Eastern Washington
Stormwater Effectiveness Studies

Quality Assurance Project Plan

Street Sweeping and Catch Basin Cleaning Comparison

Study Classification: Operational BMPs

August 1, 2018

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Proposal and QAPP Publication Information

This Detailed Study Design Proposal (Proposal) will be stored and accessible to the public at the following weblink: https://www.ci.ellensburg.wa.us/. For questions regarding the Proposal, please contact Jon Morrow by email morrowj@ci.ellensburg.wa.us or phone 509.925.6819.

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Document History

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

The Detailed Study Design Proposal (Proposal) was submitted to Ecology by Jon Morrow on June 28, 2017. Ecology approved the Proposal via email to Jon Morrow on November 8th, 2017. Appendix A contains a copy of the email along with Ecology's comments on the Proposal. Appendix B contains a summary of HDR's responses to Ecology's comments including how the comments were incorporated into the Quality Assurance Project Plan (QAPP).

The draft QAPP was reviewed by members of the Technical Advisory Group (TAG) in January 2018. Appendix C contains a summary of the TAG's comments along with a summary of HDR's response to these comments including how the comments were addressed in this document. The final QAPP was submitted to Ecology prior to the May 8, 2018 deadline for their review and comment. Appendix D contains a copy of Ecology's approval letter of the QAPP and a summary of Ecology's comments along with HDR's responses to the comments including how the comments were incorporated into the final QAPP document. The revised version of the QAPP was submitted on August 1, 2018.

QAPP Signature Page

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1.0 Table of Contents

2.0 Executive Summary

Street sweeping and catch basin cleaning are operational best management practices (BMPs) that are known to reduce the transport of sediment to receiving water bodies. In the EWA National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System Phase II Permit (MS4 Permit), only catch basin cleaning is a required operations and maintenance (O&M) practice. The permit-required frequency of catch basin inspections (and potential cleanings) will increase on December 31, 2018. Meeting these requirements will create a logistical and financial challenge for some EWA permittees due primarily to winter climate conditions which can prohibit catch basin cleaning for four months of the year. More frequent street sweeping may provide a solution to meeting the new permit requirements. Specifically, studies have shown that street sweeping can reduce the amount of sediment transported to catch basins during rainfall events. In theory, this could reduce the accumulation rate of sediment in catch basins and subsequently the frequency of which catch basins need to be cleaned.

The goal of this study is to investigate whether the frequency of street sweeping significantly influences sediment accumulation in catch basins (and transport from catch basins) during the dry season in a semiarid location. This goal will be achieved by conducting a two year study in the City of Ellensburg. The study area is a 1,065-feet long section of SR 97 which includes four catch basins located on each side of the road that each discharge runoff to a swale. During year one, one side of the road (test site) will be swept and the catch basins will be cleaned every other month starting on April 1st and ending on October 1st. On the other side of the road (control site), the catch basins will be cleaned at the same time as the test site however the street will only be swept once in April. During year two, the test site and control site will switch to the other side of the road and the catch basin cleaning and street sweeping frequency will repeat the same as year 1. During the study the City of Ellensburg will use the equipment they typically use to street sweep and clean catch basins for data collection: a 2016 Elgin Crosswind J Regenerative Air Sweeper and a 2012 VacCon V311/1000 Combination Vactor Truck, respectively. Data that will be collected during this study includes: precipitation, temperature, and wind speed; catch basin sediment depth; sediment (wet) weight, moisture content, organic content, and particle size distribution (PSD). In addition to a weather station located in the study area, data will be collected from the roadway, catch basins and swale inlets.

The results from this study will be used to recommend a combination of street sweeping and catch basin cleaning procedures for achieving NPDES MS4 Permit requirements for catch basin cleaning. If the study results indicate that more frequent street sweeping can reduce the rate of sediment accumulation in catch basins, the results will be used to recommend a condition in the next permit for O&M procedures that allow street sweeping practices to offset the frequency of required catch basins cleaning.

3.0 Introduction and Background

3.1 Introduction to the Operational BMP

This study focuses on evaluating the effectiveness of street sweeping and catch basin cleaning practices. These operational best management practices (BMPs) are generally described as a preventative actions that prevent or reduce pollutant runoff (EPA & ASCE, 2002). Catch basins are located adjacent and flush with the curb line. Catch basins are configured with a grate inlet, which allows runoff from the roadway to enter the catch basin. Pipes (storm drains) connected to the catch basin(s) convey runoff to downstream BMPs such as swales or receiving water bodies. Catch basins typically have a low area (sump) below the invert of the pipes that can retain sediment (conveyed with roadway runoff to the catch basin), reducing the quantity of solids that are conveyed through the storm drain network into receiving waters (EPA, 1999). A vactor truck is periodically used to remove sediment from catch basins by vacuuming the solids out of the sump for disposal. In comparison, street sweeping removes sediment accumulation on roads, using a vacuum assisted sweeper truck. Street sweeping is known to reduce the quantity of sediments conveyed to catch basins during rainfall events (Caraco, 2000).

The Eastern Washington Phase II NPDES MS4 Permit minimum control measure for Municipal Operations and Maintenance *(O&M)* specifies that permittees *"…implement an operation and maintenance program with the goal of preventing or reducing pollutant runoff from municipal operations."* In response to this requirement, the City of Ellensburg Stormwater Department developed an O&M Plan which includes street sweeping 100 miles of road and cleaning approximately 2,500 catch basins (City of Ellensburg, 2017). This typically includes sweeping the streets twice a year, once in the spring and again in the late summer, using a 2016 Elgin Crosswind J Regenerative Air Sweeper. On the other hand, approximately 600 catch basins are cleaned every year using a 2012 VacCon V311/1000 Combination Vactor Truck. In 2016, the combination of these practices collected an estimated 760 tons of solids which were disposed of at the city's decant facility and then transferred to the Wenatchee Waste Management (WM) Landfill (City of Ellensburg, 2017). *Section 7.3 provides more details about the City of Ellensburg's street sweeping and catch basins cleaning practices.*

3.2 Problem Description

The required frequency of catch basin cleaning and inspection is explicitly defined in the O&M section of the NPDES Municipal permit however street sweeping is not required by the permit. Currently, permittees are required to develop and implement an O&M plan that includes cleaning, regular inspection, and record keeping of the jurisdictions catch basins. In addition, all catch basins and inlets must be inspected once before December 31, 2018 and then every two years thereafter (Ecology, 2014). If the inspection shows it is necessary to clean the catch basin, typically when sediment exceeds 60% of the sump depth (Tetra Tech, 2001), the permittee must clean the catch basin. Alternatively, permittees may select other options for meeting this requirement which include (Ecology, 2103):

1. Establishing a specific, less frequent schedule based on documented evidence.
2. Identifying circuits and inspecting 25 percent of the catch basins within each circuit (frequency set by permit either annually or every two years).

3. Cleaning the whole system, including all pipes, ditches, catch basins, and inlets within a circuit once during the five year permit term, where the circuit drains to a single discharge point.

Note: An outcome of this study is to address item 1, provide documented evidence that will support a less frequent schedule for catch basin cleaning based on the frequency of street sweeping.

The increasing frequency of catch basin inspections (and potential cleanings), creates a logistical and financial challenge for some eastern Washington (EWA) jurisdictions. Specifically, in locations like the City of Ellensburg that typically experience prolonged durations of snow cover and ice on the roads during the winter months these climate conditions can prohibit catch basin cleaning for 4 months out of the year. Western Washington (WWA) permittees have the same catch basin cleaning requirements, however, since most WWA jurisdictions experience significantly less snow and ice build-up (if any) on their roads, their catch basin cleaning activities are not impacted to the same degree by climate conditions. For comparison, Figures 3.1 and 3.2 are included to illustrate some of the differences in climate conditions between Ellensburg and Olympia. The subsequent paragraphs in this section provide more details about Ellensburg's climate conditions and explain why these conditions are important to this study.

Note: An outcome of this study is to demonstrate the need for O&M permit requirements that reflect EWA climate conditions.

Ellensburg is located in Central Washington, a semi-arid region with climate conditions that are characterized by cold winters with snowfall, hot dry summers with high winds (WRCC, no date), and short-duration high intensity rainfall events from late spring through early fall (WSDOT, 2016). During the dry season (April to September) the average monthly precipitation ranges from 0.24-inches (August) to 0.67 inches (May) with maximum daily wind speeds ranging from 20 mph to 25 mph. The average maximum daily temperature ranges from 61 degrees (April) to 86 degrees (August). Rainfall events during the dry season provide on average 3-inches of the 9 mean annual precipitation (MAP) and these short duration, high intensity events are known to deposit 1-inch of rain in less than 30 minutes (based on NOAA historical rainfall records). Conversely, the wet season (October to March), provides the remaining 6-inches of MAP of which an average of 22-inches occurs as snow fall.

Variables such as climatic conditions are known to influence the effectiveness of stormwater management BMPs (Caraco, 2000; Sayre, 2006; Gautam, Acharya, Stone, 2010; Tyagi, Chongtoua, Medina, 2008). For example, in semi-arid areas like Ellensburg, roadway sediment accumulation and stormwater runoff pollutant concentrations from roads tend to be higher than marine areas like Olympia. The reason for this is pollutants and sediments have more time to build up on impervious surfaces due to the longer duration of dry periods between rain events. Recommended strategies for semi-arid areas include more frequent street sweeping during the dry period to reduce the quantity of pollutants and sediments on impervious surfaces thereby reducing the quantity available for transport to catch basins and downstream water bodies (Caraco, 2000). Figure 3.3 shows an example of sediment accumulation on roads and in a catch basin in Ellensburg during the dry season.

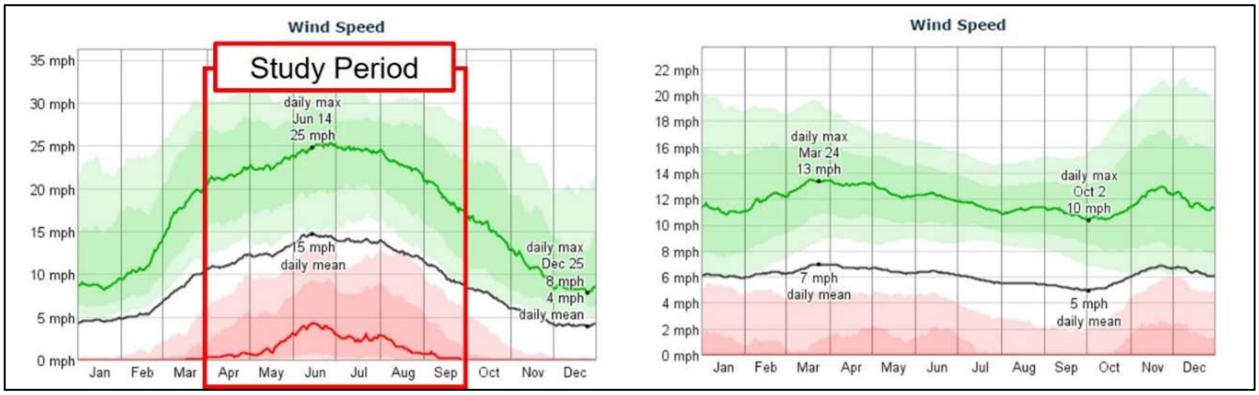


Figure 3.1 Average daily wind speeds in Ellensburg (left) and Olympia (right) (Source: https://weatherspark.com/averages)

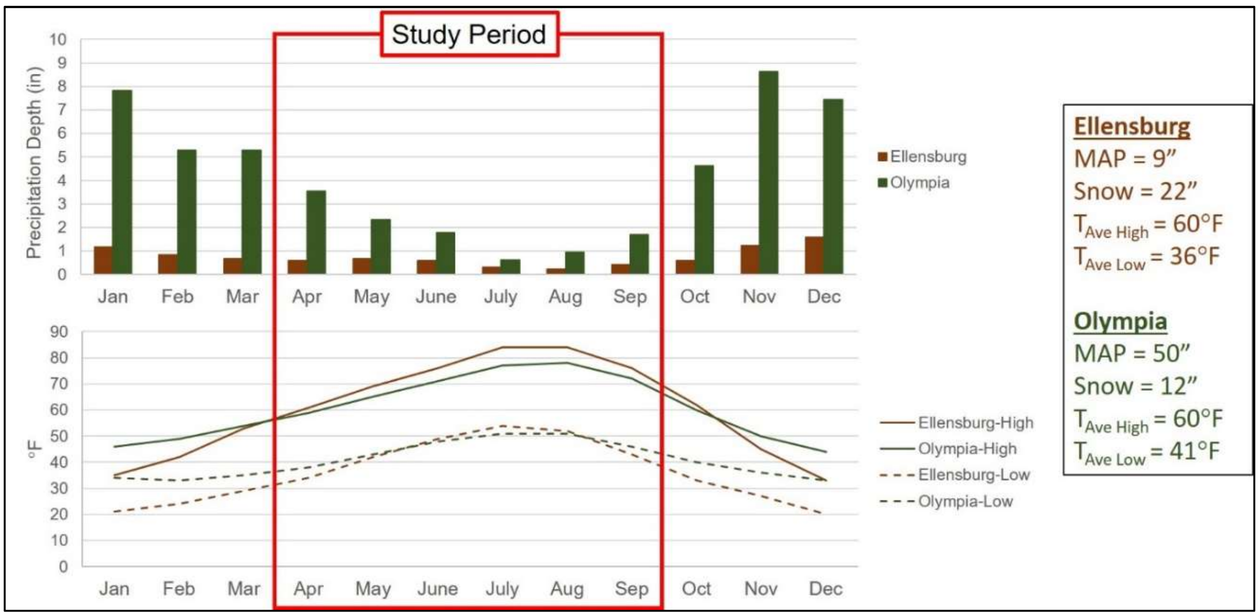


Figure 3.2 Average monthly precipitation depth and temperature in Ellensburg (left) and Olympia (right) (Source: http://www.usclimatedata.com)

Figure 3.3 Proposed study area: typical roadway and catch basin sediment accumulation

3.3 Results of Prior Studies

Street sweeping and catch basin cleaning are documented strategies for removing roadway sediments. The reported effectiveness of these practices varies depending upon the frequency of street sweeping, the type of equipment used, particle size distribution (PSD), climate conditions, and the quantity of sediment build up in catch basins (CWP, 2006; Tang, 2016). Studies have reported that street sweeping is more effective at removing finer particles compared to catch basins which are more effective at trapping larger particles (Sutherland et. at. 2002; Rockfort, 2009). These findings suggest that a combination of these practices may enhance the overall treatment performance. However, understanding how the combination or interaction of these two practices could influence their effectiveness is limited since the bulk of studies focus on the effectiveness of each individual practice. In addition, in the City of Ellensburg high winds during the dry season may also influence the distribution of particles on the roadway. Therefore, a focus of this study is to investigate whether the frequency of street sweeping in Ellensburg during the dry season could reduce sediment transport to catch basins subsequently reducing the frequency with which catch basins need to be cleaned.

No studies have been conducted at the proposed test site in the City of Ellensburg. Instead a literature search was conducted to locate similar studies for the purpose of refining the experimental design for the City of Ellensburg study. One similar study was located: the *Seattle Street Sweeping Pilot Study Monitoring Report*. This study was conducted by Seattle Public Works Utility (SPU) in 2006 (SPU, 2006). This was a 1 year study which focused on *"…evaluating whether street sweeping can significantly reduce the mass of pollutants discharged to area receiving water bodies while reducing the frequency of catch basin cleaning by removing sediment/debris from the street before it is transported in stormwater runoff"* (SPE, 2006 p. ix). The study hypothesis was that street sweeping would reduce the amount of sediment accumulation in catch basins thereby reducing the required frequency of catch basin cleaning. However, the results indicated that in areas where street sweeping occurred the sediment accumulation in catch basins was statistically insignificant compared to areas where street sweeping did not occur.

A reason provided by the researchers for these results was low sediment accumulation in the catch basins. More specifically, *"Because of the low sediment accumulation (less than 3-inches over the study period), differences in catch basin sediment accumulation may have been masked by natural variability and measurement error"*. The researchers theorized that if there was more sediment accumulation in the catch basins, the results may have shown a significant difference. Based on this theory, the researchers recommended repeating the study for a longer duration than one year.

