# 84. Effectiveness Study Interim Results and Status Report

# CITY OF SEATTLE

# NPDES PHASE I MUNICIPAL STORMWATER PERMIT

# 2015 STORMWATER MONITORING REPORT

*Street Sweeping Effectiveness Independent Study*

Prepared by
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March 8, 2016

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# 1 Introduction

## 1.1 Introduction

This document serves as the City of Seattle's (City) calendar year 2015 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. Results for the first partial calendar year (2014) where documented in an interim report titled *Effectiveness Study Interim Results and Status Report*, dated March 2, 2015, and submitted to Ecology with the other NPDES stormwater submittals in late March 2015. This report documents results collected during the first complete calendar year (2015) of monitoring. Based on the design of the study, conclusions about the effectiveness of street sweeping will not be available until all the monitoring is completed (estimated to be September 2016) and a final report covering all the results of the study will be prepared. 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 Utility (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 interim 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. The first interim report which documented results from calendar year 2014 was dated March 2, 2015 was submitted to Ecology in late March 2015.

# 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 occurred from October 2014 through July 2015 and Year 2 sampling will be targeted from October 2015 through July 2016. Sweeping was discontinued at the Impact sites late in July 2015; specifically, July 22, 2015 was the last time that the Impact sites (SS3 and SS4) were swept. This schedule provided over 2 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, etc.).
- 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 in South Seattle 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. 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 1 and 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 sampled 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.

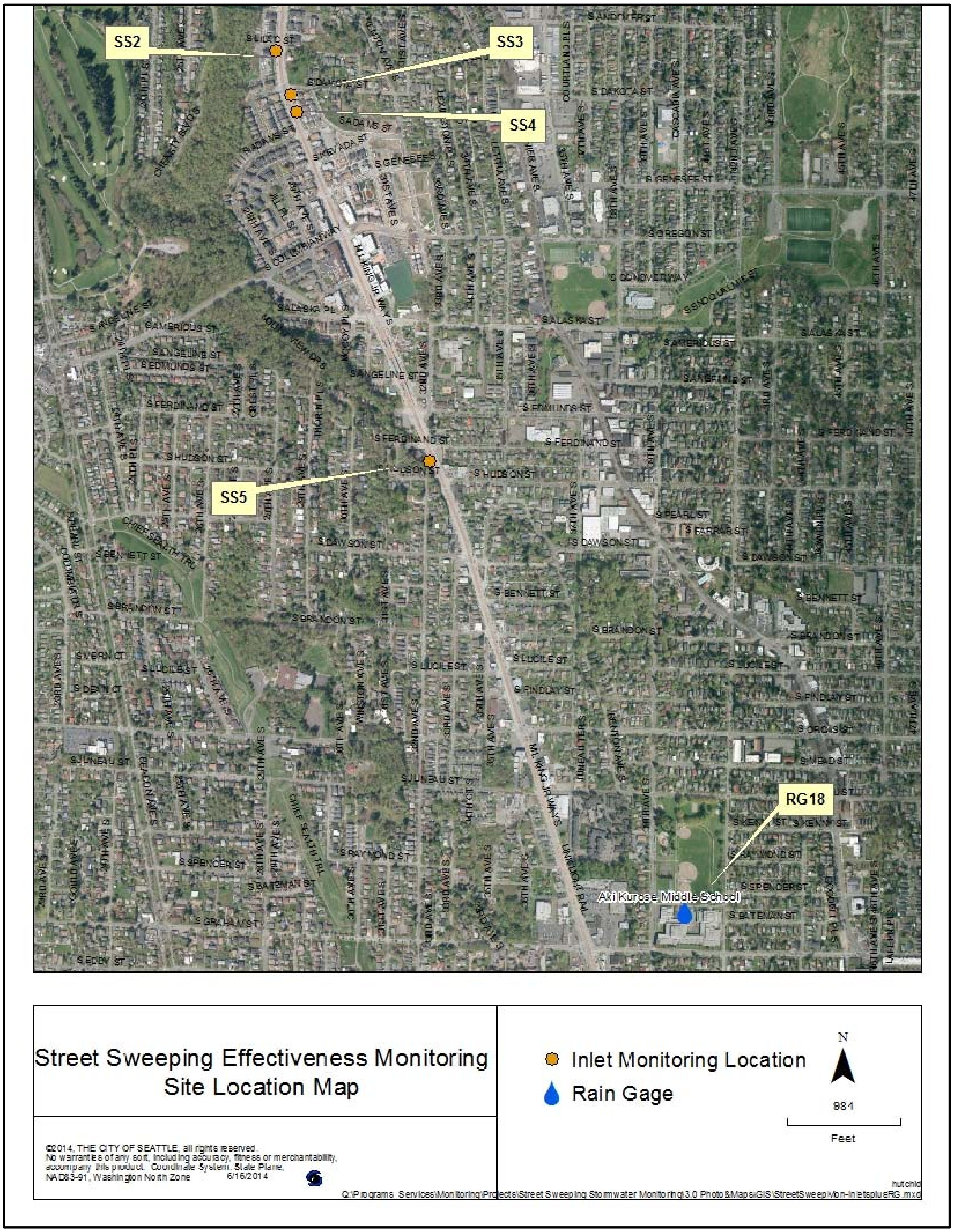
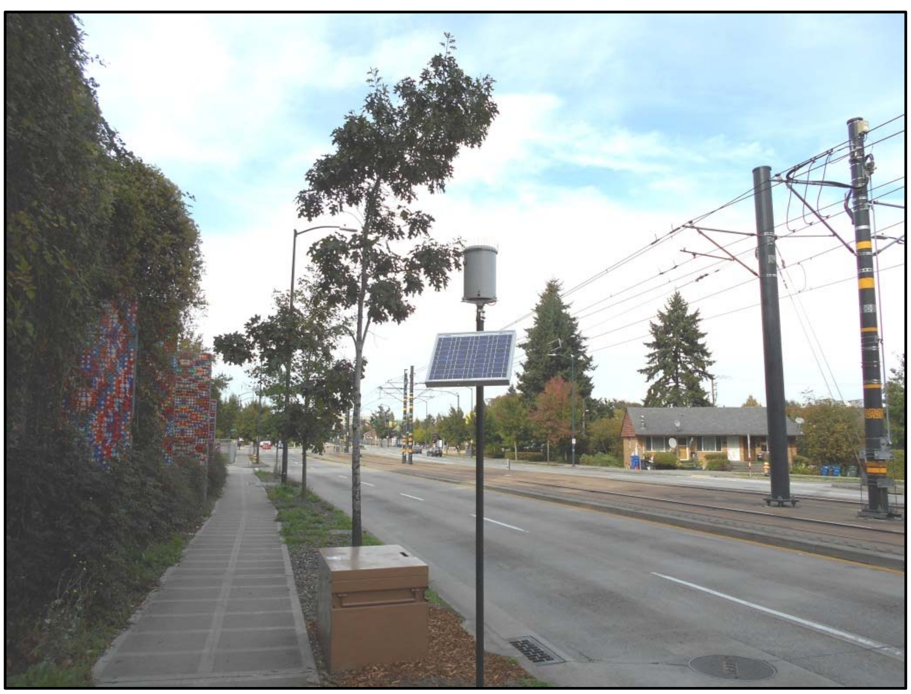


Figure 2. Photograph of monitoring station SS2 (looking south).

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).

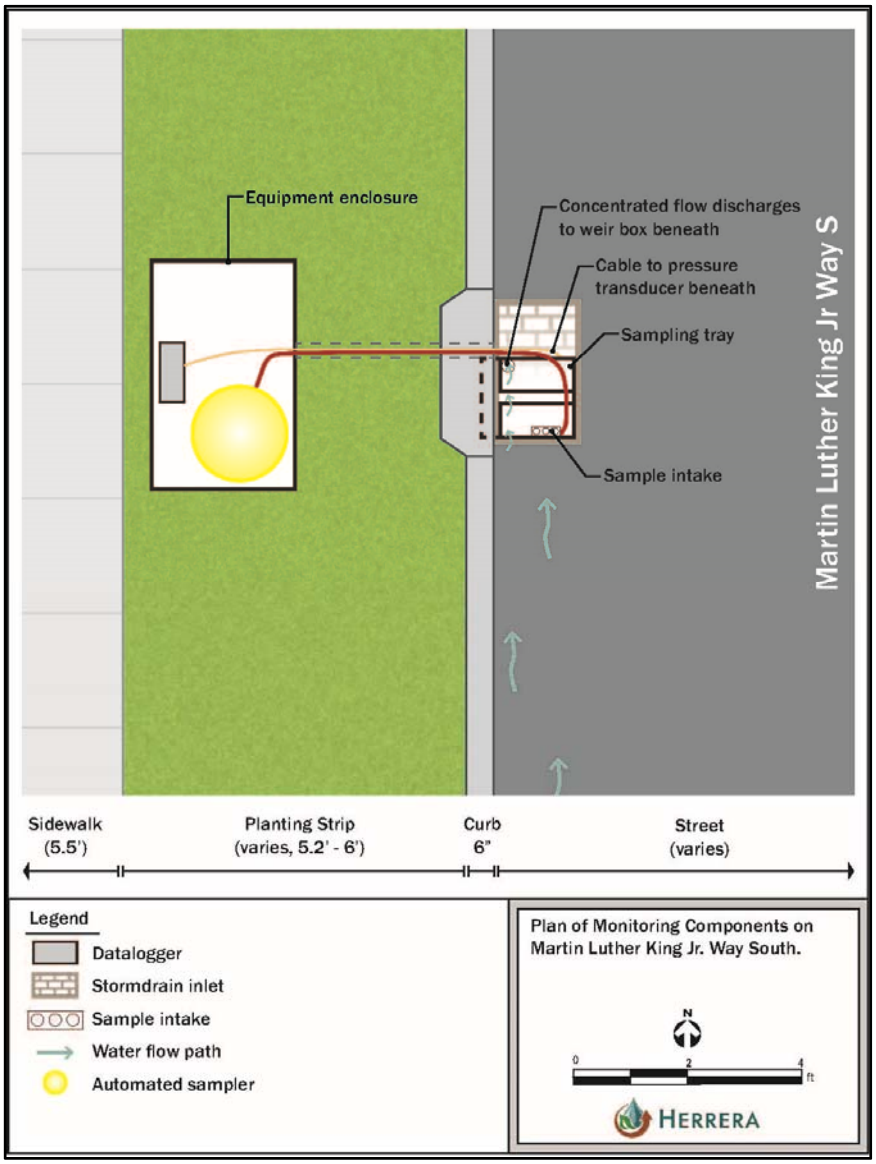
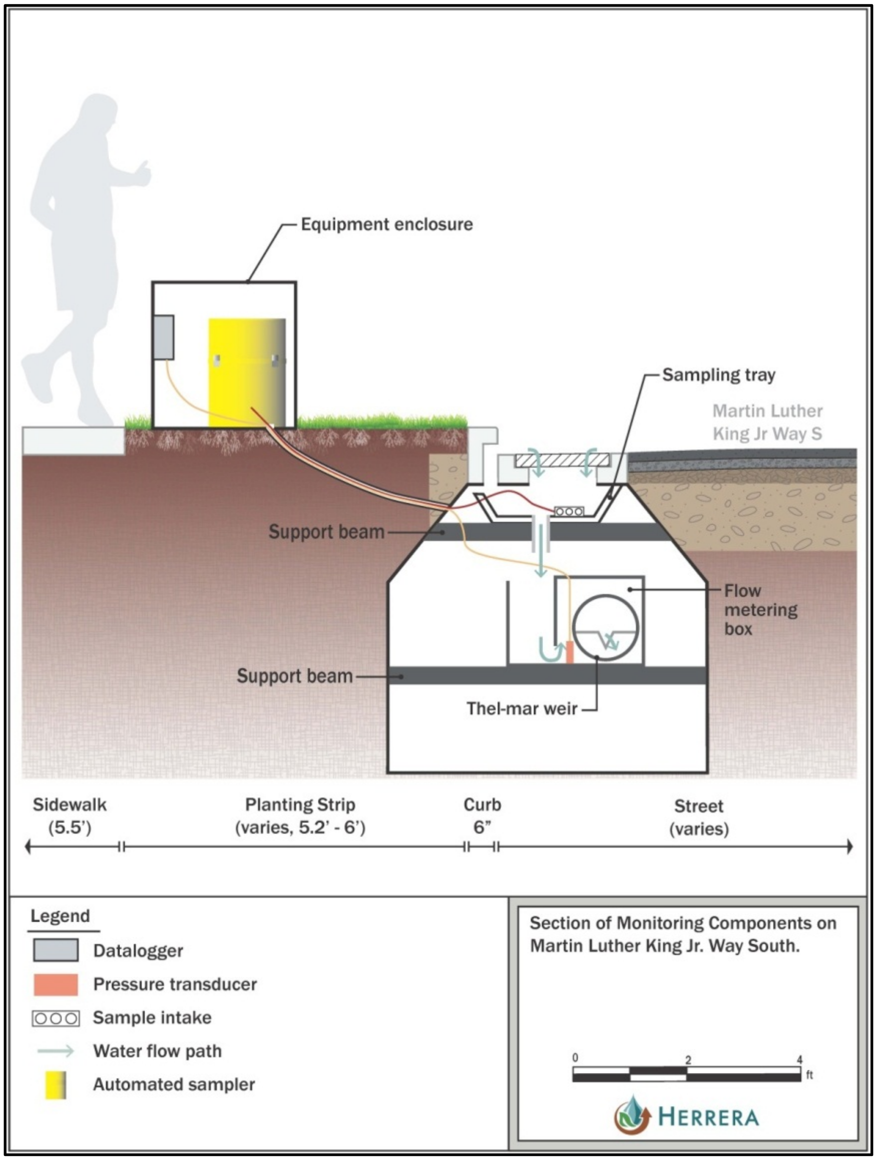


Figure 7. Monitoring station schematic detail (section view).




### 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, especially when larger particles are present such as urban stormwater runoff. 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 (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

Field QC samples are collected to evaluate the sampling operation and to quantify and document bias that can occur in the field due to sampling equipment contamination. QC samples provided the ability to assess the quality of the data produced by field sampling and a means for quantifying sampling bias. The project goal is to collect one round of field QC blanks during Year 1 and one round during Year 2. The Year 1 blanks were collected during November 2014 and documented during the previous annual report. The Year 2 blanks were initially collected during September 2015. However, due to low concentrations of some parameters detected in tubing blank samples, corrective actions were taken and a second round of tubing blanks were collected in October 2015. See Section 4.2.2 for a complete discussion of blank results and corrective actions.

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 2015.

Table 5. QC sample summary.

| QC Sample Type | Code | Description | Purpose/Info Provided | Number Collected 2015 | 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 | 9 | Sampler tubing (at each station) and composite bottle/splitting equipment (churn splitters) |
| Field Split Samples | FSS | Primary Environmental Sample (PES) split in lab by field staff | Quantify variability from laboratory procedures | 4 | Stormwater composite samples |

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 between events but rinsed with deionized (DI) 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. However, after the first round of Year 2 blanks were collected in September 2015 which contained low concentrations of some parameters, all tubing was replaced, and the samplers and new tubing was fully decontaminated with the solutions listed in Section 3.1.7. Immediately following these actions, a second round of Year 2 blanks were collected.

A combination churn splitter blank and composite bottle blank ("Churn_Bottle") was made by filling one 20L poly composite 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.

The field split samples were generated in the laboratory by field staff by filling two identical analyte-specific containers simultaneously from the churn splitter.

## 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 |
| | Copper | 0.5/(0.5) | µg/L | EPA 200.8 |

| Group Type | Parameter | Reporting Limit | Units | Lab Method |
|---|---|---|---|---|
| Metals - total/dissolved | 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 2015.

## 4.1 Sampling Summary

### 4.1.1 Stormwater Events

Monitoring and sample collection for this project began in October 2014 with four storm events (SE) sampled prior to the end of 2014. These events are identified as SE01 through SE04 and these results were presented in the previous (2014) annual report. Year 1 sampling continued from SE05 on January 15, 2015 through SE10 on July 25, 2015. Sweeping was discontinued at the Impact sites (SS3 and SS4) after the last sweeping on July 22, 2015 and no sampling was attempted for approximately 2 months to allow time street dirt accumulation and equilibration at the Impact sites between Before (Year 1) and After (Year 2) conditions.

Year 2 sampling began with SE11 on October 10, 2015 and will continue until summer 2016. This interim report presents 2015 results through the last 2015 event, SE18, on December 18, 2015 for a total of 14 events sampled in 2015.

The project 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 2015 are presented in Table 7.

