4 Sample Identification

This section will be completed for the QAPP.

8.5 Chain of Custody

This section will be completed for the QAPP.

8.6 Field Log Requirements

This section will be completed for the QAPP.

9.0 Measurement Procedures – QAPP Only

This section will be completed for the QAPP.

9.1 Procedures for Collecting Field Measurements

This section will be completed for the QAPP.

9.2 Laboratory Procedures

This section will be completed for the QAPP.

9.3 Sample Preparation Methods

This section will be completed for the QAPP.

9.4 Special Method Requirements

This section will be completed for the QAPP.

9.5 Lab(s) Accredited for Methods

This section will be completed for the QAPP.

10.0 Quality Control – QAPP Only

This section will be completed for the QAPP.

10.1 Field QC Required

This section will be completed for the QAPP.

10.2 Laboratory QC Required

This section will be completed for the QAPP.

10.3 Corrective Action

This section will be completed for the QAPP.

11.0 Data Management Plan Procedures – QAPP Only

This section will be completed for the QAPP.

11.1 Data Recording & Reporting Requirements

This section will be completed for the QAPP.

11.2 Electronic Transfer Requirements

This section will be completed for the QAPP.

11.3 Laboratory Data Package Requirements

This section will be completed for the QAPP.

11.4 Procedures for Missing Data

This section will be completed for the QAPP.

11.5 Acceptance Criteria for Existing Data

This section will be completed for the QAPP.

11.6 Environmental Information Management (EIM) Data Upload Procedures

This section will be completed for the QAPP.

12.0 Audits – QAPP Only

This section will be completed for the QAPP.

12.1 Technical System Audits

This section will be completed for the QAPP.

12.2 Proficiency Testing

This section will be completed for the QAPP.

13.0 Data Verification and Usability Assessment

Several types of data will be collected for this effectiveness study, all of which will be verified during the study. This includes:

- Gross solids captured in catch basins
- Particle size distribution of settleable solids
- Oil and hydrocarbon content in stormwater
- Flow monitoring data: inflow and outflow at each catch basin
- Cost from operation and maintenance records

This section will be updated when the QAPP is developed to include all the data that will be verified during this study.

13.1 Field Data Verification

This section to be prepared with the QAPP.

13.2 Laboratory Data Verification

This section to be prepared with the QAPP.

13.3 Data Usability Assessment

This section to be prepared with the QAPP.

14.0 Data Analysis Methods

14.1 Data Analysis Methods

This section provides an overview of the anticipated data analysis methods which will need to updated/revised when the experimental design is finalized.

- The data collected would be used to compare the relative effectiveness of the control-site and test-site. Descriptive statistics (mean, minimum, maximum, standard deviation, etc.) will be computed for each parameter analyzed (TPH, TSS and turbidity; outflow rates and total event volumes; and the weight of gross solids and particle size and percent solids of settled solids). Statistical hypothesis testing will also be performed. For example, one hypothesis could be that the quantity of gross solids collected in one series of catch basins is equal to the quantity collected in the other series of catch basins at the site, or that the mean concentration of TPH is the same for both series. See the Statistical Comparison section below for an example.

- The pollutant reduction efficiencies could be evaluated in a variety of ways. For example, the inflows to and outflow from the second basin in each series could be sampled for each runoff event to compare removal efficiencies (see pollutant reduction efficiency section below) for TPH, TSS and turbidity for a catch basin with and without an insert. Statistical distributions and hypothesis testing would be evaluated.

- Flow monitoring data will also be evaluated for a variety of reasons dependent upon the monitoring equipment selected. One reason is to assess the volume of water that passes through each system which will be used to assess the comparability of the test and control site. The discharge flow rate will also be evaluated and compared to the respective pollutant concentrations measured during the sampling event to assess the potential influence of flow (from high intensity rainfall events). If the experimental design includes collecting samples from qualifying rainfall events (as defined in TAPE), flow monitoring data will be used to verify the event meets qualifying conditions. Flow monitoring data may also be used to assess any changes in the treatment performance of the test and control site over a range of discharge conditions.

- Construction, operation, and maintenance costs for the catch basin inserts and cleaning program will be documented so that costs per unit pound of pollutant captured can be calculated and compared between two catchments, and to compare cost per pound for a basin with and without a catch basin retrofit. Effectiveness with respect to cost, will be determined based on the lowest cost per pound of pollutant removed.

Statistical Comparisons

A statistical comparison will be conducted to determine whether there was a significant difference in the analytical results between the 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 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. Two potential scenarios for the null hypothesis (H_o) and alternative hypothesis (H_a) that could be evaluated as defined below. The statistical comparison was based on a confidence level of 95% (α=0.05).

Scenario 1 - Statistical comparison for each parameter between the control site pollutant concentration and the test-site pollutant concentration.

- H_o: Effluent pollutant concentration is equal to the influent concentration
- H_a: Effluent concentrations are less or greater than influent concentrations

Scenario 2 - Statistical comparison for each parameter between the influent concentration and the effluent concentration.

- H_o: Effluent pollutant concentration is equal to the influent concentration
- H_a: Effluent concentrations are less or greater than influent concentrations

Calculation and Evaluation of Pollutant Reduction Efficiencies

The average removal efficiency and mean concentration for each parameter will be determined over sampling events. This will include calculating the removal efficiency for each pollutant from each individual sampling 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 lab included values that are non-detectable, the reporting limit for the respective pollutant will be used as defined by the standard testing method.

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

Where:

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

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

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. This section will be completed in the QAPP.

15.0 Reporting

15.1 Final Reporting

This section will be completed for the QAPP.

15.2 Dissemination of Project Documents

The final report will be shared with the participating agencies and will be posted to the lead entities webpage: add webpage

16.0 References

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

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Mullen, T. J. (2003). Maximum Utility for Minimum Cost: Simple Structural Methods for Stormwater Quality Improvement. In World Water & Environmental Resources Congress 2003 (pp. 1-12).

Smith, K. P. (2011). Effectiveness of catch basins equipped with hoods in retaining gross solids and hydrocarbons in highway runoff, Southeast Expressway, Boston, Massachusetts, 2008-09 (No. 2010-5182). US Geological Survey.

Technical Guidance Manual for Evaluationg Emerging Stormwater Treatment Technologies. 2011, Washington State Department of Ecology: Olympia.

Washington State Department of Transportation. (2016). *Highway Runoff Manual.* Retrieved from: http://www.wsdot.wa.gov/Publications/Manuals/M31-16.htm

17.0 Appendices

This section will be updated when the QAPP is developed.

Appendix 22 – Seasonal Differences in Street Sweeping Proposal

Eastern Washington
Stormwater Effectiveness Studies

Detailed Study Design Proposal

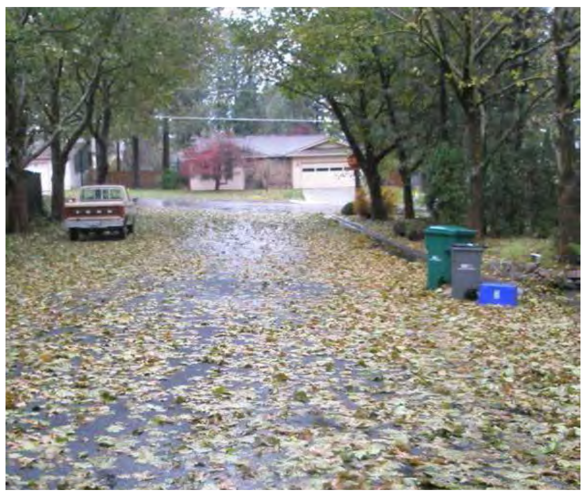
Seasonal Differences in Street Sweeping Material Removal

Study Classification:

☐ Structural BMP ☑ Operational BMP ☐ Education & Outreach

Study Objective(s):

☑ Evaluate Effectiveness ☑ Compare Effectiveness



June 30, 2017

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Proposal Publication Information

This Detailed Study Design Proposal (Proposal) will be stored and accessible to the public at the following weblink: Add Weblink where the Proposal can be accessed by the Public

For questions regarding the Proposal, please contact First and Last Name of Lead Entity Contact by email add email address or phone (509)XXX-XXXX.

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QAPP Publication Information

Will be completed for the QAPP.

QAPP Author and Contact Information

Will be completed for the QAPP.

Signature Page – Proposal

Proposal – Only the party's responsible for the contents of the Proposal and the project must sign date this page before the study proceeds to the QAPP development phase.

This page lists signatories to the document. Each party responsible for the contents of the QAPP and the project must sign and date this page before the study proceeds to the implementation phase (i.e. conduct the study).

Approved by:

____ Date ____________
Name, Primary Author, Organization

____ Date ____________
Name, Peer Review, Organization

____ Date ____________
Name, Lead Entity, Jurisdiction

____ Date ____________
Name, Participating Entity, Jurisdiction

____ Date ____________
Name, Partner Entity, Jurisdiction

____ Date ____________
Name, Ecology Contact with Approving Authority

____ Date ____________
Name, Lab Director (add a line for each additional lab)

____ Date ____________
Name, Title

____ Date ____________
Name, Title

Signature Page – QAPP Only

This section will be completed for the QAPP. List each party responsible for the contents of the QAPP and the project along with their project title, and organization. Each party must sign and date this page before the study proceeds to the implementation phase (i.e. conduct the study).

Distribution List - Proposal

Proposal – At a minimum include: the lead entity, participating entities, Ecology, and the author of the document

List each party who will receive copies of the approved **QAPP** as well as any subsequent revisions along with their contact information. This may include those who is responsible for the QAPP development and project implementation including project managers, QA managers, representatives of other groups/agencies involved, field staff, etc.

Name, Title	Organization	Contact Information: Address, Telephone, E-mail

Distribution List - QAPP Only

During the QAPP development, this section should be updated to include a list of each party who will receive copies of the approved **QAPP** as well as any subsequent revisions along with their contact information. This may include those who is responsible for the QAPP development and project implementation including project managers, QA managers, representatives of other groups/agencies involved, field staff, etc.

1.0 Table of Contents

The TOC should be updated during the QAPP development and auto generated using a word processing program.

2.0 Executive Summary – QAPP Only

This section will be completed for the QAPP.

3.0 Introduction and Background

3.1 Introduction to the Operational BMP

This effectiveness study focuses on the practice of street sweeping (i.e., street cleaning). Street sweeping is a technique for removing solids and associated pollutants from roadways, using a vacuum assisted sweeper truck. Once the material is removed, these solids are no longer available for transport by stormwater to area waterways (Caraco, 2000). A number of research studies have concluded that pollutant removal from street sweeping activities is greatest when material accumulation is highest (Pitt et. al, 2004). A challenge for small communities is knowing when to sweep. The focus of this effectiveness study is to identify when street accumulations are high so that eastern Washington communities can focus their sweeping efforts and more effectively reduce pollutants from being transported by stormwater.

3.2 Problem Description

There is a large body of research that documents the effectiveness of street sweeping as a stormwater BMP for reducing sediment and pollutant loads. A wide range of sediment and pollutant removal rates attributable to street sweeping are reported (Law et al. 2008). The most important variables affecting pollutant removal rates appear to be sweeper type and sweeping frequency (Sutherland et al. 1997, Law et al. 2008). The highest removal rates were consistently shown using high efficiency, regenerative air or vacuum machines at weekly frequencies. At lower sweeping frequencies, or with less efficient equipment like mechanical machines, much lower pollutant removal rates have been reported.