The SPU report was reviewed for the purpose of identifying lessons learned that could improve the experimental design for the city of Ellensburg study. Since insufficient catch basin sediment accumulation was the primary reported issue, the review of the SPU report focused on sections that describe the catch basin measurement procedures, analysis, results, and discussion. Some key points from this study are summarized below:

- Sediment was measured every four weeks, at both the swept and unswept sites, using a 1-inch diameter PVC pole. The pole was pushed through the sediment to the bottom of the catch basin to measure depth in 5 different locations. Since water in the catch basin sumps was not removed prior to taking measurements, most measurements were taken in approximately 2-feet of standing water.

- The volume of sediment in each catch basin was determined by multiplying the average depth of the five measurements by the catch basin area
- Temporal changes in catch basin sediment accumulation indicate that accumulation increased during the wet season and decreased during the dry season. Researchers indicated that settling and consolidation of sediment in the catch basin may have contributed to the decreases in sediment depth observed during the dry period. Since the measured decreases in depth were within the expected range of error associated with the measurement equipment, it was not possible for the researcher to conclude that there was an actual decrease in sediment.
- During a summer month without rainfall, no sediment accumulation was observed in the catch basins
- Sediment that discharged from the catch basins was not measured
- Based on the sediment accumulation measured in the catch basins during the study and considering that catch basins are cleaned when they reach 60% capacity, SPU estimates the catch basins in the study area will only need to be cleaned every 3 to 7 years.

The SPU study relied upon physical measurements in the catch basins to quantify sediment accumulation. Conditions such as *standing water* in the catch basin sump and the *range of possible error* from the measurement device may have influenced the accuracy of the readings. Furthermore, allowing the sediment to accumulate in the catch basins each month may have resulted in an *observable decrease in the volume* due to *settling and consolidation* of sediments in the catch basins. The actual quantity (mass) of sediment may have increased, however, this is not possible to determine based on the catch basin measurement procedures and devices selected for this study. In consideration of the SPU findings and their experimental design, the following is recommended and included in the Ellensburg study:

- Quantify catch basin sediment accumulation by weight and depth.
- Capture and measure sediment that discharges from the catch basin (before discharging to the swale). The basis for this recommendation is as follows:
  - The high-intensity, short-duration summer rainfall events in EWA have the potential to transport large quantities of sediment to the catch basins in a short amount of time. Given that it takes 30 minutes or more for total suspended solid (TSS) to settle out of the water column (Minton, 2013) and the time of concentration is less than 5 minutes to every catch basin grate inlet, it is likely that TSS will be transported from the catch basins to the swales during these events. If the results summarized in Section 3.2 from a study conducted by Sutherland et. al. (2002) and Rockfort (2009) are representative of the results from the City of Ellensburg study (street sweeping is more effective at removing finer particles compared to catch basins which are more effective at trapping larger particles), more frequent street sweeping should reduce quantity of TSS available for transport to and from catch basins.

  - In addition, sediment that was captured and settled to the bottom of the catch basin sump has the potential to become re-suspended during rainfall events, washout of the catch basin, and discharge through the storm drain into the swale (Howard, 2010). This further supports the need to capture and measure sediment that discharges from the catch basin.
- Since this study will be conducted during the dry period and rainfall events typically wash road sediment into catch basins, it is possible there will be months when there is no measurable sediment accumulation in the catch basins (similar to the Seattle study). However, it is anticipated that the high intensity summer rainfall events will sporadically transport large quantities of sediment to catch basins. As such, accumulation of sediments in the catch basins is expected during this study. Further, Ellensburg's high winds during the dry period will likely result in atmospheric deposits of sediment to the catch basins.

3.4 Regulatory Requirements

This study is being conducted to meet the City of Ellensburg's NPDES Municipal Stormwater Permit requirements for evaluating the effectiveness of their permit required stormwater management program activities and BMPs as defined in Section S8.B (Ecology, 2014). For this effectiveness study, the City of Ellensburg has chosen to focus on S5.B.6.a which requires permittees to implement an O&M program with the ultimate goal of preventing or reducing pollutant runoff from municipal operations. In particular, S5.B.6.a.ii specifies that the O&M plan include a schedule for inspecting and cleaning catch basins.

4.0 Project Overview

4.1 Study Goals and Outcomes

The goal of this study is to determine whether the frequency of street sweeping significantly reduces the rate of sediment accumulation in catch basins (and transported from catch basins) during the dry season in a semi-arid location. The results from this study will be used to recommend a combination of street sweeping and catch basin cleaning procedures for achieving permit requirements for catch basin cleaning. If the study results indicate that the frequency of street sweeping significantly reduces sediment accumulation in catch basins, the results will be used to justify a condition in the next permit for O&M procedures that allows street sweeping practices to offset the frequency of catch basin cleanings.

4.2 Study Description and Objectives

This is a paired study located on a 1065 foot section of State Route (SR) 97 with the test site located on one side of the road and the control site located on the other side. Each site has four catch basins located on the side of the road (eight catch basins total). Runoff from the road enters each catch basin through a herringbone grate inlet and then discharges from the catch basin through a storm drain pipe that outfalls into a biofiltration swale (swale). This study will occur over 2 years and data collection will occur over a period of 6 months (April 1st to October 1st) each year. The first year, one side of the road will be swept (test site), every other month starting in April while the other side (control site) will only be swept once in April. The following year the same street sweeping frequency will be repeated except the control site and test site will be switched to the other side of the road. The catch basins on both sides of the road will be cleaned, using a vactor truck, every other month starting April 1st (or the first business day thereafter). Both street sweeping and catch basin cleaning will be performed following the City's typical practices.

Sediment accumulated on the road, in the catch basins, and transferred from the catch basins will be collected and measured. The sediment collected in the vactor truck and street sweeper will transported to the City's decant facility where it will be dewatered and then weighed. Samples of the sediment will be collected to determine the moisture content which will be used to calculate the dry weight of the sediment collected. Before the catch basins are cleaned the average depth of sediment accumulated in the catch basins will be calculated from depth measurements taken at five different locations in each catch basin. Then sediment will be collected from each catch basin using the City's vactor truck. The storm drain pipe outfalls will be fitted with a sump sock which will capture sediment that is transported from the catch basins before the sediment discharges to the swales. Every other month, the sump sock will be collected (replaced) and the dry weight of sediment collected in each sock will be determined. The particle size distribution (PSD) of sediments collected from each location (roadway, catch basins, and sump socks) will also be determined along with the organic content of the sediment collected in the catch basins. Climate data (precipitation and wind speed) will also be collected over the duration of the study period.

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

- Characterize the particle size of sediment accumulated from each sample location: on the road, in catch basins, and transferred from the catch basin (washout) at both the test site and control site
- Quantify the mass of sediment accumulated on the street, in the catch basins, and in the sump socks (washout from the catch basin), without employing street sweeping (control site) and while employing street sweeping (test site)
- Identify potential methods of sediment transport to the road, catch basin, and sump (weather data) and assess representativeness of the climate conditions during the study (compared to historical records)
- Determine whether there is a statistically significant difference between the sediment accumulation rate in the catch basins and in the sump socks (washout from the catch basin) at the test site compared to the control site
- Estimate the relationship (using a regression analysis to develop a trend line or curve) between the catch basin sediment accumulation rate and street sweeping frequency that could be used to forecast the frequency of catch basin cleaning
- Summarize study results and recommend street sweeping and catch basin cleaning procedures for reducing the rate of sediment accumulation in catch basins

4.3 Study Location

The proposed study area is a 1065 foot section of road on State Route 97 which is located in Ellensburg, Washington between Desmond Road and West University Way (Figures 4.1 and 4.3). This road is a major hay hauling route and the land use in the study area is primarily commercial and light industrial. The road has four 12-foot lanes, a 12-foot turning lane, and two 4-foot shoulders (Figure 4.2). The speed limit on the road is 40 mph with an approximate average daily traffic (ADT) of 4000. This location was selected because the proposed test site and control site provide equivalent areas for comparison. *See section 7.2 for more information about the test site.*

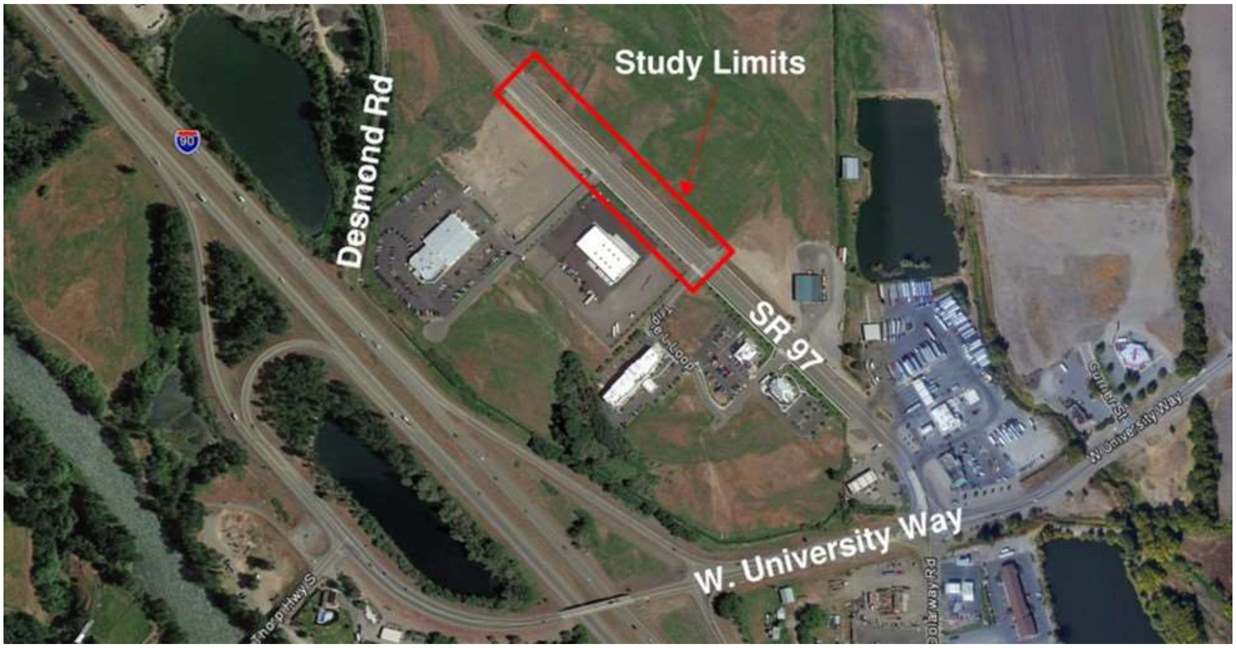


Figure 4.1 Aerial view of the propose study area in the City of Ellensburg

Figure 4.2 Street view of the proposed study area on SR 97

[1] The test-site and control-site will switch to the other sides of the road for year two.

Figure 4.3 Aerial view of the proposed study area showing the locations of the test site and control site

4.4 Data Needed to Meet Objectives

The data that will be collected during the study is summarized in Table 4.1.

Table 4.1 Data Needed to Meet Objectives

Data Type	How Data Will Be Collected	Purpose
Precipitation, temperature, and wind speed	Download from Weather Station	Identify potential methods of sediment transport to the road, catch basin, and sump; assess representativeness of the climate conditions during the study
Catch Basin Sediment Depth	Measure in each catch basin using a survey rod	Calculate density of catch basin sediment; Determine relationship between catch basin sediment accumulation rate and street sweeping frequency
Catch Basin Sediment Wet Weight and Moisture Content	Vactor truck collects sediment; transfer to basin and dewater at decant facility; weigh sediment in basin; collect samples for moisture content testing	Quantify dry weight of sediment accumulated in catch basins at test site and control site
Roadway Sediment Wet Weight and Moisture Content	Street sweeper collects sediment; transfer to basin and dewater at decant facility; weigh sediment in basins; collect samples for moisture content testing	Quantify dry weight of sediments accumulated on roadway at test site and control site
Catch Basin Sediment Washout Dry Weight	Collect manually from the sump socks located at the storm drain that discharges from the catch basin	Quantify dry mass of sediments that washout from the catch basins to the swales at test site and control site
Sediment PSD	Collect samples manually from sediment collected on roadway, in catch basins, and in sump located at catch basin storm drain discharge	Characterize the sediment sizes from each sample location
Catch Basin Sediment Organic Content	Collect samples manually from sediment collected in catch basins, submit samples to lab for analysis	Characterize the organic content of sediment in catch basins

4.5 Tasks Required to Conduct Study

Table 4.2 provides a summary of the tasks required to conduct the study and the corresponding project deliverables.

Table 4.2 Tasks Required to Conduct Study

Task Title and Description	Deliverable
1.0 Project Management Provide management and coordination of the development of the Proposal, QAPP, and work defined in this QAPP throughout the duration of the study	• Invoices and Progress Reports to the City of Ellensburg
2.0 Develop Proposal	• Draft Proposal • Final Proposal

Develop the Detailed Study Design Proposal (Proposal) sections of the EWA QAPP Template and submit the Proposal to Ecology before June 30, 2017	• Summary of Responses to Ecology Comments
3.0 Develop QAPP Develop the sections of the EWA QAPP Template that were not completed in the Proposal and submit the final QAPP to Ecology before May 8, 2018.	• Draft QAPP • Final QAPP • Summary of Responses to Ecology Comments
4.0 Technical Advisory Group Convene a technical advisory group (TAG) which will consist of EWA stormwater managers, Ecology, and interested parties. This includes scheduling meetings with TAG to discuss the project status and soliciting comments from the TAG on the study documents.	• Meeting 1: Agenda & Meeting Notes • Meeting 2: Agenda & Meeting Notes • Meeting 3: Agenda & Meeting Notes • Meeting 4: Agenda & Meeting Notes • Meeting 5: Agenda & Meeting Notes • Meeting 6: Agenda & Meeting Notes
5.0 Prepare for Data Collection • <u>Prevent Unplanned O&M Activities</u> – by notifying WSDOT about the study and requesting they not provide maintenance during the study period • <u>O&M Equipment Maintenance</u> - maintain equipment (vactor truck and street sweeper) per manufacturer standards and documented throughout the study • <u>Prepare Data Collection Equipment</u> – coordinate access to weather station with owner; maintain/calibrate equipment per standard operating procedures (SOPs); purchase and install a sump sock on each catch basin pipe outlet; purchase and setup basins and pallets for dewatering and weighing sediment at Decant facility. • <u>Training</u> – Provide the field crew with training on SOPs	• Notes from WSDOT meeting • Documentation of O&M equipment maintenance • Notes from meeting with weather station owner
6.0 Data Collection • <u>Weather Data</u> - Monthly download data • <u>Catch Basin Sediment Depth</u> - Every other month during the dry season, measure sediment depth in each catch basin, twice a year measure sediment organic content • <u>Catch Basin and Sump Sediment Accumulation</u> – Every other month during the dry season, collect, dewater, and weigh catch basin sediment from the test and control site. Submit samples to the lab for moisture content testing. • <u>Roadway Sediment Accumulation</u> - Collect sediment using the street sweeper at the test site (every other month during the dry season) and control site (in April). Dewater and weigh sediment; submit samples to the lab for moisture content testing. • <u>Characterize Sediment</u> - 2 times a year, collect sediment samples from the road, catch basin, and sump sock; submit samples to the lab to determine PSD and organic content (catch basins only)	• Completed Chain of Custody forms (moisture content and PSD) • Completed field data logs
7.0 Prepare Technical Report Develop a final technical report as defined in the QAPP Section 15.0. This will include analyzing and interpreting the data collected during the study.	• Draft Technical Report • Final Technical Report • Summary of Responses to Ecology Comments

4.6 Potential Constraints

Table 4.3 describes conditions that may impact the project schedule, budget, or scope and the steps that will be taken to reduce the impact of these conditions.

