84. Effectiveness Study Interim Results and Status Report

CITY OF SEATTLE

NPDES PHASE I MUNICIPAL STORMWATER PERMIT

2014 STORMWATER MONITORING REPORT

Street Sweeping Effectiveness Independent Study

Prepared by
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1 INTRODUCTION

1.1 Introduction

This document serves as the City of Seattle's (City) calendar year 2014 monitoring report as required by Special Condition S8.C.3 of the 2013-2018 National Pollutant Discharge Elimination System (NPDES) Phase I Municipal Stormwater Permit (Permit). On August 1, 2012, Ecology issued an updated 2013-2018 Permit that became effective on August 1, 2013. The Permit was modified on January 16, 2015.

The Permit uses a collective funding approach to fund the three components of a Regional Stormwater Monitoring Program (RSMP) created under the Permit: 1) status and trends monitoring, 2) stormwater management effectiveness studies, and 3) source identification and diagnostic monitoring. Components 1 and 2 have an option that allows Permittees to perform their own monitoring or studies in lieu of paying all or some of their allotted payment amount to the regional fund.

In a letter dated November 26, 2013, the City notified Ecology that the City had selected the Effectiveness Studies option that allows the City to both pay into a collective fund to implement RSMP effectiveness studies and independently conduct an effectiveness study that will not be undertaken as part of the RSMP. The effectiveness study that the City selected, which is the subject of this interim report, is to evaluate the effectiveness of street sweeping at reducing pollution in urban stormwater runoff.

Monitoring for this study began in October 2014 and is expected to be completed by September 2016. Based on the design of the study, conclusions about the effectiveness of street sweeping will not be available until all the monitoring is completed. The purpose of this document is to comply with Permit Condition S8.C.3.b.iv: "*Describe interim results and status of the study implementation in annual reports throughout the duration of the study*."

1.2 Background

The City elected to support the regional stormwater monitoring funded by the Permit with one exception; we chose to conduct an independent study to evaluate the effectiveness of street sweeping on stormwater quality. With technological improvements in street sweepers, the ability of sweepers to reduce street dirt, and remove finer particulate matter specifically, has been documented by an ongoing Seattle Public Utilities (SPU) study and several recent national

studies. However, the effect of street sweeping on stormwater quality has not been well studied recently and/or the limited recent studies have not had sufficient rigor.

The Seattle Department of Transportation (SDOT) owns and operates a fleet of mechanical broom and regenerative air street sweepers. Under the direction of SPU's Street Sweeping for Water Quality (SS4WQ) program, a limited number of regenerative air sweepers are used on roadways that drain to surface waters as a stormwater management/source control activity. To address the data gap of the effectiveness of street sweeping on stormwater quality, SPU created the 2-year monitoring study which is the subject of this report.

The City submitted a detailed study proposal to Ecology on January 30, 2014. On July 20, 2014, the City submitted a draft Quality Assurance Project Plan (QAPP) to Ecology. Ecology provided comments on the draft QAPP in a letter dated September 10, 2014. The comments were addressed in the final QAPP which is dated September 22, 2014 and was submitted to Ecology on October 2, 2014.

2 Street Sweeping Program and Monitoring Study Overview

2.1 Street Sweeping Program Overview

The City has been using street sweeping as a good housekeeping practice since the early 1900s. Street sweeping technology has changed significantly over the last two decades and the newer model sweepers use regenerative air and vacuum technology to remove very fine particulates (less than 10 microns [µm]). By mass, these smaller particles carry more pollutants than larger street dirt particles.

In 2006, SPU conducted a pilot study, which showed that street sweeping was effective at reducing roadway pollutants. In 2009, SPU further evaluated the economics of street sweeping and found it to be a cost-effective method for reducing the stormwater pollutant load from City roadways.

In February 2011, SPU launched the SS4WQ program which is a partnership between SPU and the SDOT. Under the direction and funding of SPU, a limited number of SDOT's regenerative air sweepers are used on roadways that drain to surface waters as a source control/stormwater management activity.

SPU sets the program direction and provides water quality expertise and funding for the portion of routes that discharge directly to Seattle's receiving waters. Currently, 24 street sweeping routes covering 660 lane miles, of which 490 drain to surface waters, are swept using regenerative air sweepers. SDOT provides operational expertise, street sweeping services, and funding for the portion of the non-SS4WQ routes on roadways that drain to sewage treatment plants.

2.2 Study Overview

2.2.1 Study Goals

The goal of this study is to quantify the effect of street sweeping on stormwater quality by directly measuring runoff concentrations from roadways from swept and unswept treatments. Specifically, this study will assess the ability of the City's current fleet of regenerative air Schwarze® A9 Monsoon™ street sweepers utilized on a weekly basis to reduce pollution in stormwater runoff.

2.2.2 Study Design Overview

A paired Before/After–Control/Impact (BACI) design will be used to test if stormwater quality differences can be detected when street sweeping is discontinued. Since sweeping is the normal

condition for arterial roadways in Seattle, sweeping will be considered the "control" and not sweeping will be considered the "impact;" meaning that this study will be testing if by not sweeping, there is a measurable impact to stormwater quality.

Stormwater monitoring will be conducted at four sites located on the same arterial street with similar characteristics, where two sites will serve as Control sites (swept on a weekly basis) and two sites will serve as Impact sites (not swept). The four sites will be monitored over a two year period where Year 1 (2014-2015) represents the Before condition and Year 2 (2015-2016) represents the After condition.

The two Control sites will be monitored under typical, weekly street sweeping operations in both years. The two Impact sites will be monitored under typical, weekly street sweeping operations in Year 1 and under unswept conditions in Year 2. Sampling will be initiated in October to sample seasonal first flush conditions and continue through July of the following year to sample under both wet and dry season conditions. Thus, Year 1 sampling will be targeted from October 2014 through July 2015 and Year 2 sampling will be targeted from October 2015 through July 2016. Sweeping will be discontinued at the Impact sites by July 2015, or when Year 1 sampling goals are met. This schedule provides 2 to 3 months of street dirt accumulation and equilibration at the Impact sites between Before (Year 1) and After (Year 2) conditions. The goal is to collect 12 composite and grabs samples from each location per each year for a total of 24 samples sets at each site.

2.2.3 Monitoring Site Selection

Finding suitable and representative monitoring locations for stormwater studies of this nature is critical to the success of the study but can be very challenging. To ensure comparable sample data, the following requirements were imposed on the stormwater monitoring site selection:

- Each monitoring site will be located on the same arterial where the basin area of each site extends only the distance between two adjacent storm drain inlets (typically 200-300 lineal feet) and from the curb line to the roadway crown.
- Sites with no significant run-on from impervious and pervious areas adjacent to the travel lanes (e.g., driveways, sloped planting strips, lack of curb).
- Sites with no nighttime parking will be selected so sweepers will be the most effective and parking restrictions will not be needed.

- Sites need to be located in arterial roadway sections of nearly identical land use, slope, size, road surface type and condition, vegetation coverage, and similar traffic counts and type of vehicle usage.
- Sites need to have no paving or construction activities planned for the next four years.
- Site need to have parking strips and adjacent residences/businesses amendable to an above-ground sampling cabinet installation; and have inlets suitable for monitoring (large enough both vertically and horizontally, enough vertical drop to bottom or water surface, abut curb, be structurally sound, etc.).

Potential arterials to monitor were investigated using a Geographical Information System (GIS) review and field reconnaissance to locate roadways that contain a minimum of six locations meeting the above requirements. Based on the review and field reconnaissance, six locations on M.L. King Jr. Way S were selected for initial, project development-phase grab sample monitoring. The goal of this grab sampling was to select four locations to monitor during the full phase study.

Between November 2013 and March 2014, a total of six rounds of roadway runoff grab samples were collected from the six initial sites (identified as SS1 through SS6) during this development phase of the project (development phase data are not presented in this report). The original plan was to identify the four stations with the most similar water quality conditions to sample under the full phase study. Because of unresolved capacity/drainage issues observed at sites SS1 and SS6, those two sites were eliminated from future consideration. The final sites selection for the full-scale study, identified as SS2 through SS5, are shown on Figure 1and location details are provided in Table 1. Photos of the four site inlets are shown on Figure 2 through Figure 5.

Table 1. Monitoring station location information.

Station ID	Address	FEA_KEY	EQNUM_ID	X_COORD	Y_COORD
SS2	4051 M. L. King Way Jr S	7329200	978552	1279074.49	210314.26
SS3	2961 S Dakota (on M. L. King Way Jr. S)	4061938	929412	1279202.99	209938.85
SS4	4118 M. L. King Way Jr S	7331900	978926	1279257.93	209787.44
SS5	No address, approx. 4925 M. L. Jr Way S, 130' south of S Ferdinand St	7349489	983834	1280405.63	206774.28

SS2 and SS5 will serve as the Control sites during this study so will they will be swept on a weekly basis over both years of the study. SS3 and SS4 will be the Impact sites so they will be under swept conditions during Year 1 and unswept conditions during Year 2.

2.2.4 Parameters analyzed

Parameters were selected based upon their known presence in stormwater, their potential for adverse impacts, or their value in providing necessary supporting information. Parameters and corresponding sample collection methods are listed in Table 2.

Table 2. Parameters analyzed.

Group Type	Parameter	Sample Collection Method
Conventional parameters in stormwater	Total Suspended Solids (TSS)	Auto sampler, composite
	Total Organic Carbon (TOC)	Auto sampler, composite
	Chemical Oxygen Demand (COD)	Auto sampler, composite
	Suspended Solids Concentration (SSC)/Particle Size Distribution (PSD)	Auto sampler, composite
	pH	Grab sample, field meter
	Hardness	Auto sampler, composite
Metals (total and dissolved) in stormwater	Copper	Auto sampler, composite
	Zinc	Auto sampler, composite
Nutrients in stormwater	Total Phosphorus	Auto sampler, composite
	Nitrate-Nitrite (N03-N02)	Auto sampler, composite
	Total Kjeldahl Nitrogen (TKN)	Auto sampler, composite
Organics in stormwater	Polycyclic Aromatic Hydrocarbons (PAHs)	Grab sample, direct in bottle
Bacteria in stormwater	Fecal coliform	Grab sample, direct in bottle
Stormwater flow data	Level/flow at each inlet	Level sensor and weir/data logger
Precipitation data	Local rainfall in project area	Tipping bucket rain gage/data logger

Figure 1. Monitoring site location map.