While sweeping at routine intervals may be a reasonable strategy in areas with more consistent pollutant accumulations, it may not be an effective strategy in areas with four distinct seasons such as Eastern Washington. This is because of seasonal changes cause influence the buildup of materials on the roadway from winter road maintenance practices as well as fall leaf material that collects in the gutters (Caraco, 2000). There may be strategies for maximizing the effectiveness of street sweeping that are driven more by region and time of year rather than by routine time intervals. A targeted study of Eastern Washington communities would help stormwater managers make more informed decisions about where and when to focus their efforts to optimize street sweeping effectiveness.

Many municipalities in Eastern Washington, commonly target their street sweeping to coincide with patterns in higher sediment, organics and associated pollutant deposition (e.g., leaf accumulation, pipe needle drop and winter sanding), in lieu of, or in addition to regular sweeping. For example, the City of Spokane Valley's street sweeping program, is divided into three different sweeping efforts that are geared to the conditions and the climate. A written action plans has been developed for each of these sweeping efforts and is available on-line at the City's web site. A brief summary of this program includes:

- Spring Sweep – Sweeping effort is designed to sweep all of the curbed streets in Spokane Valley. Its objective is to remove the large accumulation of sediments and gravel primarily used to improve traffic safety during the winter's snow and ice events. Typically the sweep will commence in March following the last winter storm and continue into June.

- Arterial Sweeping – This is a routine sweeping program that commences with the start of the Spring Sweep but is focused on sweeping the City's arterial streets at a frequency of once or twice a month depending on the arterial's traffic volume with the higher traffic arterials requiring more frequent attention. This effort continues throughout the year and involves night sweeping on some routes and generally ends with the first snowfall of the season in the late fall.

- Fall Sweep - this sweeping effort focuses on the areas of the City that experience heavy pine needle drop and leaf fall in October and November. Sweeping is prioritized by the type and density of the trees present.

This effectiveness study will be conducted from early spring to late fall and focus, using the same seasonal sweeping events as Spokane Valley: spring, fall, and routine (between spring and fall). The study will focus meeting the objectives outlined in section 4.2 for the purpose of assisting the jurisdictions with improving their sweeping program.

3.3 Results of Prior Studies

This section is not required in the Proposal. This section will be completed for the QAPP.

3.4 Regulatory Requirements

The Eastern Washington Phase II Municipal Stormwater Permit S5.B.6.a requires permittees to implement an O&M program with the ultimate goal of preventing or reducing pollutant runoff from municipal operations. *This study will evaluate the effectiveness of a targeted street sweeping program for reducing pollutant accumulation on roads*.

4.0 Project Overview

4.1 Study Goal

The goal of this study is to evaluate the effectiveness of street sweeping during different seasons. Specifically to determine how seasonal differences influence the sweeper pick-up (as a surrogate measure for actual accumulation) with respect to sediment quantity and characteristics of sediment, organics, and associated pollutant accumulations resulting from different combinations of a community's land use/street type categories. The information collected will be used to estimate the pollutant removal effectiveness of an existing street sweeping program during different seasons. The results will be used to develop recommendations that permittees could use to optimize the street sweeping program's sediment, organic and associated pollutant removals and improve the cost-effectiveness of their programs.

4.2 Study Description and Objectives:

This two year study includes streets sweeping an eastern Washington community during three different time periods (seasons) of year which correspond to different types of roadway accumulation conditions and climate. These three seasons include: <u>spring</u> when roadway sediment accumulation is typically high from winter climate conditions; <u>fall</u> following the pine needle and leaf drop, and routine sweeping which occurs at regular frequencies <u>between the spring and fall sweep</u>. Prior to commencing the study, GIS will be used to delineate street sweeping grids, based on land use/street type combinations, and identify sweeping routes and sample locations for the study. Monthly during each sweeping event, the sweeping load will quantified by measuring the weight and estimating the volume. The area where the sample was collected from will be defined based on the length of curb and land use. Five times each year samples from the sweeping load will be collected and analyzed to characterize the physical and chemical properties; this data will be assessed for relationships to the land use. The quantity of material collected during each of the three time periods and from different land use areas will evaluated to determine which seasons and locations had the largest quantity of material is removed. The data collected will be used to calibrate a computer model, Simplified Particulate Transport Model (SIMPTM). The model will use historical rainfall data to simulate the build-up, wash-off and street sweeper pick-up from the study area and predict pollutant reductions based on street sweeping occurrences. The results from this model will be used along with the results from the comparison of material quantities to recommend targeted street sweeping: when pollutant removal and the quantity of material removed is highest. Optional street sampling is also describe in this proposal.

The study goals will be achieved by the completing the following objectives:

- Determine the street sweeping routes, frequency of street sweeping, and sample locations for the proposed study
- Determine the physical and chemical characteristics of the sweeper loads; and correlate these characteristics for each of the targeted sweeping operations
- Determine the quantity of materials removed from each of the targeted sweeping efforts (season and land use): including sediment, organics and other associated pollutants found in stormwater

- Determine the effectiveness of the sweeping program by comparing the quantity of materials removed from each of the targeted sweeping efforts; the efforts with the largest material removal and estimated pollutant reductions (from modeling) will be considered the most effective
- Summarize the study results and recommend improvements to the lead entities sweeping program in terms of seasons and land use
- Determine the cost associated with the jurisdictions current street sweeping program and recommended program; assess the cost benefit for improving stormwater quality and other ancillary benefits of the sweeping program. This objective will be defined in the QAPP.

4.3 Study Location

The study will be conducted an Eastern Washington community that has four distinct seasons, an existing street sweeping program, and the ability to accurately measure and record the weight every sweeping load and associate the data to a specific "sweeping service area."

4.4 Data Needed to Meet Objectives

The data collected during the study will include:

- The weight, total volume, and organic fraction (by volume) of every sweeping load tied to a specific sweeping service area or areas where it was collected.
- The length of the curbed streets swept; quantify material collected in every sweeping load
- The particle size distribution of sweeper load along and specific sweeping service area or areas where it was collected
- The organic material fraction by weigh and volume of sweeper material obtained from samples and identify the respective sweeping service area or areas where it was collected.
- Analytical testing of the sweeper material samples to determine the concentration of the targeted pollutants associated with three sweeper material fractions. The pollutants that will be evaluated include those that are known to negatively affect the beneficial uses of downstream surface and ground water bodies including: metals (copper, chromium, lead and zinc), and nutrients (nitrate nitrite, total kjedahl nitrogen, total phosphorus, and total reactive phosphorus).

If the optional task for street dirt collection is elected, the following data will be collected:

- The weight and moisture content of each of the street dirt samples collected and tied to a specific land use/street type
- The total length of the curbed streets vacuumed to obtain each of the street dirt samples tied to a specific land use/street type

- The particle size distribution of street dirt samples collected and specific sweeping service area or areas where it was collected

- The organic material fraction by weigh and volume of the street dirt samples tied to a specific land use/street type.

- Analytical testing of the street dirt samples to determine the concentration of the targeted pollutants associated with three separate street dirt fractions.

Computer modeling, using the Simplified Particulate Transport Model (SIMPTM), will be used to help evaluate the effectiveness of each targeted sweeping operation and the overall effectiveness of the sweeping program. SIMPTM is a continuous physically based explicit program that simulates over time the various processes that are believed to result in the contamination of stormwater from the urban environment. Details of these processes are provided in Section 14.0. The model will be used to convert sweeper material pick up to an estimate of sweeping effectiveness. The effectiveness estimates will be improved if the optional street dirt sampling is completed. The sweeper material data including its physical and chemical characteristics will be used to calibrate SIMPTM.

4.5 Tasks Required to Conduct Study

Tasks required to conduct the study are:

- **Develop Quality Assurance Project Plan (QAPP)**
    - Document existing <u>street sweeping procedures</u> (will become part of standard operating procedures (SOPs) for the study)
    - Document procedures needed to <u>monitor and inspect street sweeper equipment</u>
    - Document procedures for <u>weighing each sweeper load and estimating its total volume</u> and its organic fraction (by volume) and recording such information.
    - Document procedures for <u>sweeper load sampling</u>
    - If optional task street dirt sampling is elected, document procedures for <u>street dirt sampling and land use delineation</u>
    - Document physical (i.e. sieving) and chemical analysis procedures for both sweeper material samples and street dirt samples (if elected)
- **Prepare for Data Collection:**
    - <u>Conduct GIS Analysis of Land Use/Street Type Combinations</u> – delineate street sweeping grids; this information will be used to identify the street sweeping routes for the study
    - <u>Use GIS data to identify location for sampling street dirt</u> – use information about land use to identify sampling locations: areas with significant pollutant loads
    - <u>Sweeper Maintenance</u> – Establish street sweepers maintenance procedures; follow the manufacturer recommendation and document all maintenance during the study
    - <u>Traffic Safety Support Planning for Street Dirt Sampling</u> – For optional street dirt sampling, for each of sampling sites selected, evaluate the site for traffic safety concerns and follow the lead entities-approved traffic control plan
    - <u>Collect Street Sweeping Cost Data</u> – collect information from the jurisdiction regarding the cost of their existing street sweeping program

- **Data Collection:**
    - Define Sweeper Load Characteristics - weight each street load and estimate volume; collect street load samples and analyze physical and chemical properties; track curb length and grid load was collected from
    - Define Street Dirt Characteristics (Optional) – collect street dirt samples from different land use/street type combinations and analyze physical and chemical
- **Conduct Modeling & Develop Technical Report:**
    - Analyze data
    - Conduct Modeling Using SIMPTM
    - Write Reports (final and annual)

4.6 Potential Constraints

This section describes conditions that may influence the project schedule, budget, or scope and the steps that will be taken to reduce the adverse effect of these conditions. These conditions are summarized in Table 4.1 along with the mitigation approach.

Table 4.1 Summary of Potential Study Constraints and the Subsequent Mitigation Approach

Potential Constraints	Mitigation Approach
Incremental Weather	This study focuses on understanding O&M procedures during the dry season in a semi-arid climate. Incremental or unseasonal weather such as higher than usual precipitation events could impact the study results. Sweeper material sampling could be avoided during periods of increment weather. If street dirt collection is elected dry pavement conditions are required for the sampling protocol; unseasonal wet conditions could delay sampling. The recording of sweeper materials could be impacted if the lead entity has protocols for avoiding sweeping during wet pavement conditions. If an occasional wet sweeper load is brought into the transfer station an adjustment will be made to account for the excessive water it might contain.
Unable collect street dirt samples due to traffic volumes/speeds	Coordinate appropriate level of traffic safety support as needed; follow the lead entities-approved traffic control plan; for high traffic volume streets, a police escort may be warranted during sample collection; alternatively, crash prevention vehicles may be used and minor street use traffic cones.
Insufficient sediment accumulation during the optional street dirt sampling task.	If insufficient street dirt accumulations are found during a scheduled sampling event, then more (50 foot) curb length would have to be sampled. The targeted weight of a street dirt sample is 1 to 2 kilograms. Sample sizes less than that sieve analyses can be conducted but there might be insufficient material to conduct the designated tests especially, fines less than 63 micron fraction
Equipment breakdown on street sweeper	If the lead entity uses a contracted sweeping service for their sweeping program, equipment breakdowns are less of a problem since the contractor has to provide a functioning machine. Any equipment breakdown may result in delays in the sweeping schedule may occur.

5.0 Organization and Schedule

5.1 Key Project Team Members: Roles and Responsibilities

Key Team Members	Role	Responsibility
Name Organization Phone Number Email	Lead Entity	Define
Name Organization Phone Number Email	Participating Entity	Define
Name Organization Phone Number Email	Partner Entity	Define
Name Organization Phone Number Email	Ecology Reviewer	Define
Name Organization Phone Number Email	Proposal Author	Define
Name Organization Phone Number Email	Proposal Peer Review	Define
Name Organization Phone Number Email	Key Team Member Project Role	Define

5.2 Project Schedule

Since the project schedule is based on seasonal street sweeping in a particular jurisdiction(s) and the test site has not been selected, the project schedule is TBD. The study duration is estimated at 2-years. The project schedule will be defined in the QAPP.