Table 4.3 Summary of Potential Study Constraints and the Subsequent Mitigation Approach

Potential Constraints	Mitigation Approach
Spills: Oil or Other Chemicals	Spills could require the storm sewer system be cleaned on both sides of the street. This could interfere with data collection in the affected catch basins and outfall sumps. The mitigation approach includes: weekly visual inspect of catch basins; if spills occur the catch basin will be cleaned and the incident will be noted in the data collection log. *Reference the following SOP: Inspection of the Study Area for Damage or Vandalism*
Equipment Malfunction or Vandalism	Weekly visual inspect equipment and calibrate equipment according to manufacturer instructions. *Reference the following SOP: Inspection of the Study Area for Damage or Vandalism*
Inclement Weather	This study focuses on understanding O&M procedures during the dry season in a semi-arid climate. Inclement or unseasonal weather such as higher than usual precipitation events could impact the study results. While it is not possible to mitigate the impacts of weather, the data collected from the weather station will be compared to historical weather records to assess the representativeness of the weather during the study.
Insufficient Sediment Accumulation in Catch Basins to Measure	Since this study will occur during the dry months, it is possible that roadway sediments will remain on the roadway surface instead of being transported to the catch basins resulting in immeasurable depths of sediment in the catch basin. This will be mitigated as follows: • Measure sediment accumulation at the end of the winter before the study starts each year • Clean the contents of each catch basin every other month and use the dry weight of the material to quantify accumulation
Equipment breakdown: vactor truck or street sweeper	Equipment breakdown or malfunction could cause disruption in the study. The mitigation approach is: • Follow the manufacturer's procedures for equipment maintenance • The city has two street sweepers and two vactor trucks that are same age and model. In the event of equipment breakdown the city staff will notify the project manager and principle investigator. City staff can use the other street sweeper or vactor truck or rent similar equipment.

5.0 Organization and Schedule

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

5.1 Key Project Team Members: Roles and Responsibilities

Name Organization	Role	Contact Information
Jon Morrow City of Ellensburg	Lead Entity[1]	509.925.8619 morrowj@ci.ellensburg.wa.gov
Aimee Navickis-Brasch HDR, Inc.	Principal Investigator[2]	509.995.0557 aimee.navickis-brasch@hdrinc.com
Taylor Hoffman HDR, Inc.	Researcher[3]	425.283.7239 taylor.hoffman@hdrinc.com
Gordon Crane City of Ellensburg	Data Collector[8]	509.962.7236 craneg@ci.ellensburg.wa.us
Equipment Operators City of Ellensburg	Equipment Operators[4]	
Kathy Sattler, Laboratory Project Manager	Laboratory Project Manager[5]	509.838.3999 technical@anateklabs.com
Stephen Burchett Environmental Engineer Principal	Laboratory Project Manager[5]	509.535.8841 sburchett@budingerinc.com
Chad Philips City of Spokane Valley	Participating Entity: TAG Member[6] Data Verifier[9]	509.720.5013 cphillips@spokanevalley.org
Adrianne Pearson City of Spokane	Participating Entity: TAG Member[6]	509.625.7908 apearson@spokanecity.org
Jessica Shaw City of Wenatchee	Participating Entity: TAG Member[6]	509.888.3225 jshaw@wenatcheeWA.gov
Bill Aukett City of Moses Lake	Participating Entity: TAG Member[6] Data Collector[8]	509.764.3792 baukett@cityofml.com
Danielle Mullins City of West Richland	Participating Entity: TAG Member[6]	509.967.5434 dmullins@westrichland.org

Brad Daly City of Walla Walla	Participating Entity: TAG Member[6] TAG Lead[7] Final Report Supporting Author[11]	509.524.4669 bdaly@wallawallawa.gov
Matt Carlson Asotin County, City of Asotin, and the City of Clarkston	Participating Entity: TAG Member[6] Data Verifier[9] Financial Support[10] Auditor[12]	509.243.2074 mcarlson@co.asotin.wa.us
Nigel Pickering WSU	TAG Member[6]	509.335.8624 nigel.pickering@wsu.edu
Karen Dinicola Ecology	Ecology Reviewer[13]	360.407.6550 kdin461@ecy.wa.gov
Ray Latham Ecology	Ecology Reviewer[13] TAG Member[6]	509.575.2807 rlat461@ecy.wa.gov
Doug Howie Ecology	Ecology Reviewer[13] TAG Member[6]	360.407.6444 doho461@ecy.wa.gov
Brandi Lubliner Ecology	Ecology Reviewer[13]	360.407.7140 brwa461@ecy.wa.gov

1. Lead Entity and Project Manager – Responsible for ensuring the study is conducted as described in this QAPP. Serves as the primary point of contact for the laboratory manager, the field crew, the auditor, and the principal investigator. Responsible for coordinating training for the field crew, scheduling data collection, and ensuring that all data is collected. Responsible for preparing for data collection, collecting data and/or supervising the collection of data. Responsible for submitting the study documents to Ecology including the Proposal, QAPP, and Final Technical Report.
2. Principal Investigator – Responsible for developing an Ecology approved Proposal and QAPP. This includes developing the contents of the QAPP as defined in the EWA Effectiveness Study QAPP Template, responding to TAG and Ecology comments, and updating the QAPP based on comments or changes made prior to the competition of the study. Responsible for providing technical support to the lead entity during the data collection phase of the study. Responsible for management of all study documents including field logs, audit reports, and analytical data. Responsible for providing training to the field crew and other staff conducting the tasks defined in this QAPP. Responsible for executing corrective actions. Responsible for developing the final study report including data analysis and summarizing the study findings. Responsible for ensuring that staff are trained and have adequate experience to complete their assigned tasks.
3. Researcher - Responsible for assisting the Principal Investigator.
4. Equipment Operator – Responsible for operating the street sweeper or vactor truck and data collection including: collecting roadway and catch basin sediment, transporting the sediment to the decant facility, and depositing sediment into the basins. Responsible for following related SOPs defined in this QAPP. *See Section 8.0*.
5. Laboratory Manager – Responsible for supervision of laboratory personnel involved in conducting analytical testing for this study and ensuring that laboratory personnel involved in conducting analytical testing are properly trained in conducting the standard methods for this study. Also responsible for: providing sample containers and other sampling supplies (i.e. labels); analyzing samples using the standard methods selected for this study; carrying out lab QC procedures to confirm that the related MQOs have been met; reporting results for samples and QC procedures; and reviewing data and verifying results before the results are sent to the lead entity.

6. Technical Advisory Group (TAG) Member - The goal of the TAG is to provide insight, suggestions, and professional opinions to the Principal Investigator and Lead Entity throughout the study. The responsibilities of TAG members include: attending project meetings (by webinar or in person) and participating in the meeting discussion; review/comment on research materials (i.e. QAPP, data collected, data analyzed, final report, etc.) prior to the lead entity submitting the documents to Ecology.
7. Technical Advisory Group (TAG) Lead – Responsible for organizing/scheduling meetings with the TAG members and distributing the project/meeting documents prior to the meeting. During meetings the TAG lead is responsible for ensuring that the TAG member's comments are heard and addressed as well as developing/distributing meeting notes of any actions items from the meeting.
8. Data Collector - Data collectors are responsible for collecting some or all of the data during the data collection phase of the study. This includes following the standard operating procedures (SOPs) for data collection as *defined in Section 8.0 of the QAPP.*
9. Data Verifiers - Data verifiers will review the analyzed data and verify the analysis is correct and that the data being analyzed matches the data collected in the field. *See Section 11.0 of this document.*
10. Financial Support – Responsible for providing the lead entity with some level of financial support toward the cost of the study.
11. Final Report Supporting Author – Responsible for supporting the development of the final report under the direction of the Principal Investigator. This includes analyzing the data and summarizing the findings of the study into a report as defined the QAPP. *See Sections 14.0 and 15.0.*
12. Auditor - Responsible for conducting audits to verify the study conforms to the plan and procedures as defined in *Section 12.0 of this document.* This may include: verifying the staff collecting the data are trained and follow the SOPs for data collection; verifying the data management procedures are followed including reviewing data records to ensure they are consistent, correct and complete, with no errors or omissions; and traveling to the location where the data is stored to review the data records compared to the QAPP Data Management Plan. Auditors will report their findings directly to the lead entity.
13. Ecology Reviewer – Responsible for reviewing and approving the study documents: the Proposal, QAPP, and Final Report.

5.2 Project Schedule

Table 5.1 Proposed Study Timeline

Task Name & Number	2017									2018												2019											
	Q2: Apr-Jun			Q3: Jul-Sept			Q4: Oct-Dec			Q1: Jan-Mar			Q2: Apr-Jun			Q3: Jul-Sept			Q4: Oct-Dec			Q1: Jan-Mar			Q2: Apr-Jun			Q3: Jul-Sept			Q4: Oct-Dec		
1.0 Project Management			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
2.0 Proposal Development			■																														
Ecology Proposal Review				■	■	■	■	■																									
3.0 QAPP Development								■	■	■	■																						
Ecology QAPP Review										■	■	■																					
4.0 TAG Meetings										1/2					3						4						5					6	
5.0 Data Collection Preparation							■				■	■												■									
6.0 Data Collection													■	■	■	■	■	■	■						■	■	■	■	■	■	■		
7.0 Develop Technical Report																				■	■	■	■	■							■	■	
Ecology Report Review																																■	■

5.3 Budget and Funding Sources

This study will be funded by the City of Ellensburg. Table 5.3 provides an estimated study budget broken down by the primary study tasks.

Table 5.3 Estimate Study Budget

<table>
<tr><th>Task Name</th><th>Total</th></tr>
<tr><td>1.0 Project Management</td><td>$14,721</td></tr>
<tr><td>2.0 Proposal Development</td><td rowspan="2">$29,405</td></tr>
<tr><td>3.0 QAPP Development</td></tr>
<tr><td>4.0 TAG Meetings</td><td></td></tr>
<tr><td>5.0 Data Collection Prep (Equipment) [2]</td><td>$7,900</td></tr>
<tr><td>6.0 Data Collection</td><td>$20,042</td></tr>
<tr><td>6.1 Analytical Testing[1]</td><td>$6,333</td></tr>
<tr><td>7.0 Develop Technical Reports</td><td>$25,681</td></tr>
<tr><td>Total</td><td>$104,082</td></tr>
</table>

1. Analytical testing will be conducted at Anatek and Budinger & Associates in Spokane.
2. Equipment cost includes: renting scale $4,058 (including transportation to and from the decant facility and setting up the scale) and the data collection equipment in Table 5.4 which will be used to construct the sample collection systems described in Section 7.5. The cost estimate assumes that the City of Ellensburg will install and construct the data collection systems described in Section 7.5.

Table 5.4 Summary of Data Collection Equipment

Item	Unit	Unit Cost	Quantity	Total
Polyester Felt Filter Bag, Polyester Material, 160gpm Max, 1 Micron	10-bags	$104.50	7	$731.50
8 in. x 4 in. Schedule 40 PVC Reducer Bushing SPGxS	1 bushing	$37.87	8	$302.96
4 in. PVC Sch. 40 DWV Plain End Pipe	10 ft Section	$18.31	3	$54.93
Tuf-tite 4-hole distribution box with fittings and lid	1 sump box	$43.92	8	$351.36
Tuf-tite Seal/Plug, Plastic, Orange	1 plug	$5.95	8	$47.60
6 in. x 4 in. Schedule 40 PVC Reducer Bushing SPGxS	1 bushing	$10.97	8	$87.76
Zip ties	100 zip ties	$12.99	1	$12.99
Releasable Cable Ties	25-pack	$2.99	2	$5.98
Safety Hasp, Black, 3.25-in.	1 hasp	$5.49	16	$87.84
Master Lock 1-3/4 In. Warded Steel Padlowck	1 lock	$5.00	16	$80.00
Wood Gate Screws, Black Satin, 1.25-In. 18-Pk.	18-pack	$2.59	8	$20.72
Singed Polyester Felt Filter Media Fabric Sheet, 1 Micron, Polyester	1yd x 72"	$22.99	1	$22.99
PVC Purple Primer	16-oz	$11.99	1	$11.99
PVC Pipe Cement (Oatey Clear)	16-oz	$9.99	1	$9.99
Plumbing sealant (Gorilla)	10-oz	$7.99	2	$15.98
Caulk Gun	10-oz	$7.99	1	$7.99
Rust-Oleum Specialty Plastic Primer Spray, White	12-oz	$5.99	4	$23.96
Wood pallet	1 pallet	$30.00	4	$120.00
1-1/4" PVC Sch 40 FPTxFPT Ball Valve	1 ball valve	$8.06	50	$403.00
1-1/4" PVC Sch 40 MPTxS Male Adapter	1 adapter	$1.14	50	$57.00
1-3/4 in. x 1-1/2 in. x 1/8 in. Buna Rubber O-Ring	1 bag	$1.44	50	$72.00
3" to 1.5" Clean Washed Stone or Gravel for Infiltration Trenches	cyd	$21.52		
300-Gallon Behlen Country 328 Poly Round End Tank	300-gallon tank	$239.95	4	$959.80
			Subtotal	$3,488.34
			Tax (10.1%)	$352.32
			Total	$3,840.66

6.0 Quality Objectives

This section of the QAPP provides a roadmap of the QA/QC plan that will be implemented in the experimental design and employed throughout the study.

The purpose of a QAPP is to ensure that the data collected during the study is scientifically and legally defensible (Ecology, 2011). The QAPP documents how quality assurance (QA) and quality control (QC) will be applied to a research project to assure that the results obtained are of the type and quality needed and expected. The QA/QC plan for this study is embedded throughout the QAPP and emphasizes how the data quality indicators (DQIs) and respective measurement performance criteria (MPCs) are addressed during the study.

DQIs are qualitative and quantitative measures that characterize the aspects of quality data (EPA, 2006). DQIs are goals for data quality that are specific to each study. DQIs are intended to minimize error and improve the accuracy of the data. DQIs guide the development of the experimental design as well as the process of creating and analyzing data. The six principle DQIs for Operational BMP studies are (Ecology, 2004):

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

Once established, the DQIs provide the basis for the MPCs which are; the acceptance criteria for the DQIs that specifies how good the data must be to meet the project objectives. Table 6.1 first defines each DQI, then the approach for addressing DQIs and the respective MPCs for this study are described.

Reference Section 13.0 for details regarding the process that will be employed to evaluate the quality and usability of the data for meeting the project objectives which is based primarily on whether the MPCs were met for the applicable DQIs.

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

Bias – A systematic error that results in sample values that are consistently distorted in one particular direction from the "true" or known value (EPA, 2006; Erickson, 2013). Bias can result from improper data collection, poorly calibrated analytical or sampling equipment, or limitations or errors in analytical methods and techniques (Ecology, 2011).	
Bias DQIs for This Study	**Bias MPCs for this Study**
Performing equipment maintenance per manufacturer recommendation can influence the efficiency with which the street sweeper and vactor truck collect sediment. This could cause more sediment to remain on the street or in the catch basins during data collection compared to when the equipment is maintained per the manufacturer's recommendations. As such, following the manufacturers' recommendations for equipment maintenance can reduce the potential of bias in the quantity of sediment collected from the roadway and in the catch basins.	An audit of equipment maintenance records will be compared to the respective SOPs to verify that the maintenance is occurring per the manufacturer recommendations. Data will be considered acceptable if the actual frequency of maintenance is consistent with the frequency of maintenance defined the SOPs.
Developing and consistently following SOPs for collecting samples and measuring data will minimize errors and reduce the potential of collecting bias data.	An audit (Section 12.0) will be conducted to verify that the field crew is following the SOPs. This will include interviewing the staff. Data will be considered acceptable is the field crew is following the SOPs.
The scales used to weight sediment will be calibrated per the manufacturer's recommendations to reduce the potential for bias in the sediment weight data.	To reduce the potential for biased sediment weights, the scale calibration will occur prior to the start of data collection for each year.
Precision – A measure of agreement among repeated measurements of the same property taken under identical or substantially similar conditions (EPA, 2006; Erickson, 2013; EPA, 2002). Data is considered precise when the measured values are consistently the same and imprecise when the measured values are consistently different (Erickson, 2013). Random error is a common cause of imprecise data and is always present because of normal variability in the many factors that affect measurement results. For example variability in sampling or data collection procedures and/or variations of the actual concentrations in the media being sampled (Ecology, 2011).	
Precision DQIs for This Study	**Precision MPCs for this Study**
Developing and consistently following SOPs for collecting samples and measuring data will reduce the potential of collecting imprecise data.	An audit (Section 12.0) will be conducted to verify that the field crew is following the SOPs. This will include interviewing the staff. Data will be considered acceptable is the field crew is consistently following the SOPs.
Incorrectly reading instruments (survey rod) when measuring the sediment depth could result in the collection of imprecise data.	When the first catch basin depth is measured, the depth will be measured by two different data collectors using the same instrument. The data collectors will compare their measurements for consistency. If the results are not the same, the data collectors will determine why and take immediate action to correct measurement procedures.
Duplicate analytical testing will be performed for parameters shown in Table 9.2 to verify that the quality of the results.	If the results from the duplicate testing indicate that the relative percent difference (RPD) is ≤20%, the results of the analytical testing will be considered acceptable.