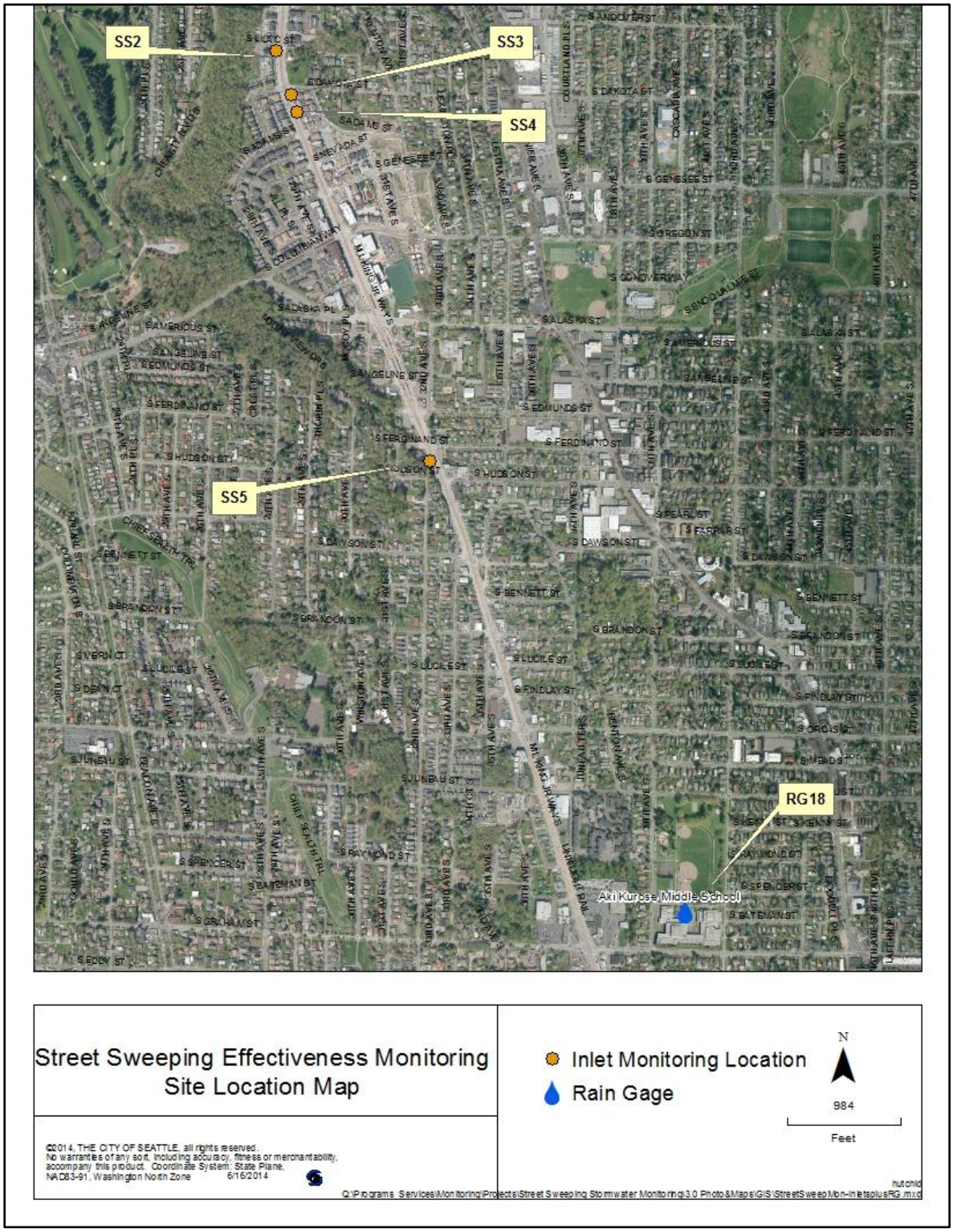
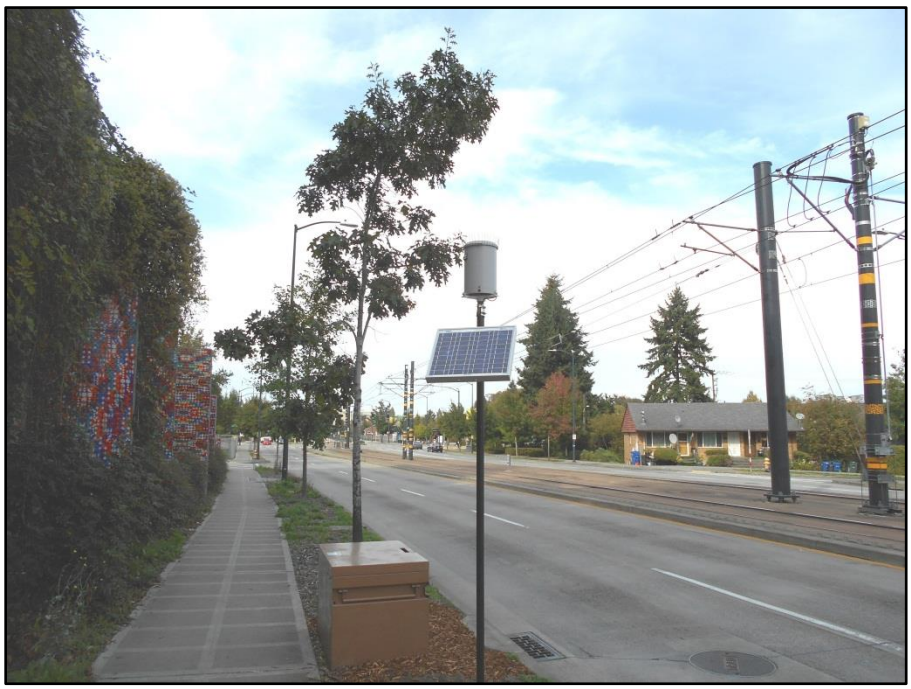


Figure 2. Photograph of monitoring station SS2 (looking south).

Figure 3. Photograph of monitoring station SS3 (looking south).

Figure 4. Photograph of monitoring station SS4 (looking south).

Figure 5. Photograph of monitoring station SS5 and project rain gage (looking north).



2.2.5 Monitoring Station Description

Each of the four monitoring stations are configured in a similar manner and consist of an aboveground metal equipment cabinet and solar panel installed in the parking strip with buried conduit connected to the adjacent storm drain inlet/catch basin structure. The one exception is there is a tipping bucket rain gage located at SS5 to measure rainfall for the localized project area. The elements of each monitoring station are shown on Figure 6 and Figure 7 and described below.

Figure 6. Monitoring station schematic detail (plan view).