5.3 Budget and Funding Sources

This study will be funded by the lead entity and potentially with funds from the Participating Entities. Table 5.3 provides an estimated study budget broken down by the primary study tasks.

Table 5.3. Estimate Study Budget

Task Name	Hours	Cost per Hour	Equipment & Analytical Testing	Total
Project Management				$15,000
QAPP Development[1]				$15,000
Prepare for Data Collection[2]	68	$120 (average)	Data collection equipment cost will be added later	$8160
Data Collection[3] & Analytical Testing[4]	132	$90	$30,080	$41,960
Conduct Modeling & Develop Technical Reports[5]	210	$150	NA	$31,500
			Total	$111,620

1. The cost includes budget to develop the QAPP. All costs assume the optional street dirt sampling has been elected.
2. The cost of equipment for sweeper load and optional street dirt sampling equipment will be included in the QAPP. Preparation time for the sampling is estimated at 8 hours for the sweeper material sampling and 8 hours for the optional street dirt sampling per sampling event. The GIS analysis is estimated at 24 hours; if street dirt sampling is elected add 12 hours to select the 5 sampling sites, and for traffic safety planning another 16 hours.
3. Estimate assumes data will be collected by the lead entity staff. Hours for this task assume the weighing of the sweeper loads; estimate of curb miles swept; the estimation of load volumes will occur at the transfer station will be routine, and two hours per month for data management. This includes compiling the data and sending the completed data collection forms to the consultant each month during the sweeping year. So that's 2 hours per month x 9 months per year x 2 years = 36 hours. Collection of sweeper material samples will require 4 hours to collect 5 samples. So that's 4 hours x 4 collections per year x 2 years = 32 hours. The street dirt collection, if elected, will require 8 hours to collect 5 samples. So that's 8 hours x 4 collections per year x 2 years = 64 hours. The hours for the following items are not included: maintenance of street sweepers; and street sweeping itself.
4. Sieve analysis will be conducted on the sweeper load samples and the optional street dirt samples. The cost is assumed to be $6 for weighing and moisture content and $40 for PSD = $46 total. The analysis will use a standard set of stainless steel sieves provided to the testing lab by the consultant. Once the sieve analysis is completed the sieved material will be composited back into four fractions that will be analyzed chemically. The fine fraction noted with the letter "F" and is the material less than 63 micron or passing the No. 230 sieve or the material in the pan. The medium fraction noted with the letter "M" is the material from 63 to 250 microns or the material passing the No. 60 and the No. 120 sieve. The course fraction noted with the letter "C" and is the material from 250 to 2000 microns or the material passing the No. 10, No. 18 and the No. 30 sieves. The final fraction we will call the organic fraction noted with the letter "O" and is the organic material; no gravel or stones or cigarette butts or anything else foreign since these materials are discarded. The organic fraction is greater than 2000 microns and the greater than 6370 microns or the organic material not passing the passing the No. 10 and ¼ sieves. The chemical testing cost for the F, M, and C fractions is limited to $100 per sample and the O fraction is limited to $45 per sample. Costs for the optional street dirt collection is included. An additional 10% was added for sample duplicates.
5. SIMPTM modeling is estimated at 130 hours with the development of the technical report at 80 hours.
6. Does not include other costs associated with weighing or special handling at a transfer station of the sweeping loads. For example, it does not include the cost of the equipment to collect that data including scale, Radio-Frequency Identification (RFID) of sweeper units, computer software/hardware to automatically document load/scale data, building a transfer station/area to accommodate load scales and technology, security of the systems required, nor calibration of the scales and equipment. It does not include the costs that may be associated with sequestering loads into special areas or bins for sampling at the transfer station to assure quality data for the study.

6.0 Quality Objectives – QAPP only

This section will be completed for the QAPP.

7.0 Experimental Design

7.1 Study Design Overview

An overview of the data collection program is described in this section. (See Table 7.1 for details about sample size and frequency and section 7.5 regarding sample collection procedures):

- Use GIS to establish street sweeping grids – The city will be divided (delineated) into a series of grids based on sweeping service area. The grids will be used to define the aerial extent of various land use/street type combinations. Developing the grids will include: identifying the significant land uses; the various land use/street type combinations and rank them by aerial extent; and determine the aerial extent of each combination within each of the sweeping service areas by the lead entity.
- Define Street Sweeping Routes - review and adjust the existing sweeping routes based on the street sweeping grids to maximize the number of routes that sweep only a specific land use/street type as or a minimum number of land use/street type combinations. The sweeper loads from these sweeper routes are candidates for sweeper material sampling.
- Define the sweeper load characteristics – This will include:
    - Track the sweeping service area - determine the miles of curbed streets swept to obtain each sweeper load
    - Quantify the Material Collected - For each sweeping load throughout the year, the amount of material collected will be weighed and its volume estimated and recorded.
    - Characterize Sweeper Load Materials - A minimum of four times each year (i.e. once during each of the three targeted sweeping events and one other time to be defined in the QAPP) collect a minimum of five samples of sweeper load material and analyzed both physical and chemical properties. Samples will be collected from different service areas to establish the materials characteristics. This information will be used to estimate the most probable range of actual accumulations in the different sweeper service areas along with the pollutant types and concentrations.
- Sweeper Type - If possible, sweepers of the same type (e.g., vacuum or regenerative air) and approximate age should be used in each of the selected communities where the study would be conducted to allow for a comparability of results among the communities participating. Because this study only includes mass pick up throughout individual communities, and not sweeper pick up efficiency (percent of deposited load removed), the sweepers do not have to be of the same type.
- Characterize Street Dirt – Optional task: A minimum of four times each year, corresponding to the same general time frame when sweeper material is being sampled, up to five sites representing up to five of the top land use/street type combinations (determined in the previous task) will have a sample of their street dirt sampled along with a record of the total length of the curbed streets vacuumed to obtain the sample. The samples will also be analyzed both physically and chemically. (The proposed pollutants to be tested in identified in Table 7.1). Knowing the specific pollutants along with the type and operational characteristics of the sweepers being used, estimates of sweeper pick-up performance can be made. (For this optional task, knowledge of the type of sweepers being used becomes is required). In addition, a comparison of the various pollutant concentrations found in the street dirt to those found in the sweepings loads can provide an

insight into which street types and land use areas throughout a community are more contaminated. Analyzing street dirt (as opposed to just sweeping loads) is important because the sweeping loads will be likely be comingled with many different land uses and street types.

- Use GIS data to identify street dirt sampling locations - GIS data will be used to identify the location and lengths of the various street types (i.e. arterial, collector and minor) and the extent and location of existing land uses. An evaluation of the GIS data along with knowledge of the street dirt characteristics, will assist in targeting the locations where sample should be collected. Specifically, locations where the land use/street types will likely have the most significant combinations of pollutants found throughout the community. Significant land use categories are those that will yield the most stormwater runoff when both effective impervious area and aerial extent are taken into consideration. This information will be used to determine the number of land use/street type categories that will be sampled; the number of samples from each of the sampled categories; and the locations of the top sites for the selection of specific streets to sample. The actual sampling sites will be selected using aerial photography.

7.2 Test-Site(s) Selection Process

Eastern Washington jurisdictions will be selected for this study that meet the following proposed criteria:

- An existing street sweeping program and the ability to accurately measure and record the weight of every sweeping load and tie it to a specific "sweeping service area" or areas where it was collected.
- Access to modern street sweeping equipment. The sweeping type (i.e. mechanical, regenerative air, and vacuum) is not that important for this proposed study but the type of sweeper will affect the interpretation of the study results. Regenerative air and vacuum machines are preferred due to their superior pick-up performance compared to mechanical machines.

7.3 Operational BMP Function

The City of Spokane Valley has established a sweeping service area map that cover the City's entire corporate limits and documents the location of 123 areas. The sweeping service areas are numbered from one to 123. A copy of the map is available on the City's web page. The City has also characterized the tree cover associated with each of the sweeping service areas in order to identify and prioritize the areas being targeted for their Fall Sweep described previously. The City has written street sweeping action plans for each of its three targeted sweeping operations which are available on the City's web site. Links to two of the plans are shown below. The QAPP will include an overview of the street sweeping procedures that the jurisdiction typically follows (and/or that will be followed during the study), including the frequency of street sweeping; any related inspections; seasons in which the practice will be conducted.

http://www.spokanevalley.org/filestorage/6862/6927/8180/8372/Arterial_Sweeping_Action_Plan.pdf

http://www.spokanevalley.org/filestorage/6862/6927/8180/8372/Fall_Sweeping_Action_Plan.pdf

7.4 Type of Data Being Collected

This section identifies the various types of data that will be collected and defines the intended purpose for each type of data. The QAPP will include a sketch/map that indicates the locations where sample collection will occur.

Data Type	Data Collection Location	Purpose	Frequency	Total[2]
Sweeper material collected	Throughout the City	Quantify the weigh, volume and organic fraction of material collected by sweepers tied to a sweeping service area or areas	Every sweeper load all year round	TBD
Length of curbed streets swept	Throughout the City	To obtain a lbs. per curb mile pick up estimate for each sweeper load	Every sweeper load all year round	TBD
Sediment particle size distribution (PSD) of the sweeper material	Sweeper loads collected throughout the city	- quantify the PSD of sweeper material focused on each of the targeted sweeping events	4 times per year for 2 years up to 5 sweeper material samples	40
Selected chemical concentrations of 4 pollutants[1] found in sweeper material	Sweeper loads collected throughout the city	Periodically quantify the pollutant concentrations of selected fractions of sweeper material	4 times per year for 2 years;4 pollutants from up to 3 fractions of up to 5 samples	480
Sediment particle size distribution (PSD) of the street dirt (optional)	Street dirt collected throughout the City	Periodically quantify the PSD of street dirt focused on each of the targeted sweeping events	4 times per year for 2 years up to 8 street dirt samples	64
Selected chemical concentrations of up to 4 pollutants found in street dirt (optional)	Street dirt collected throughout the City	Periodically quantify the pollutant concentrations of selected fractions of sweeper material	Up to 4 times per year for 2 years up to 4 pollutants from up to 3 fractions of up to 5 samples	480

1. The pollutants are anticipated to include: copper, chromium, lead and zinc, nitrate, nitrite, TKN, total phosphorus, and total reactive phosphorus.
2. The QAPP will define the final sample size and provide a justification for the sample sizes selected that addresses the following data quality indicators (DQI): representativeness and completeness.

7.5 Sample Collection Process and Design(s)

Street Load Sampling

On a minimum of four times a year, samples of the street sweepings will be collected from selected sweeping loads that have been tracked to a specific sweeping service area of the community which has been tied to a specific land use/street type or a known number of land use/street types. Samples will be mechanically sieved and analyzed to establish their particle size distribution (PSD) and their organic material fraction by weight and volume. The sediment fractions will be composited back into four fractions (i.e. less than 63 microns; 63 to 250 microns; 250 to 2000 microns and an organic fraction greater than 2000 microns) analyzed for a list of specific pollutants that will not be finalized until the QAPP is developed.

The sample collection process for the study includes two separate processes. One for the collection of samples from the sweeper material and the other is for the optional collection of street dirt. This section provides an overview of these sampling processes. The QAPP will include specific details about the equipment that will be used along with the standard operating procedures (SOPs) for sample collection.