	$RPD = 100 \times \left\lvert \frac{(original - duplicate)}{average\ (original, duplicate)} \right\rvert$
Representativeness – A qualitative term that expresses the degree to which the data accurately and precisely represents the conditions being evaluated (EPA, 2002). Common variables considered when determining the degree of representativeness include the selected sampling locations, sampling frequency and duration, and sampling methods (Ecology, 2011).	
Representativeness DQIs for This Study	**Representativeness MPCs for this Study**
The study operational procedures are consistent with the typical jurisdictions operational procedures.	To ensure that typical operational procedures are followed, the study SOPs for equipment operation were developed from interview notes with the equipment operators and project manager in which they defined their typical operating procedures. In addition, the operators will be trained on the SOPs prior to the start of the study. An audit (Section 12.0) will be conducted to verify the operators are following the SOPs. This will include interviewing operators. The data will be considered acceptable if operators are consistently following SOPs.
Sediment is typically transported into catch basins during rainfall events. As such, inclement or unseasonal weather could provide study results that are not representative of typical (average weather) conditions in Ellensburg.	The representativeness of the weather during the study will be assessed by comparing the data collected at the weather station with the historical weather conditions in Ellensburg. The weather during the study will be considered representative if the historical average weather data is similar to the data collected at the weather station.
Developing SOPs and following them consistently will support the representativeness of the collected samples.	An audit (Section 12.0) will be conducted to verify that the field crew is following the SOPs. This will include interviewing the staff. Data will be considered acceptable is the field crew is consistently following the SOPs.
Completeness DQIs for This Study	**Completeness MPCs for this Study**
Completeness - The amount of valid data needed to be obtained during the study to meet the project objectives (Ecology, 2004).	
The sample size (Table 7.4) for this study was selected based on having a sufficient amount of data to collect. Specifically, data will be collected during the dry season and rainfall events typically wash sediment into catch basins. Collecting data every other month will provide time for a measureable amount of sediment to accumulate in the catch basins and to wash out to the sump socks located at the storm drain discharge from the catch basin. Also the sample size was selected based on selecting a representative frequency with which the city will actually perform street sweeping.	The data set is considered complete when the number of valid samples collected is equal to the sample size defined in by the DQI.
Define procedures for handling missing data, use appropriate coding for missing data, and report missing data with the results	Procedures for handling missing data and coding missing data are defined in section 11.0. The Final Technical Report for this study will include consideration for how missing data could limit the comparability of the data set.

Comparability Data Quality Indicator (DQI)	Comparability Measurement Performance Criteria (MPC)
Comparability - A qualitative term that expresses the measure of confidence that one dataset can be compared to another and can be combined or contrasted for the decision(s) to be made. Data is comparable if sample collection techniques, measurement procedures, analytical methods, and reporting are equivalent for samples within a sample set, and meet acceptance criteria between sample sets.	
Define the process and provide justification for selecting the test site and control site	The process for selecting the study area is defined in section 7.2: the process focused on having a test site and control site that are equivalent
Define and consistently follow SOPs for sample collection and field measurements	SOPs were developed and will be consistently followed during this study
Use standard testing methods (analytical testing)	Standard testing methods are defined for all analytical testing in Table 9.2
Sensitivity Data Quality Indicator (DQI)	**Sensitivity Measurement Performance Criteria (MPC)**
Sensitivity - The capability of a method or instrument to discriminate between measurement responses representing different levels of the variable of interest (EPA, 2002).	
Select instruments capable of accurately measuring the different levels of the variables of interest expected during the study	The scale, survey rod, weather station, and standard analytical testing methods are all capable of measuring the different levels expected during the study

7.0 Experimental Design

7.1 Study Design Overview

This is a paired study located on a 1,065-foot section of highway with the test site located on one side of the road and the control site located on the other side. The roadway crown is located in the center of the highway and there are four Type 1 catch basins located along the curb in both the test and control site. The basin areas contributing runoff to the catch basins are pollutant generating impervious surfaces (PGIS) primarily from the roadway. Runoff from the road enters each catch basin through a Herringbone grate inlet and then discharges the catch basin through a storm drain pipe that outfalls into a biofiltration swale. Figure 7.1 provides a cross section of the typical stormwater system in the study area.

This study will occur over two years for a period of 6 months (April 1st to October 1st) each year. The first year, one side of the street will be swept (test site) every other month while the other side (control site) is only swept on April 1st (or the first business day thereafter). The following year the same street sweeping frequency will be repeated except the control site and test site will be switched to the other side of the road. Every other month, the catch basins will also be cleaned and the sump socks will be replaced and the sediment accumulation will be measured in each location. Figure 7.2 provides a plan view of the test site and control site.

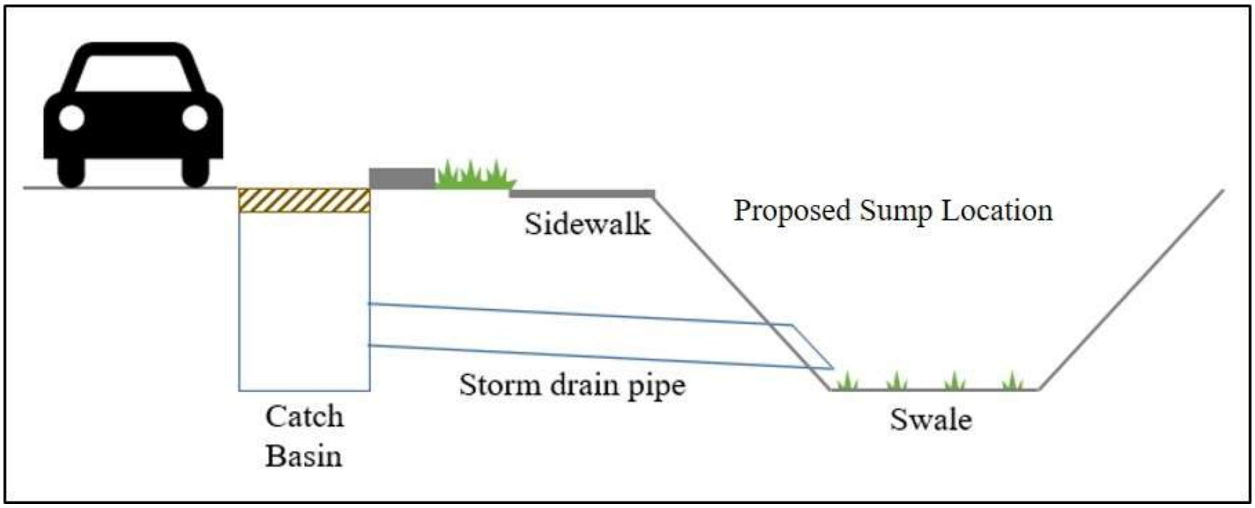


Figure 7.1 Typical Cross Section of Stormwater System in the Study Area

A summary of the data collection and analysis process is as follows:

- Roadway Sediment will be collected in the street sweeper, transported to the decant facility, and then dumped into a basin (Figure 8.1). The excess water will be drained from the basin and then the sediment will be weighed (wet weight) and three samples of the sediment will be collected and sent to the lab to determine the moisture content. The dry weight of sediment will be calculated using the wet weight of the sediment and average moisture content measured.
- Catch Basin Sediment prior to collecting the sediment in the catch basin, the average depth of sediment will be measured in each catch basin at both the test site and the control site. Then sediment will be collected in the vactor truck from the four catch basins at the test

site and transported to the decant facility. The same process used to determine the dry weight of the roadway sediment will be used to determine the dry weight of the sediment collected in the catch basins. The process will then be repeated for the control site. The data collected will be used to calculate the average dry weight of sediment accumulated in the catch basins. The annual sediment accumulation rate will be calculated using the dry sediment weight and the sediment depth and catch basin sump volume.

- Sediment Washout from Catch Basins will be collected every other month in sump socks located at the pipe (storm drain) discharge that conveys runoff from the catch basins to the swale. The sediment will be collected in a sock (with a 1 micron filter). Every other month the sock will be submitted to the lab to measure the sediment dry weight and the annual sediment accumulation rate will also be calculated.
- Additional Data Collection - A weather station will record wind, temperature, and precipitation depth continuously throughout the study. The purpose of this data is assess how sediment is transported to the catch basins. The data will also be used to assess the representativeness of the weather during the study compared to average weather conditions in Ellensburg. The sediment particle size distribution will be measured two times per year from sediment samples collected at each of the following locations: roadway, catch basins, and sump socks. The purpose of this data is to characterize sediment size in each of the different sample locations.
- Effectiveness of Street Sweeping for Reducing Sediment Accumulation in Catch Basins - The sediment dry weight measured from the test site catch basins and the sump socks will be compared (using statistical analysis) to the control site to determine whether there is statistically significant difference.
- Comparability of Test Site and Control Site - The sediment dry weight measured from the test site roadway, catch basins, and sump socks during year one will be compared (using statistical analysis) to the year two test site to determine whether there is statistically significant difference. These results will also assist in determining whether the distribution of sediment was equivalent.
- Recommendations for Street Sweeping Frequency - The frequency of street sweeping on each side of the road (test site and control site) and the sediment accumulation rate in the catch basins will be used to predict (using a regression analysis) how long it will take for the catch basins to fill (sediment accumulation exceeds 60% of the sump depth below the pipe invert). The results will be graphed and used to assist the City of Ellensburg in demonstrating how the frequency of street sweeping influences the frequency of catch basin cleaning.

7.2 Test Site(s) Selection Process

The proposed study area is located in Ellensburg, Washington, on State Route 97 (Figure 4.1) which is considered a principal arterial. The study area was surveyed in July of 2017 and the results of the survey are summarized in Figure 7.2 and described herein. The study area starts at station 0+00 and ends at station 10+65 and the roadway slopes at a 0.33% grade from the North West to the South East. The roadway crown is located in the center of the highway which directs half of the runoff to each side of the road. The area contributing runoff to each catch basin is from PGIS which includes runoff from the road and approaches to local businesses and unpaved roads. The area adjacent to the approaches (away from the road) is not included in the basin delineation because these areas slope away from the road as such runoff from these areas will not be directed toward the road. The delineated basin areas are shown in Figure 7.3 and summarized in Table 7.1. The basin areas contributing to the catch basins range from 0.17 to 0.30 acres. Differences in the areas are due primarily to difference in the locations of the inlets as well as difference in the size of the approaches.

Note: For year one, the test site will be on the north side of the road, and the control site will be the south side of the road. During year two, the south side will become the test site and the north side will become the control site.

Table 7.1 Area Contributing Runoff to Each Catch Basin

Catch Basin ID	Contributing Drainage Area (AC)
CB-1	0.19
CB-2	0.19
CB-3	0.29
CB-4	0.26
CB-5	0.17
CB-6	0.17
CB-7	0.30
CB-8	0.25

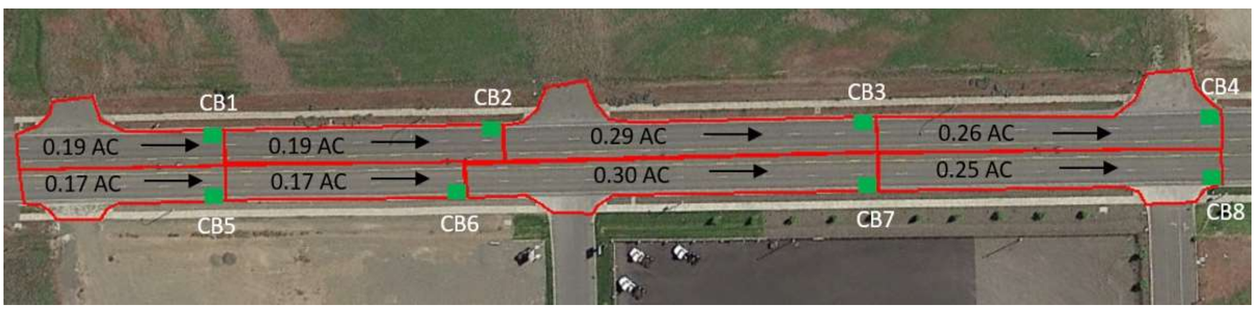


Figure 7.3 Basin delineations

The study location was selected because the proposed test site and control site provide equivalent areas for comparison including:

- The areas have the same average daily traffic (ADT), roadway topography, land use, and the same number of catch basins which are all configured to discharge to swales
- Typical variables that affect the results are not present at the study location such as leaf litter from tree canopies and parking is not permitted on the road so parked cars will not interfere street sweeping and catch basin cleaning practices
- The streets are curbed which prevents soil and associated pollutants from pervious areas from migrating onto the road

Figure 7.2 Study Area Catch Basin Station and Elevations

7.3 Operational BMP Function

The city's typical street sweeping and catch basin cleaning practices were documented from interviews with the equipment operators and the city's stormwater manager. A copy of the interview notes is located in Appendix E. This section provides a summary of the typical operating procedures for street sweeping and catch basin cleaning.

7.3.1 Street Sweeping

Street Sweeping occurs twice per month for principal arterials, once per month for secondary arterials, and once per year for collectors. The streets are swept using two 2016 Elgin Crosswind J Regenerative Air Sweepers. Regenerative air sweepers use rotating brooms and pressurized air on the street side of the pickup head under the vehicle to dislodge material from the street surface. Brooms rotate in opposite directions toward the center of the vehicle to direct material to the pickup head instead of to the outside of the vehicle (i.e. curb and gutter). A vacuum is applied on the opposite side of the pickup head from the pressurized air to pull material into the hopper. The frequencies and practices will be modified during the study to sweep the test and control site once every other month and immediately following catch basin cleaning. The modifications to procedures for this study are described in more detail in Section 8.1.3. Typical street sweeping procedures in Ellensburg are as follows:

- Step 1: At the start of the route to be swept, the sweeper pulls alongside the curb as closely as possible while still allowing the rotating brushes to reach the gutter.
- Step 2: Once the sweeper is aligned with the curb, the manifold at the front of the sweeper releases water to wet the pavement. The water is used to provide dust control, particularly later in the day, when transport of fines by wind is expected to be higher. Once the manifold is started, the brooms begin to rotate and are lowered, and the blower and vacuum near the rear of the sweeper is started.
- Step 3: The sweeper drives along the curb and gutter until the route is completed. Because higher amounts of material are expected to collect in and adjacent to the gutter, a single pass on each side of the street is typical. Once a year and following the winter season, an additional pass along the center median of arterials is performed to capture material in or next to the center median.
- Step 4: After sweeping is complete, the sweeper drives to the City's decant facility for disposal of material collected on the route.

7.3.2 Catch Basin Cleaning

To date, each catch basins is cleaned approximately once every four years using a 2012 VacCon V311/1000 Combination Vactor Truck. This frequency will be modified during the study to clean catch basins at the test and control site every other month. During the months when both street sweeping and catch basin cleaning occur the catch basins will be cleaned prior to street sweeping. The modifications to procedures for this study are described in more detail in Section 8.1.2. Typical catch basin cleaning procedures in Ellensburg are as follows:

- Step 1: The vactor truck drives to the catch basin to be cleaned, and parks alongside the curb so the front of the truck and vactor arm are in line with the inlet.

- Step 2: The catch basin grate is removed, and the arm is lowered to the bottom of the catch basin by use of remote control.
- Step 3: The vacuum is started and a high pressure water hose attached to the truck is used to wash any material adhered to the walls of the catch basin towards the bottom of the catch basin.
- Step 4: Once the accumulated material and water is removed from the catch basin, the vactor is removed and the grate is replaced on the catch basin.
- Step 5: Material collected during the catch basin cleaning is transported to the City's decant facility for disposal.

7.3.3 Equipment

The City of Ellensburg Stormwater O&M Plan includes street sweeping 100 lineal miles of road and cleaning approximately 2500 catch basins (City of Ellensburg, 2017). The city owns one street sweeper, an Elgin Crosswind J street sweeper, and two vactor trucks, VacCon Combination Truck. A summary of the equipment specifications are summarized in Table 7.2 with detailed equipment information located in Appendix E.