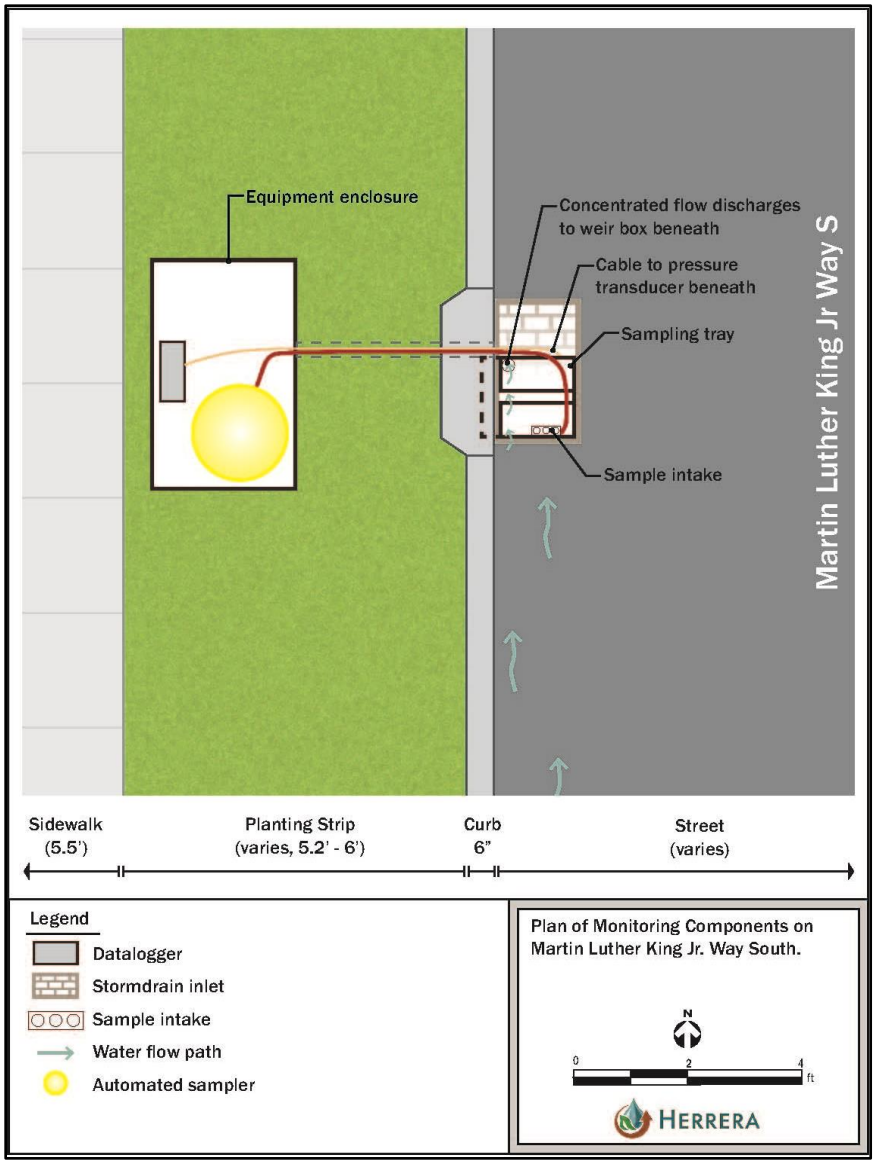
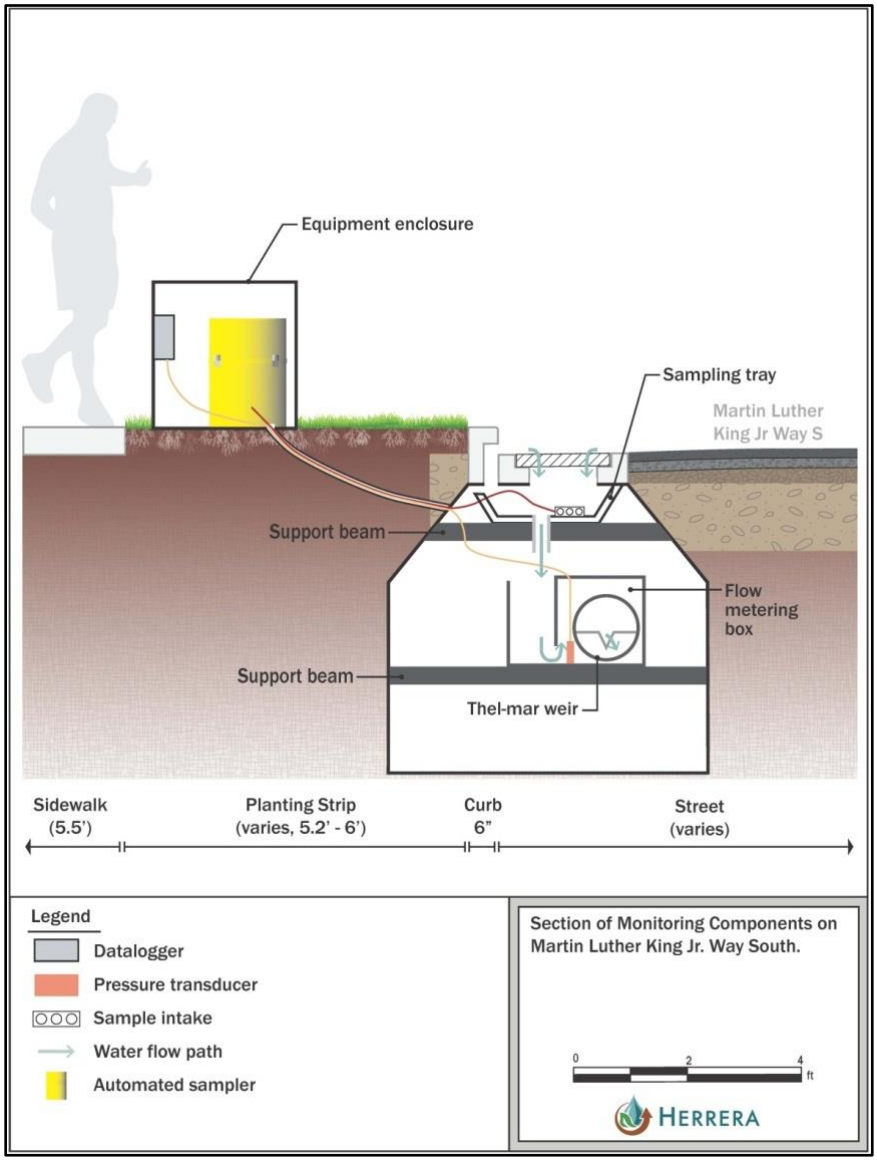


Figure 7. Monitoring station schematic detail (section view).



2.2.5.1 Flow Monitoring Equipment

Stormwater running off the roadway and entering each of the four inlets/catch basins is continuously monitored to calculate flow rate and volume. Accurate flow monitoring within catch basins is challenging since they are compact and not designed for flow monitoring. To facilitate flow monitoring, custom-made weir boxes were fabricated and installed in each monitored catch basin. A sampling tray positioned above each weir box directs all the flow entering each catch basin into the influent chamber of the weir box. An internal baffle calms the flow prior to it entering the outlet chamber where the flow exits the box through a Thel-Mar™

volumetric weir installed in the downstream wall of the outlet chamber. The weirs serve as the primary measurement devices which constrict and shape the flow, creating a relationship between hydraulic head and flow.

Figure 8. Sampling tray installed in inlet (inlet grate removed).

Figure 9. Weir box (prior to installation).

Pressure transducers (Campbell Scientific Inc. CS451-L) are installed in a stilling chamber to monitor water depth upstream of the weir in the outlet chamber.

The pressure transducers are connected to Campbell Scientific CR1000 data loggers which record water level measurements and control the automatic water sampling equipment. Loggers are programmed to record measurements every five (5) minutes. Level data are converted to flow based on an equation provided by the weir manufacturer. Each data logger is equipped with a digital cellular modem (Raven XTV) to provide remote access to flow data and adjust the pacing of the water quality sampler. Equipment is powered by rechargeable batteries augmented by solar panels. Aboveground monitoring equipment (data logger, modem, batteries and automatic samplers) are housed in Knaack Jobmaster Model 4830 storage cabinets.

2.2.5.2 Water Quality Sampling Equipment

The City purchased and is using vacuum-type automatic samplers (Manning Environmental Inc., VST3 sampler) for this project. Vacuum samplers were introduced to the market as an alternative to the more typically used (for stormwater sampling) peristaltic-pump type samplers. Vacuum samplers use an external vacuum pump to draw water samples instead of the peristaltic pumps that induce flow by compressing flexible tubing. Advantages of the vacuum pumps are reported to include higher transport velocities (5.1 feet per second [fps] at 5 feet of head for the VST3 vs. ~3 fps for the standard peristaltic pump), greater vertical lift range, larger diameter tubing options (up to 5/8-inch internal diameter), and less disruption of the water because tubing is not being squeezed. Because of these attributes, vacuum samplers are reputed to better represent the solids concentration in stormwater, especially when larger particles are present. Since getting representative solids concentrations in urban stormwater is important when quantifying the effect of street sweeping, SPU invested in this new equipment to increase the representativeness of the water quality samples.

The sampler intake strainer (perforated stainless steel sample head attached to the sample tubing) is installed in the custom-made sampling tray positioned below the inlet grate in each catch basin (see Figure 6 through Figure 8) and pump water to a 20 liter square (L) polyethylene (poly) composite bottle in the sampler base.

The data loggers (discussed in Section 2.2.5.1) are programmed to trigger the samplers every time a specified volume (referred to as the “trigger volume”) is measured at the weir at each location, creating a volume-weighted composite to generate storm event mean concentrations (EMCs). Each trigger will result in the collection of one stormwater aliquot (or subsample) collected by the sampler. Each aliquot will measure approximately 200 milliliters (mL) so the composite bottle could receive approximately 100 aliquots before filling.

Figure 10. Cabinet containing sampler (yellow) and data logger enclosure (white).

2.2.5.3 Precipitation Monitoring Equipment

A temporary, project-specific tipping bucket rain gage (Hydrological Services model TB03) is installed at monitoring station SS5 and identified as RG-SS5 (shown on Figure 5). This rain gage provides localized rain data for the four project monitoring sites and enables controlling the water sampling equipment by ending sampling activities when rainfall has ceased for a six hour period. This rain gage is maintained by Herrera Environmental Consultants (Herrera).

In addition to the temporary rain gage, SPU collects precipitation data from a network of 17 tipping bucket rain gages located throughout Seattle. Precipitation data are collected over one-minute intervals and transmitted via wireless telemetry to a centralized server. The rain gage network is operated and maintained by a combination of SPU and ADS Environmental Services, Inc. (ADS) staff.

The backup project rain gage is RG18, one of the City's 17 permanent gages, located at Aki Kurose Middle School at 3928 S. Graham Street which is located about 0.8 miles southeast of SS5 (shown on Figure 1). RG18 will be used if problems are encountered with RG-SS5.

3 SAMPLING AND MONITORING PROCEDURES

Herrera Environmental Consultants (Herrera) of Seattle, WA, under contract with the City, performed all weather tracking, flow and precipitation monitoring, and stormwater sampling activities for this project. Analytical Resources Inc. (ARI) of Tukwila, WA performed all the sampling processing and laboratory analysis.

3.1.1 Qualifying Event Criteria

This study was designed to mimic the 2011 Technology Assessment Protocol – Ecology (TAPE) procedures as much as possible with the understanding that TAPE was established to test/approve structural best management practices (BMPs) which have an inlet and outlet, have design flow rates, internal bypasses, etc.; not activities such as street sweeping. Thus, the sampling procedures and criteria followed TAPE but the future data analysis methods will not follow TAPE.

The TAPE protocol defines "representative" storms that must be monitored when ascertaining performance of structural BMPs. Storm event criteria are established to: 1) ensure that adequate flow will be discharged; 2) allow some build-up of pollutants during the dry weather intervals; and 3) ensure that the storm will be "representative" (i.e., typical for the area in terms of intensity, depth, and duration).

Collection of samples during a storm event meeting these criteria ensures that the resulting data will portray the most common conditions for each site. Ensuring a representative sample requires two considerations: 1) the storm event must be representative of typical regional rainfall, and 2) the sample collected must represent the runoff of that storm event.

Table 3 lists the qualifying storm event criteria to ensure the storm event sampled is representative.

Table 3. Qualifying storm event criteria.