Efforts were made to collect grab samples during the composite sample period, but if the rain ended before field crews could collect grabs, a makeup grab sample was collected during another event that met all storm criteria. During 2015, grabs were collected outside the composite sample period for events: SE05, SE07, SE10, SE11, and SE14. The following lists the actual dates the grabs samples were collected for these events:

SE05 – composites collected on 1/15/2015, grabs collected on 2/5/2015
SE07 - composites collected on 2/9/2015, grabs collected on 3/14/2015
SE10 – composites collected on 7/26/2014, grabs collected on 4/13/2015
SE11 – composites collected on 10/10/2015, grabs collected on 12/3/2015
SE14 – composites collected on 11/8/2015, grabs collected on 12/7/2015

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Table 7. Event Hydrologic Data - Storm Events (SE) 05-18

| Analyte Name | Goal | SE-05 | SE-06 | SE-07 | SE-08 | SE-09 | SE-10 | SE-11 | SE-12 | SE-13 | SE-14 | SE-15 | SE-16 | SE-17 | SE-18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RG-SS5 Precipitation Summary** | | | | | | | | | | | | | | | |
| Precip Start | NA | 01/15/2015 14:20 | 02/05/2015 12:55 | 02/08/2015 21:05 | 03/13/2015 23:10 | 05/13/2015 13:00 | 07/26/2015 16:50 | 10/10/2015 04:35 | 10/25/2015 16:10 | 10/30/2015 03:10 | 11/07/2015 08:45 | 11/12/2015 16:30 | 11/16/2015 23:45 | 12/01/2015 18:15 | 12/17/2015 07:55 |
| Precip Stop | NA | 01/15/2015 23:40 | 02/06/2015 14:45 | 02/09/2015 01:55 | 03/14/2015 09:00 | 05/14/2015 01:35 | 07/26/2015 18:10 | 10/10/2015 15:25 | 10/26/2015 12:20 | 11/01/2015 16:45 | 11/08/2015 11:10 | 11/15/2015 08:20 | 11/17/2015 20:00 | 12/02/2015 06:20 | 12/18/2015 06:25 |
| Storm Event Duration (hrs) | NA | 9.3 | 25.8 | 4.8 | 9.8 | 12.6 | 1.3 | 10.8 | 20.2 | 61.6 | 26.4 | 63.8 | 20.3 | 12.1 | 22.5 |
| Event Rainfall (in) | ≥ 0.15 | 0.40 | 1.20 | 0.13 | 0.70 | 0.22 | 0.10 | 0.68 | 0.40 | 1.68 | 0.58 | 3.47 | 0.58 | 0.36 | 1.09 |
| Storm Event Rainfall Mean (in/hr) | NA | 0.04 | 0.05 | 0.03 | 0.07 | 0.02 | 0.08 | 0.06 | 0.02 | 0.03 | 0.02 | 0.05 | 0.03 | 0.03 | 0.05 |
| Event Rainfall Max (in/hr) | NA | 0.12 | 0.36 | 0.24 | 0.48 | 0.12 | 0.24 | 0.48 | 0.24 | 0.48 | 0.24 | 0.72 | 0.48 | 0.12 | 0.36 |
| Antecedent Dry Period (hrs) | >6 | 100 | 4 | 23 | 64 | 14 | 902 | 62 | 164 | 31 | 118 | 39 | 9 | 179 | 31 |
| **SS2 Flow and Sampling Summary** | | | | | | | | | | | | | | | |
| Event Total Flow Mean (gpm) | NA | 2.7 | 4.2 | 2.7 | 4.1 | 1.3 | 2.7 | 5.5 | 1.6 | 3.6 | 4.2 | 8.9 | 4.4 | 2.6 | 4.6 |
| Flow Duration (hrs) | >1 | 13.2 | 27.7 | 4.0 | 16.7 | 10.2 | 2.3 | 16.8 | 17.3 | 54.0 | 29.3 | 66.9 | 23.3 | 11.7 | 28.3 |
| First Sample Time | NA | 01/15/2015 14:25 | 02/05/2015 16:10 | 02/08/2015 21:05 | 03/13/2015 23:47 | 05/13/2015 13:05 | 07/26/2015 16:52 | 10/10/2015 04:50 | 10/25/2015 16:12 | 10/30/2015 02:40 | 11/07/2015 09:02 | 11/12/2015 18:25 | 11/17/2015 02:47 | 12/01/2015 18:25 | 12/17/2015 07:50 |
| Last Sample Time | NA | 01/15/2015 23:27 | 02/06/2015 14:52 | 02/09/2015 05:27 | 03/14/2015 07:12 | 05/13/2015 21:27 | 07/26/2015 17:57 | 10/10/2015 14:17 | 10/26/2015 10:27 | 11/01/2015 19:32 | 11/08/2015 05:57 | 11/15/2015 07:32 | 11/17/2015 20:12 | 12/02/2015 02:17 | 12/18/2015 06:27 |
| Event Total Flow Max (gpm) | NA | 15.4 | 30.6 | 23.3 | 57.5 | 34.6 | 12.5 | 64.6 | 14.7 | 47.0 | 26.0 | 56.2 | 41.3 | 10.7 | 32.6 |
| No. Composite Sample Aliquots | ≥ 10 | 18 | 98 | 29 | 41 | 24 | 14 | 100 | 84 | 43 | 92 | 57 | 62 | 34 | 71 |
| Event Flow Volume Sampled (%) | ≥ 75 | 93.9 | 97.2 | 99.9 | 96.4 | 96.7 | 84.1 | 85.9 | 87.8 | 100.0 | 73.7 | 98.6 | 98.2 | 97.7 | 99.4 |
| Sample Duration (hrs) | <36 | 9.0 | 22.7 | 8.4 | 7.4 | 8.4 | 1.1 | 9.5 | 18.3 | 64.9 | 20.9 | 61.1 | 17.4 | 7.9 | 22.6 |
| Flow Start | NA | 01/15/2015 14:20 | 02/05/2015 12:50 | 02/08/2015 21:05 | 03/13/2015 23:10 | 05/13/2015 12:55 | 07/26/2015 16:50 | 10/10/2015 04:35 | 10/25/2015 16:05 | 10/30/2015 02:35 | 11/07/2015 08:40 | 11/12/2015 16:25 | 11/16/2015 23:45 | 12/01/2015 18:15 | 12/17/2015 07:50 |
| Flow Stop | NA | 01/16/2015 03:30 | 02/06/2015 16:25 | 02/09/2015 08:35 | 03/14/2015 17:00 | 05/13/2015 23:00 | 07/26/2015 19:00 | 10/10/2015 21:20 | 10/26/2015 14:25 | 11/01/2015 19:40 | 11/08/2015 13:50 | 11/15/2015 14:15 | 11/17/2015 23:10 | 12/02/2015 05:50 | 12/18/2015 12:20 |
| Event Total Flow Volume (gal) | NA | 2,163 | 7,002 | 646 | 4,126 | 803 | 371 | 5,511 | 1,700 | 11,509 | 7,446 | 35,784 | 6,198 | 1,849 | 7,762 |
| **SS3 Flow and Sampling Summary** | | | | | | | | | | | | | | | |
| Event Total Flow Mean (gpm) | NA | 1.1 | 1.1 | 0.7 | 0.6 | 0.4 | 0.8 | 2.3 | 0.5 | 1.3 | 0.6 | 1.1 | 0.9 | 0.8 | 1.7 |
| Flow Duration (hrs) | >1 | 17.5 | 32.0 | 5.8 | 15.1 | 10.3 | 2.0 | 8.8 | 16.6 | 28.8 | 29.3 | 60.9 | 18.8 | 10.1 | 22.8 |
| First Sample Time | NA | 01/15/2015 14:25 | 02/05/2015 16:05 | 02/08/2015 21:12 | 03/13/2015 23:10 | 05/13/2015 13:00 | 07/26/2015 16:52 | 10/10/2015 04:50 | 10/25/2015 16:17 | 10/30/2015 02:40 | 11/07/2015 08:42 | 11/12/2015 18:50 | 11/17/2015 02:37 | 12/01/2015 18:25 | 12/17/2015 08:00 |
| Last Sample Time | NA | 01/15/2015 23:52 | 02/06/2015 15:27 | 02/09/2015 00:32 | 03/14/2015 09:37 | 05/13/2015 21:17 | 07/26/2015 18:02 | 10/10/2015 15:12 | 10/26/2015 08:17 | 11/01/2015 15:12 | 11/08/2015 05:52 | 11/15/2015 05:07 | 11/17/2015 19:15 | 12/02/2015 00:52 | 12/18/2015 06:17 |
| Event Total Flow Max (gpm) | NA | 7.1 | 4.8 | 5.1 | 2.5 | 12.0 | 3.4 | 15.6 | 4.7 | 9.6 | 6.8 | 10.9 | 15.9 | 2.6 | 12.6 |
| No. Composite Sample Aliquots | ≥ 10 | 24 | 67 | 25 | 35 | 29 | 15 | 86 | 35 | 42 | 73 | 32 | 30 | 34 | 43 |
| Event Flow Volume Sampled (%) | ≥ 75 | 96.4 | 95.4 | 96.0 | 97.7 | 96.0 | 84.8 | 98.4 | 89.7 | 99.9 | 70.4 | 96.7 | 97.8 | 95.4 | 98.1 |
| Sample Duration (hrs) | <36 | 9.5 | 23.4 | 3.3 | 10.5 | 8.3 | 1.2 | 10.4 | 16.0 | 60.5 | 21.2 | 58.3 | 16.6 | 6.5 | 22.3 |
| Flow Start | NA | 01/15/2015 14:15 | 02/05/2015 12:50 | 02/08/2015 21:10 | 03/13/2015 23:10 | 05/13/2015 12:55 | 07/26/2015 16:50 | 10/10/2015 04:45 | 10/25/2015 16:05 | 10/30/2015 02:35 | 11/07/2015 08:40 | 11/12/2015 16:25 | 11/16/2015 23:45 | 12/01/2015 18:20 | 12/17/2015 07:50 |
| Flow Stop | NA | 01/16/2015 07:40 | 02/06/2015 20:45 | 02/09/2015 02:55 | 03/14/2015 14:10 | 05/13/2015 23:10 | 07/26/2015 18:45 | 10/10/2015 15:50 | 10/26/2015 13:35 | 11/01/2015 17:15 | 11/08/2015 13:50 | 11/15/2015 08:40 | 11/17/2015 20:55 | 12/02/2015 04:25 | 12/18/2015 07:40 |
| Event Total Flow Volume (gal) | NA | 1,196 | 2,071 | 232 | 521 | 222 | 95 | 1,216 | 503 | 2,220 | 1,010 | 3,853 | 1,026 | 499 | 2,358 |

Table 7 continued. Event Hydrologic Data - Storm Events (SE) 05-18

| Analyte Name | Goal | SE-05 | SE-06 | SE-07 | SE-08 | SE-09 | SE-10 | SE-11 | SE-12 | SE-13 | SE-14 | SE-15 | SE-16 | SE-17 | SE-18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **SS4 Flow and Sampling Summary** | | | | | | | | | | | | | | | |
| Event Total Flow Mean (gpm) | NA | 1.0 | 2.5 | 0.8 | 1.6 | 0.4 | 0.7 | 2.1 | 0.8 | 1.4 | 0.8 | 1.7 | 2.4 | 1.5 | 3.4 |
| Flow Duration (hrs) | >1 | 12.2 | 28.8 | 11.7 | 17.9 | 18.7 | 1.6 | 10.2 | 22.4 | 48.3 | 27.1 | 62.8 | 19.2 | 10.5 | 27.3 |
| First Sample Time | NA | 01/15/2015 14:25 | 02/05/2015 16:10 | 02/08/2015 21:10 | 03/13/2015 23:32 | 05/13/2015 13:00 | 07/26/2015 16:52 | 10/10/2015 04:50 | 10/25/2015 16:10 | 10/30/2015 04:07 | 11/07/2015 09:07 | 11/12/2015 18:50 | 11/17/2015 02:42 | 12/01/2015 18:22 | 12/17/2015 08:00 |
| Last Sample Time | NA | 01/15/2015 23:47 | 02/06/2015 16:57 | 02/09/2015 03:52 | 03/14/2015 10:17 | 05/14/2015 02:37 | 07/26/2015 17:52 | 10/10/2015 15:17 | 10/26/2015 08:02 | 11/01/2015 15:22 | 11/08/2015 06:40 | 11/15/2015 07:02 | 11/17/2015 20:47 | 12/02/2015 03:12 | 12/18/2015 02:12 |
| Event Total Flow Max (gpm) | NA | 4.6 | 8.8 | 7.8 | 13.3 | 14.8 | 2.1 | 14.2 | 6.0 | 15.8 | 6.6 | 12.6 | 15.3 | 5.0 | 9.8 |
| No. Composite Sample Aliquots | ≥ 10 | 30 | 79 | 33 | 81 | 49 | 9 | 81 | 51 | 76 | 98 | 52 | 79 | 61 | 100 |
| Event Flow Volume Sampled (%) | ≥ 75 | 97.1 | 93.2 | 94.4 | 98.8 | 97.2 | 80.6 | 98.7 | 88.3 | 98.4 | 75.4 | 97.8 | 98.7 | 97.7 | 90.1 |
| Sample Duration (hrs) | <36 | 9.4 | 24.8 | 6.7 | 10.8 | 13.6 | 1.0 | 10.5 | 15.9 | 59.3 | 21.5 | 60.2 | 18.1 | 8.8 | 18.2 |
| Flow Start | NA | 01/15/2015 14:20 | 02/05/2015 12:50 | 02/08/2015 21:00 | 03/13/2015 23:10 | 05/13/2015 12:55 | 07/26/2015 16:50 | 10/10/2015 04:45 | 10/25/2015 16:05 | 10/30/2015 02:35 | 11/07/2015 08:40 | 11/12/2015 16:25 | 11/17/2015 02:10 | 12/01/2015 18:15 | 12/17/2015 07:50 |
| Flow Stop | NA | 01/16/2015 02:25 | 02/06/2015 17:35 | 02/09/2015 08:35 | 03/14/2015 17:00 | 05/14/2015 07:30 | 07/26/2015 18:20 | 10/10/2015 16:20 | 10/26/2015 14:25 | 11/01/2015 18:25 | 11/08/2015 13:50 | 11/15/2015 09:05 | 11/17/2015 23:00 | 12/02/2015 04:40 | 12/18/2015 11:00 |
| Event Total Flow Volume (gal) | NA | 738 | 4,247 | 568 | 1,686 | 483 | 64 | 1,266 | 1,077 | 4,193 | 1,302 | 6,294 | 2,765 | 927 | 5,516 |
| **SS5 Flow and Sampling Summary** | | | | | | | | | | | | | | | |
| Event Total Flow Mean (gpm) | NA | 0.4 | 1.7 | 1.0 | 2.2 | 0.4 | 1.6 | 3.2 | 1.0 | 1.3 | 1.0 | 2.0 | 1.4 | 1.0 | 2.2 |
| Flow Duration (hrs) | >1 | 10.3 | 33.9 | 11.7 | 13.0 | 11.5 | 2.5 | 12.8 | 18.0 | 54.3 | 29.3 | 59.3 | 25.9 | 17.2 | 26.6 |
| First Sample Time | NA | 01/15/2015 14:30 | 02/05/2015 13:12 | 02/08/2015 21:22 | 03/13/2015 23:27 | 05/13/2015 13:05 | 07/26/2015 16:57 | 10/10/2015 04:47 | 10/25/2015 16:10 | 10/30/2015 02:45 | 11/07/2015 09:12 | 11/12/2015 18:45 | 11/17/2015 02:32 | 12/01/2015 18:25 | 12/17/2015 08:05 |
| Last Sample Time | NA | 01/15/2015 22:52 | 02/06/2015 14:12 | 02/09/2015 08:22 | 03/14/2015 08:22 | 05/13/2015 21:27 | 07/26/2015 18:07 | 10/10/2015 11:17 | 10/26/2015 11:17 | 11/01/2015 17:27 | 11/07/2015 23:22 | 11/15/2015 04:02 | 11/17/2015 21:52 | 12/02/2015 03:57 | 12/18/2015 06:22 |
| Event Total Flow Max (gpm) | NA | 1.1 | 6.8 | 6.7 | 24.2 | 7.2 | 8.1 | 28.2 | 11.8 | 19.6 | 9.3 | 15.2 | 14.1 | 6.0 | 18.4 |
| No. Composite Sample Aliquots | ≥ 10 | 9 | 82 | 84 | 17 | 16 | 16 | 100 | 34 | 54 | 20 | 16 | 64 | 69 | 69 |
| Event Flow Volume Sampled (%) | ≥ 75 | 87.8 | 91.6 | 97.8 | 95.4 | 95.0 | 87.0 | 70.4 | 95.4 | 99.0 | 69.1 | 94.0 | 99.0 | 98.5 | 98.1 |
| Sample Duration (hrs) | <36 | 8.4 | 25.0 | 11.0 | 8.9 | 8.4 | 1.2 | 6.5 | 19.1 | 62.7 | 14.2 | 57.3 | 19.3 | 9.5 | 22.3 |
| Flow Start | NA | 01/15/2015 14:20 | 02/05/2015 12:50 | 02/08/2015 21:00 | 03/13/2015 23:10 | 05/13/2015 12:55 | 07/26/2015 16:50 | 10/10/2015 04:30 | 10/25/2015 16:05 | 10/30/2015 02:40 | 11/07/2015 08:40 | 11/12/2015 16:35 | 11/16/2015 23:45 | 12/01/2015 18:10 | 12/17/2015 07:55 |
| Flow Stop | NA | 01/16/2015 01:25 | 02/06/2015 22:40 | 02/09/2015 08:35 | 03/14/2015 12:20 | 05/14/2015 00:20 | 07/26/2015 19:15 | 10/10/2015 17:50 | 10/26/2015 14:25 | 11/01/2015 20:55 | 11/08/2015 13:50 | 11/15/2015 08:45 | 11/18/2015 01:45 | 12/02/2015 12:10 | 12/18/2015 10:25 |
| Event Total Flow Volume (gal) | NA | 221 | 3,519 | 671 | 1,743 | 305 | 246 | 2,484 | 1,103 | 4,274 | 1,678 | 7,086 | 2,238 | 1,042 | 3,482 |

Appendix A presents an Individual Storm Report (ISR) for each event sampled in the 2015. 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

The QC samples collected in 2015 are summarized in Table 5. A tubing blank was collected on each of the four automatic sampler tubes, and one sampling processing blank was taken on the combination of composite bottle and churn splitter the composite bottle and churn splitter on September 9 and 18, 2015. Based the results of the September 2015 tubing blanks, corrective actions were initiated in the field and a second round of tubing blanks were taken on October 9, 2015. See Section 4.2.2 for a discussion of Field QC results.