Table 7.2 Street Sweeper and Vactor Truck Equipment Specifications

2016 Elgin Crosswind J Street Sweeper (2016 Freightliner Chassis)	
Material Storage Capacity	8 CY
Broom Type	Dual Gutter Brooms
Total Sweeping Path	120 in.
Vacuum Pickup Head	2700 sq. in.
Blower Rating	20,000 cfm
Water Storage Capacity	240 gal
Number of Spray Nozzles	16
Pick-Up Efficiency	96.4%
2012 VacCon V311/1000 Combination Truck (2012 International Chassis)	
Material Storage Capacity	11 CY
Diameter of Vacuum Hose	8 in.
Vacuum Pickup Head	200 in. H_2O
Blower Rating	8000 cfm
Water Storage Capacity	1000 gal

7.4 Type of Data Being Collected

This section provides an overview of the types of data that will be collected. Specifically, Table 7.3 identifies the various types of data that will be collected, the location where data will be collected, equipment that will be used to collect data, the frequency of data collection, and the total number of samples that will be collected. In addition, Table 7.4 provides a timeline for when the data will be collected.

Table 7.3 Summary of Data Being Collected

Data Type	Data Collection Location	Equipment Used to Collect Data	Frequency	Total Number of Samples
Precipitation, Temperature, and wind speed	Weather Station	Weather Station	Continuously; (15 minute intervals) throughout the study	Continuously
Catch Basin Sediment Depth	Each Catch Basin	Survey Rod	Every other month before the catch basins are cleaned	64
Catch Basin Sediment Wet Weight and Moisture Content	All Catch Basins at Test Site	Vactor Truck	Every other month for two 6 month periods; starting on April 1st and ending on October 1st	8 & 24
	All Catch Basins at Control Site			8 & 24
Roadway Sediment Wet Weight and Moisture Content	Roadway Length at *Test Site*	Street Sweeper	Every other month for two 6 month periods; starting on April 1st and ending on October 1st	10 & 30
	Roadway Length at *Control Site*			2 & 6
Catch Basin Sediment Washout Dry Weight	All sump socks at *Test Site*	Manual	Every other month for two 6 month periods; starting on April 1st and ending on October 1st	32
	All sump socks at *Control Site*			32
Roadway, Catch Basin, and Sump Sediment PSD	Each sample location (roadway, catch basin, sump socks) at both the *Test Site and Control Site*	Manual	Two times per year from	22
Catch Basin Sediment Organic Content	All catch basins at the *Test Site and Control Site*	Manual	One time per year	4

Table 7.4 Proposed Annual Data Collection Schedule over Two Year Study Duration[7]

Location	Activity	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar
Study Area	Weather Station	X	X	X	X	X	X	X	X	X	X	X	X
Test Site	Street Sweep	X[1]		X[1,4]		X[1]		X[1,4]					
	Catch Basin Cleaning	X[2,3,4,6]		X[2,3]		X[2,3,4]		X[2,3]					
	Catch Basin Sediment Washout	X[5]		X[4,5]		X[5]		X[4,5]					
Control Site	Street Sweep	X[1,4]											
	Catch Basin Cleaning	X[2,3.4,6]		X[2,3]		X[2,3,4]		X[2,3]					
	Catch Basin Sediment Washout	X[5]		X[4,5]		X[5]		X[4,5]					

1. Collect roadway sediment and measure the wet weight from the control site once a year and the test site four times per year for a total of 5 wet weights per year (10 wet weights over the duration of the study). After weighing, collect three samples of sediment and submit samples to the lab to measure the moisture content. A total of 15 samples per year will be submitted to the lab for moisture content testing (30 samples over the duration of study).
2. Collect sediment from all the catch basins at the control site and then all the catch basins at the test site. The sediment wet weight will be measured four times per year for a total of 8 wet weights per year (16 wet weights total over the duration of the study). After weighing, collect three samples of sediment and submit samples to the lab to measure the moisture content. A total of 24 samples per year will be submitted to the lab for moisture content testing (48 samples total over the duration of study).
3. Measure the depth of sediment in each catch basin every other month at the test site (16 catch basins per year for a total of 32 measurements over the duration of the study) and at the control site (16 catch basins per year for a total of 32 measurements over the duration of the study).
4. Collect sediment samples and submit samples to the lab to determine PSD. The samples will be collected from the roadway sediment (2 from the test site and 1 from the control site per year for a total of 6 over the duration of the study), the catch basin sediment (2 from the test site and 2 from the control site per year for a total of 8 over the duration of the study), and catch basin sediment washout (2 from the test site and 2 from the control site per year for a total of 8 over the duration of the study).
5. Collect the sediment that washed out from the catch basins (into the socks located in the sumps) and submit the socks to the lab to determine the sediment dry weight. This will include collecting the socks every other month that are located in the sumps at the test site (16 socks per year for a total of 32 socks over the duration of the study) and at the control site (16 socks per year for a total of 32 socks over the duration of the study).
6. Submit samples of sediment from the catch basins to lab to determine the organic content. Samples will be collected once per year at the test site (for a total of two samples over the duration of the study) and at the control site (for a total of two samples over the duration of the study).
7. Data collection activities will occur on the 1st day of the month or the first day working day thereafter.

7.5 Sample Collection Process and Design(s)

This section provides an overview of the process for collecting the various types of data including the equipment that will be used to collect samples and where applicable the design of the sample collection system is described. Reference Section 8.0 for the detailed procedures (SOPs) for collecting samples and measuring field data.

7.5.1 Climate Data

A weather station will record precipitation, temperature, and wind speed data continuously at 15 minute intervals throughout the duration of the study. The weather station is located at 1306 W. Dolarway Road, which is approximately 1.5 miles from the study area as shown in Figure 7.4. The parcel where the weather station is located is owned by DirectTV, Inc. Personnel at that property will operate and maintain the weather station.

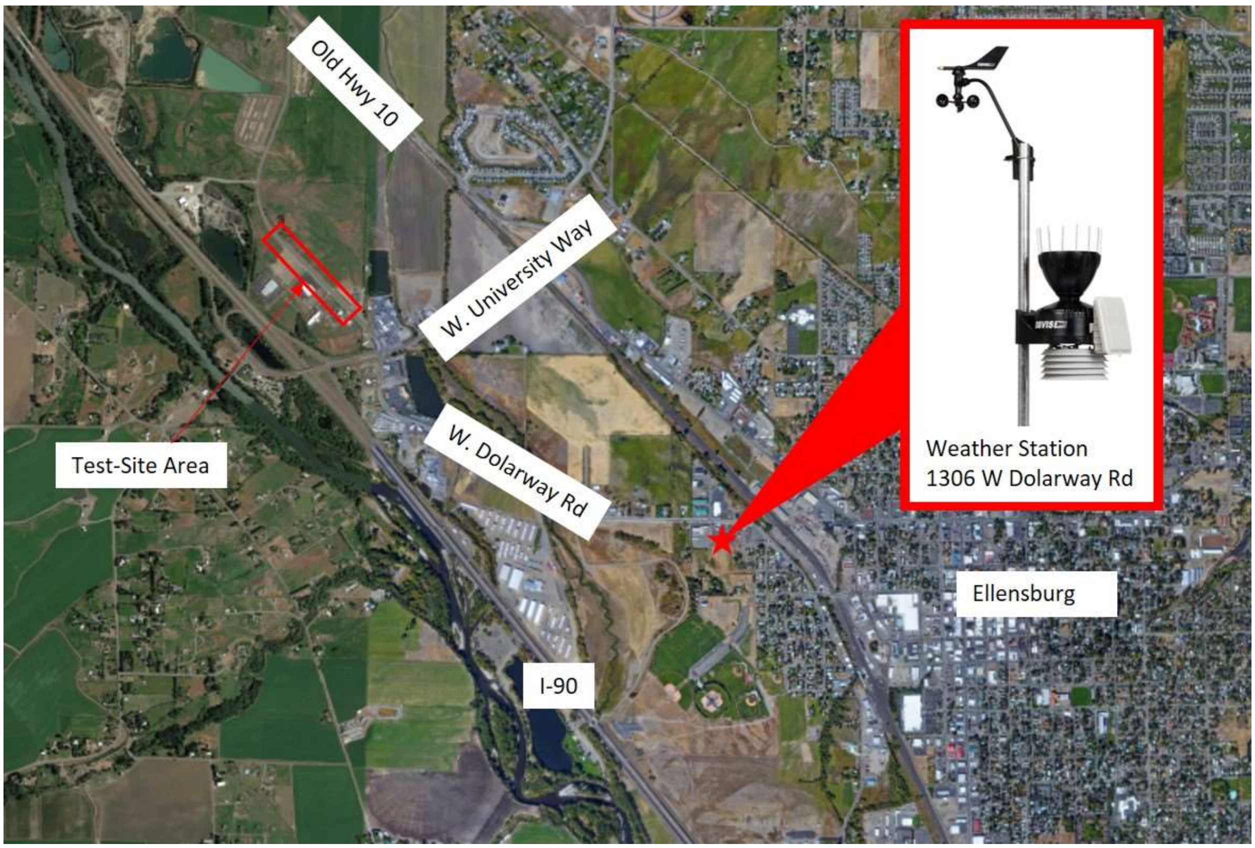


Figure 7.4 Location of Weather Station in Relation to the Study Area

The weather station is a Davis Instruments Vantage Pro2 station, which has the ability to measure rainfall, wind speed and direction, temperature, and humidity. Precipitation depth measured by the weather station is recorded through the use of a tipping bucket. The bucket has a level of accuracy of ±4% or ±0.01-inches, whichever is greater, for rain rates up to 4-inches per hour. Rainfall data is recorded every 20-24 seconds. A storm event is recorded once 0.02-inches has accumulated within the bucket, and the storm event is ended after 24 hours without further accumulation.

Wind speed is measured through the use of a cup anemometer. Speed is measured in 1 miles per hour (mph) increments and is recorded every 2.5 to 3 seconds. The data is also compiled into 10 to 15 minute intervals. The meter has a range of 1 to 200 mph and an accuracy of ±2 mph or ±5%, whichever is greater.

Temperature is measured through the use of a PN junction silicone diode (thermal diode), located beneath a solar radiation shield on the station. The temperature sensor is able to measure temperature between -40°F and 150°F. The temperature sensor is accurate to within ±0.5°F. Temperature is updated every 10 seconds and is compiled into 10 to 15 minute intervals.

Data recorded by the weather station is uploaded to Weather Underground (wunderground.com), a website which presents forecast and historical weather data. Data for the weather station at 1306 W Dolarway Road can be accessed and downloaded by the public at the webpage for the station (https://www.wunderground.com/personal-weather-station/dashboard?ID=KWAELLEN22).

7.5.2 Catch Basin Sediment Depth

The depth of sediment in each catch will be measured using a fiberglass, telescoping survey rod with hundredths of a foot gradations. This will include measuring from the rim of the catch basin to the top of the sediment in five different locations (Figure 7.5) before cleaning catch basins and subtracting these measurements from the depth of the catch basin empty. The average sediment depth in each catch basin will be determine by averaging the five measurements.

Figure 7.5 Catch basin sediment depth: measure in five locations full (left) and empty (right)

7.5.3 Catch Basin Sediment Wet Weight and Moisture Content

The catch basin sediment will be collected in the city's vactor truck following the procedures defined in Section 8.1.2. Sediment from the test site and control site will be collected and weighted separately. The sediment will be transported to the city's decant facility. Once the truck arrives at the decant facility, the sediment will be transferred to a basin for dewatering (Figure 7.6). The transfer of sediment to the basin is expected to take 5-10 minutes to prevent water and sediment from spattering outside of the basin. The dewatering basin will be retrofit with drains covered with a 1 micron felt filter fabric and attached to ball valves. The sediment will dewater by opening the valves and allow excess water to drain from the basin.

After excess water has been drained, the basin will be transported to a scale using a fork lift and pallet located under the basin to measure the wet weight. A Coti Global floor scale and Transcell TI-500E SS digital indicator will be used to measure the weight (Appendix M). The scale is 4-feet by 4-feet, with a 10,000 pound capacity. The digital indicator is set to display load from the floor scale in 0.1 pound increments. The sensitivity of the scale and digital indicator is 3 millivolts per volt (mV/V). The accuracy of the scale is ±1.06%. Additional information for the scale and digital indicator are located in Appendix M.

After the sediment has been weighted, three samples will be collected and submitted to the lab to determine the moisture content of the sediment collected. Sediment from the test site and control site will be collected and weighted separately.

Figure 7.6 Catch Basin Sediment Accumulation Data Collection

7.5.4 Roadway Sediment Wet Weight and Moisture Content

The roadway sediment will be collected in the city's street sweeper following the procedures defined in Section 8.1.3. Sediment from the test site and control site will be collected and weighted separately. The sediment will be transported to the city's decant facility and transferred to a basin for dewatering (Figure 7.7). Transfer of the sediment to the basin is expected to take approximately 5 minutes to prevent water and sediment from spattering outside of the basin. The equipment and process for dewatering, weighting the sediment, and collecting moisture content samples is the same as described in Section 7.5.3. Sediment from the test site and control site will be collected and weighted separately.

Figure 7.7 Roadway Sediment Accumulation Data Collection

7.5.5 Sump Sock Sediment Dry Weight

Sediment washed out of the catch basins through the storm drain pipe, will be collected in a sock (a 1-micron filter bag) that is installed in a sump on the discharge end of the pipe in the swale. An example of the typical setup is illustrated in Figure 7.8a and 7.8b which includes notes for constructing the setup and a copy of the sock cut-sheet is located in Appendix G. The sump will be retrofit with 1-inch drain holes on the bottom of the sump to allow excess water drain from the sump. Underneath the sump, existing soils will be replaced with a 2-foot by 2-foot by 2-foot section of 3-inch to 1½-inch gravel infiltration trench. The trench will provide additional storage for runoff discharging from the sump which will reduce the amount of water in the sump subsequently reducing the period of time that the sock is saturated. Sediment captured in the sock will be collected every other month after the respective catch basin is cleaned. This will include flushing the drain pipe of any residual sediment using the hose on the vactor truck. After excess water has drained from the sock, the sock will be replaced with a new sock and the old sock will be transferred to a sealable plastic container and submitted the lab to measure the sediment dry weight. Sediment from the test site and control site will be collected and weighted separately.

7.5.6 Catch Basin, Roadway, and Sump Sediment Particle Size Distribution

Two times each year, samples of sediment collected from the roadway, catch basins, and sump socks will be analyzed for particle size distribution. After the sediment has been weighted, samples will be collected and submitted to the lab for analysis.