Criteria	Requirements
Minimum storm depth	A minimum of 0.15 inches of precipitation over a 24-hour period
Minimum storm duration	Target storms must have a duration of at least one hour
Antecedent dry period	A period of at least 6 hours preceding the event with less than 0.04 inches of precipitation.
Post-storm dry period	A continuous 6-hour period with less than 0.04 inches of precipitation.

Table 4 lists the criteria to ensure that the composite sample collected is representative of the storm event sampled.

Table 4. Qualifying composite sample collection criteria.

Storm event duration	<24 hours	>24 hours
Minimum storm volume sampled	75 percent of the storm event hydrograph	75 percent of the hydrograph of the first 24 hours of the storm
Minimum aliquot number	At least 10 flow-weighted sub-samples (aliquots) must be collected during the duration of the event. If fewer than 10, but 7 or more aliquots are collected, then the sample will be considered valid only if all other sampling criteria have been met.	
Maximum time period for sample collection (hours)	36	

Weather and rainfall data are continuously monitored using multiple forecasting, radar and satellite sources to target storms that meet the criteria for a qualifying event, listed above.

3.1.2 Flow Monitoring Procedures

Flow monitoring equipment type and configuration per each station are described in Section 2.2.5.1. The level sensors are calibrated prior to each sampled storm event. During periods without routine stormwater sampling (e.g., summer), flow monitor maintenance visits will be performed monthly or as-needed based on remote real-time monitor checks or data reviews. Each maintenance visit includes cleaning debris out of the weir box and calibration of the level sensor.

Level, flow, and rain data are automatically downloaded daily for maintenance purposes and on an as-needed basis around storm events. Data are inspected prior to each sampled storm event for any significant trends in reliability and/or accuracy (i.e., substantial level jump, spikes, flat-line data, or missing data). If anomalies are observed, a maintenance team is sent to the monitoring site to test and troubleshoot any issues observed.

After each maintenance visit, a review of the data was completed for the preceding period between maintenance visits. Because each maintenance visit included an actual measurement of the water level, level data were corrected for level drift if the difference between the actual and measured level was greater than 0.01 ft. The adjusted level data were then used to calculate the flow using the level-flow relationship provided by the weir manufacturer.

Both raw and edited/finalized flow data are stored in the Herrera's time-series database (AQUARIUS). Only finalized data are presented in this report.

3.1.3 Stormwater Grab Sampling Procedures

Grab samples were collected by removing the inlet grate and filling bottles directly from stormwater runoff entering the catch basin structure (see Figure 11). Ideally, all grab samples were collected between the first and last volume-proportional composite sample aliquot at each site. However, if the rain/runoff ended before the field crew could be present to collect the grab sample; a makeup grab sample was collected for the missed event during another event that met the storm criteria.

Figure 11. Collecting stormwater grab samples.

3.1.4 Stormwater Composite Sampling Procedures

Volume-proportioned stormwater composite samples were collected using Manning Environmental VST3 automatic samplers. The samplers utilize a vacuum pump to draw stormwater from the strainer (a perforated stainless steel sample head affixed to the end of the sampler tube) installed in the sampling tray and distribute it to a 20 L polyethylene (poly) composite bottle in the sampler base.

The data loggers were programmed to trigger the samplers every time a specified volume (referred to as the "trigger volume") was measured passing through the weir box, creating a volume-weighted composite. The trigger volume is determined by past rainfall to runoff relationships and the predicted rainfall amount for each storm. Each trigger results in the collection of one stormwater aliquot (or subsample) collected by each sampler which deposited into the 20L composite bottle. Each aliquot is 200 mL so the composite bottle can receive 100 aliquots before becoming full.

Flows and sample collection times were monitored remotely using the telemetry systems associated with each data logger. Field crews were mobilized to each site during the event if it appeared that the composite bottle was at risk of filling, and bottles were removed and replaced as needed.

3.1.5 Precipitation Monitoring Procedures

The project rain gage was tested and calibrated before deployment. The rain gage was or will be inspected and maintained quarterly. Maintenance included: checking the levelness of the gage and re-leveling, if necessary; and cleaning of filter screens, drain holes, and siphons. Gages will be verified and calibrated semi-annually by sending a known volume of water through the gage a minimum of two times, averaging the gage's measurement and comparing the average to the known volume. If the measurement is greater than +/- 2 percent of the actual volume, the gage will be adjusted in the field until it reads within 2 percent; or replaced with another gage, with the inaccurate gage sent back to the manufacturer for calibration.

3.1.6 Sample Processing Procedures

Since stormwater samples, specifically stormwater solids concentrations and related contaminants, can be readily biased without proper processing procedures; all composite samples were composited and split in the project analytical laboratory (ARI) using 22 liter (L) polyethylene churn splitters for all events. The churn splitter keeps solids suspended and the sample mixed as the composite sample is split and deposited into analyte-specific containers.

Figure 12. Compositing/splitting samples with churn splitter.

3.1.7 Decontamination Procedures

All water quality sampling equipment was initially decontaminated with the following procedure:

1. Wash in a solution of laboratory-grade, non-phosphate soap and tap (city) water.
2. Rinse in tap water.
3. Wash in a 10 percent nitric acid/deionized water solution.
4. Rinse in deionized water.
5. Final rinse in deionized water.

Sampling and sample processing equipment was decontaminated prior to every use with the exception of sampler tubing. Following the initial wash, sampler tubing and the sampling tray was rinsed with deionized water immediately prior to each sampling event. This is consistent with Ecology's *Standard Operating Procedure for Automatic Sampling for Stormwater Monitoring – ECY002*, dated September 16, 2009.

3.1.8 Field Quality Control (QC) Sample Collection Procedures

During 2014, which included only 3 months of monitoring from October to December, a limited number of field QC samples were collected to evaluate the sampling operation and to quantify and document bias that can occur in the field since sampling began in October. QC samples provided the ability to assess the quality of the data produced by field sampling and a means for quantifying sampling bias.

The following table lists the types of QC samples collected, description of how the QC samples were collected, the purpose and information provided by each sample, and the number of QC samples collected during 2014.

Table 5. QC sample summary.

QC Sample Type	Code	Description	Purpose/Info Provided	Number Collected WY2014	Collected on
Field Equipment Blank Sample	FEB	Blank water passed through decontaminated or new equipment	Tests cleaning procedures or cleanliness of sampling and processing equipment	6	Sampler tubing (at each station) and composite bottle/splitting equipment (churn splitters)

The field equipment blanks were made by field staff passing reagent grade deionized (DI) water over or through decontaminated sample equipment and capturing the blank water in analyte-specific bottles.

The sampler tubing was not fully decontaminated but rinsed with deionized water (consistent with Ecology's *Standard Operating Procedure for Automatic Sampling for Stormwater Monitoring – ECY002*, dated September 16, 2009) prior to sample or blank collection.

A combination composite bottle and churn splitter blank was made by filling a 20L poly bottle with reagent grade DI water, letting it sit for 30 minutes and then pouring the DI water into the churn splitter. Analyte-specific bottles were filled while churning following the same process used for compositing/splitting stormwater samples.

3.2 Analytical QA/QC Procedures, Methods and Reporting Limits

3.2.1 Analytical Data QA/QC Procedures

A laboratory data package was received for each sample delivery group (SDG) including a hard copy report and electronic data deliverable (EDD). The laboratory data packages were reviewed for completeness, analytical methods, quality control issues and corrective action taken, and adherence to EDD formatting requirements.

The data in each SDG were evaluated by analytical method for reporting limits (RLs), sample preservation and holding time, blank contamination, accuracy, and precision per the measurement quality objectives (MQOs) stated in the project QAPP. A data validation report (DVR) detailing the data evaluation and summarizing data qualification flags by analytical parameter, sample, and MQO quality control check was prepared for each SDG.

Data qualifiers from the DVRs were added to the EDDs and each validated EDD was loaded into the EQuIS™ project database. In EQuIS, a final assessment of the data was performed by reviewing validator and laboratory data qualifiers (populating the interpreted qualifiers field), populating the remarks field related to the MQO quality control checks, and adding a signature indicating final approval for each sample from each SDG.

3.2.2 Analytical Methods and Reporting Limits

The following table presents the methods and reporting limits (RL) used by the project analytical laboratory (ARI). Reporting limits represent the minimum concentration of an analyte in a specific matrix that can be identified and quantified above the method detection limit and within specified limits of precision and bias during routine analytical operating conditions. Reporting limits can vary by individual samples, particularly for sediments where the quantity and dilution analyzed affect the minimum detectable value.

Table 6. Stormwater Analytes, Methods and Reporting Limits (RL)

Group Type	Parameter	Reporting Limit	Units	Lab Method
Conventional parameters	Total Suspended Solids (TSS)	1	mg/L	SM2540D
	Total Organic Carbon (TOC)	1.5	mg/L	SM 5310B
	Chemical Oxygen Demand (COD)	10	mg/L	EPA 410.4
	Modified Suspended Solids Concentration (SSC)	0.01	mg/L	ASTM D3977-97
	pH	0.2	standard units	EPA 150.2
	Hardness as CaCO3	330	µg/L CaCO3	SM2340B
Metals - total/dissolved	Copper	0.5/(0.5)	µg/L	EPA 200.8
	Zinc	4/(4)	µg/L	EPA 200.8
Nutrients	Total Phosphorus	0.008	mg/L	SM4500-PE
	Nitrate-Nitrite (N03-N02)	0.01	mg-N/L	EPA 353.2
	Total Kjeldahl Nitrogen (TKN)	1	mg-N/L	EPA 351.2
Bacteria	Fecal Coliform	1	cfu/100mL	SM9222D
Organics	Polycyclic Aromatic Hydrocarbons (PAHs)	0.1	µg/L	8270D-SIM

4 Sampling Events and Results

The following sections present a summary of storm events sampled and the stormwater analytical data for calendar year 2014.