The first process will involve a random hand sampling of recently deposited sweeper loads from a known sweeping service area or areas. The process will require a transfer station where the load can be deposited under cover protected from the weather and provide sampling access. The hand sampling process is straightforward and only requires a stainless steel scoop and a stainless steel bucket. While the loads cannot be sieved into separate fractions, hand screening can be used which is designed to separate the sediment like material from the organic material. The QAPP will outline the best practices for obtaining samples that are representative of the entire PSD of the sweeper load.

Street Dirt Sampling

Four times per year, samples of the street sweepings will be collected from selected sweeping loads that have been tracked to a specific sweeping service area of the community which has been tied to a specific land use/street type or a known number of land use/street types. Samples will be mechanically sieved and analyzed to establish their particle size distribution (PSD) and their organic material fraction by weigh and volume. The sediment fractions will be composited back into four fractions (i.e. less than 63 microns; 63 to 250 microns; 250 to 2000 microns and an organic fraction greater than 2000 microns) analyzed for a list of specific pollutants that will not be finalized until the QAPP is developed.

The methodology for collecting street sediments is anticipated to be a random sample collection within the sampling area and include the gutter and some street surface at varying distances from the curb depending on the traffic volume and pavement texture. The reason sample collection is focused on the gutter area is because studies have found that almost all roadway sediment accumulates in the first 3-feet from the curb line (Pitt, 2004; Sartor, 1972; Novotny, 2003). Sample locations will be measured and recorded: distances along the curb and the length from the curb to the sample location in the street. The sample collection will involve the use of an industrial vacuum cleaner with a stainless steel canister powered by a generator with a gas engine. Once the material is collected the sample is transferred to zip lock bags avoiding high wind conditions. The procedure uses a 2.5 micron Dacron filter that covers the vacuum canister and keeps the fine material trapped in the canister on not in the vacuum's paper filter.

The anticipated equipment sampling is listed below:

1. Heavy duty industrial vacuum (100 ft^3/min or greater air flow) with a stainless steel canister (Shop Vac Model 610 wet/dry vacuum or equivalent).
2. Several Dacron filter cloths (2.5 micron openings) or equivalent (needed to cover the stainless steel vacuum canister and retain small particles within the canister).
3. Vacuum accessories including a hose and wand.
4. 4000 watt gas powered electric generator (needed to power the vacuum).
5. Approximately 50 feet of heavy duty grounded electrical cord to plug the vacuum into the generator.
6. Pick-up truck to transport the equipment to the sampling locations.
7. Two new paint brushes (3 inch wide; used to brush out the sample from the vacuum canister)
8. Traffic cones (plastic, stackable, approximately 6)
9. Gas container for refilling the generator.
10. Several respirators for breathing protection when transferring samples.
11. Box of gallon sized Zip-lock bags.
12. Fine-point magic marker for sample ID marking.
13. Stainless steel digital kitchen scale (for accurate Metric/English unit weights up to ~6 lbs.)
14. Standard metal coat hanger (will use to make zip lock bag holder during sample transfer).
15. Tap measure at least 25 feet.
16. Marking spray paint for marking sampled length along the curb.

8.0 Sampling Procedures – QAPP Only

This section will be completed for the QAPP.

8.1 Standard Operating Procedures

This section will be completed for the QAPP.

8.2 Containers, Preservation Methods, Holding Times

This section will be completed for the QAPP.

8.3 Equipment Decontamination

This section will be completed for the QAPP.

8.4 Sample Identification

This section will be completed for the QAPP.

8.5 Chain of Custody

This section will be completed for the QAPP.

8.6 Field Log Requirements

This section will be completed for the QAPP.

9.0 Measurement Procedures – QAPP Only

This section will be completed for the QAPP.

9.1 Procedures for Collecting Field Measurements

This section will be completed for the QAPP.

9.2 Laboratory Procedures

This section will be completed for the QAPP.

9.3 Sample Preparation Methods

This section will be completed for the QAPP.

9.4 Special Method Requirements

This section will be completed for the QAPP.

9.5 Lab(s) Accredited for Methods

This section will be completed for the QAPP.

10.0 Quality Control – QAPP Only

This section will be completed for the QAPP.

10.1 Field QC Required

This section will be completed for the QAPP.

10.2 Laboratory QC Required

This section will be completed for the QAPP.

10.3 Corrective Action

This section will be completed for the QAPP.

11.0 Data Management Plan Procedures – QAPP Only

This section will be completed for the QAPP.

11.1 Data Recording & Reporting Requirements

This section will be completed for the QAPP.

11.2 Electronic Transfer Requirements

This section will be completed for the QAPP.

11.3 Laboratory Data Package Requirements

This section will be completed for the QAPP.

11.4 Procedures for Missing Data

This section will be completed for the QAPP.

11.5 Acceptance Criteria for Existing Data

This section will be completed for the QAPP.

11.6 Environmental Information Management (EIM) Data Upload Procedures

This section will be completed for the QAPP.

12.0 Audits – QAPP Only

This section will be completed for the QAPP.

12.1 Technical System Audits

This section will be completed for the QAPP.

12.2 Proficiency Testing

This section will be completed for the QAPP.

13.0 Data Verification and Usability Assessment

The section defines 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. This section will be updated with the QAPP is developed.

The data collected which will be verified as part of this study includes:

- Delineated sweeper grids and corresponding land use
- Curb lane length per sweeper load
- The weight and volume of the sweeper load
- The physical and chemical characteristics of the sampled sweeper load
- If elected, the physical and chemical characteristics of the sampled street dirt

13.1 Field Data Verification

This section will be completed for the QAPP.

13.2 Laboratory Data Verification

This section will be completed for the QAPP.

13.3 Data Usability Assessment

This section will be completed for the QAPP.

14.0 Data Analysis Methods

This section defines the process and methods the project will use to analyze the data and addresses the study goals outlined in Section 4.0 as well as describe how the data will be presented in the final report. This section will be updated in the QAPP to reflect the final data analysis methods. The data analysis is expected to include:

- Descriptive statistics of the sweeper load weights, volumes, and curb length (which the sample was collected from)
- Descriptive statistics the physical and chemical characteristics of the sweeper material collected from each of the targeted sweeping operations;
- Statistical analysis to will be used to evaluate whether street load datasets between targeted sweep areas and sweep events are significantly different
- If elected, statistical analysis of the physical and chemical characteristics of the accumulated street dirt associated with the most frequently occurring combinations of land use and street type throughout the community;
- The use of the Simplified Particulate Transport Model (SIMPTM) to estimate the effectiveness of each of the targeted sweeping operations in removing sediment, organics and other associated pollutants from the stormwater

14.1 Data Analysis Methods

Statistical Analyses

Simple descriptive statistics will be used to determine the average, standard deviation and distribution of the following:

- Sweeper material removal measured in lbs. per curb mile swept and material density measured in lbs. per curb length (the sample was collected from) or cubic yards since load volumes are being estimated. This analysis can be done on both a monthly and an annual basis.
- Particle size distributions (PSDs) of the sampled sweeper material and the concentration of the various pollutants found in each of the four fractions of sweeper material
- If elected, the PSD of the sampled street dirt and the concentration of the various pollutants found in each of the four fractions of street dirt.

Statistical analysis (i.e. hypothesis testing) of the street load data will be used to identify whether there are significant factors (e.g., timing, land use) affecting the amount of material picked up by each sweeping event (a surrogate for sediment deposition rate). Graphical analysis will be used to characterize the volume and weight of material and estimated associated pollutants picked up with each sweeping event to help identify patterns within the community or differences between communities.

SIMPTM Analysis

SIMPTM (SIMplified Particulate Transport Model) is a continuous physically based explicit program that simulates, over time, the various processes that result in the contamination of stormwater from the urban environment.

These processes include: (1) the dry weather accumulation of contaminated sediment referred to as “street dirt” and found on impervious surfaces such as roadways, driveways, and parking lots; (2) the wet weather accumulation of contaminated sediment from adjacent previous and impervious surfaces which augments the street dirt found on roadways, driveways and parking lots which has been called wet weather washon; (3) the washoff of these accumulated contaminated sediments due to either shallow overland or concentrated gutter flows governed by established sediment transport equations that include armoring processes; (4) the removal of this accumulated contaminated sediment by street sweeping governed by sweeper pick-up equations developed for specific types and models of street sweepers; (5) the removal of sediments entrained and in transport by sediment trapping catchbasins as governed by established equations; and (6) the association of other pollutants of interest by assigning potencies which are ratios of a given pollutant to various particle sizes of accumulated sediment based on street dirt data. The SIMPTM is able tocontinuously account for eightdifferent particle size ranges throughout its simulation of these major processes.

The SIMPTM simulation is driven by a historic hourly rainfall trace which should be available from the precipitation gage near the lead entity. The focus of the SIMPTM analysis is to use the information available to simulate the build-up, washoff and street sweeper pick-up during the unfrozen portion of the 2 years in which sweeper pick-up data has been collected. This will be the data used to calibrate the model since SIMPTM has the ability to simulate the amount of material being pick-up by a sweeping program. The model’s predictions can be compared to the actual data collected. The modeling analysis will rely on the principal investigators knowledge of model parameters associated with street sweeper pick-up performance tied to the type of sweeper and its forward sweeping speed. Model parameters will be adjusted to most closely match the sweeper material pick-up data. If the optional street dirt data is collected, the model calibration will be easier as the street dirt data will provide some information on the actual accumulation..

SIMPTM uses the Yalin-Einstein and Foster-Meyer equations for sediment transport that continuously accounts for the effects of sediment armoring to compute the capacity of the flow trace to transport available accumulated sediment from paved areas. This method has been shown to be much more accurate than the empirically based exponential washoff used, for example, in the EPA’s Stormwater Management Model (SWMM).

SIMPTM accounts for sediment deposition and resuspension. Between events, SIMPTM calculates dry deposition and resuspension processes and models the removals associated with scheduled cleaning of streets. Removals estimates from these practices are estimated by SIMPTM based upon measurable data rather than assumed removal percentages input by the user as most stormwater quality models require.

The figure below illustrates the dry weather accumulation function within SIMPTM and shows how the traditional maximum accumulation reflects an equilibrium state. Accumulations, both above and below, the equilibrium trend at the same rate. The underlying process of deposition balanced by removal from traffic and wind remained unchanged. Wet weather accumulation or washon from higher volume and intensity runoff events result in sediment accumulations that exceed the equilibrium accumulation level. When this occurs, the net result of the following dry weather is a decrease in sediment accumulation not an increase, which shows that dry days do not always accumulate material.

The focus of the modeling will be to simulate the various land use/street type combinations for the period of time when unfrozen conditions existed during the 2 year data collection period. Many input parameters can be measured or easily estimated from topographic maps, aerial photos, or GIS based drainage system inventories.

Once the model is calibrated, it can be used to provide an understanding of the effectiveness of each of the targeted sweeping efforts in removing sediment, organics and other associated pollutants from the stormwater. The QAPP will further document how this can occur.

14.2 Data Presentation

This section provides examples for how the data will be presented (i.e. tables, charts, and/or graphs) in the final reports to illustrate trends, relationships, and anomalies. What is provided below is several examples of figures, graphs and charts that have been used in previous projects SIMPTM projects.