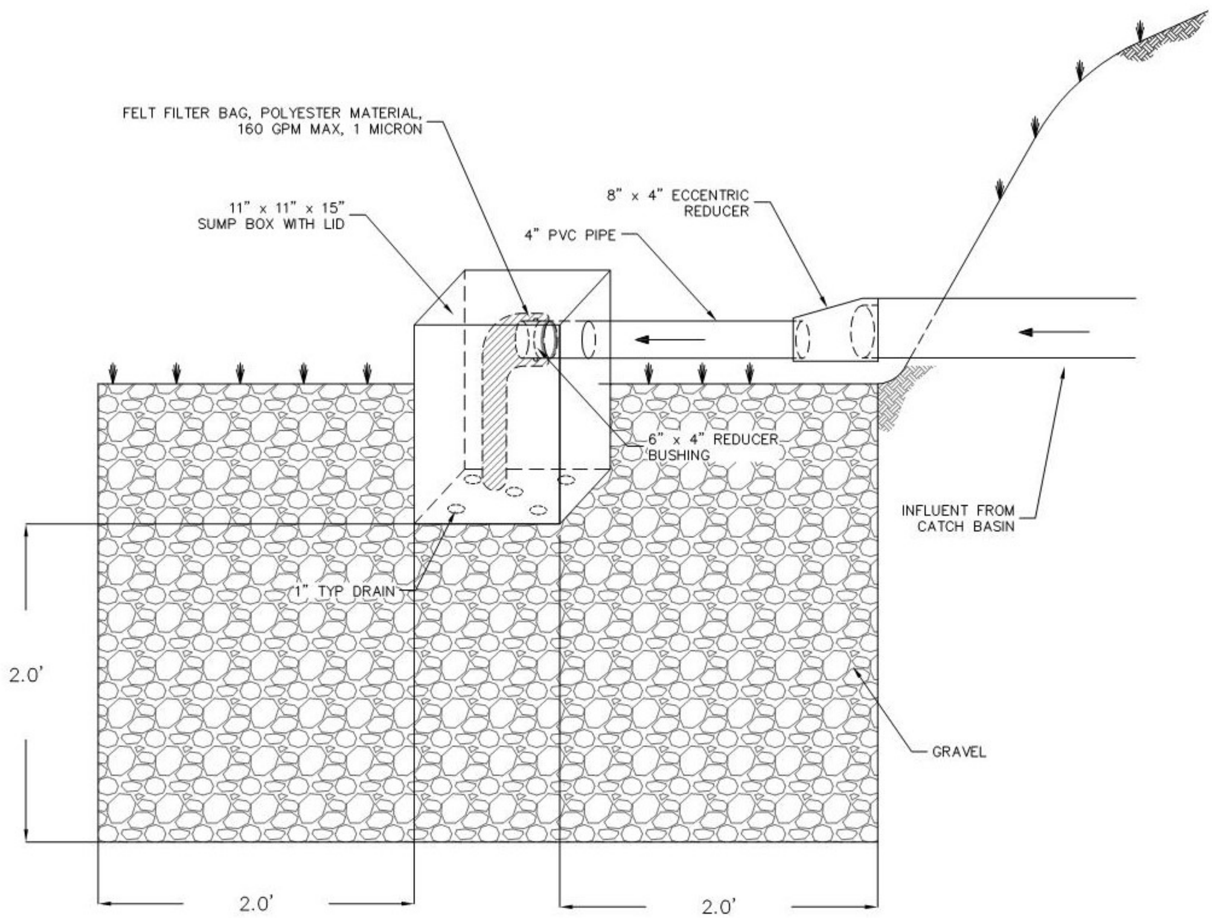


Figure 7.8a Typical Detail for Sump Sock Installation

Equipment List:

1 8"x4" Eccentric Reducer
1 4" PVC Sch. 40 DWV Plain End Pipe, 10 ft Section
1 Tuf-Tite 4-Hole Distribution Box with fittings and solid lid
1 6"x4" Reducer Bushing SPGxS
1 Safety Hasp, 3 ¼"
1 ¼" Wood Screws
1 Master Lock 1 ¾" Warded Steel Padlock
Zip ties, hose clamps, or similar
PVC Purple Primer
PVC Pipe Cement
Plumbing Sealant (optional, for extra seal)
Caulk Gun (optional, for extra seal)
Rust-Oleum Specialty Plastic Primer Spray, White
1.5" to 3" Clean Washed Stone or Gravel
Saw
Paper towels
Squirt/Spray bottle with water
1" Drill Bit, assorted phillips head drill bits
Cordless Drill
Appropriate PPE

Construction Notes:

1. Remove rock, sediment, and other material around the existing outlet pipe in the swale as needed to be able to cut the pipe. Dig out area necessary for infiltration trench as shown on detail.
2. Cut off enough of the mitered end of the pipe so the 8" x 4 " eccentric reducer can fit around the outlet pipe without any gaps or spaces between the reducer end and pipe end.
3. Wash off end of outlet pipe with water to remove any sediment or material on the pipe. Dry with a paper towel. Apply PVC primer around the outside of the pipe end once the pipe is dry, as well as to the inside of the 8" reducer opening.
4. Quickly apply PVC cement to the outside of the pipe and inside of the reducer where primer was applied. Push the reducer onto the pipe outlet firmly and twist the bushing while holding the pipe in place to get a good seal.
5. Cut an approximately 2.5-ft long section of 4" Sch 40 PVC pipe. Wash off one end of the outlet pipe with water and dry with a paper towel. Apply PVC primer to clean pipe end and inside of the 4" reducer opening. Quickly apply PVC cement to where the PVC primer was applied on the outside of the pipe and inside of the reducer, push pipe into reducer, and twist the pipe while holding the reducer in place to get a good seal.
6. If needed, remove the highest plug on the Tuf-Tite box and cut the plug per manufacturer instructions to allow a 4" pipe to fit through the plug. Replace the plug once the hole has been cut.
7. Drill at least five 1-inch holes using a cordless drill and 1-inch drill bit in the base of the Tuf-Tite Box.
8. Slide the end of the 4" Sch 40 PVC pipe opposite the 8" x 4" eccentric reducer into the opening in the side of the Tuf-Tite box. Cut off any excess PVC pipe length as necessary. Provide support for the Tuf-Tite box as needed while the filter is assembled inside the box.
9. Wash off the end of the pipe inside the Tuf-Tite box and dry with a paper towel. Apply PVC primer around the outside of the pipe and the inside of the 6" x 4" reducer bushing (4") opening. Quickly apply PVC cement to the outside of the pipe and inside of the reducer bushing opening where PVC primer was applied. Slide the reducer bushing onto the end of the pipe, and twist the bushing while holding the pipe in place to get a good seal.
10. Slide filter bag over the outside of the reducer bushing so the opening of the filter bag rests on the 4" Sch 40 PVC pipe. Tightly fasten a zip tie, hose clamp, or similar around the outside of the filter bag so the bag cannot slip off the end of the pipe and so water will not easily leak out of the opening of the filter bag.
11. Place the lid on top of the Tuf-Tite box.
12. Backfill the infiltration trench area with 3" to 1.5" clean washed stone or gravel to the existing grade.
13. Use the cordless drill to fasten the safety hasp to the lid and box with the wood screws. Once the hasp has been attached, lock the box with the padlock.
14. Spray the exposed PVC pipe and 8" x 4" reducer bushing with the plastic primer spray to protect pipe from UV damage.

Figure 7.8b Notes for Installing Catch Basin Washout Sediment Collection System

8.0 Sampling Procedures

This section defines the field procedures for collecting samples, measuring data, and the procedures for operating the equipment (i.e. street sweepers, vactor trucks, etc.) during the study. The order of the procedures in the following section represents the order in which the procedures will occur during the study.

Note: For year one, the test site will be on the north side of the road, and the control site will be the south side of the road. During year two, the south side will become the test site and the north side will become the control site.

8.1 Standard Operating Procedures

The standard operating procedures (SOPs) that will be followed during this study are summarized below and described in the subsequent 8.1 subsections.

8.1.1 Measuring Catch Basin Sediment Depth

8.1.2 Catch Basin Sediment Collection

8.1.3 Roadway Sediment Collection

8.1.4 Catch Basin Sediment Washout Collection

8.1.5 Dewatering and Weighing Sediment Samples

8.1.6 Sample Collection and Handling: Moisture Content, Organic Content, and PSD

8.1.7 Inspection of the Study Area for Damage or Vandalism

8.1.8 Calibration of Equipment: Scale and Weather Station

8.1.9 Maintenance of Street Sweeper and Vactor Truck

8.1.1 Measuring Catch Basin Sediment Depth

This sections describes the procedures for measuring the sediment depth in each catch basin.

Equipment needed:

- Survey Rod, minimum 10-feet long, with hundredths of a foot gradations
- Field Data Collection Form: Catch Basin Sediment Depth Measurements (Appendix H)

Summary of procedures for taking measurements prior to cleaning the catch basin:

- Step 1: This process will be followed at each of the 8 catch basins every other month (April 1st to October 1st) immediately before removing sediments from the catch basins using the vactor truck.
- Step 2: Remove the grate inlet
- Step 3: Select the center of one of the quadrants or the center of the tee as shown in Figure 7.5

- Step 4: Lower the survey rod into the catch basin taking care not to disrupt the sediment on the bottom of the catch basin
- Step 5: Place the survey rod on top of the sediment, verify the rod is perpendicular to the bottom of the catch basin, record the depth on the survey rod at the rim of the catch basin on the data collection form
- Step 6: Repeat steps 3-5 at the center of one of the other four quadrant locations or the center of the tee, as shown in Figure 7.5, until the depth has been measured in all five locations
- Step 7: Calculate the average depth of the five measurements and record the value on the data collection form.
- Step 8: Calculate the average depth of sediment in each catch basin: subtract the average depth measured in the clean catch basin (Step 15) from the step 7 average depth calculated

Summary of procedures for taking measurements after cleaning the catch basin:

- Step 9: Complete steps 10-15 at each of the 8 catch basins once during the study immediately after the catch basins has been cleaned using the vactor truck.
- Step 10: Remove the grate inlet
- Step 11: Select a location in the catch basin
- Step 12: Place the survey rod on the bottom of the catch basin
- Step 13: Verify the rod is perpendicular to the bottom of the catch basin, record the depth on the survey rod at the rim of the catch basin on the field data collection form
- Step 14: Repeat steps 11-13 at four more locations in the catch basin
- Step 15: Calculate the average depth of the five measurements and record the value on the data collection form

8.1.2 Catch Basin Sediment Collection

During the study, four catch basins will be cleaned on each side of State Route 97 (eight catch basins total). Each catch basin will be cleaned once every other month for the duration of the study. The catch basin should be cleaned prior to street sweeping. Typical catch basin cleaning for Ellensburg are located in Section 7.3.2. Modifications to the procedures for catch basin cleaning for this study site are as follows:

- Step 1: Prior to travelling to the site to clean the catch basins, empty and clean the inside of the vactor truck debris tank by spraying the tank with a water until there is no visible sediment in the tank
- Step 2: The vactor truck drives to one of the four catch basins to be cleaned at either the test site or control site, and parks alongside the curb so the front of the truck and vactor arm are in line with the inlet.
- Step 3: The catch basin grate is removed, and the arm is lowered to the bottom of the catch basin by use of remote. A high pressure water hose attached to the truck will be used to wash any material accumulated on the grate rim into the catch basin.
- Step 4: The vacuum is started and a high pressure water hose attached to the truck is used to wash any material adhered to the walls of the catch basin towards the bottom of the catch

basin. Take care not to disturb the tee inside of the catch basin; if the tee is displaced, reconnect to the existing pipe.

- Step 5: Once the accumulated material and water is removed from the catch basin, the vactor is removed.
- Step 6: After the catch basin has cleaned, use the vactor truck hose to flush residual sediment from the drain pipe that discharges runoff from the catch basin to the swale. See Section 8.1.4 for procedures. After the drain pipe has been flushed, the grate should be replaced on the catch basin.
- Step 7: Steps 2-6 are repeated for the rest of the catch basins on the same side of the road.
- Step 8: Once all four catch basins have been cleaned on one side of the site (either test site or control site), collected sediment is transported to the City's decant facility for disposal. During the study, the material from catch basin cleaning will be will be disposed of in a basin (Figure 8.1), dewatered (Section 8.1.5), weighed, and then samples will be collected for analysis.
- Step 9: Once the vactor truck arrives at the decant facility, the truck will back into one of the decant bays. The basin should be placed below the rear door of the vactor truck on top of a wood pallet.
- Step 10: The rear door of the vactor truck is opened slightly and sediment and water are allowed to slowly flow out into the basin taking care to prevent water and sediment from splashing outside of the basin. The debris tank should be elevated hydraulically as needed to allow more sediment and water to flow into the basin. Once water stops flowing out of the debris tank, a hose will be used to remove any sediment remaining in the debris tank. Emptying of the debris tank into the basin is expected to take 5-10 minutes. The sediment in the basin will then dewater according to the procedures in Section 8.1.5. Following dewatering, the sediment is weighed (Section 8.1.5) and samples are collected (Section 8.1.6).
- Step 11: Once all of the sediment has been removed from the debris tank, clean the inside of the vactor truck debris tank by spraying the tank with a water until there is no visible sediment in the tank. Then return to the site and repeat steps 2-7 to collect sediment from the side opposite of what side was collected previously.
- Step 12: Repeat steps 9-10, but use a different basin and pallet to dewater, weigh, and collect samples from sediment collected on the other side of the site.

8.1.3 Roadway Sediment Collection

During the study, the test and control site (Station 0+00 to approximately 10+65) will be swept once every other month immediately following catch basin cleaning. Typical street sweeping practices for Ellensburg and for State Route 97 (primary arterial) are located in Section 7.3.1. Modifications to the procedures for sweeping for this study site are as follows:

- Step 1: If necessary, empty and clean the inside of the sweeper debris tank prior to travelling to the site.
- Step 2: The sweeper will pull alongside the curb on the north side of State Route 97 (test site) at Station 0+00 just downstream of the catch basin at the downstream end of the study area (CB-4, see Figure 7.2).

- Step 3: Once the sweeper is aligned with the curb, the manifold at the front of the sweeper will release water to wet the pavement, the brooms will begin to rotate and will be lowered, and the vacuum near the rear of the sweeper will be started.
- Step 4: Sweeping of the study area will be complete once the sweeper reaches the study area boundary just downstream of the catch basin upstream of CB-1, near Station 10+65 (See Figure 7.2). During the study, the contributing basin areas immediately upstream of State Route 97 which contribute runoff and sediment loads, such as turnouts, will not be swept in order to match typical street sweeping procedures.
- Step 5: After sweeping is complete on the north side of State Route 97, the sweeper will dispose of the material at the City's decant facility. During this study, the material will be disposed of in a basin (Figure 8.1) for measurement and analysis.
- Step 6: Once the sweeper arrives at the decant facility, the vehicle will back into one of the decant bays. The basin should be placed below the rear door of the sweeper on top of a wood pallet.
- Step 7: The rear door of the sweeper truck is opened and sediment is allowed to slowly slide out into the basin taking care to prevent water and sediment from splashing outside of the basin. The hopper is elevated hydraulically as needed to allow more sediment to slide into the basin. Once sediment stops sliding out of the hopper, a hose will be used to remove any sediment remaining in the hopper. Emptying of the hopper into the basin is expected to take approximately 5 minutes. The sediment in the basin will then dewater according to the procedures in Section 8.1.5. Following dewatering, the sediment is weighed (Section 8.1.5) and samples are collected (Section 8.1.6).
- Step 8: Steps 1-3 will be repeated for the south side of State Route 97 only on April 1st (or the next business day thereafter). Prior to returning to the site, all of the sediment should be removed from the tank into the basin and the tank should be cleaned using a water until there is no visible sediment in the tank. The sweeper will start sweeping at Station 10+65 and end at 0+00 (CB-8, see Figure 7.2).
- Step 9: After sweeping is complete on the south side of State Route 97, steps 4-6 should be repeated, and sediment from the south side of the road should be disposed of in a separate basin from the one used for the north side sediment.
- Step 10: During the second year of the study, the south side of State Route 97 will become the test site, and Steps 2-6 outlined above will be performed for the south side of the road only, except on April 1st (or the next business day thereafter).

Note: Only the curb lines will be sampled since studies have repeatedly found most roadway sediment accumulates in the first 3-feet from the curb line (Pitt, 2004; Sartor, 1972; Novotny, 2003).

8.1.4 Catch Basin Sediment Washout Collection

This sections describes the procedures for collecting sediment from the sump socks located at the end of the drain pipe in the swale.

Equipment Needed:

- 8 Sump Socks
- Key for padlock

- Eight sealable plastic bags
- Scissors, razor, or screwdriver
- Releasable cable ties
- Zip ties or similar fastener
- Permanent markers
- Chain of Custody form (Appendix I)
- Sump Sock Sediment Collection and Dry Weight Analysis Field Data Collection Form (Appendix H)

Summary of procedures for collecting sediment from sumps.

- Prior to field work, the sump sock will be weighted in the City of Ellensburg Laboratory (to the nearest 2-grams) and each sock will be labeled. The label should match the respective catch basin for which the sock will be installed as shown on Figure 7.2 (i.e., CB1, CB2, etc). Both the weight and label will be documented on the data collection form.
- Step 1: Unlock the lid of the sump box using the padlock keys and remove the lid
- Step 2: After the catch basin has cleaned, use the vactor truck hose to flush residual sediment from the drain pipe into the sump. Observe water entering the filter sock over the pipe end. Note if any water bypasses the sock or if any holes or tears are present on the data collection form.
- Step 3: Allow excess water to drain from the sump (no visible standing water)
- Step 4: Squeeze the filter sock to release any excess water. Seal the open sock end using a releasable cable tie.
- Step 5: Use the scissors, razor, or screwdriver to remove the zip tie or similar fastener attaching the filter sock to the end of the pipe. Take care not to cut the filter sock. Then place the filter sock into a sealable plastic bag and label the plastic container with the catch basin number and date.
- Step 6: Place a clean filter sock over the coupler and end of the pipe inside the box so the opening of the filter sock is around the pipe. Secure the filter sock on the pipe by tightly fastening a zip tie or similar fastener around the filter sock just below the opening. Then lock the sump box using the padlocks
- Step 7: Repeat steps 1-6 at each sump at the test site and the control site
- Step 8: Fill out the chain of custody form and transport (or ship) the samples and the form to the lab immediately after collecting sediment from the last sump.
    - Mailing address for Anatek is as follows:
      Anatek Labs
      504 E Sprague Ave # D
      Spokane, WA 99202

- The lab will determine the dry weight of the sediment in each sock following the procedures defined in Section 9.4.