4.1 Sampling Summary

4.1.1 Stormwater Events

Monitoring and sample collection for this project began in October 2014. Four storm events (SE) were sampled prior to the end of 2014. The events are identified as SE-01 through SE-04. The goal is to sample 12 events annually beginning in October and ending the following September. Precipitation, flow, and sample information for each event sampled in 2014 are presented in Table 7. All event criteria and goals were met without exception.

No grab samples were collected during the SE-03 event composite sample period on December 6, 2014 because rainfall ceased before a field crew could collect grabs. The grab samples designated for SE-03 were collected earlier on October 22, 2014 from an event that met all storm criteria but equipment problems resulted in no composite samples being submitted.

Table 7. Event Hydrologic Data - Storm Events (SE) 01-04

Analyte Name	Goal	SE-01	SE-02	SE-03	SE-04
RG-SS5 Precipitation Summary					
Precipitation Start		10/25/14 8:20	11/21/14 3:35	12/6/14 0:25	12/9/14 21:10
Precipitation Stop		10/25/14 19:45	11/21/14 19:10	12/6/14 6:50	12/10/14 7:50
Storm Event Duration (hrs)	NA	11.4	15.6	6.4	10.7
Event Rainfall (in)	≥ 0.15	0.38	0.66	0.22	0.41
Event Rainfall Mean (in/hr)	NA	0.03	0.04	0.03	0.04
Event Rainfall Max (in/hr)	NA	4.32	2.88	2.88	2.88
Antecedent Dry Period (hrs)	>6	10.2	26.1	13.9	10
SS2 Flow and Sampling Summary					
Event Total Flow Mean (gpm)	NA	1.4	3.3	2.3	3.8
Flow Duration (hrs)	>1	11.3	16.3	9.0	12.2
First Sample Time	NA	10/25/14 15:07	11/21/14 3:40	12/6/14 0:25	12/9/14 21:20
Last Sample Time	NA	10/25/14 19:17	11/21/14 17:32	12/6/14 4:27	12/10/14 3:37
Event Total Flow Max (gpm)	NA	21.8	20.4	23.5	22.9
No. Composite Sample Aliquots	≥ 10	10	100	12	24

Analyte Name	Goal	SE-01	SE-02	SE-03	SE-04
Event Flow Volume Sampled (%)	≥75	84.3	97.5	98.5	98.4
Sample Duration (hours)	<36	4.2	13.9	4.0	6.3
Flow Start	NA	10/25/14 8:25	11/21/14 3:40	12/6/14 0:20	12/9/14 21:10
Flow Stop	NA	10/25/14 22:10	11/21/14 20:55	12/6/14 13:10	12/10/14 12:40
Event Total Flow Volume (gal)	NA	949.3	3233.2	1223.8	2793.5
SS3 Flow and Sampling Summary					
Event Total Flow Mean (gpm)	NA	0.9	1.2	1.1	2.0
Flow Duration (hours)	>1	18.2	17.5	14.6	15.6
First Sample Time	NA	10/25/14 14:00	11/21/14 3:47	12/6/14 0:25	12/9/14 21:20
Last Sample Time	NA	10/25/14 21:57	11/21/14 18:32	12/6/14 11:27	12/10/14 7:52
Event Total Flow Max (gpm)	NA	12.1	7.7	13.0	13.2
No. Composite Sample Aliquots	≥ 10	27	84	33	39
Event Flow Volume Sampled (%)	≥75	87.4	98.5	95.1	96.9
Sample Duration (hours)	<36	8.0	14.8	11.0	10.5
Flow Start	NA	10/25/14 8:25	11/21/14 3:35	12/6/14 0:20	12/9/14 21:10
Flow Stop	NA	10/26/14 3:40	11/21/14 21:00	12/6/14 14:50	12/10/14 12:40
Event Total Flow Volume (gal)	NA	955.6	1268.3	980.0	1909.9
SS4 Flow and Sampling Summary					
Event Total Flow Mean (gpm)	NA	1.7	0.9	0.8	1.3
Flow Duration (hours)	>1	8.5	16.0	11.0	9.2
First Sample Time	NA	10/25/14 14:27	11/21/14 3:40	12/6/14 0:25	12/9/14 21:25
Last Sample Time	NA	10/25/14 19:22	11/21/14 17:17	12/6/14 12:12	12/10/14 7:42
Event Total Flow Max (gpm)	NA	13.7	3.4	7.8	5.8
No. Composite Sample Aliquots	≥ 10	36	100	36	24
Event Flow Volume Sampled (%)	≥75	87.3	95.3	98.8	99.0
Sample Duration (hours)	<36	4.9	13.6	11.8	10.3
Flow Start	NA	10/25/14 8:25	11/21/14 3:40	12/6/14 0:20	12/9/2014 21:15
Flow Stop	NA	10/25/14 21:40	11/21/2014 20:30	12/6/14 14:30	12/10/14 12:40
Event Total Flow Volume (gal)	NA	874.1	832.2	497.5	692.9
SS5 Flow and Sampling Summary					
Event Total Flow Mean (gpm)	NA	1.8	1.1	0.9	1.5
Flow Duration (hours)	>1	10.5	13.25	6.0833	15.5
First Sample Time	NA	10/25/14 8:27	11/21/14 8:05	12/6/14 0:30	12/9/14 21:25
Last Sample Time	NA	10/25/14 19:47	11/21/14 17:32	12/6/14 3:22	12/10/14 8:27
Event Total Flow Max (gpm)	NA	16.7	7.4	5.5	9.7
No. Composite Sample Aliquots	≥ 10	25	22	23	46
Event Flow Volume Sampled (%)	≥75	98.0	95.2	96.6	95.8
Sample Duration (hours)	<36	11.3	9.5	2.9	11.0

Analyte Name	Goal	SE-01	SE-02	SE-03	SE-04
Flow Start	NA	10/25/14 8:25	11/21/14 3:45	12/6/14 0:25	12/9/14 21:10
Flow Stop	NA	10/25/14 21:30	11/21/14 19:25	12/6/14 12:30	12/10/14 12:40
Event Total Flow Volume (gal)	NA	1133.2	880.4	316.8	1401.3

Appendix A presents an Individual Storm Report (ISR) for each event sampled in the 2014. The ISRs contain a hydrograph for each event which presents flow, rain, and aliquot information graphically in addition to repeating the tabular information presented above.

4.1.2 Field QC Sample Events

A limited number of QC samples were collected in 2014 as summarized in Table 5. A tubing blank was collected on each of the four automatic sampler tubes on November 5, 2014. A sampling processing blank was taken on the combination of composite bottle and churn splitter on November 17, 2014. Based the results of this sample, corrective actions were initiated by the laboratory and a second sample processing blank was taken on December 17, 2014. See Section 4.1.4 for a discussion of Field QC results.

4.1.3 Stormwater Analytical Data Summary

All stormwater sample analytical results including qualifiers collected during 2014 are presented in Table 8 to 11. The qualifiers are a combination of laboratory applied qualifiers and those applied during SPU's internal data validation.

Qualifiers are defined as follows:

U – Analyte was not detected above the reported result.
J – Analyte was positively identified and the reported resulted is an estimate.
UJ – Analyte was not detected above the reported estimate.

Since this is an interim report, and based on the design of the study, no conclusions about the effectiveness of street sweeping will be able to be made until the monitoring is completed in 2016. Thus, no sample result discussion or statistical testing is included in this report.

Table 8. Analytical Summary – SS2.

	Event ID	SE-01	SE-02	SE-03	SE-04
	Event Date	25 Oct 2014	21 Nov 2014	06 Dec 2014*	10 Dec 2014
Analyte	Units				
Conventionals					
Total Suspended Solids	mg/l	273	54.3	91	64.7
Total Organic Carbon	mg/l	13.3	13.5	18.8	15.1
Chemical Oxygen Demand	mg/l	55.8	65.6	13	47.7
pH	pH	6.6	6	6.8	7.6
Hardness	ug/l	37000	35000	37000	33000
Metals					
Copper, Dissolved	ug/l	6.3	6.8	4.3	2.8
Copper, Total	ug/l	44.4	28.7	40.7	26.2
Zinc, Dissolved	ug/l	14	15	15	11
Zinc, Total	ug/l	103	65 J	132	81
Nutrients					
Phosphorus, Total	mg/l	0.255	0.132	0.223	0.15
Nitrate + Nitrite	mg/l	0.129 J	0.171 J	0.144 J	0.083 J
Nitrogen, Total Kjeldahl	mg/l	1.3	1 U	1.2	1.1
Bacteria					
Fecal Coliform	cfu/100ml	195 J	260	88	1520
Polycylic Aromatic Hydrocarbons (PAHs)					
1-Methylnaphthalene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
2-Methylnaphthalene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Acenaphthene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Acenaphthylene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Anthracene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Benzo(A)Anthracene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Benzo(A)Pyrene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Benzo(G,H,I)Perylene	ug/l	0.1 UJ	0.1 U	0.1 U	0.1 U
Benzofluoranthenes, Total	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Chrysene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
d10-2-Methylnaphthalene	ug/l	2.15	2.19	2.07	1.91
d10-Fluoranthene	ug/l	2.56	2.27	2.84	1.81
d14-Dibenzo(a,h)anthracene	ug/l	1.79	1.68	1.95	1.49
Dibenzo(A,H)Anthracene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Dibenzofuran	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Fluoranthene	ug/l	0.1	0.1 U	0.12	0.13
Fluorene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Indeno(1,2,3-Cd)Pyrene	ug/l	0.1 UJ	0.1 U	0.1 U	0.1 U
Naphthalene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Phenanthrene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Pyrene	ug/l	0.11	0.1 U	0.12	0.2
Sediment Concentration					
Sediment Conc. > 500 um	mg/l	56.2	0.99	26.4	12.25
Sediment Conc. 500 to 250 um	mg/l	18.91	2.43	71.13	21.36
Sediment Conc. 250 to 62.5 um	mg/l	44	6.41	106.11	42.16
Sediment Conc. 62.5 to 3.9 um	mg/l	0.01 U	0.01 U	0.36	0.01 U
Sediment Conc. < 3.9 um	mg/l	65.29	36.66	65.45	50.53
Sediment Conc. Total	mg/l	184.4	46.49	269.45	126.3

Note:
* - The grab sample for SE-03 was collected on 10/22/2014, not during the SE-03 composite sample period on 12/6/2014.