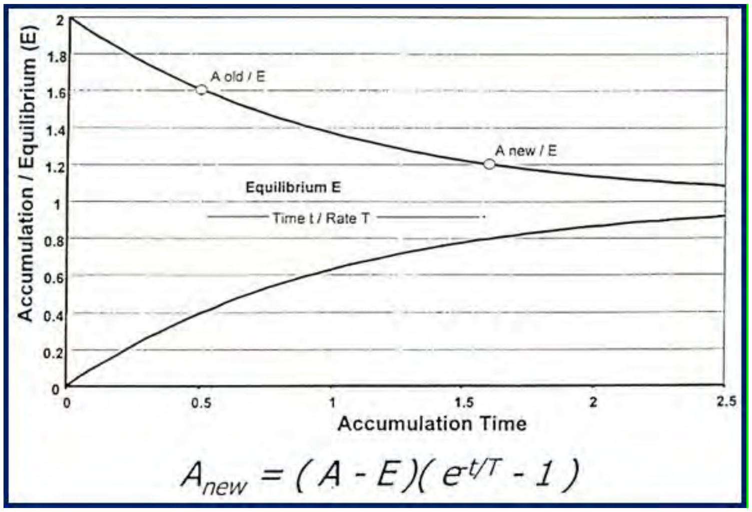


Figure 1- Accumulation function in SIMPTM

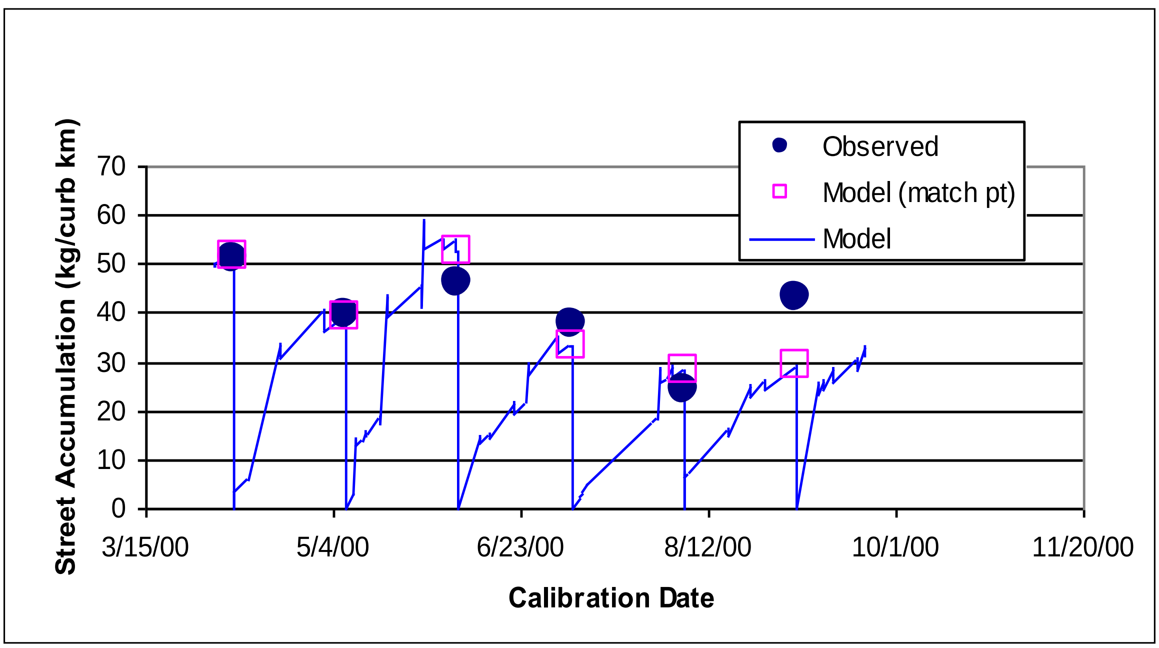


Figure 2 - Comparison of Modeled verses Observed Street Dirt Accumulations from Livonia study (Sutherland, 2000)

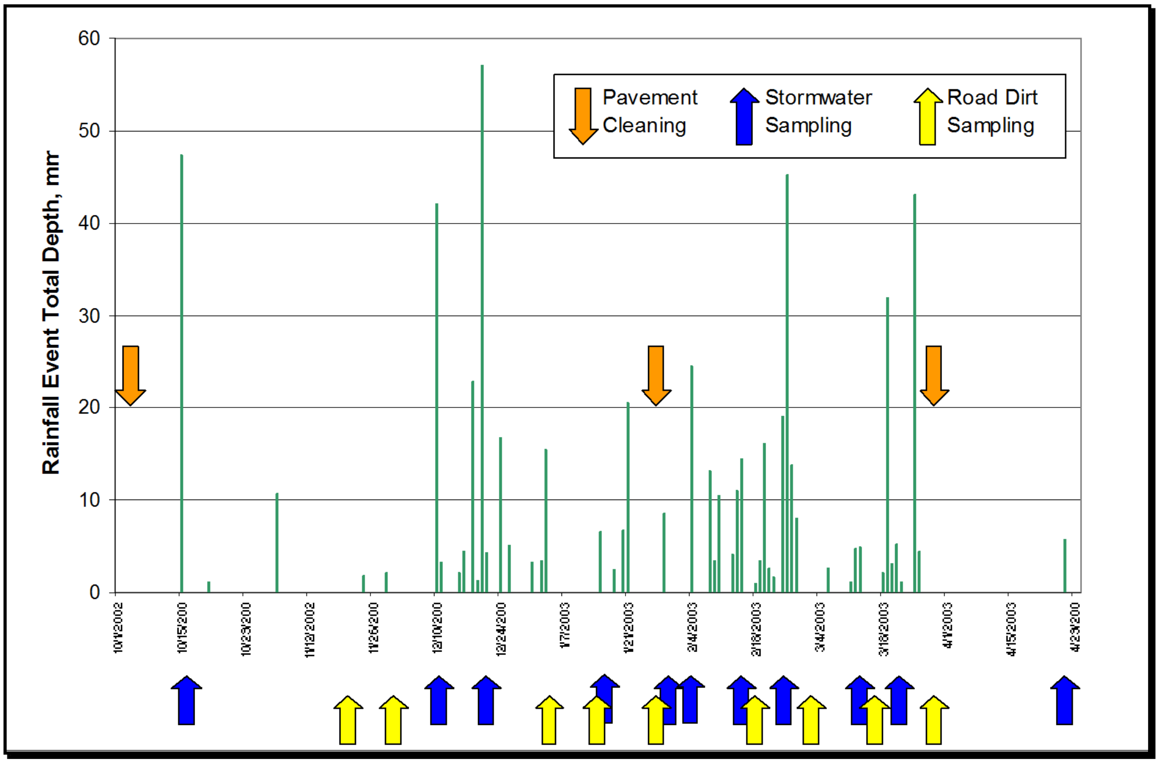


Figure 3- SIMPTM calibration period from Cross Israel Highway project (Sutherland, 2004)

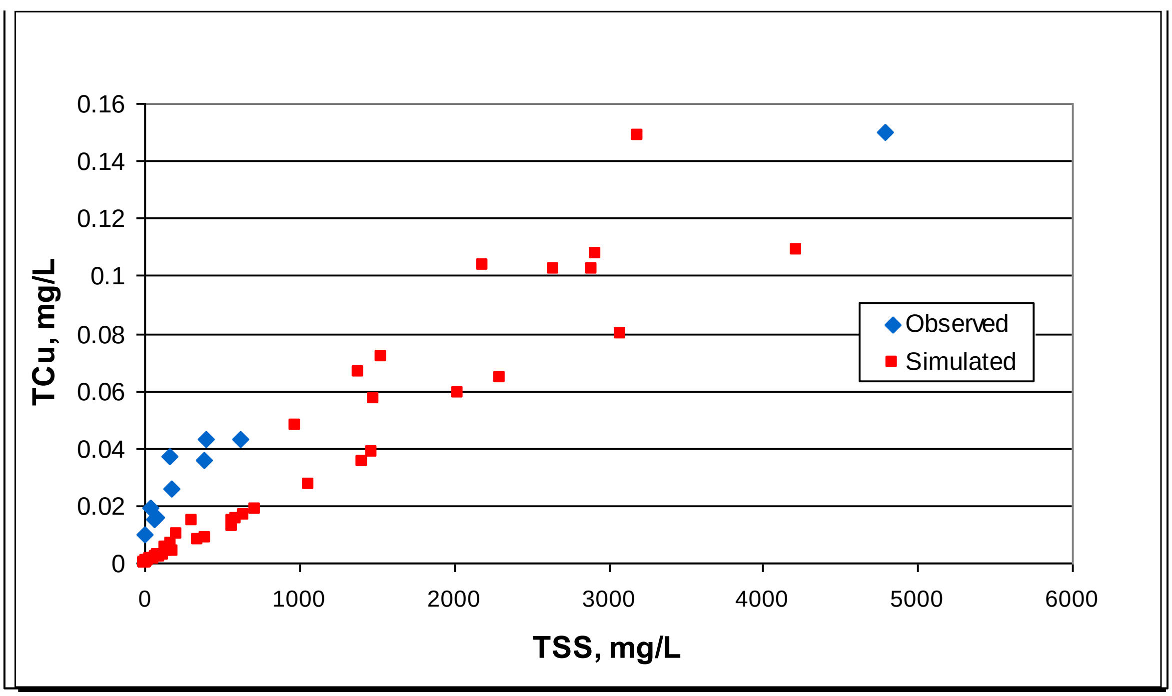


Figure 4- Simulated verse Observed Relationship between TCu and TSS from CIH project (Sutherland, 2004)

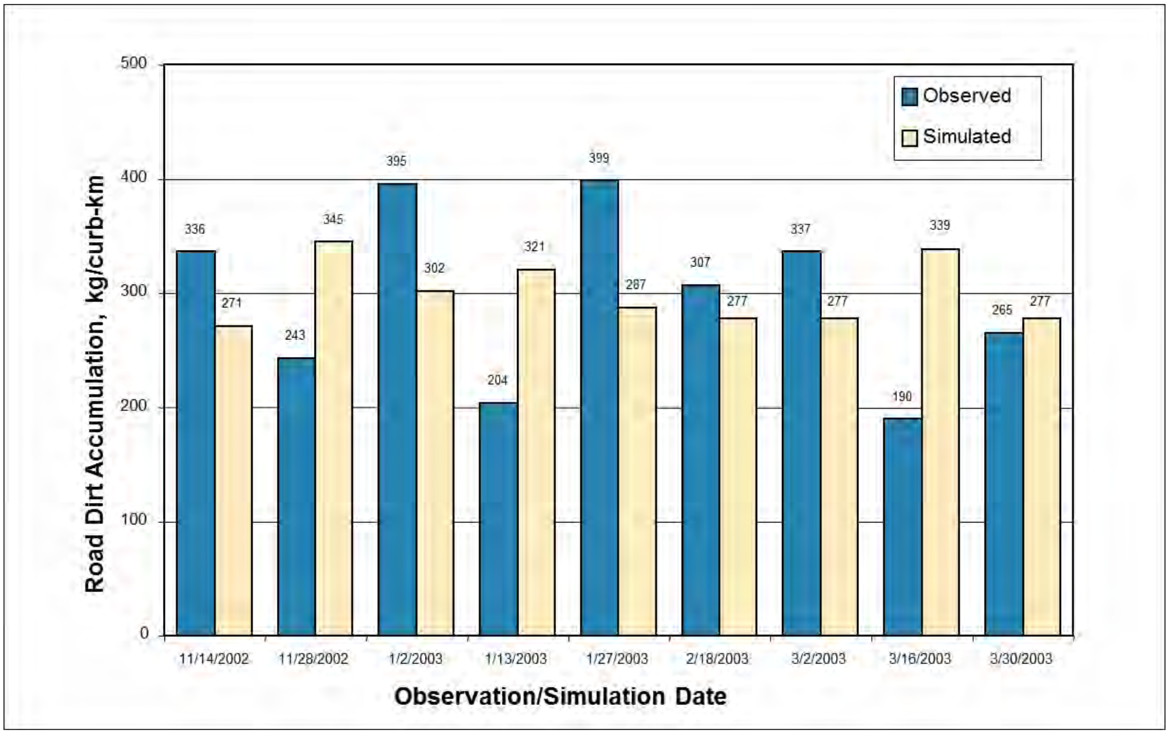


Figure 5- Comparison between Observed verses Simulated Street Dirt Accumulation from CIH study (Sutherland, 2004)

15.0 Reporting

This section describes how the study findings will be reported and disseminated.