### 4.1.3 Stormwater Analytical Data Summary

All stormwater sample analytical results including qualifiers collected during 2015 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.

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Table 8. Analytical Summary – SS2.

| Analyte | Units | SE05* | SE06 | SE07* | SE08 | SE09 | SE10* | SE11* | SE12 | SE13 | SE14* | SE15 | SE16 | SE17 | SE18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Event Date | | 15 Jan 2015 | 06 Feb 2015 | 09 Feb 2015 | 14 Mar 2015 | 13 May 2015 | 26 Jul 2015 | 10 Oct 2015 | 25 Oct 2015 | 01 Nov 2015 | 08 Nov 2015 | 15 Nov 2015 | 17 Nov 2015 | 02 Dec 2015 | 18 Dec 2015 |
| Conventionals | | | | | | | | | | | | | | | |
| Solids, Total Suspended | mg/l | 121 | 125 J | 74.2 | 81.7 J | 234 | 114 | 89.9 | 79.7 | 58.1 | 97.4 | 43.1 | 99.7 | 77.7 | 69.8 |
| Total Organic Carbon | mg/l | 19.2 | 11 | 13.8 | 9.81 | 38.1 | 47.9 | 10.8 | 18.7 | 6.95 | 8.83 | 8.19 | 13.8 | 15.9 | 8.89 |
| Chemical Oxygen Demand | mg/l | 87.8 | 66.2 J | 57.8 | 50.7 | 261 | 210 | 52.3 | 88.6 | 44.4 | 101 | 32.4 | 75.3 | 65.7 | 37.4 |
| pH | pH | 8.6 | 6.4 | 8 | 7.8 | 8 | 8 | 7.3 | 7.5 | 7.3 | 7.7 | 7.5 | 7.9 | 7.5 | 8.1 |
| Hardness | ug/l | 35000 | 37000 | 39000 | 33000 | 69000 | 54000 | 37000 | 44000 | 31000 | 48000 | 26000 | 41000 | 33000 | 32000 |
| Metals | | | | | | | | | | | | | | | |
| Copper, Dissolved | ug/l | 5 | 3.9 | 4.7 | 7.9 | 16 | 38 | 6.7 | 14 | 5 | 7 | 5 | 9.1 | 10 | 3.8 |
| Copper, Total | ug/l | 48.9 | 45.6 J | 25.5 J | 29.3 J | 114 | 109 | 31 | 55 | 31 | 45 | 22 | 52.5 | 44 | 35.8 |
| Zinc, Dissolved | ug/l | 12 | 13 | 10 | 16 | 40 | 80 | 12 | 40 | 20 | 30 | 10 | 22 | 20 | 12 |
| Zinc, Total | ug/l | 123 | 105 J | 68 J | 77 J | 390 | 280 | 110 | 170 | 80 | 150 | 70 | 133 | 130 | 91 |
| Nutrients | | | | | | | | | | | | | | | |
| Phosphorus, Total | mg/l | 0.209 | 0.267 J | 0.285 | 0.163 | 0.593 | 0.338 | 0.17 | 0.183 | 0.101 | 0.158 | 0.06 | 0.164 | 0.184 | 0.129 |
| Nitrate + Nitrite | mg/l | 0.115 J | 0.048 J | 0.176 | 0.321 | 0.679 | 0.553 | 0.379 | 0.395 | 0.101 | 0.193 | 0.091 | 0.089 | 0.184 | 0.095 |
| Nitrogen, Total Kjeldahl | mg/l | 1 U | 1.2 | 2.5 | 1.3 | 6.9 | 2.8 | 2.3 | 2.5 | 1.9 | 2.7 | 1.6 | 2.2 | 1.8 | 1.2 |
| Bacteria | | | | | | | | | | | | | | | |
| Fecal Coliform | cfu/100ml | 600 | 1900 | 600 | 18 J | 4640 | 2670 R | 68 | 6000 J | 10700 J | 200 | 15200 | 240 | 36 J | 320 |
| Polycyclic Aromatic Hydrocarbons (PAHs) | | | | | | | | | | | | | | | |
| 1-Methylnaphthalene | ug/l | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 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 | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 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 | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 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 | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 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 | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 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 | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 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 | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U |
| Benzo(G,H,I)Perylene | ug/l | 0.15 | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.18 | 0.1 U | 0.17 | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U |
| Benzofluoranthenes, Total | ug/l | 0.13 | 0.13 | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U |
| Chrysene | ug/l | 0.11 | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.14 | 0.1 U | 0.13 | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U |
| Dibenzo(A,H)Anthracene | ug/l | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 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 | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U |
| Fluoranthene | ug/l | 0.2 | 0.16 | 0.1 U | 0.1 U | 0.19 | 0.24 | 0.1 U | 0.2 | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.14 | 0.12 |
| Fluorene | ug/l | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U |
| Indeno(1,2,3-Cd)Pyrene | ug/l | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U |
| Naphthalene | ug/l | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U |
| Phenanthrene | ug/l | 0.12 | 0.1 U | 0.1 U | 0.1 U | 0.14 | 0.17 | 0.1 U | 0.16 | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.14 | 0.11 |
| Pyrene | ug/l | 0.28 | 0.17 | 0.1 U | 0.1 U | 0.2 | 0.28 | 0.13 | 0.3 | 0.1 U | 0.1 U | 0.12 | 0.1 U | 0.22 | 0.17 |
| Sediment Concentration | | | | | | | | | | | | | | | |
| Sediment Conc. > 500 um | mg/l | 23.35 | 139.79 J | 17.29 | 53.28 | 17.5 | 4.9 | 6.6 | 197.7 | 14 | 36.3 | 101.8 | 224.4 | 97.4 J | 30.7 |
| Sediment Conc. 500 to 250 um | mg/l | 27.05 | 93.47 J | 25.89 | 32.56 | 13.2 | 10 | 4.3 | 13.7 | 6.6 | 12.8 | 11.3 | 18.3 | 21.8 J | 30.2 |
| Sediment Conc. 250 to 62.5 um | mg/l | 51.25 | 92.32 J | 43.39 | 0.01 U | 51.8 | 37.3 | 26.1 | 41.7 | 21 | 27.1 | 4 | 44.6 | 25.7 J | 49.9 |
| Sediment Conc. 62.5 to 3.9 um | mg/l | 84.04 | 74.79 J | 49.8 U | 31.74 | 179.6 | 64.4 | 16.2 | 15.1 | 0.1 U | 53.1 | 19.5 | 34.9 | 21.1 J | 37.9 |
| Sediment Conc. < 3.9 um | mg/l | 29.99 | 11.18 J | 49.8 U | 5.21 | 16.1 | 5.6 | 2.9 | 30.8 | 30.4 | 9.8 | 3.3 | 5.8 | 3.4 J | 8.3 |
| Sediment Conc. Total | mg/l | 215.68 | 411.55 J | 136.57 | 122.8 | 278.1 | 122.1 | 56.3 | 299.2 | 72 | 139.1 | 139.9 | 328 | 169.3 J | 156.9 |

Note:
* - The grab sample (pH, bacteria, PAHs) for events with an asterisk next to the date were not collected during the composite sample period. See Section 4.1.1. for exact grab sample dates for these events.

Table 9. Analytical Summary – SS3.

| | Event ID | SE05* | SE06 | SE07* | SE08 | SE09 | SE10* | SE11* | SE12 | SE13 | SE14* | SE15 | SE16 | SE17 | SE18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Event Date | 15 Jan 2015 | 06 Feb 2015 | 09 Feb 2015 | 14 Mar 2015 | 13 May 2015 | 26 Jul 2015 | 10 Oct 2015 | 25 Oct 2015 | 01 Nov 2015 | 08 Nov 2015 | 15 Nov 2015 | 17 Nov 2015 | 02 Dec 2015 | 18 Dec 2015 |
| Analyte | Units | | | | | | | | | | | | | | |
| Conventionals | | | | | | | | | | | | | | | |
| Solids, Total Suspended | mg/l | 154 | 114 | 75 | 80 | 270 | 216 | 21.8 | 85.8 | 260 | 116 | 226 | 94.6 | 54 | 107 |
| Total Organic Carbon | mg/l | 28.2 | 12.3 | 10.1 | 11.6 | 49.2 | 64 | 5.01 | 16.6 | 12.2 | 14 | 7.37 | 16.6 | 12 | 10.1 |
| Chemical Oxygen Demand | mg/l | 74.1 | 51.4 | 54.3 | 114 | 325 | 274 | 23.6 | 76.2 | 78.1 | 131 | 48.1 | 76.3 | 60.3 | 50.4 |
| pH | pH | 8.4 | 6.5 | 7.9 | 7.8 | 7.8 | 8 | 7.2 | 7.2 | 7.4 | 7.7 | 7.6 | 7.9 | 7.4 | 8 |
| Hardness | ug/l | 43000 | 43000 | 38000 | 31000 | 83000 | 68000 | 20000 | 48000 | 58000 | 46000 | 32000 | 42000 | 36000 | 80000 |
| Metals | | | | | | | | | | | | | | | |
| Copper, Dissolved | ug/l | 4.1 | 3.4 | 5.3 | 4.5 | 11 | 36 | 4.9 | 9 | 3.7 | 7 | 3.5 | 5.6 | 7 | 3.1 |
| Copper, Total | ug/l | 46.5 | 41.3 | 22 | 20.1 | 129 | 133 | 14.9 | 58 | 56 | 102 | 33 | 43.7 | 33 | 64.4 |
| Zinc, Dissolved | ug/l | 8 | 9 | 10 | 13 | 30 | 90 | 13 | 30 | 12 | 20 | 8 | 18 | 20 | 10 |
| Zinc, Total | ug/l | 160 | 136 | 57 | 77 | 520 | 400 | 39 | 230 | 240 | 210 | 150 | 132 | 120 | 184 |
| Nutrients | | | | | | | | | | | | | | | |
| Phosphorus, Total | mg/l | 0.228 | 0.252 | 0.129 J | 0.998 | 0.675 | 0.493 | 0.067 | 0.254 | 0.402 | 0.276 | 0.192 | 0.269 | 0.137 | 0.95 |
| Nitrate + Nitrite | mg/l | 0.133 J | 0.046 J | 0.166 | 0.179 | 0.527 | 0.33 | 0.116 | 0.256 | 0.019 | 0.184 | 0.085 | 0.099 | 0.138 | 0.075 |
| Nitrogen, Total Kjeldahl | mg/l | 1.6 | 1.4 | 0.87 | 7.7 | 8.5 | 3.8 | 1.2 | 3.2 | 5.9 | 2.6 | 2.8 | 2.1 | 1.5 | 1.3 |
| Bacteria | | | | | | | | | | | | | | | |
| Fecal Coliform | cfu/100ml | 1200 | 15 | 1350 | 16 J | 5400 | 9000 | 600 | 2900 J | 300 J | 135 | 1020 | 260 | 24 J | 200 |
| Polycyclic Aromatic Hydrocarbons (PAHs) | | | | | | | | | | | | | | | |
| 1-Methylnaphthalene | ug/l | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 20 |
| 2-Methylnaphthalene | ug/l | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 27 |
| Acenaphthene | ug/l | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 6.8 J |
| Acenaphthylene | ug/l | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 2 |
| Anthracene | ug/l | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.76 J |
| Benzo(A)Anthracene | ug/l | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 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 | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U |
| Benzo(G,H,I)Perylene | ug/l | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 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 | 0.12 | 0.12 | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 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 | 0.1 | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.12 |
| Dibenzo(A,H)Anthracene | ug/l | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 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 | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 3.1 |
| Fluoranthene | ug/l | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.22 | 0.14 | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 1.1 |
| Fluorene | ug/l | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 4.6 |
| Indeno(1,2,3-Cd)Pyrene | ug/l | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U |
| Naphthalene | ug/l | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 2.4 |
| Phenanthrene | ug/l | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.14 | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 2.4 |
| Pyrene | ug/l | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.23 | 0.18 | 0.1 | 0.15 | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 6 |
| Sediment Concentration | | | | | | | | | | | | | | | |
| Sediment Conc. > 500 um | mg/l | 15.24 | 244.58 J | 30.86 | 26.17 | 56.7 | 19.6 | 0.7 | 261.8 | 349.9 | 627.2 | 12.9 | 608.3 | 50.3 J | 1574.2 |
| Sediment Conc. 500 to 250 um | mg/l | 13.77 | 72.56 J | 15.48 | 52.03 | 29.1 | 17.9 | 1.4 | 91.5 | 148.7 | 50.6 | 18.2 | 90 | 21.2 J | 615.4 |
| Sediment Conc. 250 to 62.5 um | mg/l | 44.68 | 106.9 J | 34.75 | 82.32 | 113.9 | 67.5 | 7 | 66.2 | 120.9 | 46.4 | 53.2 | 49.9 | 24.9 J | 205.9 |
| Sediment Conc. 62.5 to 3.9 um | mg/l | 35.39 | 142.57 J | 43.06 U | 67.06 | 218.5 | 128.5 | 0.1 U | 36 | 52.2 | 59.5 | 22.8 | 33.6 | 13.3 J | 42.5 |
| Sediment Conc. < 3.9 um | mg/l | 67.5 | 48.29 J | 43.06 U | 11.02 | 25.1 | 5.7 | 10 | 5.2 | 8.4 | 10.5 | 3.8 | 5.2 | 2 J | 9.4 |
| Sediment Conc. Total | mg/l | 176.58 | 614.9 J | 124.16 | 239.2 | 443.2 | 239.2 | 19 | 460.7 | 680 | 794.3 | 110.8 | 787 | 111.8 J | 2447.4 |

Note:
* - The grab sample (pH, bacteria, PAHs) for events with an asterisk next to the date were not collected during the composite sample period. See Section 4.1.1. for exact grab sample dates for these events.