Table 9. Analytical Summary – SS3.

	Event ID	SE-01	SE-02	SE-03	SE-04
	Event Date	25 Oct 2014	21 Nov 2014	06 Dec 2014	10 Dec 2014
Analyte	Units				
Conventionals					
Total Suspended Solids	mg/l	102	47.4	77	44.5
Total Organic Carbon	mg/l	10.6	12.4	7.57	7.49
Chemical Oxygen Demand	mg/l	112	59.6	11.1	23.3
pH	pH	6.8	6.9	6.7	7.4
Hardness	ug/l	45000	33000	36000	34000
Metals					
Copper, Dissolved	ug/l	5.6	5.5	4.1	3
Copper, Total	ug/l	48.1	26.5	27.7	20.4
Zinc, Dissolved	ug/l	15	17	13	11
Zinc, Total	ug/l	142	69	86	63
Nutrients					
Phosphorus, Total	mg/l	0.282	0.142	0.157	0.112
Nitrate + Nitrite	mg/l	0.076 J	0.159 J	0.159 J	0.081 J
Nitrogen, Total Kjeldahl	mg/l	1.2	1 U	1.1	1 U
Bacteria					
Fecal Coliform	cfu/100ml	445 J	1380	72	205
Polycylic Aromatic Hydrocarbons (PAHs)					
1-Methylnaphthalene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
2-Methylnaphthalene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Acenaphthene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Acenaphthylene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Anthracene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Benzo(A)Anthracene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Benzo(A)Pyrene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Benzo(G,H,I)Perylene	ug/l	0.1 UJ	0.1 U	0.1 U	0.1
Benzofluoranthenes, Total	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Chrysene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
d10-2-Methylnaphthalene	ug/l	2.19	2.38	1.95	1.66
d10-Fluoranthene	ug/l	2.7	2.63	2.73	1.68
d14-Dibenzo(a,h)anthracene	ug/l	1.74	2.23	2.09	1.03
Dibenzo(A,H)Anthracene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Dibenzofuran	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Fluoranthene	ug/l	0.1 U	0.1 U	0.1 U	0.11
Fluorene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Indeno(1,2,3-Cd)Pyrene	ug/l	0.1 UJ	0.1 U	0.1 U	0.1 U
Naphthalene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Phenanthrene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Pyrene	ug/l	0.1	0.1 U	0.1 U	0.18
Sediment Concentration					
Sediment Conc. > 500 um	mg/l	17.87	4.17	107.06	21.01
Sediment Conc. 500 to 250 um	mg/l	14.86	4.28	61.34	14.87
Sediment Conc. 250 to 62.5 um	mg/l	51.33	15.31	73.31	30.7
Sediment Conc. 62.5 to 3.9 um	mg/l	0.01 U	0.01 U	0.01 U	0.01 U
Sediment Conc. < 3.9 um	mg/l	75.98	46.65	74.73	32.66
Sediment Conc. Total	mg/l	160.04	70.41	316.44	99.24

Note
* - The grab sample for SE-03 was collected on 10/22/2014, not during the SE-03 composite sample period on 12/6/2014.

Table 10. Analytical Summary – SS4.

	Event ID	SE-01	SE-02	SE-03	SE-04
	Event Date	25 Oct 2014	21 Nov 2014	06 Dec 2014*	10 Dec 2014
Analyte	Units				
Conventionals					
Total Suspended Solids	mg/l	63.6	40.5	62.4	51.1
Total Organic Carbon	mg/l	5.77	10.2	9.58	4.79
Chemical Oxygen Demand	mg/l	69.6	40.1	12.7	10 U
pH	pH	6.8	6.7	6.7	7.5
Hardness	ug/l	32000	30000	35000	28000
Metals					
Copper, Dissolved	ug/l	3.5	4.8	3.5	2.3
Copper, Total	ug/l	30.9	21.2	22.8	13.4
Zinc, Dissolved	ug/l	10	14	11	10
Zinc, Total	ug/l	79	55	85	43
Nutrients					
Phosphorus, Total	mg/l	0.14	0.109	0.135	0.074
Nitrate + Nitrite	mg/l	0.057 J	0.121 J	0.143 J	0.052 J
Nitrogen, Total Kjeldahl	mg/l	1	1 U	1 U	1 U
Bacteria					
Fecal Coliform	cfu/100ml	110 J	160	64	135
Polycylic Aromatic Hydrocarbons (PAHs)					
1-Methylnaphthalene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
2-Methylnaphthalene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Acenaphthene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Acenaphthylene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Anthracene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Benzo(A)Anthracene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Benzo(A)Pyrene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Benzo(G,H,I)Perylene	ug/l	0.1 UJ	0.1 U	0.1 U	0.1 U
Benzofluoranthenes, Total	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Chrysene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
d10-2-Methylnaphthalene	ug/l	2.04	2.37	2.14	1.9
d10-Fluoranthene	ug/l	2.72	2.56	2.78	2.22
d14-Dibenzo(a,h)anthracene	ug/l	2.1	2.04	2.36	1.68
Dibenzo(A,H)Anthracene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Dibenzofuran	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Fluoranthene	ug/l	0.1 U	0.1 U	0.1 U	0.15
Fluorene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Indeno(1,2,3-Cd)Pyrene	ug/l	0.1 UJ	0.1 U	0.1 U	0.1 U
Naphthalene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Phenanthrene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Pyrene	ug/l	0.1 U	0.1 U	0.1 U	0.19
Sediment Concentration					
Sediment Conc. > 500 um	mg/l	15.7	1.08	78.83	7.26
Sediment Conc. 500 to 250 um	mg/l	7.38	1.84	10.45	9.21
Sediment Conc. 250 to 62.5 um	mg/l	24.66	7.14	44.4	38.16
Sediment Conc. 62.5 to 3.9 um	mg/l	0.01 U	0.01 U	0.01 U	0.01 U
Sediment Conc. < 3.9 um	mg/l	43.78	35.96	42.71	31.71
Sediment Conc. Total	mg/l	91.52	46.02	176.39	86.34

Note:
* - The grab sample for SE-03 was collected on 10/22/2014, not during the SE-03 composite sample period on 12/6/2014.

Table 11. Analytical Summary – SS5.

	Event ID	SE-01	SE-02	SE-03	SE-04
	Event Date	25 Oct 2014	21 Nov 2014	06 Dec 2014*	10 Dec 2014
Analyte	Units				
Conventionals					
Total Suspended Solids	mg/l	64.5	97.6	85.8	75
Total Organic Carbon	mg/l	8.83	12.4	19.4	14.7
Chemical Oxygen Demand	mg/l	75.7	48.9	12.7	10.5
pH	pH	6.9	6.7	6.5	7.2
Hardness	ug/l	32000	30000	31000	36000
Metals					
Copper, Dissolved	ug/l	5.1	6.5	4.2	2.7
Copper, Total	ug/l	33.5	31.2	37.7	24.3
Zinc, Dissolved	ug/l	15	29	16	12
Zinc, Total	ug/l	86	79	128	87
Nutrients					
Phosphorus, Total	mg/l	0.267	0.188	0.205	0.176
Nitrate + Nitrite	mg/l	0.121 J	0.108 J	0.114 J	0.088 J
Nitrogen, Total Kjeldahl	mg/l	1.1	1.2	1.1	1.3
Bacteria					
Fecal Coliform	cfu/100ml	260 J	80	420	260
Polycylic Aromatic Hydrocarbons (PAHs)					
1-Methylnaphthalene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
2-Methylnaphthalene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Acenaphthene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Acenaphthylene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Anthracene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Benzo(A)Anthracene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Benzo(A)Pyrene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Benzo(G,H,I)Perylene	ug/l	0.1 UJ	0.1 U	0.1 U	0.13
Benzofluoranthenes, Total	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Chrysene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
d10-2-Methylnaphthalene	ug/l	2	2.18	2.22	0.97
d10-Fluoranthene	ug/l	2.12	2.37	3.18	1.83
d14-Dibenzo(a,h)anthracene	ug/l	1.05	1.51	2.13	1.65
Dibenzo(A,H)Anthracene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Dibenzofuran	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Fluoranthene	ug/l	0.1 U	0.1 U	0.1 U	0.15
Fluorene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Indeno(1,2,3-Cd)Pyrene	ug/l	0.1 UJ	0.1 U	0.1 U	0.1 U
Naphthalene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Phenanthrene	ug/l	0.1 U	0.1 U	0.1 U	0.1 U
Pyrene	ug/l	0.12	0.1 U	0.1 U	0.22
Sediment Concentration					
Sediment Conc. > 500 um	mg/l	33.6	52.8	64	10.14
Sediment Conc. 500 to 250 um	mg/l	10.12	9.92	6.65	4.36
Sediment Conc. 250 to 62.5 um	mg/l	20.87	27.01	19.94	16.03
Sediment Conc. 62.5 to 3.9 um	mg/l	0.01 U	0.01 U	0.01 U	0.01 U
Sediment Conc. < 3.9 um	mg/l	41.58	72.58	59.82	60.89
Sediment Conc. Total	mg/l	106.17	162.31	150.41	91.42

Note:
* - The grab sample for SE-03 was collected on 10/22/2014, not during the SE-03 composite sample period on 12/6/2014.

4.1.4 Field QC Data Analytical Data Summary and Discussion

All field QC samples collected during 2014 are presented in Table 12 .