15.1 Final Reporting – QAPP Only

This section will be completed for the QAPP.

15.2 Dissemination of Project Documents

The final report will be shared with the participating agencies and posted to the lead entities website: add website

16.0 References

Caraco, et. al. (2000). Stormwater Strategies for Arid and Semi-Arid Watersheds. Watershed Protection Techniques, 3(3), 41-51.

Law, N. L., DiBlasi, K., Ghosh, U., Stack, B., Stewart, S., Belt, K., ... & Welty, C. (2008). Deriving reliable pollutant removal rates for municipal street sweeping and storm drain cleanout programs in the Chesapeake Bay basin. Center for Watershed Protection.

Novotny, V. (2003). Water quality: Diffuse pollution and watershed management. John Wiley & Sons.

Pitt, R., Williamson, D., Voorhees, J., & Clark, S. (2004). Review of historical street dust and dirt accumulation and washoff data. Effective Modeling of Urban Water Systems, Monograph, 13, 43-54.

Sartor, J. D., & Gaboury, D. R. (1984). Street sweeping as a water pollution control measure: lessons learned over the past ten years. Science of the Total Environment, 33(1-4), 171-183.

Sutherland, R. C., & Jelen, S. L. (1997). Contrary to conventional wisdom, street sweeping can be an effective BMP. Advances in modeling the management of stormwater impacts, 5(9), 179-190.

17.0 Appendices

This section will be developed for the QAPP.

Appendix 24 – Determine Pollutant contributions MS4 SW in EWA GIS Proposal

Eastern Washington
Stormwater Effectiveness Studies

Detailed Study Design Proposal

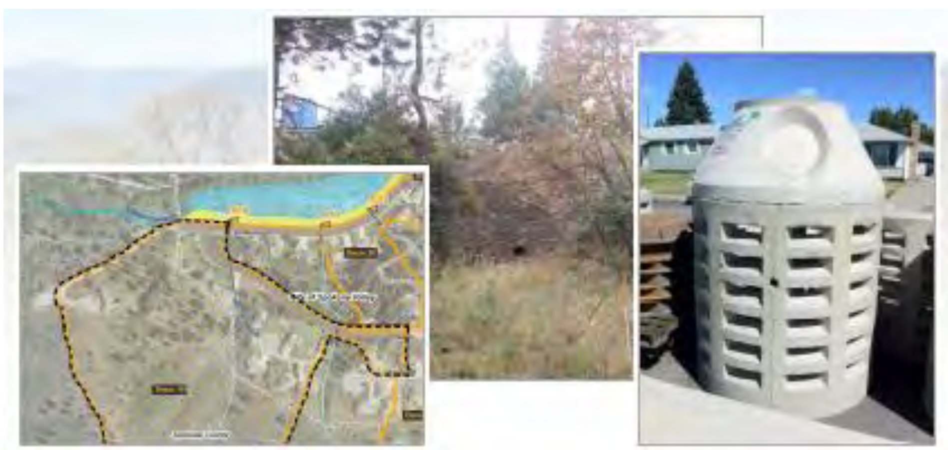
Determining Pollutant Contributions from Municipal Stormwater in EWA Using GIS

Study Classification:

☑ Structural BMP ☑ Operational BMP ☑ Education & Outreach

Study Objective(s):

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



June 30, 2017

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Proposal Publication Information

This Detailed Study Design Proposal (Proposal) will be stored and accessible to the public at the following weblink: Add Weblink where the Proposal can be accessed by the Public

For questions regarding the Proposal, please contact First and Last Name of Lead Entity Contact by email add email address or phone (509)XXX-XXXX.

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QAPP Publication Information

Will be completed for the QAPP.

QAPP Author and Contact Information

Will be completed for the QAPP.

Signature Page - Proposal

Proposal – Only the party's responsible for the contents of the Proposal and the project must sign date this page before the study proceeds to the QAPP development phase.

This page lists signatories to the document. Each party responsible for the contents of the QAPP and the project must sign and date this page before the study proceeds to the implementation phase (i.e. conduct the study).

Approved by:

____ Date ______________
Name, Primary Author, Organization

____ Date ______________
Name, Lead Entity, Jurisdiction

____ Date ______________
Name, Participating Entity, Jurisdiction

____ Date ______________
Name, Partner Entity, Jurisdiction

____ Date ______________
Name, Ecology Contact with Approving Authority

____ Date ______________
Name, Lab Director (add a line for each additional lab)

____ Date ______________
Name, Title

____ Date ______________
Name, Title

Signature Page – QAPP Only

This section will be completed for the QAPP.

List each party responsible for the contents of the QAPP and the project along with their project title, and organization. Each party must sign and date this page before the study proceeds to the implementation phase (i.e. conduct the study).

Distribution List - Proposal

Proposal – At a minimum include: the lead entity, participating entities, Ecology, and the author of the document

List each party who will receive copies of the approved **QAPP** as well as any subsequent revisions along with their contact information. This may include those who is responsible for the QAPP development and project implementation including project managers, QA managers, representatives of other groups/agencies involved, field staff, etc.

Name, Title	Organization	Contact Information: Address, Telephone, E-mail

Distribution List - QAPP Only

During the QAPP development, this section should be updated to include a list of each party who will receive copies of the approved **QAPP** as well as any subsequent revisions along with their contact information. This may include those who is responsible for the QAPP development and project implementation including project managers, QA managers, representatives of other groups/agencies involved, field staff, etc.

1.0 Table of Contents

The TOC should be updated during the QAPP development and auto generated using a word processing program.

2.0 Executive Summary

This section will be completed for the QAPP.

3.0 Introduction and Background

3.1 Introduction to the Structural BMP

This study will provide information that may allow municipal jurisdictions in Eastern WA, (EWA) and the NPDES MS4 permits (Ecology, 2012) applicable to them, to prioritize and differentially target areas that contribute pollutant loads of concern to surface waters and areas contributing to groundwaters. Pollutants of concern for these two types of areas are likely to be different and involve different management practices targeted to the specific pollutants.

3.2 Problem Description

A number of municipalities in EWA, and elsewhere in the semi-arid interior northwest, have stormwater management facilities and practices, along with stormwater flows and pollutant loads that are very different than those associated with larger cities in wetter climates. Many of these semi-arid and arid cities often have soils conditions in at least parts of their overall municipal jurisdiction that are effective for infiltrating stormwater discharges. In some cases, this is authorized and implemented through the Underground Injection Control (UIC) process (Washington Administrative Code. 173-218), in other cases it may be simply facilitated by road systems with flush-shoulders (no curbs and gutters) that allow flows to disperse into adjoining grassy areas, often via sheet flow. These latter areas may have been developed prior to Low Impact Development (LID) program requirements, but they effectively achieve many of the goals of the LID programs. Because of the soils are suitable for infiltrating stormwater, a number of these municipalities have been able to disconnect large portions of their jurisdictions stormwater outfalls from discharging to waters of the State or Nation. As a result, these cities inherently generate lower stormwater flows and consequently lower pollutant loads compared to cities where a large portion of their stormwater discharges through outfalls.

A number of EWA municipalities implement the requirements of the MS4 program throughout their entire jurisdiction, either because that is the expectation of the permit, or because some management practices are more administratively convenient to adopt everywhere. One factor that encourages uniformity in programs is that stormwater managed under the MS4 requirements establishes compliance with the UIC requirements. This is because in Washington, groundwater is defined as a *Water of the State* is protected to the same level as surface water bodies (RCW 90-48-020). Although utilizing uniform stormwater management practices may be more administratively convenient, it may not result in the most effective, control of pollutants to surface waters and groundwater. Surface waters may be impaired or impacted by pollutants such as metals, oils, phosphorus, sediment and bacteria, or other toxics such as PCBs (EPA, 2016; LimnoTech, 2016). Pollutants of concern for groundwater are those most likely to leach through the soil profile and impact drinking water aquifers or wells, or possibly migrate to surface water via shallow groundwater pathways.

Pollutants of concern for groundwater are often soluble or do not readily adsorb to soils. Soluble pollutants in stormwater may include road salts, nitrate, and total dissolved solids. It is also likely that some pollutants and targeted stormwater practices will overlap MS4 surface water and UIC objectives, for example, street sweeping to remove winter-applied sand to roads will benefit both surface waters impaired for sediment and prevent clogging of UIC facilities.

The stormwater management practices noted in the previous paragraph include those that are both site management oriented and operations and maintenance oriented. The study will evaluate the jurisdiction's (selected to participate in this study) stormwater management program practices and activities that are typically conducted in each of the areas that apply the three different approaches to managing stormwater discharges. These approaches include: 1) drainage and discharge to surface waters (outfalls), 2) underground injection, and 3) LID and LID-like infiltration.

3.3 Results of Prior Studies

A number cities similar in size and climate to EWA cities have conducted extensive monitoring of stormwater runoff quantity and quality. Boise, Idaho is a metropolitan area covered by a Phase I MS4 permit. Similar to Spokane, Boise has a population of just over 200,000 and is located in a semi-arid climate area. The co-permittees in the Boise metropolitan area began monitoring stormwater outfalls in the early 2000's to meet their NPDES MS4 permit requirements. The co-permittees included the City of Boise, Ada County Highway District (ACHD), Boise State University, Garden City, Idaho Transportation Department, and a local Drainage District. The current program has five monitoring sites (as shown in Figure 3-1) that collect precipitation depth, flow rate, and concentrations of pollutants that are common in urban areas (i.e. DO, temperature, pH, conductivity, NO_3-NO_2, TSS, TKN, DOP, TP, E. coli, etc.). Information about the stormwater outfall monitoring program for Boise (and other co-permittees) is available to the public on the Ada County Highway District website at the following link: http://www.achdidaho.org/Departments/TechServices/Drainage.aspx.

This study proposes to use Boise's data to characterize stormwater pollutants in equivalent EWA areas that discharge to surface waters and groundwaters. Use of Boise data would be cost effective and timely compared to establishing an extensive monitoring program in multiple EWA cities. Boise data could be supplemented with other regional stormwater monitoring data. For example, the Spokane River Regional Task Force website (http://srrttf.org/) contains information about PCB testing that has been conducted which includes stormwater runoff and sediments from storm sewer systems

Figure 3.1 Boise Metro Area Stormwater Outfall Monitoring Locations (source: Brown and Caldwell, 2015)

3.4 Regulatory Requirements

This study will focus broadly on Section S8.B evaluating permit required stormwater management practices and activities including: structural BMPs, operational BMPs, and education and outreach programs. The study will indirectly evaluate the jurisdictions (selected to participate in this study) stormwater management program practices and activities that are typically conducted in each of the areas that apply the three different approaches to managing stormwater discharges. These approaches include: 1) drainage and discharge to surface waters (outfalls), 2) underground injection, and 3) LID and LID-like infiltration. The jurisdictions stormwater management program practices and activities are conducted with the intent of complying with the six minimum control measures of the MS4 permit for EWA which include: 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, and 6) operations and maintenance.