Table 10. Analytical Summary – SS4.

| | Event ID | SE05* | SE06 | SE07* | SE08 | SE09 | SE10* | SE11* | SE12 | SE13 | SE14* | SE15 | SE16 | SE17 | SE18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Event Date | 15 Jan 2015 | 06 Feb 2015 | 09 Feb 2015 | 14 Mar 2015 | 14 May 2015 | 26 Jul 2015 | 10 Oct 2015 | 25 Oct 2015 | 01 Nov 2015 | 08 Nov 2015 | 15 Nov 2015 | 17 Nov 2015 | 02 Dec 2015 | 18 Dec 2015 |
| Analyte | Units | | | | | | | | | | | | | | |
| Conventionals | | | | | | | | | | | | | | | |
| Solids, Total Suspended | mg/l | 138 | 78.6 | 78.4 | 50.8 | 243 | 145 | 36.8 | 50.8 | 82.1 | 78.2 | 133 | 55.5 | 52.2 | 47.6 |
| Total Organic Carbon | mg/l | 21.6 | 9.02 | 9.3 | 11.1 | 41.7 | 58.8 | 5.49 | 12 | 5.88 | 8.15 | 4.84 | 13.2 | 10.6 | 5.08 |
| Chemical Oxygen Demand | mg/l | 71.1 | 69.4 J | 37.2 | 127 | 263 | 249 | 32.8 | 61.6 | 30.7 | 79 | 46.8 | 61.6 | 39.4 | 39.9 |
| pH | pH | 8.5 | 6.4 | 7.8 | 7.8 | 8.2 | 8 | 7.4 | 7.1 | 7.4 | 7.7 | 7.5 | 7.9 | 7.4 | 8 |
| Hardness | ug/l | 45000 | 36000 | 48000 | 33000 | 70000 | 57000 | 23000 | 42000 | 32000 | 40000 | 32000 | 39000 | 32000 | 28000 |
| Metals | | | | | | | | | | | | | | | |
| Copper, Dissolved | ug/l | 3.4 | 2.8 | 5.1 | 4.5 | 13 | 31 | 4.9 | 7 | 3.7 | 5.7 | 3.7 | 6.4 | 6 | 2.3 |
| Copper, Total | ug/l | 39 | 24.9 | 21.1 | 19.8 | 103 | 106 | 19.9 | 33 | 21 | 33 | 24 | 36 | 29 | 18.4 |
| Zinc, Dissolved | ug/l | 8 | 9 | 6 | 11 | 30 | 80 | 12 | 20 | 9 | 15 | 7 | 17 | 20 | 9 |
| Zinc, Total | ug/l | 137 | 71 | 55 | 75 | 390 | 260 | 53 | 110 | 70 | 120 | 180 | 107 | 100 | 62 |
| Nutrients | | | | | | | | | | | | | | | |
| Phosphorus, Total | mg/l | 0.224 | 0.189 | 0.126 | 1.3 | 0.495 | 0.34 | 0.068 | 0.167 | 0.106 | 0.226 | 0.095 J | 0.161 | 0.164 | 0.102 |
| Nitrate + Nitrite | mg/l | 0.104 | 0.05 | 0.163 | 0.17 | 0.422 | 0.266 | 0.112 | 0.252 | 0.035 | 0.148 | 0.086 | 0.075 | 0.117 | 0.05 |
| Nitrogen, Total Kjeldahl | mg/l | 1.4 | 1 | 0.94 | 9.6 | 4.6 | 3.3 | 1.5 | 2.1 | 1.8 | 1.8 | 1.2 | 2 | 1.5 | 0.87 |
| Bacteria | | | | | | | | | | | | | | | |
| Fecal Coliform | cfu/100ml | 880 | 15 | 20000 R | 8 J | 17400 | 580000 | 180 | 1150 J | 975 J | 225 | 1220 | 185 | 76 J | 80 |
| Polycyclic Aromatic Hydrocarbons (PAHs) | | | | | | | | | | | | | | | |
| 1-Methylnaphthalene | ug/l | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 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 | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 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 | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 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 | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 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 | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 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 | 0.1 U | 0.1 UJ | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 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 | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U |
| Benzo(G,H,I)Perylene | ug/l | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 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 | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 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 | 0.1 U | 0.1 UJ | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U |
| Dibenzo(A,H)Anthracene | ug/l | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 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 | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U |
| Fluoranthene | ug/l | 0.1 U | 0.11 | 0.1 U | 0.1 U | 0.1 U | 0.1 UJ | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U |
| Fluorene | ug/l | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U |
| Indeno(1,2,3-Cd)Pyrene | ug/l | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U |
| Naphthalene | ug/l | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 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 | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.12 | 0.1 U |
| Pyrene | ug/l | 0.1 U | 0.14 | 0.1 U | 0.1 U | 0.12 | 0.1 UJ | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.16 | 0.12 |
| Sediment Concentration | | | | | | | | | | | | | | | |
| Sediment Conc. > 500 um | mg/l | 185.37 | 55.97 J | 24.13 | 135.62 | 18.1 | 8.5 | 9.6 | 462.5 | 70.4 | 274.8 | 71.2 | 47.2 | 33.8 J | 375.1 |
| Sediment Conc. 500 to 250 um | mg/l | 93.9 | 43.17 J | 6.16 | 37.73 | 11.4 | 10.5 | 2.4 | 42.3 | 15.5 | 36.2 | 8.1 | 25.3 | 8.7 J | 31.9 |
| Sediment Conc. 250 to 62.5 um | mg/l | 70.74 | 45.07 J | 31.97 | 22.99 | 65.3 | 37.1 | 12.5 | 28.2 | 32.1 | 27.4 | 17.9 | 40.1 | 19.3 J | 30.1 |
| Sediment Conc. 62.5 to 3.9 um | mg/l | 17.86 | 50.58 J | 42.9 U | 26.23 | 164.8 | 76.8 | 12.5 | 23.3 | 22.3 | 39.9 | 19.7 | 24.6 | 13.6 J | 19.7 |
| Sediment Conc. < 3.9 um | mg/l | 65.21 | 10.8 J | 42.9 U | 4.63 | 17.2 | 4.2 | 3.3 | 6.2 | 5 | 6.8 | 3 | 4.1 | 2.8 J | 4.5 |
| Sediment Conc. Total | mg/l | 433.08 | 205.59 J | 105.16 | 227.2 | 276.8 | 137.1 | 40.3 | 562.5 | 145.3 | 385.2 | 119.9 | 141.3 | 78.2 J | 461.3 |

Note:

* - The grab sample (pH, bacteria, PAHs) for events with an asterisk next to the date were not collected during the composite sample period. See Section 4.1.1. for exact grab sample dates for these events.

Table 11. Analytical Summary – SS5.

| Analyte | Units | SE05* | SE06 | SE07* | SE08 | SE09 | SE10* | SE11* | SE12 | SE13 | SE14* | SE15 | SE16 | SE17 | SE18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Event Date | 15 Jan 2015 | 06 Feb 2015 | 09 Feb 2015 | 14 Mar 2015 | 13 May 2015 | 26 Jul 2015 | 10 Oct 2015 | 25 Oct 2015 | 01 Nov 2015 | 07 Nov 2015 | 15 Nov 2015 | 17 Nov 2015 | 02 Dec 2015 | 18 Dec 2015 |
| Conventionals | | | | | | | | | | | | | | | |
| Solids, Total Suspended | mg/l | 216 | 75 | 61.1 | 49.5 | 290 | 163 | 22.4 | 71.8 | 50 | 124 J | 59 | 125 | 68.8 | 102 |
| Total Organic Carbon | mg/l | 49 | 10.4 J | 11.1 | 6.1 | 48.6 | 55.1 | 4.97 | 14.4 | 15.5 | 24.3 | 17.2 | 24.6 | 16.6 | 22.8 |
| Chemical Oxygen Demand | mg/l | 158 | 61.4 | 45.6 | 35.8 | 314 | 219 | 32.2 | 83.8 J | 73.4 | 104 J | 62.6 | 93 | 63.9 | 80.4 |
| pH | pH | 8.5 | 6.5 | 8 | 7.9 | 8 | 8 | 7.4 | 7.1 | 7.3 | 7.7 | 7.5 | 7.9 | 7.4 | 8.1 |
| Hardness | ug/l | 57000 | 35000 | 52000 | 24000 | 73000 | 54000 | 20000 | 37000 | 39000 | 40000 | 30000 | 43000 | 32000 | 32000 |
| Metals | | | | | | | | | | | | | | | |
| Copper, Dissolved | ug/l | 12.3 | 4 | 5.6 | 5 | 16 | 39 | 5.6 | 10 | 6 | 8 | 7 | 11 | 10 | 3.7 |
| Copper, Total | ug/l | 75 | 34.5 | 24 | 24.3 | 119 | 125 | 17.3 | 44 | 35 | 49 | 33 | 49.3 | 41 | 33.3 |
| Zinc, Dissolved | ug/l | 21 | 9 | 8 | 11 | 50 | 80 | 13 | 30 | 20 | 30 | 20 | 24 | 20 | 14 |
| Zinc, Total | ug/l | 239 | 92 | 65 J | 72 | 420 | 360 | 41 | 130 | 110 | 180 | 130 | 127 | 130 | 108 |
| Nutrients | | | | | | | | | | | | | | | |
| Phosphorus, Total | mg/l | 0.441 | 0.183 | 0.199 | 0.166 | 0.56 | 0.409 | 0.104 | 0.627 | 0.439 | 0.262 | 0.191 | 0.262 | 0.199 | 0.934 |
| Nitrate + Nitrite | mg/l | 0.411 | 0.047 J | 0.212 | 0.132 | 0.553 | 0.554 | 0.128 | 0.287 | 0.071 | 0.294 | 0.093 | 0.079 | 0.168 | 0.082 |
| Nitrogen, Total Kjeldahl | mg/l | 3.1 | 1.3 | 1.3 | 0.97 | 6.8 | 3.6 | 1.3 | 4.7 | 2.7 | 3 | 2.1 | 2.8 | 1.8 | 9.4 J |
| Bacteria | | | | | | | | | | | | | | | |
| Fecal Coliform | cfu/100ml | 80 | 25 | 3500 | 84 J | 2240 J | 210 | 587 | 1700 J | 1020 J | 1180 | 500 | 190 | 40 J | 280 |
| Polycyclic Aromatic Hydrocarbons (PAHs) | | | | | | | | | | | | | | | |
| 1-Methylnaphthalene | ug/l | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 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 | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 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 | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 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 | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 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 | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 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 | 0.1 U | 0.1 U | 0.1 UJ | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 UJ |
| Benzo(A)Pyrene | ug/l | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U |
| Benzo(G,H,I)Perylene | ug/l | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.15 | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 UJ |
| Benzofluoranthenes, Total | ug/l | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.15 | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 UJ |
| Chrysene | ug/l | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.12 | 0.1 UJ | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 UJ |
| Dibenzo(A,H)Anthracene | ug/l | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 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 | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U |
| Fluoranthene | ug/l | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.26 | 0.1 J | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 J |
| Fluorene | ug/l | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U |
| Indeno(1,2,3-Cd)Pyrene | ug/l | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 UJ | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 UJ |
| Naphthalene | ug/l | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 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 | 0.1 U | 0.1 U | 0.11 | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.1 U |
| Pyrene | ug/l | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.14 | 0.25 | 0.17 J | 0.1 U | 0.1 U | 0.11 | 0.1 U | 0.1 U | 0.12 | 0.18 J |
| Sediment Concentration | | | | | | | | | | | | | | | |
| Sediment Conc. > 500 um | mg/l | 15.33 | 9.02 J | 21.51 | 29.6 | 10.3 | 6.5 | 0.7 J | 103.4 | 127.1 | 133.4 | 45 | 72.7 | 53.8 J | 90.7 |
| Sediment Conc. 500 to 250 um | mg/l | 12.56 | 3.36 J | 14.37 | 22.5 | 6.9 | 12.2 | 0.5 J | 28.5 | 11.9 | 21 | 9 | 19.7 | 8.9 J | 56.5 |
| Sediment Conc. 250 to 62.5 um | mg/l | 37.14 | 19.3 J | 29.48 | 30.8 | 23.4 | 42.5 | 5.7 | 25.1 | 26 | 43.8 | 25.2 | 33.1 | 22.8 J | 47.3 |
| Sediment Conc. 62.5 to 3.9 um | mg/l | 136.3 | 62.57 J | 44.93 U | 23.7 | 144.7 | 101.9 | 0.1 U | 23 | 35.8 | 52.5 | 45.1 | 35 | 14.1 J | 43.5 |
| Sediment Conc. < 3.9 um | mg/l | 58.75 | 12.82 J | 44.93 U | 4.2 | 11.8 | 7.6 | 14.6 | 4.2 | 6 | 8.5 | 5.4 | 3.9 | 2.4 J | 8.3 |
| Sediment Conc. Total | mg/l | 260.11 | 107.07 J | 110.29 | 110.9 | 197.1 | 170.7 | 21.5 | 184.1 | 206.9 | 259.2 | 129.7 | 164.4 | 102 J | 246.3 |

Note:
* - The grab sample (pH, bacteria, PAHs) for events with an asterisk next to the date were not collected during the composite sample period. See Section 4.1.1. for exact grab sample dates for these events.

## 4.2 Analytical Data QA/QC Results

### 4.2.1 Laboratory Data QA/QC Data Summary and Discussion

This section summarizes the quality of the analytical data for all sample delivery groups including general conditions of the data, any systematic problems, and data qualifications based on data validation of the laboratory-provided QC samples.

All analytical data presented in this report have been validated and flagged accordingly. No major QA/QC deficiencies were found. Two (2) of a total of 2,072 primary sample results were qualified as rejected (R) for a total completeness of 99.9 percent, which exceeded the project goal of 90 percent. Analytical methods and reporting limits were per project specifications and consistent among data sets. Data qualifications by project data quality indicators by analyte are provided below. A complete, detailed QA/QC narrative report will be included in the final project report scheduled for late 2016.

#### *4.2.1.1 Sample Preservation/Holding Time*

- *Fecal Coliform*. Sixteen (16) primary sample results for Fecal Coliform bacteria for samples SS2-03152015-G, SS3-03152015-G, SS4-03152015-G, SS5-03152015-G, SS2-102515-G, SS3-102515-G, SS4-102515-G, SS5-102515-G, SS2-103115-G, SS3-103115-G, SS4-103115-G, SS5-103115-G, SS2-120115-G, SS3-120115-G, SS4-120115-G, and SS5-120115-G were qualified as estimated (UJ/J) due to exceedance of the method required holding time.

- *Suspended Sediment Concentration ("Sediment Concentration")*. Twenty-four (24) primary sample results for Sediment Concentration, including size fractions > 500 um, 500 to 250 um, 250 to 62.5 um, 62.5 to 3.9 um, < 3.9 um, and Total for samples SS2-120215-C, SS3-120215-C, SS4-120215-C, and SS5-120215-C were qualified as estimated (UJ/J) due to exceedance of the method required holding time.

#### *4.2.1.2 Laboratory Blanks*

- *Total Phosphorus*. One primary sample result for Total Phosphorus for sample SS4-111515-C was qualified as estimated (J) on the basis of laboratory blank contamination.

#### *4.2.1.3 Accuracy*

- *Polycyclic Aromatic Hydrocarbons (PAHs).*

  - Eight primary sample results for PAHs for Indeno(1,2,3-cd)pyrene and Benzo(g,h,i)perylene for samples SS2-102514-G, SS3-102514-G, SS4-102514-G, and SS5-102514-G were qualified as estimated (UJ/J) due to laboratory continuing calibration verification standards outside laboratory control limits.

  - Four primary sample results for Fluoranthene, Pyrene, Benzo(a)anthracene, and Chrysene for sample SS4-04132015-G were qualified as estimated (UJ/J) due to low surrogate recoveries.

  - Seven primary sample results for Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Indeno(1,2,3-cd)pyrene, Benzo(g,h,i)perylene, and Total Benzofluoranthenes for sample SS5-121715-G were qualified as estimated (UJ/J) due to low matrix spike/matrix spike duplicate recoveries.

  - Five primary sample results for Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, and Indeno(1,2,3-cd)pyrene for sample SS5-120315-G were qualified as estimated (UJ/J) due to low matrix spike/matrix spike duplicate recoveries.

- *Chemical Oxygen Demand (COD).* Three primary sample results for COD for samples SS2-020615-C, SS5-102515-C and SS5-110715-C were qualified as estimated (UJ/J) due to low matrix spike recoveries.

- *Total Metals*. One primary sample result for Total Zn for sample SS2-020615-C was qualified as estimated (UJ/J) due to low matrix spike recovery.

#### *4.2.1.4 Precision*

- *Total Metals.* Two primary sample results for Total Zn for samples SS2-112114-C and SS5-020915-C were qualified as estimated (UJ/J) due to laboratory duplicate precision.

- *Total Suspended Solids (TSS).* Two primary sample results for TSS for samples SS2-03142015-C and SS5-110715-C were qualified as estimated (UJ/J) due to laboratory duplicate precision.

- *Fecal Coliform.* One primary sample result for Fecal Coliform bacteria for sample SS5-051315-G was qualified as estimated (UJ/J) due to laboratory duplicate precision.

- *Suspended Sediment Concentration ("Sediment Concentration").* Two sample results for Sediment Concentration for sample SS5-101015-C, including size fractions > 500 um and 500 to 250 um, were qualified as estimated (UJ/J) due to laboratory duplicate precision.

- *Total Kjeldahl Nitrogen (TKN).* One primary sample result for TKN for sample SS5-121815-C was qualified as estimated (UJ/J) due to laboratory duplicate precision.

##### *4.2.1.5 Compound Quantitation and Reporting Limits*

- *Fecal Coliform.* Fecal coliform results for two samples were qualified as rejected (R) due to an inability of the laboratory to quantify fecal coliform bacteria in the analysis for samples SS4-03142015-G and SS2-04132015-G.