Table 12. Analytical Summary – Field QC samples.

	Sample ID	SS2_Tubing Blank	SS3_Tubing Blank	SS4_Tubing Blank	SS5_Tubing Blank	Churn_Bottle Blank	Churn_Bottle Blank
	Date	05 Nov 2014	05 Nov 2014	05 Nov 2014	05 Nov 2014	17 Dec 2014	17 Dec 2014
Analyte	Units						
Metals							
Copper, Total	ug/l	0.6	0.8	0.8	0.5	0.5 U	NA
Zinc, Total	ug/l	4 U	4 U	4 U	4 U	4 U	NA
Nutrients							
Nitrate + Nitrite	mg/l	0.01 U	0.01 U	0.01 U	0.01 U	0.04	0.01 U
Phosphorus, Total	mg/l	0.008 U	0.008 U	0.008 U	0.008 U	0.008 U	NA

NA – not analyzed.

Tubing blanks were non-detect for all analytes except for minor detections of total copper ranging from 0.5 to 0.8 micrograms per liter (µg/L). The detected range of the total copper in the associated stormwater samples was greater than ten (10) times the amount detected in the highest blank so no corrective action or sample qualification were needed.

The first composite bottle/churn splitter blank collected on November 17, 2014 was non-detect for all analytes except for 0.04 milligrams nitrogen per liter (mg-N/L) of nitrate-nitrite. Although this result was just above the reporting limit of 0.01 mg-N/L, it was within ten (10) times some of the initial stormwater sample results so correction action was required. SPU observed the nitrate-nitrite contamination during early data screening and requested that the field and laboratory staff investigate. After extensive testing, the source of contamination was determined to be a sodium hydroxide (NaOH) solution used by the lab to preserve samples immediately prior to analysis. Corrective action was taken by the lab and another composite bottle/churn splitter blank was taken on December 17, 2014 which was non-detect for nitrate-nitrite and the lab has since observed no recurrence of the contamination.

The corrective actions were put in place by December 15, 2014. Sample results within 10 times the blank concentrations and collected prior to December 15, 2014 have been qualified as discussed in the following section.

4.2 Analytical Data QA/QC Results

All analytical data presented in this report have been validated and flagged accordingly. No major QA/QC deficiencies were found. A complete QA/QC narrative report will be included in the final project report scheduled for late 2016.

Nitrate-nitrite results for stormwater samples collected using the same field collection and laboratory preservation procedures as the composite bottle/churn splitter ("Churn_Bottle") blank collected on November 17, 2014 and before corrective action was taken on December 15, 2014 were qualified based on the following criteria:

- No additional qualification was made to sample results reported as non-detect ("U-" qualified) at the method reporting limit (RL).
- Sample results reported as detected above the RL but less than the concentration of the churn bottle blank were qualified as non-detect at the reported concentration of the sample.
- Sample results reported as detected at or above the churn bottle blank concentration but less than ten (10) times the churn bottle blank concentration were qualified as estimated ("J-" qualified).
- No qualification was made to sample results reported as detected at or above ten (10) times the concentration of the churn bottle blank.

4.3 Summary of 2014 Street Sweeping Effectiveness Monitoring

During calendar year 2014, the City was successful in implementing a study to evaluate the effectiveness of street sweeping on stormwater quality. Street use permits were obtained, monitoring equipment was installed and tested, the collection of continuous flow and rain data was initiated, and four storm events were sampled and analyzed.

The City is on schedule to meet the project sampling goals and no major problems with the study design or implementation have been encountered.

Data collected during 2015 will be presented in next year's annual report, and all project data will be analyzed and the effectiveness of street sweeping will be presented in the 2016 report.

5 ACKNOWLEDGEMENTS

Stormwater sampling is very challenging environmental field work due to, among other factors: the difficulties of forecasting weather and targeting storms; operating and maintaining automatic sampling equipment continuously within elements of a drainage system; working in traffic and confined spaces at irregular hours in inclement weather, etc. Data in reports such as this are presented in a matter-of-fact style which typically does not acknowledge that sampling and laboratory personnel are constantly required to rearrange their work and personal schedules to prioritize capturing and analyzing stormwater samples.

During 2014, the project team successfully permitted and constructed the monitoring stations, initiated collection of hydrologic data and stormwater samples, and analyzed all samples received. Many dedicated scientists collaborated effectively to get this project started successfully.

The City of Seattle would like to acknowledge the dedication and hard work of the following staff:

Herrera Environmental Consultants – field sampling and monitoring staff
John Lenth (field project manager)
Dylan Ahearn (field supervisor)
Dan Bennett, Jeremy Bunn, Alex Svendsen, George Iftner (field sampling staff)

Analytical Resources, Inc. – primary project analytical laboratory
Mark Harris (project manager) and staff

Seattle Public Utilities
Doug Hutchinson (principal investigator, study manager, report author)
Jennifer Arthur (data validator)

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Appendix A: INDIVIDUAL STORM REPORTS AND EVENT HYDROGRAPHS

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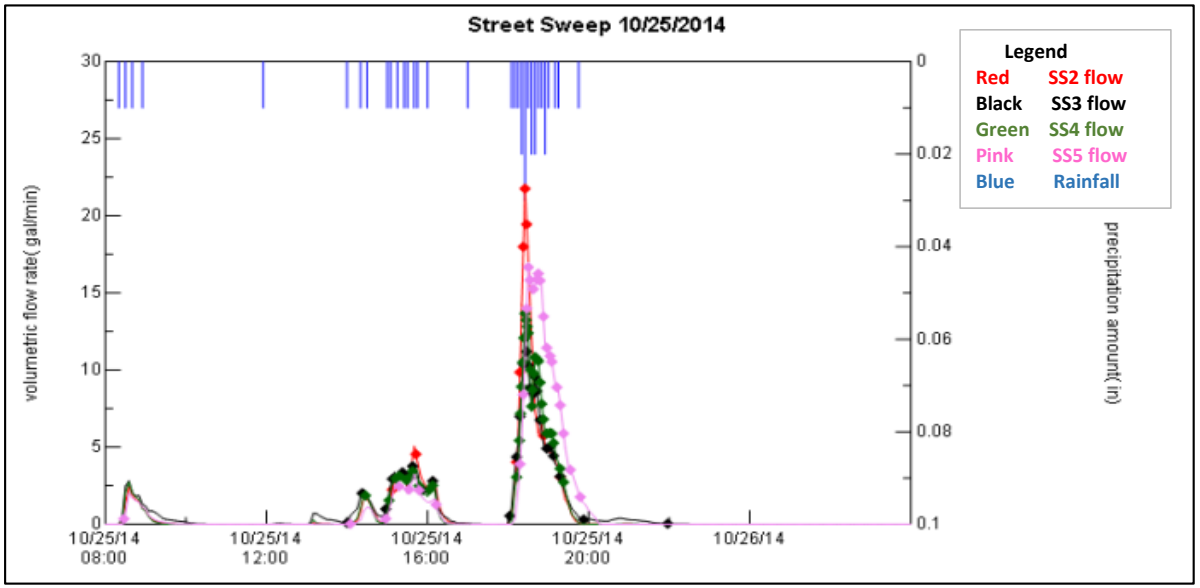
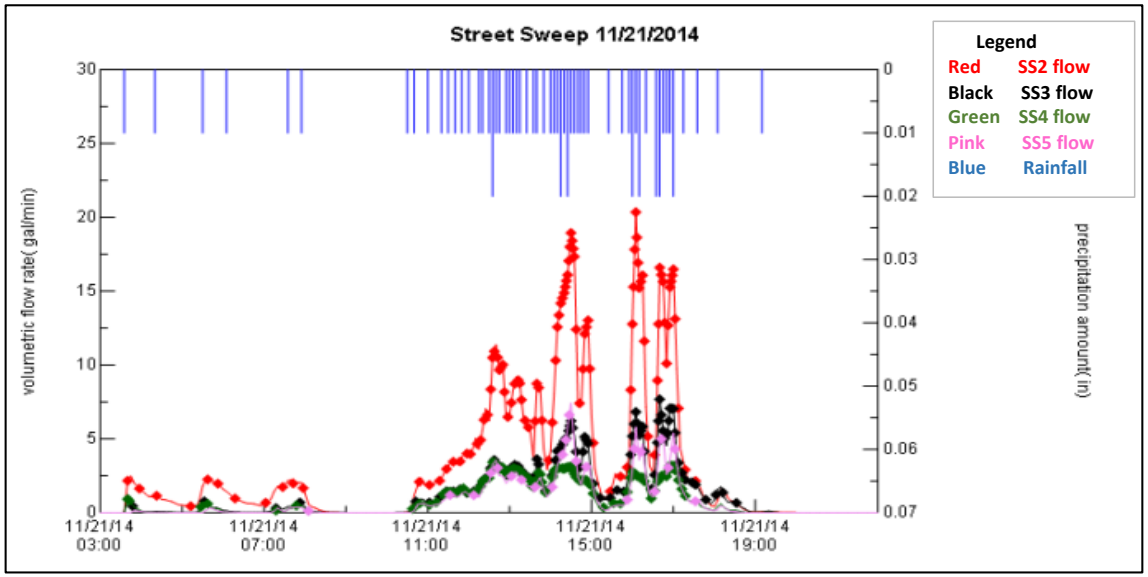
Street Sweeping Effectiveness Study
Individual Storm Report
SE-01: October 25, 2014



Flow and Sample Statistics	
Precip Start	10/25/2014 8:20
Precip Stop	10/25/2014 19:45
Storm Event Duration (hrs)	11.4
Event Rainfall (in)	0.38
Storm Event Rainfall Mean (in/hr)	0.0333
Event Rainfall Max (in/hr)	4.32
Antecedent Dry Period (hr)	10.2