8.1.5 Dewatering and Weighing Sediment Samples

This sections describes the procedures for dewatering the roadway and catch basin sediment after the sediment has been transferred to the basin (Figure 8.1).

Equipment Needed:

- Dewatering basin (See Figure 8.1)
- Shovel
- Forklift
- Coti Global floor scale and Transcell TI-500E SS digital indicator
- Sediment Weight Data Collection form (Appendix H)

Summary of procedures for dewatering sediment samples.

- Step 1: Inspect the filter fabric on the fitting for any tears or lose fittings. If needed replace the filter fabric prior to disposing of the sediment in the basin.
- Step 2: Weigh the basin and the wood pallet empty and record the weight on the data collection form.
- Step 3: Allow the roadway and catch basin sediment to settle in the basin for a minimum of 1 hour (the time required for a 10µm diameter of sediment to fall 1-foot, see Appendix M). *Alternatively, allow the basin to sit undisturbed and covered for 7 days (the time required for sediment 1µm in diameter to settle to the bottom of the basin) and the filter fabric on the top 3 rows of values maybe removed.*
- Step 4: Open the top row of drain valves on the side of the basin and allow the excess water to drain from the sediment. Wait 20 minutes before opening the second row of valves from the top.
- Step 5: Once the second row of valves has been opened, wait an additional 20 minutes to open the third row of valves from the top.
- Step 6: After the third row of valves has been opened, wait an additional 20 minutes to open the final row of valves.
- Step 7: Sediment may need to be shifted in the basin to allow water to fully drain out of the valves. Use a shovel or other barrier in the basin to hold soil away from the drain valves. Open the bottom valve on the end of the tank to allow any remaining water to drain out of the basin. Carefully remove any sediment from the shovel back into the basin by lightly tapping the shovel on the sides of the basin.
- Step 8: The dewatering process is complete when there is no visible standing water in the basin and when visual and tactile estimates of the sediment suggest that the soil moisture content is less than 100%. Visual and tactile estimates will be made in accordance with NRCS documentation (Natural Resource Conservation Service, 1998), as described in Table 8.1. The soil will be allowed to dewater until it meets the criteria for 75-100% (highlighted below) in Table 8.1.
- Step 9: Close the valves. Use a forklift and the pallet below the basin to transfer the basin to the scale. Record the weight of the dewatered sediment on the data collection form.
- Step 10: Collect moisture content, organic content, and PSD samples as described in Section 8.1.6

Table 8.1 – Guidelines for Estimating Soil Moisture Conditions

Available Soil Moisture Percent	Soil Moisture Indicators for Coarse Texture – Fine Sand and Loamy Fine Sand
0-25	Dry, loose, will hold together if not disturbed, loose sand grains on fingers with applied pressure.
25-50	Slightly moist, forms a very weak ball with well-defined finger marks, light coating of loose and aggregated sand grains remain on fingers.
50-75	Moist, forms a weak ball with loose and aggregated sand grains on fingers, darkened color, moderate water staining on fingers, will not ribbon.
75-100	Wet, forms a weak ball, loose and aggregated sand grains remain on fingers, darkened color, heavy water staining on fingers, will not ribbon.
Field Capacity (100%)	Wet, forms a weak ball, moderate to heavy soil/water coating on fingers, wet outline of soft ball remains on hand.

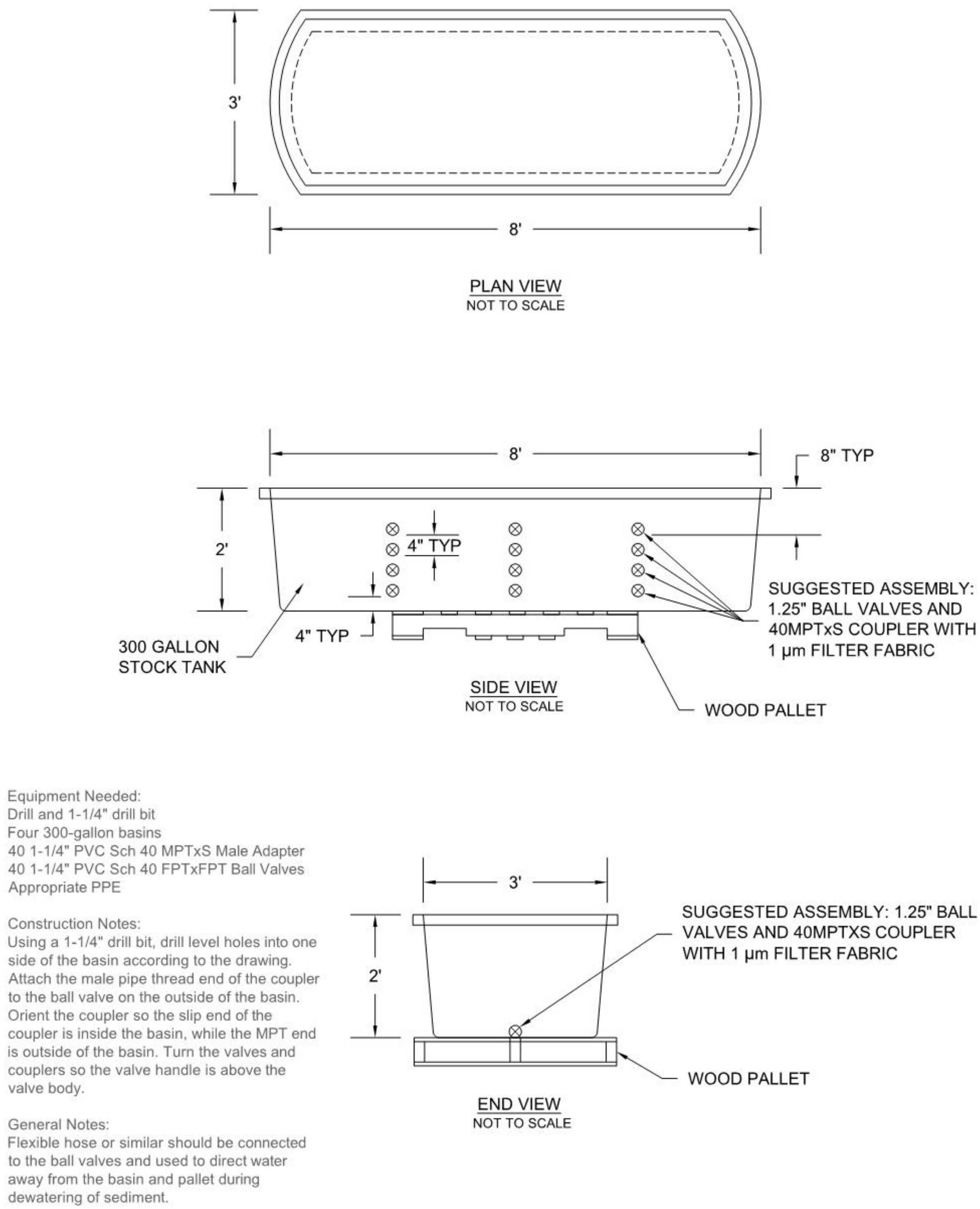


Figure 8.1 Sediment Basin and Dewatering

8.1.6 Sample Collection and Handling: Moisture Content, Organic Content, and PSD

This sections describes the procedures for collecting roadway and catch basin sediment samples which will be submitted to the Laboratory for moisture content, organic content, and PSD testing.

Equipment Needed:

- Stainless steel scoop
- Stainless Steel Bowl
- Sealable plastic containers (See Table 9.2)
- Chain of Custody form (Appendix I)
- Sediment Weight Field Data Collection Form: Roadway and Catch Basins Form (Appendix H)

Summary of procedures for collecting sediment samples.

- Step 1: The stainless steel scoop and bowl should be washed with soap and water and dried before collecting samples
- Step 2: After the roadway and catch basin sediment has been weighted and while it is still in the dewatering basin, randomly select three to six locations in the sediment pile. Using the stainless scoop, collect samples from the a few inches below the surface. Empty the samples into to a stainless steel bowl and homogenize the sample using the stainless steel scoop.
- Step 3: Using the stainless steel scoop, fill the sealable plastic containers with sediment and immediately refrigerate the samples. *Reference Table 9.2 regarding standard testing methods, the sample size, preservation methods, and holding time*
- *Note PSD and organic content will only be tested twice each year*
- Step 4: Fill out the chain of custody form and label the samples.
- Step 5: Transport the samples and the form to the lab
  - Mailing address for the lab is as follows:
    Anatek Labs
    504 E Sprague Ave # D
    Spokane, WA 99202

- Step 6: After samples are collected, the sediment in the basin should be disposed of with other catch basin and street sweeping sediment at the decent facility. Clean the basin by spraying the inside of the basin with tap water. Turn the basin upside down on the pallet and allow the basin to dry.

8.1.7 Inspection of the Study Area for Damage or Vandalism

This sections describes the procedures for inspecting the study area for damage or vandalism.

Equipment Needed:

- Note pad and pen
- Camera

Summary of procedures for inspecting study area. Inspections should occur once a week.

- Step 1: Visually inspect the inside of the catch basin for spills (i.e. oil) or illicit discharge. If spills or illicit discharge is identified, have catch basin cleaned as soon as possible.
- Step 2: Visually inspect the sump (in the swale) for damage or vandalism. If the sump is damaged, repair the sump as soon as possible.
- Step 3: Report any incidents in note pad including the day of the inspection
- Step 4: Maintain inspection the note pad throughout the study. Create PDF copies of the inspection notes once a month and email a copy to the Project Manager within 24 hours of making the PDF copy.

8.1.8 Calibration and Maintenance of Equipment: Scale and Weather Station

Weather Station

The weather station is owned by Direct TV, Inc., as such they are responsible for maintenance and calibration of the equipment. Records of the maintenance and calibration activities will be obtained from Direct TV and stored with the data for this study.

Scale

The scale that will be located at the decant facility, for weighing catch basin and roadway sediment, will be rented for this study. Each year the vendor will transport the scale to the decant facility and calibrate the equipment during setup (prior to April 1st). At the end of the study period (October), the vendor will pick up the scale. The vendor is also responsible for maintaining the scale. Records of the maintenance and calibration activities will be obtained from the vendor and stored with the data for this study

8.1.9 Maintenance of Street Sweeper and Vactor Truck

This sections describes the procedures for maintaining the street sweeper and vactor truck.

Equipment Needed:

- Maintenance Record Reports

Summary of procedures:

- The equipment will be maintained per the manufactures recommendations
- Records of maintenance activities will be kept throughout the study
- PDF copies of the records will be created monthly or (if longer than a month between maintenance activities) create PDF copies following any maintenance activities. A copy of the PDF should be emailed to the Project Manager within 24 hours of making the copy.
- Maintenance records will be stored with the data for this study as described in Section 11.

8.2 Containers, Preservation Methods, Holding Times

Table 9.2 includes the containers, sample size, preservation, and holding times for each parameter that will be collected during this study: moisture content, organic content, and PSD.

8.3 Equipment Decontamination

The SOPs in Section 8.1 describes how the sampling equipment will be decontaminated between sampling events and procedures for disposing of any waste collected during the study.

8.4 Sample Identification

This section defines the protocol for labeling (identifying) samples and data collected in the field during the study. Samples collected in the field include moisture content, organic content, PSD, and sump socks. Each sample will have a consistent identification that incorporates the items noted below:

- Date and year sample was collected: two digit number for the month, day, and year
- Location sample was collected: test site (TS) or control site (CS) and catch basin (CB#) or catch basin sump sock number (CBS#)
- Parameters to be measured: moisture content (MC), organic content (OC), particle size distribution (PSD), or sump sock (SS) dry weight
- Where multiple samples of the same parameter will be tested, the sample number (S#) will also be included

8.5 Chain of Custody

A chain of custody form will be completed at the time samples are collected and the form will accompany all samples to the lab and document all persons in possession of the sample from the time the sample is collected until the sample is submitted to the lab for testing. A copy the standard chain of custody form that will be used during the study is located in Appendix I.

8.6 Field Log Requirements

Standard forms have been developed for collecting data. These forms are defined where applicable in the Section 8.1 SOPs. Copies of the forms are located in Appendix H.

9.0 Measurement Procedures

The purpose of this section is to identify the methods required to measure the data collected during the study in the laboratory procedures.

9.1 Procedures for Collecting Field Measurements

Procedures for collecting and measuring data in the field are defined in Section 8.1.

9.2 Laboratory Procedures

This section defines the measurement procedures for all analytical testing that will be performed by the lab.

Table 9.2. Parameter Laboratory Testing Methods and Procedures

Parameter	Testing Method	Sample Size (grams)	Sample Container	Preservation Method	Laboratory	Number of Samples[1]
Moisture Content	ASTM D2216	10	4 oz. Clear Glass Wide Jar	Refrigerate to 4°C	Anatek	78
Particle Size Distribution Sieve Analysis Sizes: Gravel >2mm Coarse Sand 0.25-2mm Fine Sand 75-250 µm Silt/Clay <75µm	ASTM D422	100	16 oz. Soil Jar	Refrigerate to 4°C	Budinger & Associates, Inc.	22
Organic Content	ASTM D2974	50	4 oz. Soil Jar	Refrigerate to 4°C	Anatek	4
Sump Sock Sediment Dry Weight	See Section 9.4	Sump Sock	Sump Sock and Plastic Bag	Refrigerate to 4°C	Anatek	64

1. See Table 7.4 footnotes for details regarding how the number of samples were calculated.

9.3 Sample Preparation Methods

Sample preparation methods are defined in Section 8.1.

9.4 Special Method Requirements

The sump sock sediment dry weight will be determined at the laboratory using the following procedures:

- The laboratory will receive the sump socks in sealed plastic bags and the socks will be analyzed to the dry weight.

- If sump socks are saturated when removed from the plastic bags, they will be hung to dry until the socks are no longer saturated. Care will be taken to prevent the sediment inside the socks from spilling out from the socks.
- The sump socks will be placed in the oven at 105º. The socks will be minimally folded or coiled to fit in the oven and may have to be manipulated during the drying process to insure all parts of the filter bag are dried consistently.
- Depending on the wetness of the socks, they will remain in the oven until the socks feel completely dry to the touch which is estimate to be between 24 to 48 hours.
- Then the sock will be weighted (to the nearest 2-gram) every hour and the weight will be recorded. When the difference in the sock weight is less than 1%, the final sock weight (W_{SF}) will be recorded.
- The sediment dry weight will be determined by subtracting the final weight (W_{SF}) from the initial sock weight (W_{SF}). If the particle size distribution (PSD) is not tested, the sock will be disposed of after determining the final weight of the sock.
- When PSD is tested, the sediment will be removed from each sock and composited. This will include pouring the sediment from the sock and vigorously shaking the sock into a ziplock bag. After the sock is emptied, the sock will be disposed of.

9.5 Lab(s) Accredited for Methods

All parameters noted in Table 9.1, except particle size distribution, will be tested at Anatek which is an Ecology accredited laboratory. Particle size distribution will be tested by Budinger & Associates, Inc.

10.0 Quality Control

This section describes the QC procedures for lab and field activities that will be employed to minimize errors.