- *PAHs.* Two primary sample results for PAHs for Acenaphthene and Anthracene for sample SS3-121715-G were qualified as estimated (J) because the sample results for these analytes in both sample and sample dilution were identified by the laboratory but exhibited poor spectral match.

### 4.2.2 Field QC Data Analytical Data Summary and Discussion

The following subsections discuss the results of the field-generated quality control samples.

#### *4.2.2.1 Field Blank Results*

All field QC samples collected during 2015 are presented in Table 12a and Table 13b. Year 2 tubing and bottle/churn blanks were initially collected on September 9 and 18, 2015. These blanks are the first round of field equipment blanks collected during Year 2.

Table 12a. Analytical Summary – Field QC samples (Year 2 - Round 1)

| | Sample ID | SS2_Tubing Blank | SS3_Tubing Blank | SS4_Tubing Blank | SS5_Tubing Blank | Churn_Bottle Blank |
|---|---|---|---|---|---|---|
| | Date | 09 Sep 2015 | 18 Sep 2015 | 09 Sep 2015 | 09 Sep 2015 | 09 Sep 2015 |
| Analyte | Units | | | | | |
| Metals | | | | | | |
| Copper, Total | ug/l | 3.5 | 0.7 | 1.7 | 0.5 U | 1.1 |
| Zinc, Total | ug/l | 8 | 4 U | 4 U | 4 U | 4 U |
| Nutrients | | | | | | |
| Nitrate + Nitrite | mg/l | 0.017 | 0.014 | 0.01 U | 0.011 | 0.01 U |
| Phosphorus, Total | mg/l | 0.013 | 0.014 | 0.012 | 0.008 U | 0.008 U |

Several parameters were detected at low concentrations in all September tubing blanks as discussed below, which resulted in corrective field action (discussed later in this section) and flagging the associated primary samples results, where applicable. Since these September 2015 blanks were the first round of blanks collected since the previous (Year 1) blanks in November 2014, a decision was required as to which primary samples from which dates were potentially impacted by contaminants measured in the September 2015 blanks. Since the November 2014 (Year 1) blanks tested "clean" indicating there was no residual contamination on the tubing at that time, the working assumption is that the three additional events sampled in calendar year 2014 (events SE02 to 04) were also collected under conditions when the tubing, bottle and churn were still clean enough to not impact the primary sample results. Therefore, no retrospective flagging will be done on 2014 samples (which were previously presented in the 2014 interim report).

With the assumption that tubing contamination accumulates in a linear manner over sampling events, primary samples beginning in calendar 2015 could have been potentially impacted by levels of residual contamination at concentrations high enough to warrant considering the primary data as estimates. Therefore, a conservative approach to flagging primary sample data was taken: all primary sample data collected from January 2015 and ending prior to blanks collected in September 2015 were evaluated for flagging. The associated primary sample concentrations that were within ten (10) times the blank result collected on tubing at the corresponding location where the blank was collected were flagged as estimated (J). Primary sample results that were greater than ten (10) times the associated blanks result were not flagged. A total of 13 primary sample results were qualified based on tubing blank contamination.

Total copper tubing blank sample concentrations from September 2015 ranged from non-detect to 3.5 micrograms per liter (µg/L). Corresponding total copper concentrations in all January to

September 2015 primary samples ranged from 19.8 to 133 µg/L. The blank hits resulted in two SS2 primary samples, SS2-020915-C and SS2-03142015-C, flagged as estimated (J).

Total zinc was detected in the tubing blank sample from SS2 only from September 2015 at a concentration of 8 µg/L. Corresponding total zinc concentrations in all January to September 2015 SS2 primary samples ranged from 68 to 390 µg/L. The blank hit resulted in two SS2 primary samples, SS2-020915-C and SS2-03142015-C, flagged as estimated (J).

Nitrate-nitrite tubing blank sample concentrations from September 2015 ranged from non-detect to 0.07 milligrams per Liter (mg/L). Corresponding nitrate-nitrite concentrations in all January to September 2015 primary samples ranged from 0.046 to 0.679 µg/L. The blank hits resulted in three SS2 samples, SS2-020615-C, SS2-020615-CD, and SS2-011515-C; three SS3 samples, SS3-020615-C, SS3-020615-CD, and SS3-011515-C; and two SS5 samples, SS5-020615-C and SS5-020615-CD, flagged as estimated (J).

Total phosphorus tubing blank concentrations from September 2015 ranged from non-detect to 0.014 mg/L. Corresponding total phosphorus concentrations in all January to September 2015 primary samples ranged from 0.126 to 1.3 mg/L. The blank hits resulted in one SS3 sample, SS3-020915-C, flagged as estimated (J).

The only parameter detected in the churn/bottle blank sample was total copper at a concentration of 1.1 µg/L. The detected range of the total copper in the associated stormwater samples was greater than ten (10) times this blank concentration so no corrective action or sample qualification were needed related to the churn/bottle blank.

Based on the September 2015 tubing blank results, corrective action was considered necessary. However, it is important to note that passing DI water through sample tubing provides “worst-case scenario” assessment of residual contamination since DI water, because it is free of ions, salts, metals, trace elements, and micro-particles acts like to a solvent to scavenge any trace concentrations from the sampling equipment. All sample tubing was replaced with new Teflon-lined tubing and the tubing and internal parts of the automatic sampler that contacts stormwater were decontaminated using the solutions listed in Section 3.1.7 (soapy, 10% nitric, and DI rinses). Following this corrective action, another round of tubing blanks were collected on October 9, 2015 and the results are presented in the table below.

Table 13b. Analytical Summary – Field QC samples (Year 2 - Round 2)

| | Sample ID | SS2_Tubing Blank | SS3_Tubing Blank | SS4_Tubing Blank | SS5_Tubing Blank |
|---|---|---|---|---|---|
| | Date | 09 Oct 2015 | 09 Oct 2015 | 09 Oct 2015 | 09 Oct 2015 |
| Analyte | Units | | | | |
| Metals | | | | | |
| Copper, Total | ug/l | 0.7 | 0.7 | 0.5 U | 0.5 U |
| Zinc, Total | ug/l | 4 U | 4 U | 4 U | 4 U |
| Nutrients | | | | | |
| Nitrate + Nitrite | mg/l | 0.05 U | 0.016 | 0.01 U | 0.01 U |
| Phosphorus, Total | mg/l | 0.01 U | 0.01 U | 0.01 U | 0.01 U |

The second round of tubing blanks was non-detect for most analytes except for minor detections of total copper and nitrate+nitrite. The total copper concentrations ranged from non-detect up to 0.7 µg/L and nitrate+nitrite was detected in the blank from SS3 at a concentration of 0.016. The detected amount of the total copper and nitrate + nitrite in the associated stormwater samples was greater than ten (10) times the amount detected in the highest blank so no addition corrective action or sample qualification were needed.

### *4.2.2.2 Field Duplicate Sample Results*

Field duplicate (split) samples were generated in the laboratory for samples collected on February 6, 2015. Relative percent difference (RPD) values between the primary (SSx-020615-C) and field split (SSx-020615-CD) samples were calculated for each sampling location for each analytical parameter to help evaluate laboratory analysis precision. In the cases where RPD values exceeded the project control limit (CL) (25 percent), parent (primary) and field split samples at that specific location were qualified, as applicable. A detailed description of sample qualification by analytical parameter is provided below.

- *Chemical Oxygen Demand (COD)*. RPD values between primary and field split sample results were greater the project CL at locations SS2 and SS4. COD results for samples SS2-020615-C, SS2-020615-CD, SS4-020615-C, and SS4-020615-CD were qualified as estimated (J) on this basis.

- *Total Copper*. The RPD value between primary and field split sample results was greater the project CL at location SS2. Total copper results for samples SS2-020615-C and SS2-020615-CD were qualified as estimated (J) on this basis.

- *Total Phosphorus*. The RPD value between primary and field split sample results was greater the project CL at location SS2. Total phosphorus results for samples SS2-020615-C and SS2-020615-CD were qualified as estimated (J) on this basis.

- *Total Suspended Solids (TSS).* The RPD value between primary and field split sample results was greater the project CL at location SS2. TSS results for samples SS2-020615-C and SS2-020615-CD were qualified as estimated (J) on this basis.

- *Total Organic Carbon (TOC).* The RPD value between primary and field split sample results was greater the project CL at location SS5. TOC results for samples SS5-020615-C and SS5-020615-CD were qualified as estimated (J) on this basis.

- *Suspended Sediment Concentration ("Sediment Concentration").* Samples from each location were analyzed for Sediment Concentration including five size fractions plus a total value, comprising 24 primary sample measurements total. Fourteen out of 24 (58 percent of) primary sample SSC results exceeded the RPD CL, indicating a systematic analysis error. Due to low confidence in the overall precision of the results, *all* SSC data for all sampling locations were flagged as estimated (UJ/J).

## 4.3 Summary of 2015 Street Sweeping Effectiveness Monitoring

During calendar year 2015, the City was successful in continuing the monitor study to evaluate the effectiveness of street sweeping on stormwater quality. During the first water year of monitoring (Year 1), the goal was to sample 12 events but the abnormally dry 2014-2015 water year led to only 10 events being sampled. The revised goal is to oversample during Year 2; instead of targeting 12 events, 14 events will be targeted. A total of 14 events was sampled in 2015 so it appears good progress is being made towards the increased event goal.

The sampling is expected to be completed by September 2016. After sampling is completed, all project data will be analyzed and the effectiveness of street sweeping will be presented in the 2016 annual report which is due by March 2017.

# 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 2015, the project team continued with the successfully implementation of this study. 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, flow data steward and validator)
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 co-author)
Rex Davis (report co-author)
Jennifer Arthur (chemistry data steward and validator)

# Appendix A: INDIVIDUAL STORM REPORTS AND EVENT HYDROGRAPHS

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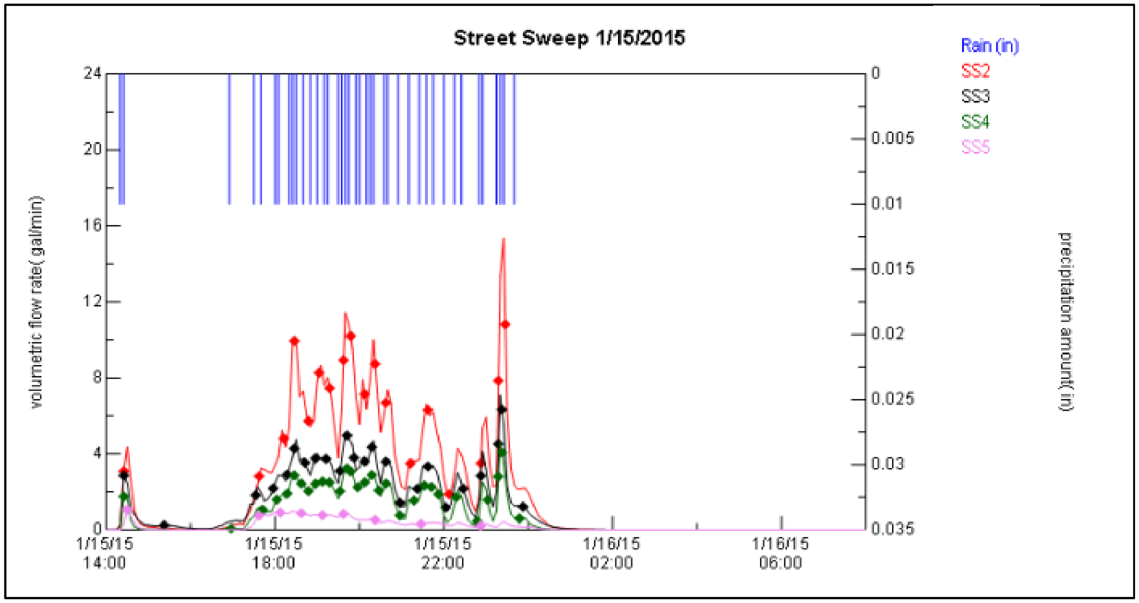
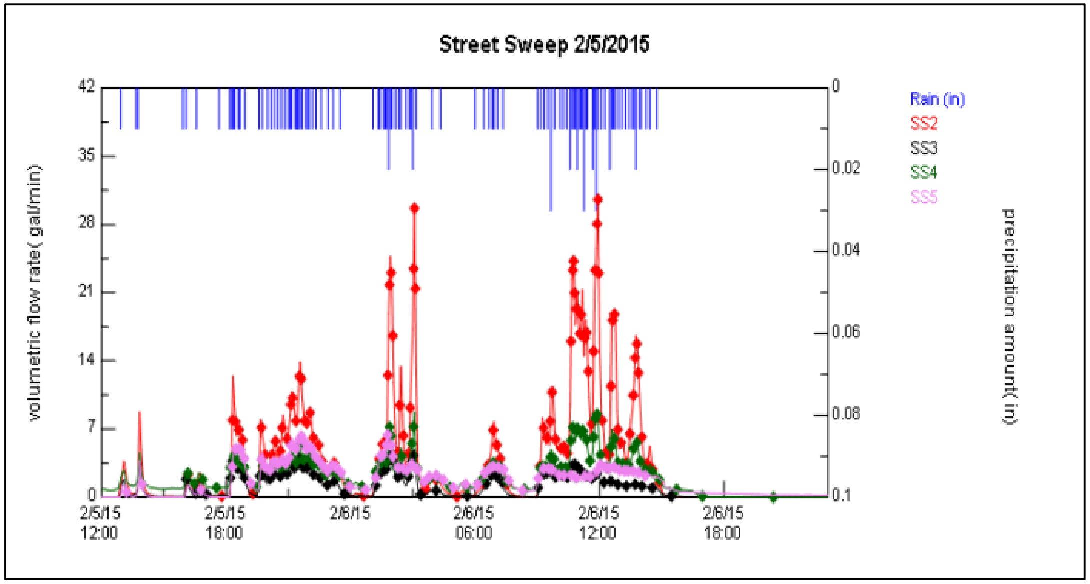
**Street Sweeping Effectiveness Study**
**Individual Storm Report**
**SE-05: January 15, 2015**




| Flow and Sample Statistics | |
|---|---|
| Precip Start | 1/15/2015 14:20 |
| Precip Stop | 1/15/2015 23:40 |
| Storm Event Duration (hrs) | 9.3 |
| Event Rainfall (in) | 0.4 |
| Storm Event Rainfall Mean (in/hr) | 0.04 |
| Event Rainfall Max (in/hr) | 0.12 |
| Antecedent Dry Period (hr) | 100.4 |

| Flow and Sample Statistics | SS2 | SS3 | SS4 | SS5 |
|---|---|---|---|---|
| Start | 1/15/2015 14:20 | 1/15/2015 14:15 | 1/15/2015 14:20 | 1/15/2015 14:20 |
| Stop | 1/16/2015 3:30 | 1/16/2015 7:40 | 1/16/2015 2:25 | 1/16/2015 1:25 |
| Flow Duration (hrs) | 13.2 | 17.5 | 12.2 | 10.3 |
| Event Total Flow Mean (gpm) | 2.7 | 1.1 | 1.0 | 0.4 |
| Event Total Flow Max (gpm) | 15.4 | 7.1 | 4.6 | 1.1 |
| Event Total Flow Volume (gal) | 2162.8 | 1195.8 | 738.0 | 220.7 |
| No. Composite Sample Aliquots | 18 | 24 | 30 | 9 |
| First Sample Time | 1/15/2015 14:25 | 1/15/2015 14:25 | 1/15/2015 14:25 | 1/15/2015 14:30 |
| Last Sample Time | 1/15/2015 23:27 | 1/15/2015 23:52 | 1/15/2015 23:47 | 1/15/2015 22:52 |
| Grab Sample Time 1 | 2/5/2015 9:00 | 2/5/2015 9:15 | 2/5/2015 9:25 | 2/5/2015 10:10 |
| Sample Duration (hrs) | 9.0 | 9.5 | 9.4 | 8.4 |
| Event Flow Volume Sampled (%) | 93.9 | 96.4 | 97.1 | 87.8 |