Flow and Sample Statistics	SS2	SS3	SS4	SS5
Start	10/25/2014 8:25	10/25/2014 8:25	10/25/2014 8:25	10/25/2014 8:25
Stop	10/25/2014 22:10	10/26/2014 3:40	10/25/2014 21:40	10/25/2014 21:30
Flow Duration (hrs)	11.3	18.2	8.5	10.5
Event Total Flow Mean (gpm)	1.4	0.9	1.7	1.8
Event Total Flow Max (gpm)	21.8	12.1	13.7	16.7
Event Total Flow Volume (gal)	949.3	955.6	874.1	1133.2
No. Composite Sample Aliquots	10	27	36	25
First Sample Time	10/25/2014 15:07	10/25/2014 14:00	10/25/2014 14:27	10/25/2014 8:27
Last Sample Time	10/25/2014 19:17	10/25/2014 21:57	10/25/2014 19:22	10/25/2014 19:47
Sample Duration (hrs)	4.2	8.0	4.9	11.3
Event Flow Volume Sampled (%)	84.3	87.4	87.3	98.0

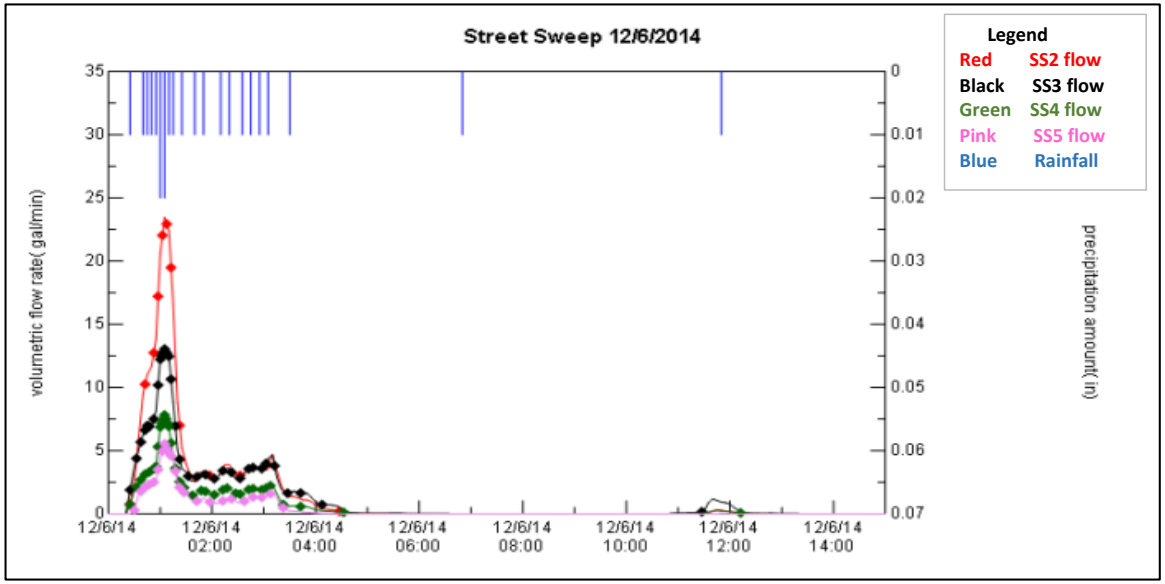
Street Sweeping Effectiveness Study
Individual Storm Report
SE-02: November 21, 2014



Flow and Sample Statistics	
Precip Start	11/21/2014 3:35
Precip Stop	11/21/2014 19:10
Storm Event Duration (hrs)	15.6
Event Rainfall (in)	0.66
Storm Event Rainfall Mean (in/hr)	0.04
Event Rainfall Max (in/hr)	2.88
Antecedent Dry Period (hr)	26.1

Flow and Sample Statistics	SS2	SS3	SS4	SS5
Start	11/21/2014 3:40	11/21/2014 3:35	11/21/2014 3:40	11/21/2014 3:45
Stop	11/21/2014 20:55	11/21/2014 21:00	11/21/2014 20:30	11/21/2014 19:25
Flow Duration (hrs)	16.3	17.5	16.0	13.3
Event Total Flow Mean (gpm)	3.3	1.2	0.9	1.1
Event Total Flow Max (gpm)	20.4	7.7	3.4	7.4
Event Total Flow Volume (gal)	3233.2	1268.3	832.2	880.4
No. Composite Sample Aliquots	100	84	100	22
First Sample Time	11/21/2014 3:40	11/21/2014 3:47	11/21/2014 3:40	11/21/2014 8:05
Last Sample Time	11/21/2014 17:32	11/21/2014 18:32	11/21/2014 17:17	11/21/2014 17:32
Sample Duration (hrs)	13.9	14.8	13.6	9.5
Event Flow Volume Sampled (%)	97.5	98.5	95.3	95.2

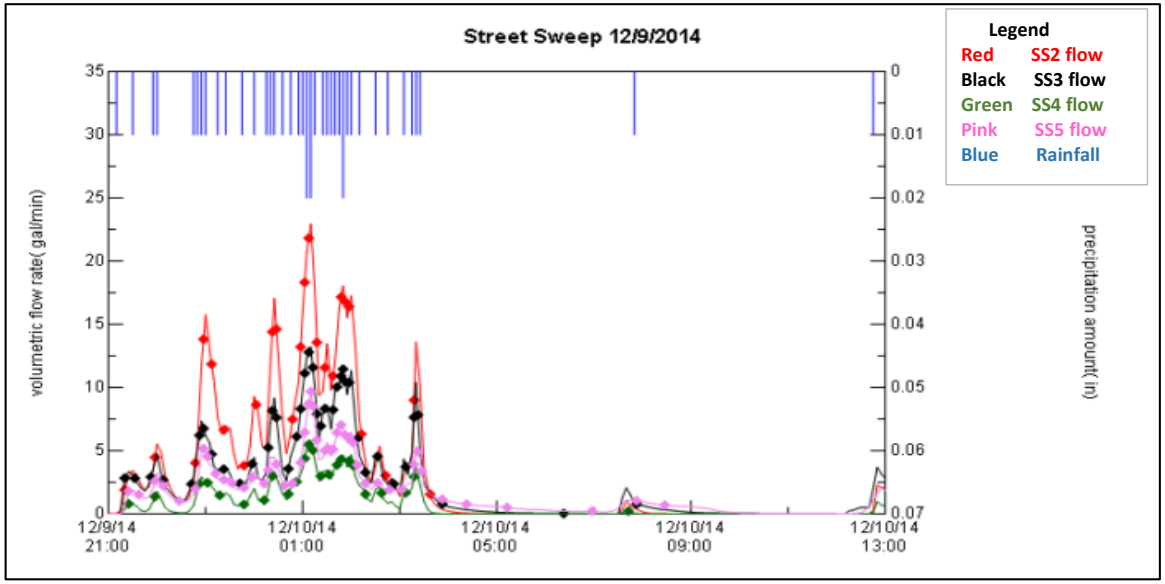
Street Sweeping Effectiveness Study
Individual Storm Report
SE-03: December 6, 2014



Flow and Sample Statistics	
Precip Start	12/6/2014 0:25
Precip Stop	12/6/2014 6:50
Storm Event Duration (hrs)	6.4
Event Rainfall (in)	0.22
Storm Event Rainfall Mean (in/hr)	0.03
Event Rainfall Max (in/hr)	2.88
Antecedent Dry Period (hr)	13.9

Flow and Sample Statistics	SS2	SS3	SS4	SS5
Start	12/6/2014 0:20	12/6/2014 0:20	12/6/2014 0:20	12/6/2014 0:25
Stop	12/6/2014 13:10	12/6/2014 14:50	12/6/2014 14:30	12/6/2014 12:30
Flow Duration (hrs)	9.0	14.6	11.0	6.1
Event Total Flow Mean (gpm)	2.3	1.1	0.8	0.9
Event Total Flow Max (gpm)	23.5	13.0	7.8	5.5
Event Total Flow Volume (gal)	1223.8	980.0	497.5	316.8
No. Composite Sample Aliquots	12	33	36	23
First Sample Time	12/6/2014 0:25	12/6/2014 0:25	12/6/2014 0:25	12/6/2014 0:30
Last Sample Time	12/6/2014 4:27	12/6/2014 11:27	12/6/2014 12:12	12/6/2014 3:22
Sample Duration (hrs)	4.0	11.0	11.8	2.9
Event Flow Volume Sampled (%)	98.5	95.1	98.8	96.6

Street Sweeping Effectiveness Study
Individual Storm Report
SE-04: December 9-10, 2014



Flow and Sample Statistics	
Precip Start	12/9/2014 21:10
Precip Stop	12/10/2014 7:50
Storm Event Duration (hrs)	10.7
Event Rainfall (in)	0.41
Storm Event Rainfall Mean (in/hr)	0.04
Event Rainfall Max (in/hr)	2.88
Antecedent Dry Period (hr)	10.0

Flow and Sample Statistics	SS2	SS3	SS4	SS5
Start	12/9/2014 21:10	12/9/2014 21:10	12/9/2014 21:15	12/9/2014 21:10
Stop	12/10/2014 12:40	12/10/2014 12:40	12/10/2014 12:40	12/10/2014 12:40
Flow Duration (hrs)	12.2	15.6	9.2	15.5
Event Total Flow Mean (gpm)	3.8	2.0	1.3	1.5
Event Total Flow Max (gpm)	22.9	13.2	5.8	9.7
Event Total Flow Volume (gal)	2793.5	1909.9	692.9	1401.3
No. Composite Sample Aliquots	24	39	24	46
First Sample Time	12/9/2014 21:20	12/9/2014 21:20	12/9/2014 21:25	12/9/2014 21:25
Last Sample Time	12/10/2014 3:37	12/10/2014 7:52	12/10/2014 7:42	12/10/2014 8:27
Sample Duration (hrs)	6.3	10.5	10.3	11.0
Event Flow Volume Sampled (%)	98.4	96.9	99.0	95.8