The stormwater management practices noted in the previous paragraph include those that are both site management oriented and operations and maintenance oriented The study will indirectly evaluate the jurisdictions stormwater management program practices and activities that are typically conducted in each of the areas that apply the three different approaches to managing stormwater discharges. These approaches include: 1) drainage and discharge to surface waters (outfalls), 2) underground injection, and 3) LID and LID-like infiltration.

4.0 Project Overview

4.1 Study Goal

The goal of this study is to evaluate the combined effectiveness of the jurisdictions typical stormwater management practices and activities in each of the three areas that apply different approaches to managing stormwater discharges including: 1) drainage and discharge to surface waters (outfalls), 2) UICs, and 3) LID and LID-like infiltration. Effectiveness will be based on the estimated cost of the stormwater management programs and activities (using a metric such as $/lb) that reduce polluted runoff to surface water bodies and to groundwater via infiltration practices. This will allow jurisdictions, and the MS4 permits applicable to them, to prioritize and differentially target areas that contribute pollutant loads of concern to surface waters and to groundwaters, which are likely to involve different pollutants and different management practices targeted to the specific pollutants for each type of area. Stormwater management activities related to flood management and groundwater protection (e.g., UIC programs) will likely still be needed, but the nature and cost of those activities may be different than those discharging to surface waters, especially impaired surface waters.

4.2 Study Description and Objectives:

This study would evaluate and characterize several stormwater programs and activities from jurisdictions similar to the study area, and in particular, map and segregate those areas within each jurisdiction that discharge to surface water outfalls; areas from those that rely on infiltration (both UIC-like and LID-like). The study would identify if there are any differences in the stormwater management practices currently being used in the three types of areas; and also estimate or document stormwater program costs for each program area/activity for which data are available. The study will estimate how effective, using a metric such as $/lb removed, stormwater management programs and activities are in reducing polluted runoff to surface water bodies and to groundwater via infiltration practices.

For some activities, a direct estimate of costs and pollutants removed can be obtained from specific activity costs and removals already documented by the jurisdiction. For example, annual pollutant loads from each of the three types of areas in a given jurisdiction could be estimated for a given outfall to a receiving stream. In this hypothetical example, assume it is an older area in a commercial district that currently has only minimal stormwater containment or treatment. Also assume the stream is impaired due to phosphorus discharges. Assume also that through a planned redevelopment, it will be possible to capture and infiltrate, and hence mostly disconnect, the entire drainage to this outfall due to suitable local soils and groundwater levels. The existing annual loading of phosphorus from this area could be estimated with a Simple Method tool (e.g., GIS-based tool such as PLOAD or WinSLAMM) using local hydrology and the Boise area event mean concentration for a commercial area. That loading would be essentially eliminated with redevelopment, but the loading of various pollutants to groundwater may increase. Those increased loadings (say of nitrate or total nitrogen) could be similarly estimated. The cost per pound of phosphorus removed would be calculated with the costs associated with the infiltration BMPs. One scenario could include a UIC infiltration system and another assuming bioswale infiltration. A third scenario might include non-infiltration phosphorus treatment BMPs. The example in this paragraph is hypothetical, but the actual study would focus on real areas within the jurisdiction(s).

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

- Delineate and characterize the land areas (for each participating jurisdiction and the Boise metro area) where the different approaches to managng stormwater discharges are applied. Characterize the stormwater management programs and activities that occur in the three different types of areas for each jurisdiction participating in the study.
- Determine the effectiveness of the combined stormwater management program activities and practices in each of the three areas with different approaches to managing stormwater discharges.
- Summarize the study results and provide stormwater managers in EWA with recommendations for a targeted stormwater management program based upon an areas approach to managing stormwater discharges: 1) drainage and discharge to surface waters (outfalls), 2) UICs, and 3) LID and LID-like infiltration.

4.3 Study Location

This study will be conducted in one EWA community and use data from other jurisdictions (such as Boise) in semi-arid locations.

4.4 Data Needed to Meet Objectives

The data needed to meet the study objectives include:

- Information from at least one and preferably several MS4 jurisdictions regarding stormwater practices and how they are deployed in each of the three types of areas including: 1) drainage and discharge to surface waters, 2) underground injection, and 3) LID-like infiltration.
- Collect information from Boise including: stormwater monitoring data and contributing basins characteristics.
- Delineated maps of the three types of areas from each participating jurisdiction as well as Boise. GIS database tools will be used to map the three types of areas in each study area to the extent possible for data storage and analysis.

4.5 Tasks Required to Conduct Study

Tasks required to conduct the study are:

- Develop Detailed Study Design Proposal (Proposal Development)
- Develop Quality Assurance Project Plan (QAPP)
    - Locate comparable cities with monitoring data that could be used for this study
    - Locate EWA jurisdictions that will participate in this study

- Data Collection and Analysis
  - Locate existing mapping of storm sewer systems and outfall locations, and input data to a GIS database if not already in a GIS format.
  - Collect information needed to characterize potential stormwater pollutants including land use(s), the percent impervious areas, topography, basins discharging to surface waters, soils/climate, etc.
  - Estimate the initial contribution of pollutants using monitoring programs and studies that report relevant regional averages of stormwater characteristics (i.e. pollutant types and concentrations) from similar land uses (e.g., Boise area monitoring data).
  - Document outfall disconnection (since the effective date of the first MS4 permit cycle in EWA).
  - Collect information on stormwater management practices being used in the three types of areas within each jurisdiction and costs associated with the main elements of the stormwater programs to be used for effectiveness demonstration (e.g., $/lb. removed).
  - Develop comparative analyses and graphics to represent various soils/climate types, proportionate discharges to surface water outfalls or soils and potentially groundwaters, and degrees of outfall disconnectedness. These will include total pollutant loads from the jurisdiction, unit loads (e.g., pounds per acre), and $/lb removed for the entire jurisdiction compared to the portion of the jurisdiction with surface water outfalls.
- Reporting - Summarize the study finding into a final report

4.6 Potential Constraints

Different jurisdictions may have differing levels of stormwater management related data in GIS database formats, however, it is assumed that at least several jurisdictions will have, or can provide, sufficient data to satisfy the key research objectives of this study.

5.0 Organization and Schedule

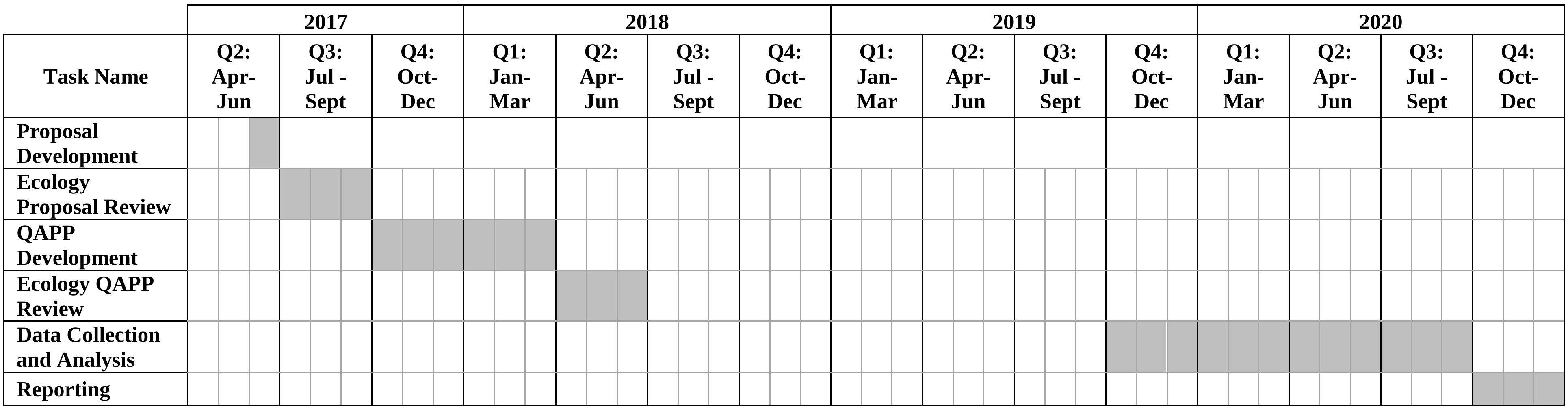
5.1 Key Project Team Members: Roles and Responsibilities

Key Team Members	Role	Responsibility
Name Organization Phone Number Email	Lead Entity	Define
Name Organization Phone Number Email	Participating Entity	Define
Name Organization Phone Number Email	Partner Entity	Define
Name Organization Phone Number Email	Ecology Reviewer	Define
Name Organization Phone Number Email	Proposal Author	Define
Name Organization Phone Number Email	QAPP Author	Define
Name Organization Phone Number Email	Key Team Member Project Role	Define

5.2 Project Schedule

A task timeline based on quarterly activities is shown in Table 5.1. The tasks identified in Sections 4.5 and 5.3 can be completed within a 12 month study duration. The timeline shown includes a 15 month delay between the QAPP approval and Data Collection. This is the maximum amount of time allowed between these activities based on the NPDES permit.

Figure 5.1 Proposed Project Timeline



5.3 Budget and Funding Sources

An estimated project budget is provided in Table 5.2. For this estimate it was assumed that public agency staff (city and/or county) would be conducting the study. The funding source for this study was not determined when the Proposal was written. The final budget is dependent upon the selected study approach and site(s) selected. This section will be updated when the QAPP is developed.

Table 5.2 Estimated Project Budget

Tasks	Hours Jr. Staff	$ Jr. Staff	Hours Sr. Staff	$ Sr. Staff	Total $
Identification of Jurisdictions Included in Study	40	$1,600	20	$1,500	$3,100
Finalize QAPP	50	$2,000	20	$1,500	$3,500
Collect and Compile Storm System and Outfall Mapping	180	$7,200	20	$1,500	$8,700
Collect and Compile Land Use, Topo, Imperviousness, etc.	180	$7,200	40	$3,000	$10,200
Estimate Pollutants and Flows Using Existing Data (e.g., Boise)	40	$1,600	20	$1,500	$3,100
Document Outfall Disconnection Efforts	40	$1,600	16	$1,200	$2,800
Collect and Compile SWM Information and Costs	120	$4,800	20	$1,500	$6,300
Comparative Analyses and Graphics	80	$3,200	40	$3,000	$6,200
Final Study Report	60	$2,400	20	$1,500	$3,900
Meetings	40	$1,600	40	$3,000	$4,600
Total Hours and $	830	$33,200	256	$19,200	$52,400
Estimated loaded labor cost/hr (public sector)	$40		$75		

*** Add 10% for Project Management*

6.0 Quality Objectives – QAPP Only

This section will be completed for the QAPP.

7.0 Experimental Design

7.1 Study Design Overview

This study is different than most others in the EWA studies list because it does not involve collection of field monitoring data. It instead this study will rely on existing information on stormwater management programs available from EWA stormwater jurisdiction(s) and historical monitoring data from cities of similar size and climate. Thus, this section on experimental design focuses only on the process that likely will be used to select the EWA jurisdictions involved in the study.

7.2 Test-Site(s) Selection Process

The criteria that will be used to select the study location(s) as well as the location that will supply the monitoring data for this study will be defined in the QAPP. The following items will likely be included in the selection process:

- The process for selecting the jurisdictions including the jurisdiction that will supply the monitoring data will focus on comparability with the participating jurisdiction including similar: land use characteristics, population and/or population density, % or density of impervious area, management approaches to stormwater discharge, weather, pollutants of concern

- The jurisdiction(s) selected to participate in this study will be ones with available data in electronic formats, preferably GIS databases that include the information needed for the evaluations.