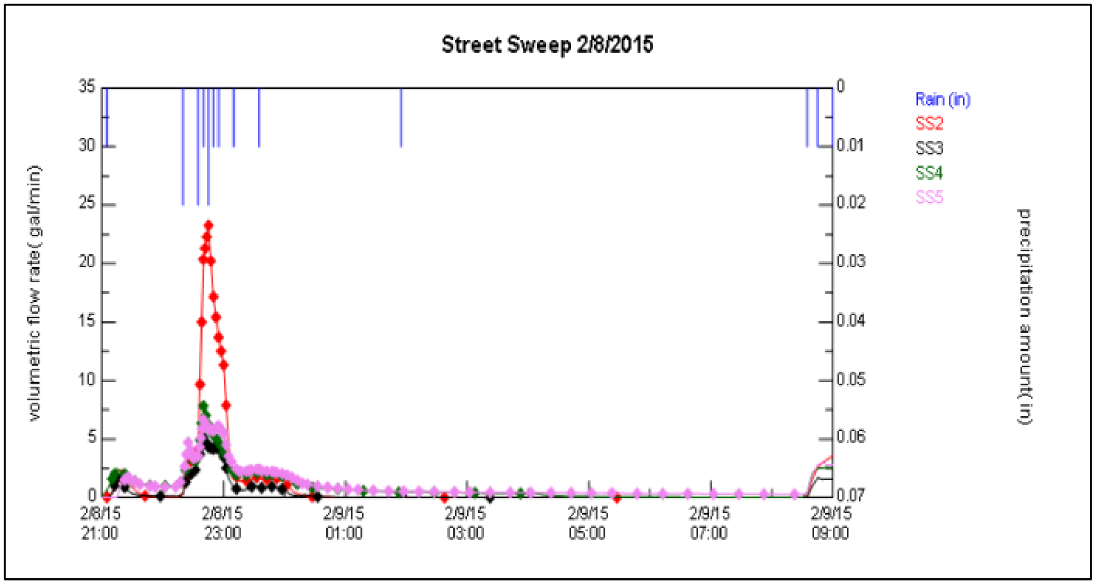
**Street Sweeping Effectiveness Study**
**Individual Storm Report**
**SE-06: February 5, 2015**




| Flow and Sample Statistics | |
|---|---|
| Precip Start | 2/5/2015 12:55 |
| Precip Stop | 2/6/2015 14:45 |
| Storm Event Duration (hrs) | 25.8 |
| Event Rainfall (in) | 1.2 |
| Storm Event Rainfall Mean (in/hr) | 0.05 |
| Event Rainfall Max (in/hr) | 0.36 |
| Antecedent Dry Period (hr) | 4.25 |

| Flow and Sample Statistics | SS2 | SS3 | SS4 | SS5 |
|---|---|---|---|---|
| Start | 2/5/2015 12:50 | 2/5/2015 12:50 | 2/5/2015 12:50 | 2/5/2015 12:50 |
| Stop | 2/6/2015 16:25 | 2/6/2015 20:45 | 2/6/2015 17:35 | 2/6/2015 22:40 |
| Flow Duration (hrs) | 27.7 | 32.0 | 28.8 | 33.9 |
| Event Total Flow Mean (gpm) | 4.2 | 1.1 | 2.5 | 1.7 |
| Event Total Flow Max (gpm) | 30.6 | 4.8 | 8.8 | 6.8 |
| Event Total Flow Volume (gal) | 7001.9 | 2071.4 | 4246.9 | 3519.4 |
| No. Composite Sample Aliquots | 98 | 67 | 79 | 82 |
| First Sample Time | 2/5/2015 16:10 | 2/5/2015 16:05 | 2/5/2015 16:10 | 2/5/2015 13:12 |
| Last Sample Time | 2/6/2015 14:52 | 2/6/2015 15:27 | 2/6/2015 16:57 | 2/6/2015 14:12 |
| Grab Sample Time | 2/5/2015 22:00 | 2/5/2015 21:40 | 2/5/2015 21:45 | 2/5/2015 21:30 |
| Sample Duration (hrs) | 22.7 | 23.4 | 24.8 | 25.0 |
| Event Flow Volume Sampled (%) | 97.2 | 95.4 | 93.2 | 91.6 |

**Street Sweeping Effectiveness Study**
**Individual Storm Report**
**SE-07: February 8, 2015**

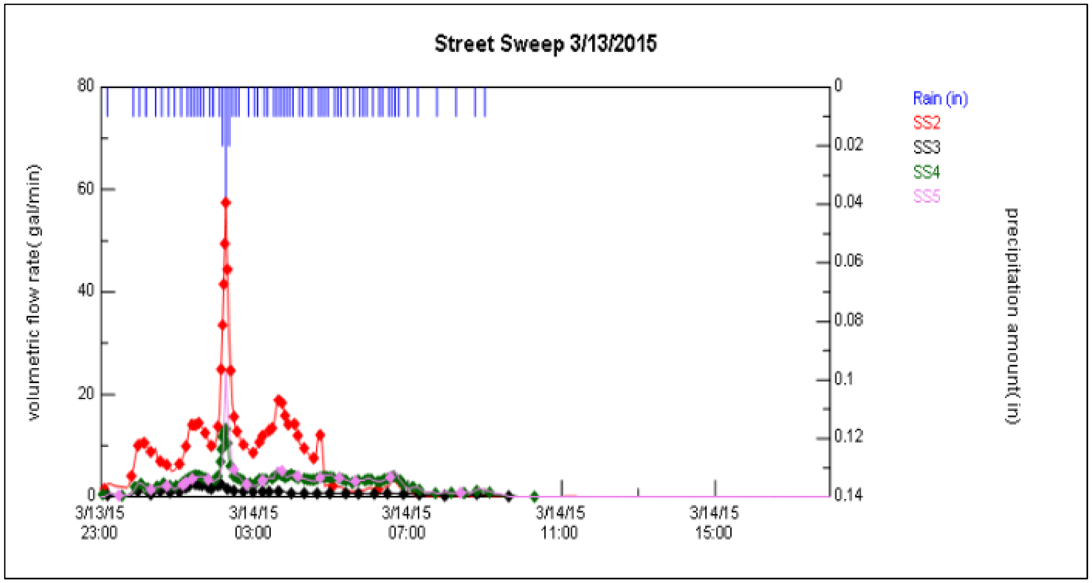



| Flow and Sample Statistics | |
|---|---|
| Precip Start | 2/8/2015 21:05 |
| Precip Stop | 2/9/2015 1:55 |
| Storm Event Duration (hrs) | 4.8 |
| Event Rainfall (in) | 0.13 |
| Storm Event Rainfall Mean (in/hr) | 0.03 |
| Event Rainfall Max (in/hr) | 0.24 |
| Antecedent Dry Period (hr) | 23.1 |

| Flow and Sample Statistics | SS2 | SS3 | SS4 | SS5 |
|---|---|---|---|---|
| Start | 2/8/2015 21:05 | 2/8/2015 21:10 | 2/8/2015 21:00 | 2/8/2015 21:00 |
| Stop | 2/9/2015 8:35 | 2/9/2015 2:55 | 2/9/2015 8:35 | 2/9/2015 8:35 |
| Flow Duration (hrs) | 4.0 | 5.8 | 11.7 | 11.7 |
| Event Total Flow Mean (gpm) | 2.7 | 0.7 | 0.8 | 1.0 |
| Event Total Flow Max (gpm) | 23.3 | 5.1 | 7.8 | 6.7 |
| Event Total Flow Volume (gal) | 645.6 | 232.1 | 567.6 | 671.2 |
| No. Composite Sample Aliquots | 29 | 25 | 33 | 84 |
| First Sample Time | 2/8/2015 21:05 | 2/8/2015 21:12 | 2/8/2015 21:10 | 2/8/2015 21:22 |
| Last Sample Time | 2/9/2015 5:27 | 2/9/2015 0:32 | 2/9/2015 3:52 | 2/9/2015 8:22 |
| Grab Sample Time 1 | 3/15/2015 13:30 | 3/15/2015 14:45 | 3/15/2015 14:20 | 3/15/2015 13:50 |
| Sample Duration (hrs) | 8.4 | 3.3 | 6.7 | 11.0 |
| Event Flow Volume Sampled (%) | 99.9 | 96.0 | 94.4 | 97.8 |

1 grabs collected outside storm event, see section 4.1.1

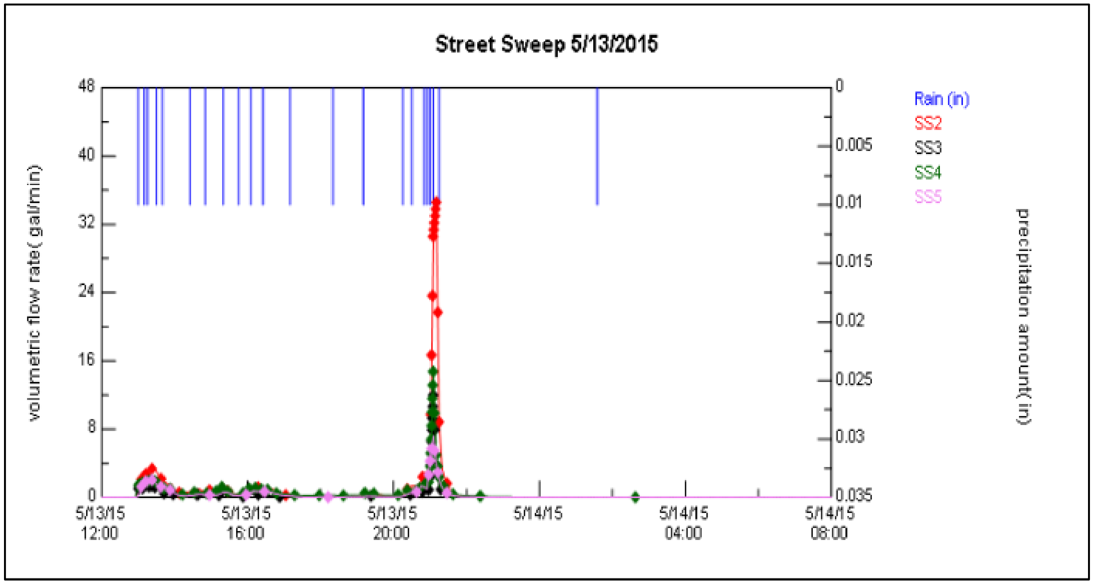
**Street Sweeping Effectiveness Study**
**Individual Storm Report**
**SE-08: March 13, 2015**




| Flow and Sample Statistics | |
|---|---|
| Precip Start | 3/13/2015 23:10 |
| Precip Stop | 3/14/2015 9:00 |
| Storm Event Duration (hrs) | 9.8 |
| Event Rainfall (in) | 0.70 |
| Storm Event Rainfall Mean (in/hr) | 0.07 |
| Event Rainfall Max (in/hr) | 0.48 |
| Antecedent Dry Period (hr) | 63.8 |

| Flow and Sample Statistics | SS2 | SS3 | SS4 | SS5 |
|---|---|---|---|---|
| Start | 3/13/2015 23:10 | 3/13/2015 23:10 | 3/13/2015 23:10 | 3/13/2015 23:10 |
| Stop | 3/14/2015 17:00 | 3/14/2015 14:10 | 3/14/2015 17:00 | 3/14/2015 12:20 |
| Flow Duration (hrs) | 16.7 | 15.1 | 17.9 | 13.0 |
| Event Total Flow Mean (gpm) | 4.1 | 0.6 | 1.6 | 2.2 |
| Event Total Flow Max (gpm) | 57.5 | 2.5 | 13.3 | 24.2 |
| Event Total Flow Volume (gal) | 4125.6 | 521.0 | 1685.9 | 1742.7 |
| No. Composite Sample Aliquots | 41 | 35 | 81 | 17 |
| First Sample Time | 3/13/2015 23:47 | 3/13/2015 23:10 | 3/13/2015 23:32 | 3/13/2015 23:27 |
| Last Sample Time | 3/14/2015 7:12 | 3/14/2015 9:37 | 3/14/2015 10:17 | 3/14/2015 8:22 |
| Grab Sample Time | 3/14/2015 8:17 | 3/14/2015 8:30 | 3/14/2015 8:50 | 3/14/2015 9:00 |
| Sample Duration (hrs) | 7.4 | 10.5 | 10.8 | 8.9 |
| Event Flow Volume Sampled (%) | 96.4 | 97.7 | 98.8 | 95.4 |

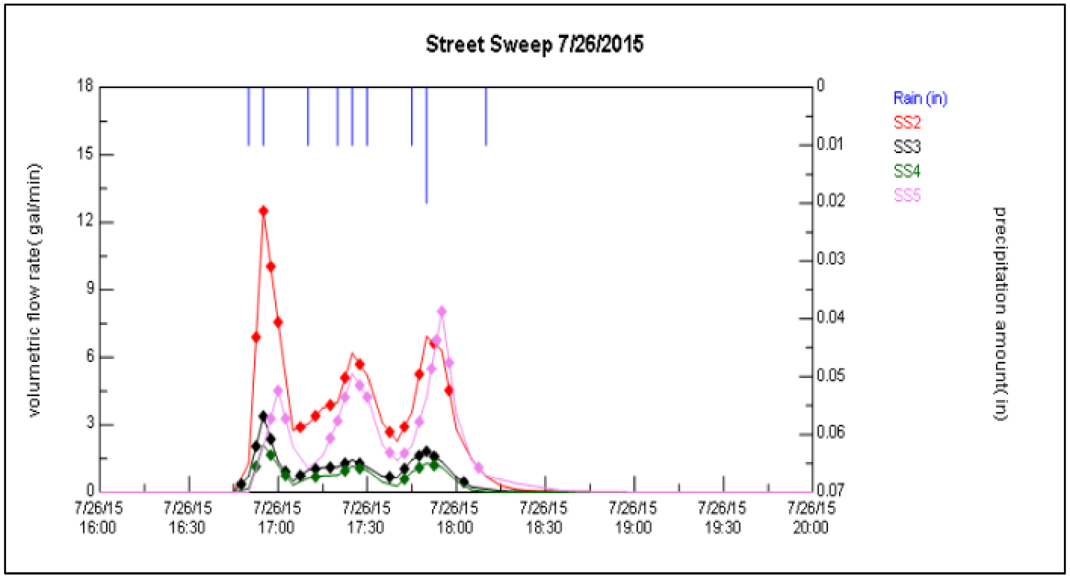
**Street Sweeping Effectiveness Study**
**Individual Storm Report**
**SE-09: May 13, 2015**




| Flow and Sample Statistics | |
|---|---|
| Precip Start | 5/13/2015 13:00 |
| Precip Stop | 5/14/2015 1:35 |
| Storm Event Duration (hrs) | 12.6 |
| Event Rainfall (in) | 0.22 |
| Storm Event Rainfall Mean (in/hr) | 0.02 |
| Event Rainfall Max (in/hr) | 0.12 |
| Antecedent Dry Period (hr) | 13.6 |

| Flow and Sample Statistics | SS2 | SS3 | SS4 | SS5 |
|---|---|---|---|---|
| Start | 5/13/2015 12:55 | 5/13/2015 12:55 | 5/13/2015 12:55 | 5/13/2015 12:55 |
| Stop | 5/13/2015 23:00 | 5/13/2015 23:10 | 5/14/2015 7:30 | 5/14/2015 0:20 |
| Flow Duration (hrs) | 10.2 | 10.3 | 18.7 | 11.5 |
| Event Total Flow Mean (gpm) | 1.3 | 0.4 | 0.4 | 0.4 |
| Event Total Flow Max (gpm) | 34.6 | 12.0 | 14.8 | 7.2 |
| Event Total Flow Volume (gal) | 802.8 | 221.6 | 483.0 | 304.9 |
| No. Composite Sample Aliquots | 24 | 29 | 49 | 16 |
| First Sample Time | 5/13/2015 13:05 | 5/13/2015 13:00 | 5/13/2015 13:00 | 5/13/2015 13:05 |
| Last Sample Time | 5/13/2015 21:27 | 5/13/2015 21:17 | 5/14/2015 2:37 | 5/13/2015 21:27 |
| Grab Sample Time | 5/13/2015 14:30 | 5/13/2015 14:55 | 5/13/2015 15:00 | 5/13/2015 15:25 |
| Sample Duration (hrs) | 8.4 | 8.3 | 13.6 | 8.4 |
| Event Flow Volume Sampled (%) | 96.7 | 96.0 | 97.2 | 95.0 |