7.3 Summary of Typical Stormwater Management Practices and Activities

This section will be updated when the QAPP is developed to include a list of typical stormwater management practices and activities as well as the corresponding minimum control measure. See Table 7.1 for an example of the information that may be provided.

Typical Stormwater Management Practice or Activity	Minimum Control Measure					
	Public Education & Outreach	Public Involvement & Participation	Illicit Discharge Detection & Elimination	Construction Site SW Runoff Control	Post-Construction SW Management	Operations & Maintenance

7.4 Type of Data Being Collected

This section identifies the various types of data that will be collected and defines the intended purpose for each type of data. Recommend using tables to keep the section brief. Suggestions for this section include:

Table 1: Summary of data being collected.

Data Type	**Purpose**	**Frequency**
Historical stormwater outfall water quality monitoring data, including available statistical summaries such as event mean concentrations for a variety of pollutants (Boise metro area data is one example)	Provides the basis to estimate pollutant concentrations and loads from outfalls with similar land uses and storm water management features for EWA stormwater jurisdictions.	Available historical data in electronic formats since 2000
Stormwater management program mapping and inventory information/data: stormwater system for each outfall and for areas that are not connected to surface water outfalls existing structural BMPs for MS4 and UIC areas area of application of non-structural BMPs for MS4 and UIC areas	Characterize the SW program features and locations for each participating EWA jurisdiction	Document changes over time in these characteristics to the extent that the information is available, probably no further back than 2000
Stormwater management program O&M technical information	Same as above	Same as above
Stormwater management program non-structural BMP and O&M cost information (FTEs and labor costs by SW program area)	Same as above, and to estimate cost-effectiveness	Same as above
Structural BMP construction costs by BMP type	Sane as above	Same as above

7.5 Precipitation Monitoring

Not applicable to this study.

7.6 Water Quality Sampling

Not applicable to this study.

7.7 Sediment Sampling

Not applicable to this study.

8.0 Sampling Procedures – QAPP Only

This section will be completed for the QAPP.

9.0 Measurement Procedures – QAPP Only

This section will be completed for the QAPP

10.0 Quality Control – QAPP Only

This section will be completed for the QAPP.

11.0 Data Management Plan Procedures – QAPP Only

This section will be completed for the QAPP.

12.0 Audits – QAPP Only

This section will be completed for the QAPP.

13.0 Data Verification and Usability Assessment

It is anticipated that the following data will be verified during this study:

- Historical stormwater quality data collected by others (e.g., Boise metro area data) has already been subjected to appropriate and applicable QA/QC procedures as dictated by Clean Water Act MS4 permits, thus additional data validation/verification is not needed.
- If historical water quality data from individual storm events are used in the study (as opposed to using compiled or published statistical results such as event mean concentrations), then a comparison of statistics will be made to confirm that the individual data points have been copied or imported and the statistical results match those available from the agency that conducted and reported the monitoring results
- The data from the jurisdictions (selected to participate in this study) will be assessed for comparability

13.1 Field Data Verification

This section will be complete for the QAPP.

14.0 Data Analysis Methods

Based upon the study design proposed in this document, the proposed data analyses are as follows:

- A key method in this proposed study is to use historical water data from other jurisdictions with similar land use and climate to EWA permittees. As noted in earlier sections, one likely source of this data is the Boise metro area. Figure 3.1 in Section 3 shows the five existing stormwater outfall monitoring locations. The tables below provide additional information on how these or similar data could be used. These tables were "Snapshots" from the PDF file of the latest annual report (Brown and Caldwell, 2015). "Table 1" shows land uses and impervious cover for each (note that other outfall locations have also been monitoring in the Boise metro area since the first MS4 permit was issued in 2000). "Table 12" and "Table 16" are examples of how data can be normalized on a per acre basis or land use basis for entry into a loading tool or model such as Excel, PLOAD or WinSLAMM. Specific data normalization methods will be further defined when specific EWA jurisdictions have been selected and their program data availability better understood.

- The cost per pound of pollutant will be determined for each of the three types of areas by using pollutant loading and loading reduction estimates, as described in the bullet above, in conjunction with associated cost information for each EWA jurisdiction for stormwater program construction and O&M identified in Section 7.4. The cost per pound of pollutant removed will be a key indicator of effectiveness, along with the load reductions in annual pounds and annual percent reductions.

Table 1. Monitoring Station Information

Station Information	Lucky (Site ID:3)	Whitewater (Site ID:11)	Main (Site ID:12)	Stilson (Site ID:13)	Americana (Site ID:14)
Subwatershed Area	105 ac.	498 ac.[1]	79 ac.	131 ac.	875 ac.[1]
Land Use Percentage	Right of Way (22%) Residential Med (78%)	Right of Way (36%) Commercial (4%) Residential Med (50%) Residential High (7%) Public and Schools (3%)	Right of Way (43%) Commercial (37%) Residential Med (14%) Residential High (5%) Public (1%)	Right of Way (34%) Commercial and Industrial (20%) Residential Med (32%) Residential High (8%) Public (6%)	Right of Way (30%) Commercial (13%) Residential (Hi/Med/Low) (39%) Parks and Open Space (14%) Public and Schools (4%)
Percent Impervious Ground Cover[2]	40%	43%	55%	44%	39%
Receiving Water	Eagle Drain	Crane Creek to Farmers Union Canal to Boise River	Boise River	Boise River	Boise River
Outfall Distance from Station	350 ft	2,100 ft	500 ft	1,000 ft	108 ft
Rain Gauge Location	Cynthia Mann Elementary School and Collister	Whitewater (at monitoring station)	Front	Whitewater	Front and East
Rain Gauge Distance from Station	750 ft and 5,650 ft.	10 ft	2,900 ft	3,300 ft	1,800 ft and 9,600 ft

Notes:

[1] Acreages have been updated from last year based on results of additional delineation efforts.

[2] Impervious cover includes roads and streets, rooftops, and parking lots.

Table 12. Event Loading per Acre[1]							
Event Date	Monitoring Station	E. coli	TSS	Total Phosphorus	Ammonia	Nitrate + Nitrite (N)	TKN
October 21, 2014	Lucky	0.285	0.646	0.013	0.011	0.005	0.041
	Whitewater	0.098	0.253	0.005	0.005	0.002	0.015
	Main	–	0.691 [2]	0.007	0.013	0.005	0.034
	Stilson[3]	–	0.412	0.003	0.005	0.002	0.013
	Americana	0.0541 [2]	0.820	0.007	0.007	0.00	0.025
December 19, 2014	Lucky	–	–	–	–	–	–
	Whitewater	0.002	0.253	0.002	0.001	0.002	0.004
	Main	0.021	0.886	0.002	0.005	0.002	0.010
	Stilson[3]	0.007	0.589	0.001	0.001	0.001	0.005
	Americana[2]	0.028	0.478	0.002	0.002	0.00	0.007
March 24, 2015	Lucky	0.002	0.317	0.004	0.007	0.002	0.020
	Whitewater	0.007	0.574	0.006	0.007	0.003	0.020
	Main	0.033	–	–	–	–	–
	Stilson[3]	0.000	0.400	0.002	0.004	0.001	0.004
	Americana	0.007	0.573	0.004	0.005	0.00	0.014
May 15, 2015	Lucky	–	0.405	0.004	0.008	0.004	0.021
	Whitewater	–	–	–	–	–	–
	Main	0.033 [2]	1.549	0.005	0.022	0.007	0.039
	Stilson	–	–	–	–	–	–
	Americana	–	0.992	0.003	0.007	0.003	0.017
July 22, 2015	Lucky	0.076	–	–	–	–	–
	Whitewater	–	–	–	–	–	–
	Main[2,4]	0.015	–	–	–	–	–
	Stilson[3]	0.012	–	–	–	–	–
	Americana	–	–	–	–	–	–

Notes:

– No sample

[1] Loading estimates are presented in pounds except E.coli, which is presented as billion colonies.

[2] Loading estimate used qualified analytical data. See notes at the bottom of Table 10 for details.

[3] Loading estimate used qualified flow data. See notes at the bottom of Table 5 for details.

[4] Pollutant loads estimated using the EPA Simple Method.

Table 16. Unit Loading Calculation Input Concentrations[1]					
ACHD Land Use	WinSLAMM Land Use	Hydrologic Soil Group	Total Suspended Solids (mg/l)	Total Phosphorus (mg/l)	E. Coli (MPN/100 ml)
Agricultural	Open Space	A	199.17	0.1934	4,859
		B	157.67	0.2397	4,390
		C/D	146.89	0.2517	4,268
Commercial	Strip Commercial	A	133.53	0.2699	5,617
		B	133.55	0.2729	5,620
		C/D	133.39	0.2755	5,752
Industrial[2]	Light Industrial	A	107.11	0.3500	5,117
		B	107.11	0.3500	5,133
		C/D	107.11	0.3500	5,138
Open Space	Open Space	A	199.17	0.1934	4,859
		B	157.67	0.2397	4,390
		C/D	146.89	0.2517	4,268
Parks	Parks	A	232.15	0.1692	9,038
		B	248.59	0.2389	8,231
		C/D	253.68	0.2605	7,982
Public	Miscellaneous Institutional	A	149.68	0.2537	5,876
		B	149.76	0.2677	5,831
		C/D	149.63	0.2727	5,808
High Density Residential[2]	High Density Residential with Alleys	A	86.07	0.6200	3,996
		B	86.07	0.6200	3,976
		C/D	86.07	0.6200	3,875
Low Density Residential[2]	Low Density Residential	A	86.07	0.6200	9,342
		B	86.07	0.6200	8,682
		C/D	86.07	0.6200	8,471
Medium Density Residential[2]	Medium Density Residential with no Alleys	A	86.07	0.6200	8,976
		B	86.07	0.6200	8,688
		C/D	86.07	0.6200	8,331
School	Schools-Institutional	A	137.36	0.3010	4,140
		B	137.82	0.3185	4,114
		C/D	137.93	0.3251	4,098

Notes:

[1]See Appendix C for assumptions regarding input concentrations.

[2]Influent concentrations based on ACHD monitoring results.

14.1 Data Analysis Methods

This section will be complete for the QAPP.

14.2 Data Presentation

This section will be complete for the QAPP.

15.0 Reporting

15.1 Final Reporting

This section will be completed for the QAPP.

15.2 Dissemination of Project Documents

The final report will be shared with the participating agencies and will be posted to the lead entity's webpage: add webpage

16.0 References

Brown and Caldwell. (2015). NPDES Phase I Annual Stormwater Monitoring Report for Water Year 2015. Prepared for ACHD.

Ecology. (2012). *Eastern Washington Phase II Municipal Stormwater Permit*. Washington State Department of Ecology (Ecology), Department of Water Quality, Olympia. Retrieved from: http://www.ecy.wa.gov/programs/wq/stormwater/municipal/phaseiiEwa/ewph2permit.html

EPA. (2016). National Rivers and Streams Assessment 2008-2009: A Collaborative Survey (EPA/841/R-16/007). U.S. Environmental Protection Agency (EPA). Office of Water and Office of Research and Development. Washington, DC.

LimnoTech. (2016). 2016 Comprehensive Plan to Reduce Polychlorinated Biphenyls (PCBs) in the Spokane River. Spokane River Regional Toxics Task Force. Spokane, WA.

Revised Code of Washington. Water Pollution Control. RCW 90-48-020.

Washington Administrative Code. Underground Injection Control Program. WAC 173-218.

17.0 Appendices

The appendices should include all supporting information for the items described in the body of the QAPP.