**Street Sweeping Effectiveness Study**
**Individual Storm Report**
**SE-10: July 26, 2015**

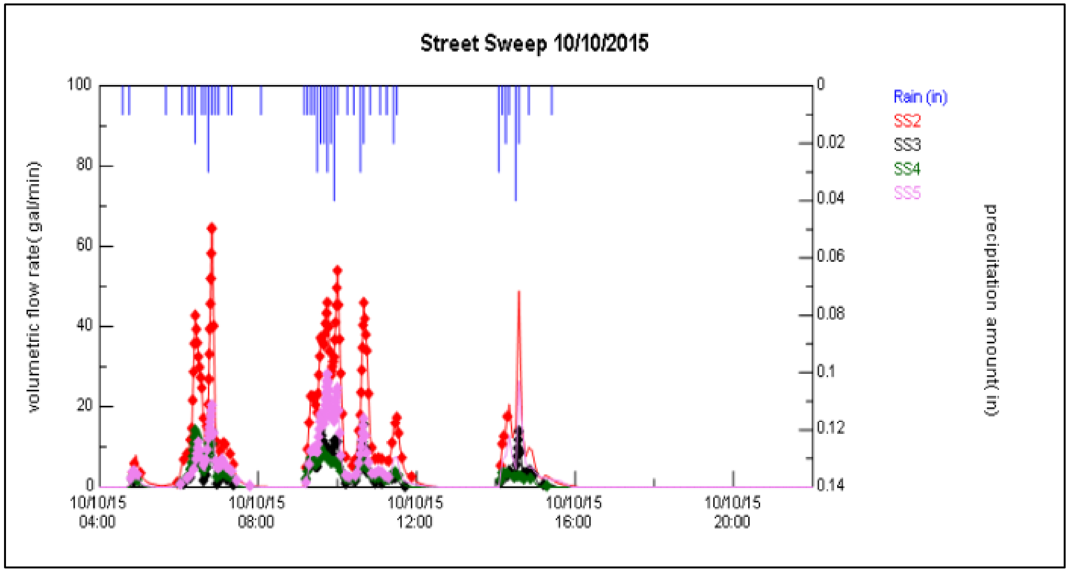



| Flow and Sample Statistics | |
|---|---|
| Precip Start | 7/26/2015 16:50 |
| Precip Stop | 7/26/2015 18:10 |
| Storm Event Duration (hrs) | 1.3 |
| Event Rainfall (in) | 0.10 |
| Storm Event Rainfall Mean (in/hr) | 0.08 |
| Event Rainfall Max (in/hr) | 0.24 |
| Antecedent Dry Period (hr) | 901.8 |

| Flow and Sample Statistics | SS2 | SS3 | SS4 | SS5 |
|---|---|---|---|---|
| Start | 7/26/2015 16:50 | 7/26/2015 16:50 | 7/26/2015 16:50 | 7/26/2015 16:50 |
| Stop | 7/26/2015 19:00 | 7/26/2015 18:45 | 7/26/2015 18:20 | 7/26/2015 19:15 |
| Flow Duration (hrs) | 2.3 | 2.0 | 1.6 | 2.5 |
| Event Total Flow Mean (gpm) | 2.7 | 0.8 | 0.7 | 1.6 |
| Event Total Flow Max (gpm) | 12.5 | 3.4 | 2.1 | 8.1 |
| Event Total Flow Volume (gal) | 370.7 | 95.2 | 64.4 | 246.5 |
| No. Composite Sample Aliquots | 14 | 15 | 9 | 16 |
| First Sample Time | 7/26/2015 16:52 | 7/26/2015 16:52 | 7/26/2015 16:52 | 7/26/2015 16:57 |
| Last Sample Time | 7/26/2015 17:57 | 7/26/2015 18:02 | 7/26/2015 17:52 | 7/26/2015 18:07 |
| Grab Sample Time 1 | 4/13/2015 15:10 | 4/13/2015 14:55 | 4/13/2015 14:45 | 4/13/2015 14:25 |
| Sample Duration (hrs) | 1.1 | 1.2 | 1.0 | 1.2 |
| Event Flow Volume Sampled (%) | 84.1 | 84.8 | 80.6 | 87.0 |

1 grabs collected outside storm event, see section 4.1.1

**Street Sweeping Effectiveness Study**
**Individual Storm Report**
**SE-11: October 10, 2015**

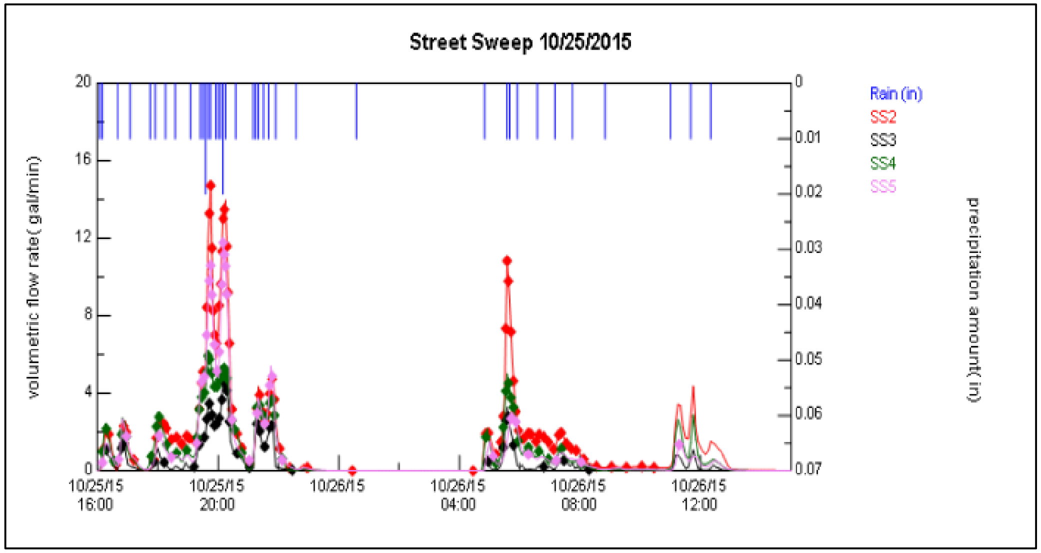



| Flow and Sample Statistics | |
|---|---|
| Precip Start | 10/10/2015 4:35 |
| Precip Stop | 10/10/2015 15:25 |
| Storm Event Duration (hrs) | 10.8 |
| Event Rainfall (in) | 0.68 |
| Storm Event Rainfall Mean (in/hr) | 0.06 |
| Event Rainfall Max (in/hr) | 0.48 |
| Antecedent Dry Period (hr) | 62.1 |

| Flow and Sample Statistics | SS2 | SS3 | SS4 | SS5 |
|---|---|---|---|---|
| Start | 10/10/2015 4:35 | 10/10/2015 4:45 | 10/10/2015 4:45 | 10/10/2015 4:30 |
| Stop | 10/10/2015 21:20 | 10/10/2015 15:50 | 10/10/2015 16:20 | 10/10/2015 17:50 |
| Flow Duration (hrs) | 16.8 | 8.8 | 10.2 | 12.8 |
| Event Total Flow Mean (gpm) | 5.5 | 2.3 | 2.1 | 3.2 |
| Event Total Flow Max (gpm) | 64.6 | 15.6 | 14.2 | 28.2 |
| Event Total Flow Volume (gal) | 5510.8 | 1216.4 | 1265.5 | 2484.3 |
| No. Composite Sample Aliquots | 100 | 86 | 81 | 100 |
| First Sample Time | 10/10/2015 4:50 | 10/10/2015 4:50 | 10/10/2015 4:50 | 10/10/2015 4:47 |
| Last Sample Time | 10/10/2015 14:17 | 10/10/2015 15:12 | 10/10/2015 15:17 | 10/10/2015 11:17 |
| Grab Sample Time 1 | 12/3/2015 6:45 | 12/3/2015 7:00 | 12/3/2015 7:15 | 12/3/2015 7:30 |
| Sample Duration (hrs) | 9.5 | 10.4 | 10.5 | 6.5 |
| Event Flow Volume Sampled (%) | 85.9 | 98.4 | 98.7 | 70.4 |

1 grabs collected outside storm event, see section 4.1.1

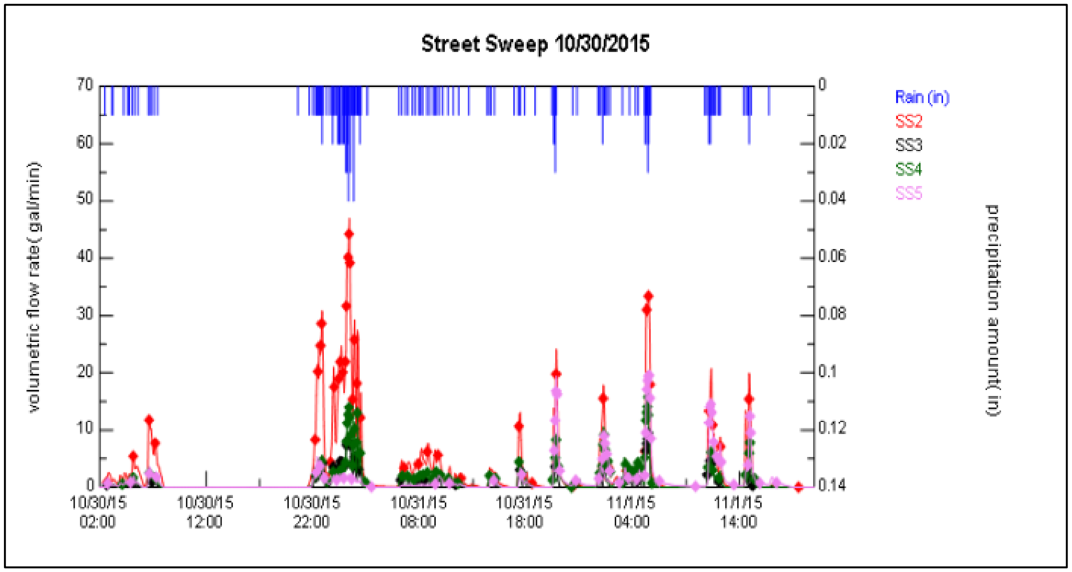
**Street Sweeping Effectiveness Study**
**Individual Storm Report**
**SE-12: October 25, 2015**




| Flow and Sample Statistics | |
|---|---|
| Precip Start | 10/25/2015 16:10 |
| Precip Stop | 10/26/2015 12:20 |
| Storm Event Duration (hrs) | 20.2 |
| Event Rainfall (in) | 0.40 |
| Storm Event Rainfall Mean (in/hr) | 0.02 |
| Event Rainfall Max (in/hr) | 0.24 |
| Antecedent Dry Period (hr) | 164.3 |

| Flow and Sample Statistics | SS2 | SS3 | SS4 | SS5 |
|---|---|---|---|---|
| Start | 10/25/2015 16:05 | 10/25/2015 16:05 | 10/25/2015 16:05 | 10/25/2015 16:05 |
| Stop | 10/26/2015 14:25 | 10/26/2015 13:35 | 10/26/2015 14:25 | 10/26/2015 14:25 |
| Flow Duration (hrs) | 17.3 | 16.6 | 22.4 | 18.0 |
| Event Total Flow Mean (gpm) | 1.6 | 0.5 | 0.8 | 1.0 |
| Event Total Flow Max (gpm) | 14.7 | 4.7 | 6.0 | 11.8 |
| Event Total Flow Volume (gal) | 1699.6 | 502.7 | 1076.8 | 1102.9 |
| No. Composite Sample Aliquots | 84 | 35 | 51 | 34 |
| First Sample Time | 10/25/2015 16:12 | 10/25/2015 16:17 | 10/25/2015 16:10 | 10/25/2015 16:10 |
| Last Sample Time | 10/26/2015 10:27 | 10/26/2015 8:17 | 10/26/2015 8:02 | 10/26/2015 11:17 |
| Grab Sample Time | 10/25/2015 18:00 | 10/25/2015 17:45 | 10/25/2015 17:25 | 10/25/2015 17:12 |
| Sample Duration (hrs) | 18.3 | 16.0 | 15.9 | 19.1 |
| Event Flow Volume Sampled (%) | 87.8 | 89.7 | 88.3 | 95.4 |

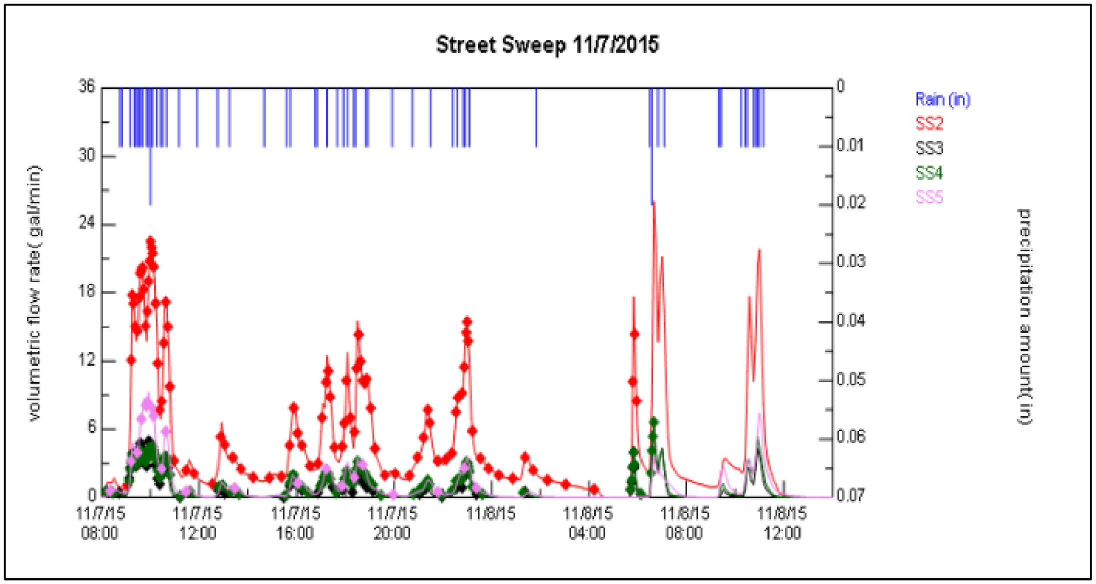
**Street Sweeping Effectiveness Study**
**Individual Storm Report**
**SE-13: October 30, 2015**




| Flow and Sample Statistics | |
|---|---|
| Precip Start | 10/30/2015 3:10 |
| Precip Stop | 11/1/2015 16:45 |
| Storm Event Duration (hrs) | 61.6 |
| Event Rainfall (in) | 1.68 |
| Storm Event Rainfall Mean (in/hr) | 0.03 |
| Event Rainfall Max (in/hr) | 0.48 |
| Antecedent Dry Period (hr) | 31.2 |

| Flow and Sample Statistics | SS2 | SS3 | SS4 | SS5 |
|---|---|---|---|---|
| Start | 10/30/2015 2:35 | 10/30/2015 2:35 | 10/30/2015 2:35 | 10/30/2015 2:40 |
| Stop | 11/1/2015 19:40 | 11/1/2015 17:15 | 11/1/2015 18:25 | 11/1/2015 20:55 |
| Flow Duration (hrs) | 54.0 | 28.8 | 48.3 | 54.3 |
| Event Total Flow Mean (gpm) | 3.6 | 1.3 | 1.4 | 1.3 |
| Event Total Flow Max (gpm) | 47.0 | 9.6 | 15.8 | 19.6 |
| Event Total Flow Volume (gal) | 11508.6 | 2219.6 | 4193.3 | 4274.5 |
| No. Composite Sample Aliquots | 43 | 42 | 76 | 54 |
| First Sample Time | 10/30/2015 2:40 | 10/30/2015 2:40 | 10/30/2015 4:07 | 10/30/2015 2:45 |
| Last Sample Time | 11/1/2015 19:32 | 11/1/2015 15:12 | 11/1/2015 15:22 | 11/1/2015 17:27 |
| Grab Sample Time | 10/31/2015 9:23 | 10/31/2015 10:40 | 10/31/2015 10:15 | 10/31/2015 9:45 |
| Sample Duration (hrs) | 64.9 | 60.5 | 59.3 | 62.7 |
| Event Flow Volume Sampled (%) | 100.0 | 99.9 | 98.4 | 99.0 |

**Street Sweeping Effectiveness Study**
**Individual Storm Report**
**SE-14: November 7, 2015**

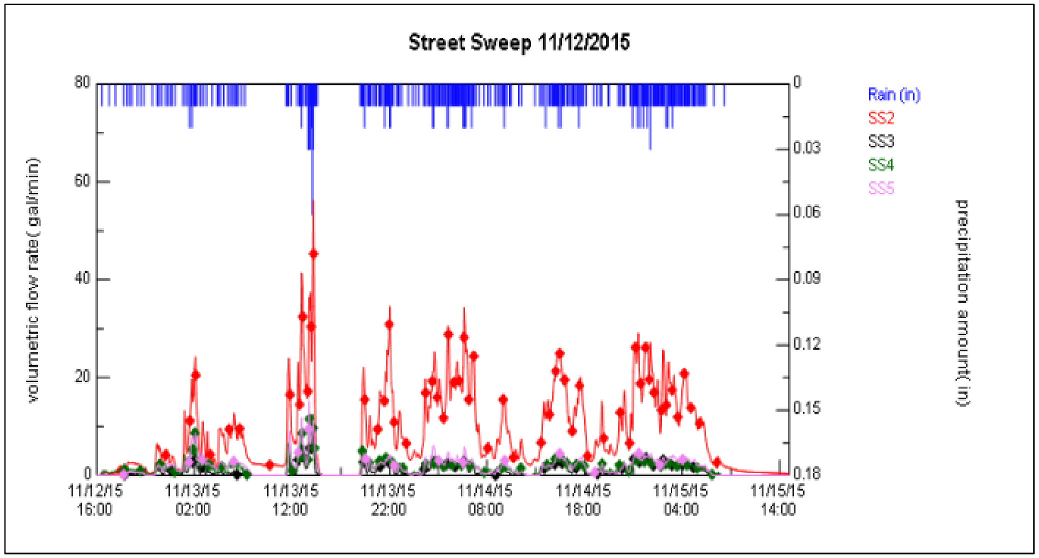



| Flow and Sample Statistics | |
|---|---|
| Precip Start | 11/7/2015 8:45 |
| Precip Stop | 11/8/2015 11:10 |
| Storm Event Duration (hrs) | 26.4 |
| Event Rainfall (in) | 0.58 |
| Storm Event Rainfall Mean (in/hr) | 0.02 |
| Event Rainfall Max (in/hr) | 0.24 |
| Antecedent Dry Period (hr) | 117.7 |

| Flow and Sample Statistics | SS2 | SS3 | SS4 | SS5 |
|---|---|---|---|---|
| Start | 11/7/2015 8:40 | 11/7/2015 8:40 | 11/7/2015 8:40 | 11/7/2015 8:40 |
| Stop | 11/8/2015 13:50 | 11/8/2015 13:50 | 11/8/2015 13:50 | 11/8/2015 13:50 |
| Flow Duration (hrs) | 29.3 | 29.3 | 27.1 | 29.3 |
| Event Total Flow Mean (gpm) | 4.2 | 0.6 | 0.8 | 1.0 |
| Event Total Flow Max (gpm) | 26.0 | 6.8 | 6.6 | 9.3 |
| Event Total Flow Volume (gal) | 7445.8 | 1010.0 | 1302.1 | 1677.7 |
| No. Composite Sample Aliquots | 92 | 73 | 98 | 20 |
| First Sample Time | 11/7/2015 9:02 | 11/7/2015 8:42 | 11/7/2015 9:07 | 11/7/2015 9:12 |
| Last Sample Time | 11/8/2015 5:57 | 11/8/2015 5:52 | 11/8/2015 6:40 | 11/7/2015 23:22 |
| Grab Sample Time 1 | 12/7/2015 11:25 | 12/7/2015 11:15 | 12/7/2015 11:05 | 12/7/2015 10:50 |
| Sample Duration (hrs) | 20.9 | 21.2 | 21.5 | 14.2 |
| Event Flow Volume Sampled (%) | 73.7 | 70.4 | 75.4 | 69.1 |

1 grabs collected outside storm event, see section 4.1.1

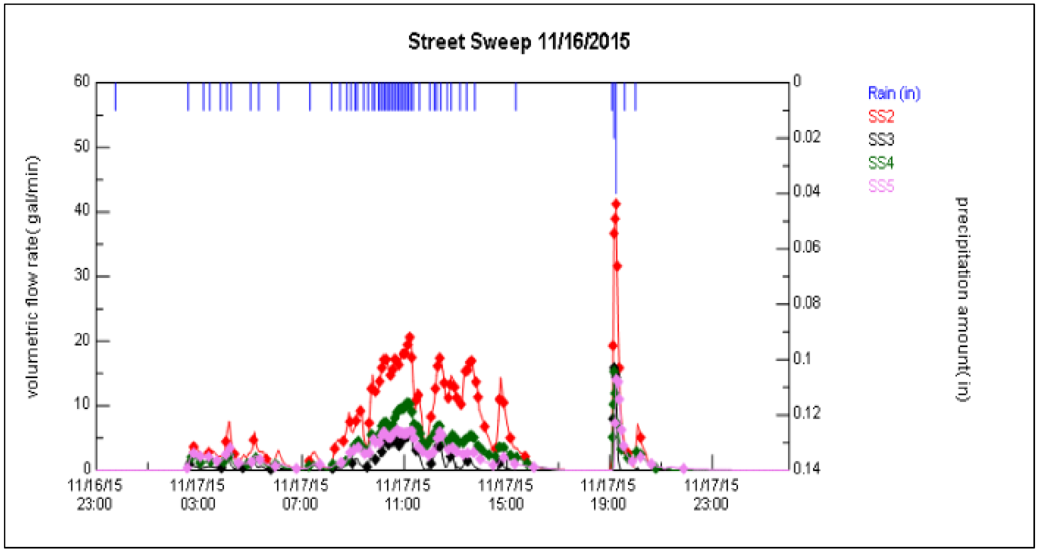
**Street Sweeping Effectiveness Study**
**Individual Storm Report**
**SE-15: November 12, 2015**




| Flow and Sample Statistics | |
|---|---|
| Precip Start | 11/12/2015 16:30 |
| Precip Stop | 11/15/2015 8:20 |
| Storm Event Duration (hrs) | 63.8 |
| Event Rainfall (in) | 3.47 |
| Storm Event Rainfall Mean (in/hr) | 0.05 |
| Event Rainfall Max (in/hr) | 0.72 |
| Antecedent Dry Period (hr) | 38.9 |

| Flow and Sample Statistics | SS2 | SS3 | SS4 | SS5 |
|---|---|---|---|---|
| Start | 11/12/2015 16:25 | 11/12/2015 16:25 | 11/12/2015 16:25 | 11/12/2015 16:35 |
| Stop | 11/15/2015 14:15 | 11/15/2015 8:40 | 11/15/2015 9:05 | 11/15/2015 8:45 |
| Flow Duration (hrs) | 66.9 | 60.9 | 62.8 | 59.3 |
| Event Total Flow Mean (gpm) | 8.9 | 1.1 | 1.7 | 2.0 |
| Event Total Flow Max (gpm) | 56.2 | 10.9 | 12.6 | 15.2 |
| Event Total Flow Volume (gal) | 35783.7 | 3852.7 | 6293.6 | 7085.9 |
| No. Composite Sample Aliquots | 57 | 32 | 52 | 16 |
| First Sample Time | 11/12/2015 18:25 | 11/12/2015 18:50 | 11/12/2015 18:50 | 11/12/2015 18:45 |
| Last Sample Time | 11/15/2015 7:32 | 11/15/2015 5:07 | 11/15/2015 7:02 | 11/15/2015 4:02 |
| Grab Sample Time | 11/13/2015 12:40 | 11/13/2015 12:15 | 11/13/2015 12:25 | 11/13/2015 12:00 |
| Sample Duration (hrs) | 61.1 | 58.3 | 60.2 | 57.3 |
| Event Flow Volume Sampled (%) | 98.6 | 96.7 | 97.8 | 94.0 |

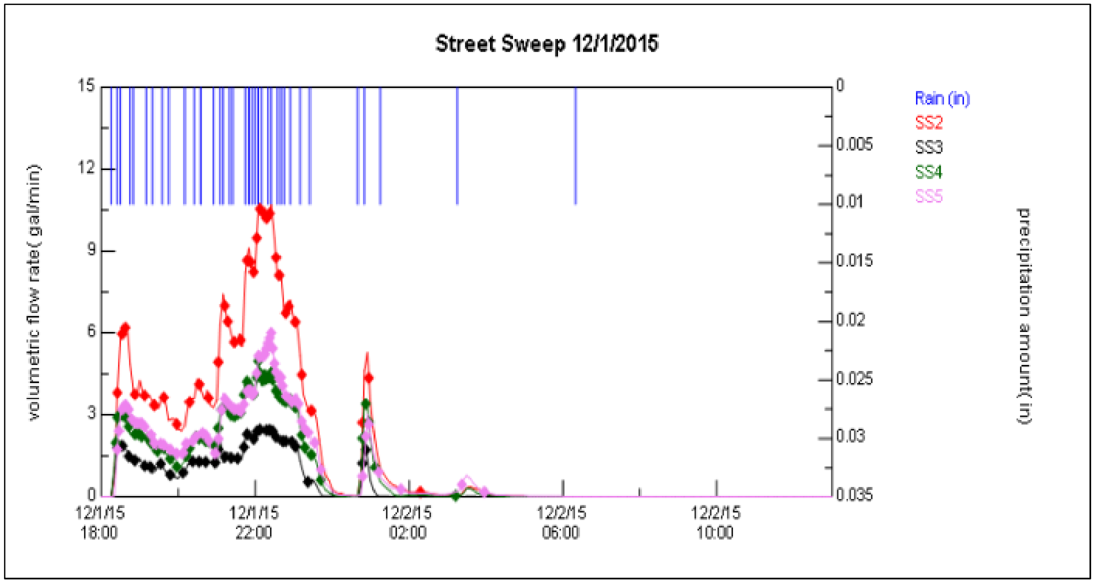
**Street Sweeping Effectiveness Study**
**Individual Storm Report**
**SE-16: November 16, 2015**




| Flow and Sample Statistics | |
|---|---|
| Precip Start | 11/16/2015 23:45 |
| Precip Stop | 11/17/2015 20:00 |
| Storm Event Duration (hrs) | 20.3 |
| Event Rainfall (in) | 0.58 |
| Storm Event Rainfall Mean (in/hr) | 0.03 |
| Event Rainfall Max (in/hr) | 0.48 |
| Antecedent Dry Period (hr) | 8.8 |

| Flow and Sample Statistics | SS2 | SS3 | SS4 | SS5 |
|---|---|---|---|---|
| Start | 11/16/2015 23:45 | 11/16/2015 23:45 | 11/17/2015 2:10 | 11/16/2015 23:45 |
| Stop | 11/17/2015 23:10 | 11/17/2015 20:55 | 11/17/2015 23:00 | 11/18/2015 1:45 |
| Flow Duration (hrs) | 23.3 | 18.8 | 19.2 | 25.9 |
| Event Total Flow Mean (gpm) | 4.4 | 0.9 | 2.4 | 1.4 |
| Event Total Flow Max (gpm) | 41.3 | 15.9 | 15.3 | 14.1 |
| Event Total Flow Volume (gal) | 6197.7 | 1026.4 | 2765.2 | 2238.4 |
| No. Composite Sample Aliquots | 62 | 30 | 79 | 64 |
| First Sample Time | 11/17/2015 2:47 | 11/17/2015 2:37 | 11/17/2015 2:42 | 11/17/2015 2:32 |
| Last Sample Time | 11/17/2015 20:12 | 11/17/2015 19:15 | 11/17/2015 20:47 | 11/17/2015 21:52 |
| Grab Sample Time | 11/17/2015 11:10 | 11/17/2015 10:50 | 11/17/2015 10:25 | 11/17/2015 10:05 |
| Sample Duration (hrs) | 17.4 | 16.6 | 18.1 | 19.3 |
| Event Flow Volume Sampled (%) | 98.2 | 97.8 | 98.7 | 99.0 |

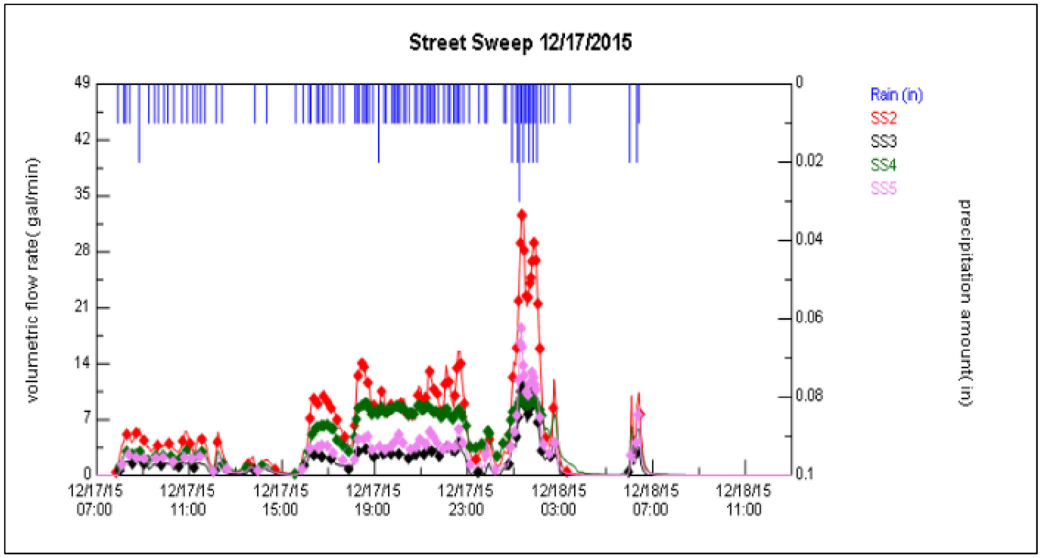
**Street Sweeping Effectiveness Study**
**Individual Storm Report**
**SE-17: December 1, 2015**




| Flow and Sample Statistics | |
|---|---|
| Precip Start | 12/1/2015 18:15 |
| Precip Stop | 12/2/2015 6:20 |
| Storm Event Duration (hrs) | 12.1 |
| Event Rainfall (in) | 0.36 |
| Storm Event Rainfall Mean (in/hr) | 0.03 |
| Event Rainfall Max (in/hr) | 0.12 |
| Antecedent Dry Period (hr) | 178.8 |

| Flow and Sample Statistics | SS2 | SS3 | SS4 | SS5 |
|---|---|---|---|---|
| Start | 12/1/2015 18:15 | 12/1/2015 18:20 | 12/1/2015 18:15 | 12/1/2015 18:10 |
| Stop | 12/2/2015 5:50 | 12/2/2015 4:25 | 12/2/2015 4:40 | 12/2/2015 12:10 |
| Flow Duration (hrs) | 11.7 | 10.1 | 10.5 | 17.2 |
| Event Total Flow Mean (gpm) | 2.6 | 0.8 | 1.5 | 1.0 |
| Event Total Flow Max (gpm) | 10.7 | 2.6 | 5.0 | 6.0 |
| Event Total Flow Volume (gal) | 1848.6 | 498.8 | 926.8 | 1041.9 |
| No. Composite Sample Aliquots | 34 | 34 | 61 | 69 |
| First Sample Time | 12/1/2015 18:25 | 12/1/2015 18:25 | 12/1/2015 18:22 | 12/1/2015 18:25 |
| Last Sample Time | 12/2/2015 2:17 | 12/2/2015 0:52 | 12/2/2015 3:12 | 12/2/2015 3:57 |
| Grab Sample Time | 12/1/2015 20:50 | 12/1/2015 21:10 | 12/1/2015 21:30 | 12/1/2015 21:50 |
| Sample Duration (hrs) | 7.9 | 6.5 | 8.8 | 9.5 |
| Event Flow Volume Sampled (%) | 97.7 | 95.4 | 97.7 | 98.5 |

**Street Sweeping Effectiveness Study**
**Individual Storm Report**
**SE-18: December 17, 2015**




| Flow and Sample Statistics | |
|---|---|
| Precip Start | 12/17/2015 7:55 |
| Precip Stop | 12/18/2015 6:25 |
| Storm Event Duration (hrs) | 22.5 |
| Event Rainfall (in) | 1.09 |
| Storm Event Rainfall Mean (in/hr) | 0.05 |
| Event Rainfall Max (in/hr) | 0.36 |
| Antecedent Dry Period (hr) | 30.8 |

| Flow and Sample Statistics | SS2 | SS3 | SS4 | SS5 |
|---|---|---|---|---|
| Start | 12/17/2015 7:50 | 12/17/2015 7:50 | 12/17/2015 7:50 | 12/17/2015 7:55 |
| Stop | 12/18/2015 12:20 | 12/18/2015 7:40 | 12/18/2015 11:00 | 12/18/2015 10:25 |
| Flow Duration (hrs) | 28.3 | 22.8 | 27.3 | 26.6 |
| Event Total Flow Mean (gpm) | 4.6 | 1.7 | 3.4 | 2.2 |
| Event Total Flow Max (gpm) | 32.6 | 12.6 | 9.8 | 18.4 |
| Event Total Flow Volume (gal) | 7762.1 | 2358.3 | 5516.3 | 3482.3 |
| No. Composite Sample Aliquots | 71 | 43 | 100 | 69 |
| First Sample Time | 12/17/2015 7:50 | 12/17/2015 8:00 | 12/17/2015 8:00 | 12/17/2015 8:05 |
| Last Sample Time | 12/18/2015 6:27 | 12/18/2015 6:17 | 12/18/2015 2:12 | 12/18/2015 6:22 |
| Grab Sample Time | 12/17/2015 9:45 | 12/17/2015 10:25 | 12/17/2015 10:15 | 12/17/2015 10:00 |
| Sample Duration (hrs) | 22.6 | 22.3 | 18.2 | 22.3 |
| Event Flow Volume Sampled (%) | 99.4 | 98.1 | 90.1 | 98.1 |