10.1 Field QC Required

This section defines the QC procedures that will be implemented for field activities. The QC procedures for this study include:

- Data collection activities will be performed following the schedule outlined in Table 5.2
- SOPs were developed (Section 8.0 and (9.4) that define procedures for collecting and measuring data. Prior to the start of data collection, the field staff will be trained on the SOPs for this study to ensure consistent and quality controlled data collection
- The field staff will consistently follow the SOPs for data collection
- Standard testing methods will be followed for all analytical testing (Section 9.0)
- Manufacturers recommendations for equipment maintenance (i.e. street sweepers and vactor trucks) will be followed and documented as defined in the Section 8.0 SOP
- The manufactures recommendations for maintenance will be followed and documented as defined in the Section 8.0 SOP
- Record keeping procedures were developed and will be consistently followed (see section 11.0 Data Management)
- Audits will be performed to verify that the QAPP is being followed (Section 12.0)

10.2 Laboratory QC Required

This section defines the QC measures that the lab will employ during the study. Anatek and Budinger & Associates, Inc. will follow their typical QC procedures and provide the lead entity with records of QC results from analyzing study samples. Duplicate samples will also be tested for moisture content, organic content, and PSD to verify the quality of the data produced by the lab.

10.3 Corrective Action

The auditor will notify the lead entity and principal investigator in writing (via email) within 2 business days if corrective actions is needed based on the audit findings. The lead entity and principal investigator are responsible for developing and implementing a written corrective action plan within 30 days of being notified by the auditor. A record of the corrective action plan will be kept throughout the study (see example in Appendix K) and included in the final report.

11.0 Data Management Plan Procedures

This section defines the data management plan for the study. Specifically how the data and other important project documents will be managed, stored, and archived during the study. This plan was developed to reduce the potential for errors during the data collection and analysis phases of the project.

11.1 Data Recording and Reporting Requirements

This section describes the procedures for recording data and compiling the data collected (transferring the data to an electronic format).

Data recorded in the field will be documented on the following standard forms that were developed specifically for this study:

- Field Data Collection Forms (Appendix H)
- Chain of Custody (Appendix J)

These forms will be completed by the field crew and then the hard copy of the form will be given to the Lead Entity for the City of Ellensburg (Project Manager) within 1 business day of the data being collected. The lead entity will then verify that the data collection forms have been completely filled out.

Data that will be compiled includes:

- Completed Field Data Collection Forms
- Completed Chain of Custody Forms
- Analytical Testing Results Received from the Lab
- Audit findings

The lead entity is responsible for saving a PDF version of the all documents within one business day of receiving the documents and ensuring that the data is archived until after the Final Technical Report has been approved by Ecology. All documents will be saved to the City of Ellensburg's share point site at the following link:
https://g3coe-my.sharepoint.com/:f:/g/personal/morrowj_ci_ellensburg_wa_us/EmXog-Qy29ZKrp7mgWC3MzcB3qihJ14cPlXw7LkPSr3nlA?e=qfnfCc

The Principal Investigator is responsible for transferring data from the lab and the field forms to Excel Spreadsheets for analysis. The data verifiers (see Section 5.0) are responsible for verifying that the data collected in the field has been correctly transferred in the Excel format.

11.2 Electronic Transfer Requirements

This section describes the project protocol for transferring data electronically during the data collection phase of the study. Data that maybe transferred electronically includes:

- Completed Field Data Collection Forms

- Completed Chain of Custody Forms
- Analytical Testing Results Received from the Lab

The Lab will transfer data electronically to the lead entity via email. The lead entity will email electronic copies of the documents to the Principal Investigator.

All electronic files will be saved with a unique file name that is easily searchable which will include the date the data was collected and the type of data collected.

11.3 Laboratory Data Package Requirements

The laboratory data package includes a report of the analytical results for each parameter in a PDF format which will be emailed to the lead entity.

11.4 Procedures for Missing Data

Any data missing from the field data collection forms or the lab will be documented in the Excel Spreadsheet by coding the data as M (for missing). In addition a note will be added to the spreadsheet explaining the reasons why the data is missing (if known). Missing data will be reported in the final technical report along with a description of how the data set was analyzed without the missing data.

11.5 Acceptance Criteria for Existing Data

Not applicable to this study.

11.6 Data Upload Procedures

For this project, data storage and delivery will be submitted to the municipal stormwater permit manager in an electronic spreadsheet format with the final report. This spreadsheet will contain all of the data from the study including all of the useable quality assured data used for the analysis and the rejected or un-useable data gathered as part of the study. The rejected data, along with annotation as to the reason for its exclusion, can be included in a separate file or tab. At the end of the study, the data collected will be uploaded to the International BMP database.

11.7 Revisions to the QAPP

If significant changes are made to the QAPP after the QAPP is approved and prior to the completion of the study, the QAPP will be revised and submitted to Ecology for review and approval. After the *revised* QAPP is approved, the document will be submitted (by the lead entity or the principal investigator) to the all persons on the Distribution List in this document. In addition, revisions to the QAPP will be documented using the Summary of QAPP Revisions Table located in Appendix K. A completed copy of this table will be included in the final technical report.

12.0 Audits

This section describes the types of audits that will be conducted, the audit process and procedures, number of audits, frequency, and who is responsible for conducting the audits. The QAPP Guidance Document (Ecology, 2004) includes two types of audits: Technical System Audit (Sections 12.1) and Proficiency Testing (Section 12.2).

12.1 Technical System Audits

This section identifies the technical system audits that will be conducted during the study, defines the procedures for conducting the audit, and identifies the party responsible for conducting each audit. Technical System Audits are qualitative audits performed to verify that the study is conducted in conformance to the QAPP. Ideally, the audit is conducted soon after work has commenced, so that corrective actions can be implemented early in the project. For the Eastern Washington Effectiveness studies, audits will be conducted by the auditors defined in Section 5.0.

Audits that will be conducted include:

- Verify the equipment operators are following the SOPs defined in Section 8.0 for operating the equipment (i.e. for street sweeping and catch basin)
- Verify equipment and instruments are being maintained and/or calibrated per the manufacturers requirements
- Verify the field staff are following the SOPs for sample collection and field data measurements in Section 8.0
- Verify the data management procedures defined in Section 11.0 are followed
- Verify that the laboratory is following the standard testing methods (Section 9.0)

Each audits will include:

- Visiting the study area during data collection once per year and interviewing the field crew regarding the SOP they are following in the field and comparing interview responses to the SOPs
- Visiting the site where the data is stored once per year and interviewing the lead entity or principal investigator regarding their data management procedures and comparing interview responses to the Data Management Plan in Section 11.0
- Reviewing the electronic files to verify that the data management procedures are followed
- Where a discrepancy is found, reference Section 10.3 for the corrective action plan

12.2 Proficiency Testing

Not applicable to this study.

13.0 Data Verification and Usability Assessment

This section defines the process the project will employ to evaluate the quality of the data and the usability of the data for meeting the project objectives.

The data that will be verified during the study which includes:

- Data collected from weather station, such as wind speed, temperature, and precipitation
- Catch basin sediment depth Measurements
- Sediment weight (wet weight) from the roadway, the catch basins, and sumps
- Moisture content, organic content, and PSD of sediments accumulated in catch basin, roadway, or sump

13.1 Field Data Verification

This section describes the process that will be employed to evaluate the quality of the data created in the field and identify responsible party for verifying the data.

13.2 Laboratory Data Verification

The analytical testing performed by the lab will be considered usable if the lab QC procedures are followed and the RPD for the parameters being analyzed is less than 20%. Also the chain of custody forms will be reviewed to verify that the sample preservation methods and holding times are consistent with the standard testing methods (Table 9.2). If any of these items are not met (i.e., QC procedures followed, RPD is greater than 20%, and preservation and holding times on the chain of custody form are not consistent with Table 9.2), the usability of the data will be evaluated by the lab manager, the lead entity, and the principal investigator. If it is determined that data is still of the quality needed to meet the study goals and objectives, the data will be considered useable and included in the data set analyzed. Otherwise the data will be considered unusable and not included in the data set for analysis. The process for deciding whether data is useable will be documented in the final report.

13.3 Data Usability Assessment

This section describes the procedures that will be used to establish the usability of the data for meeting the project objectives. This includes assessing whether the MPCs have been met for each of the applicable DQIs as defined in Table 6.1. If the MPCs have been met, then data should be of sufficient quality to be usable for meeting project objectives and will be considered useable. If the MPCs have not been met, the data will be evaluated by the lab manager, the lead entity, and the principal investigator. If it is determined that data is still of the quality needed to meet the study goals and objectives, the data will be considered useable and included in the data set analyzed. Otherwise the data will be considered unusable and not included in the data set for analysis. The process for deciding whether data is useable will be documented in the final report.

14.0 Data Analysis Methods

14.1 Data Analysis Methods

The goal of this study is to determine whether the frequency of street sweeping significantly reduces the rate of sediment accumulation in catch basins (and transported from catch basins). This will be evaluated by comparing the sediment accumulation rate during both year one and two. Specifically, comparing the sediment accumulation rate in the catch basins at the test site to the control site (Hypothesis 1) and the sediment accumulation rate in the sump socks (washout from catch basins) at the test site to the control site (Hypothesis 2). If there is a statistically significant difference, less sediment accumulation in the catch basins or the sump socks at the test site compared to the control site, the results will indicate that more frequent street sweeping reduces the accumulation of sediment in catch basins. Conversely if the differences are insignificant, the results will indicate that street sweeping did not reduce the accumulation of sediment in catch basins and sumps.

The distribution of sediment on the roadway will also be evaluated to determine if the sediment on the roadway was equivalent between year one and year two. This will be evaluated by comparing the sediment accumulation rate on the roadway during year one at the test site to the sediment accumulation rate on the roadway at the test site during year two (Hypothesis 3). If the difference is statistically significant, the results will indicate that the distribution of sediment is not equivalent between year one and two year. Conversely if the differences are insignificant, the results will indicate that the distribution of sediment is equivalent between year one and two year.

The process for determining the sediment accumulation rate for the catch basins, sumps, and roadway is described below. Then a statistical comparison of the data sets will be conducted.

- Calculate the average moisture content (from 3 samples) using Equation 1. This will include calculating the average moisture content from each sample location (roadway, catch basins, sump socks) for the test site and the control site. The Table 14.1 Sediment Accumulation form will be used to solve for and track results from Equation 1 and 2.

$$\omega_{average} = \frac{(\omega_1+\omega_2+\omega_3)}{3} \qquad \text{Equation 1}$$

Where:

$\omega_{average}$ = Average moisture content based on dry sediment weight (%)
$\omega_{1,2,3}$ = Moisture content of each sample based on dry sediment weight (%)

- Calculate the dry weight of sediment (Equation 2) using the sediment wet weight and the average moisture contents measured during the same months. This will include calculating the dry weight from each sample location (roadway, catch basins, sumps) for the test site and the control site.

$$W_{s-d} = \frac{W_{s-w}}{\left(1+\frac{\omega_{average}}{100}\right)} \qquad \text{Equation 2}$$

Where:

W_{s-w} = Sediment wet weight measured at the decant facility (pounds)
W_{s-d} = Sediment dry weight (pounds)

- Calculate the rate of sediment accumulation by weight for catch basins and sump sock (Equation 3). Since the basin areas were not the same size (Table 7.1), the data will need to be normalized for comparison to other studies using Equation 3. This will include calculating the average rate for catch basin and sump at the test site and the control site.

$$S_{AR} = \frac{\frac{\frac{W_{S-d}}{A_B} \times A_S}{N}}{T} \qquad \text{Equation 3}$$

Where:

$S_{AR\text{-}CB}$ = Sediment accumulation rate in catch basins $\left(\frac{\frac{Pounds}{catc\ \ basin}}{day}\right)$

$S_{AR\text{-}SS}$ = Sediment accumulation rate in sump socks $\left(\frac{\frac{Pounds}{sump\ sock}}{day}\right)$

A_B = Contributing basin area at test site or control site (sqft)
A_S = Total street area swept in test site or control site (sqft)
N = Number of catch basins or sump socks at the test site or control site
T = Number of days since last cleaning (days)

- Calculate the rate of sediment accumulation on the roadway by weight (Equation 4) for the test site and the control site per lineal mile. Since the basin areas were not the same size (Table 7.1), the data will need to be normalized for comparison to other studies using Equation 4.

$$S_{AR-RW} = \frac{\frac{\frac{W_{S-d}}{A_B} \times A_S}{L_m}}{T} \qquad \text{Equation 4}$$

Where:

$S_{AR\text{-}RW}$ = Sediment accumulation rate $\left(\frac{\frac{Pounds}{lineal\ mile}}{day}\right)$

L_m = lineal mile swept at the test site or control site (lineal mile)

Statistical Comparison of Datasets

A statistical comparison will be conducted to assess whether there was a significant difference in the sediment accumulation rate between datasets defined in hypothesis 1-3. This includes evaluating whether the data is normally distributed using the Ryan-Joiner test (similar to Shapiro-Wilk test) (Helsel & Hirsch, 2002). Normality will be assumed if the tests produced a p-value greater than 0.05 (Ecology, 2008). If the data is normally distributed, a two sample t-test will be used to determine if there is a significant difference between the sediment accumulation at the test site and the control site concentrations. If the data is non-normally distributed, a Wilcoxon rank sum test (a nonparametric analogue to the paired t-test) will be used instead. The specific null hypothesis (H_o) and alternative hypothesis (H_a) that will be evaluated is defined below. The statistical comparison will be based on a confidence level of 95% (α=0.05).

Hypothesis 1:

- H_o: The sediment accumulation rate in the catch basins at the test site is equal to the sediment accumulation in the catch basins at the control site
- H_a: The sediment accumulation rate in the catch basins at the test site is not equal to the sediment accumulation in the catch basins at the control site

Hypothesis 2:

- H_o: The sediment accumulation rate in the sumps at the test site is equal to the sediment accumulation in the catch basins and sumps at the control site
- H_a: The sediment accumulation rate in the sumps at the test site is not equal to the sediment accumulation in the catch basins and sumps at the control site

Hypothesis 3:

- H_o: The sediment accumulation rate on the roadway during year one at the test site is equal to the sediment accumulation rate on the roadway at the test site during year two
- H_a: The sediment accumulation rate on the roadway during year one at the test site is not equal to the sediment accumulation rate on the roadway at the test site during year two

For datasets with sample sizes ($n \leq 12$) and/or unequal sample sizes, the effect size will also be considered as part of the hypothesis testing to determine if there is a statistically significant difference between two datasets. The effect size (d) is a measure of the magnitude of the difference between datasets based on the relationship between the mean and standard deviation of two data sets as shown in equation 5 (de Winter, 2013). For extremely small sample sizes ($n \leq 5$), an effect size of $d \geq 3$ is equivalent to an 80% power when the confidence level is 95% or higher ($\alpha \leq 0.05$).

$$d = \frac{\bar{x}_{cs1} - \bar{x}_{ts2}}{\sqrt{\frac{\sigma_{cs1}^2 - \sigma_{ts2}^2}{2}}} \qquad \text{Equation 5}$$

Where:

$\bar{x}_{cs1}$ = Average value from control site dataset
$\bar{x}_{ts2}$ = Average value from test site dataset
σ_{cs1} = standard deviation from control site dataset
σ_{ts2} = standard deviation from test site dataset

Relationship Between Catch Basin Accumulation Rate and Frequency of Street Sweeping

The rate at which a catch basin fills with sediment will be determined for the purpose of forecasting when catch basins need to be cleaned (typically 60% of sump depth) based on the frequency of street sweeping. This will include calculating the sediment accumulation rate by volume (Equation 6) using the sediment depth measured in the catch basins (Section 8.1.1 and Appendix H Catch Basin Sediment Depth Measurements). This data will be used to develop a trend line (using regression analysis) similar to the one shown in Figure 14.1.

- Calculate the average depth of each catch basin after cleaning and without sediment (Equation 6). This will include taking the average of five measurements from each catch basin (Section 7.5.2 and 8.1.1).

$$D_{CB\ average} = \frac{\sum_{i=1}^{n} D_{CB-i}}{n}$$ Equation 6

Where:
$D_{CB\ average}$ = Average depth in catch basin without sediment (inches)
D_{CB-i} = individual measurements in a catch basin without sediment (inches)
n = total number of measurements (five)

- Calculate the average depth to the top of sediment in each catch basin before cleaning the catch basin (Equation 7). This will include taking the average of five measurements from each catch basin (Section 7.5.2 and 8.1.1).

$$D_{CB-S\ average} = \frac{\sum_{i=1}^{n} D_{CB-S\ i}}{n}$$ Equation 7

Where:
$D_{CB\text{-}S\ average}$ = Average depth in catch basin with sediment (inches)
$D_{CB\text{-}S\ i}$ = individual measurements in a catch basin to top of sediment (inches)
n = total number of measurements (five)

- Calculate the average depth of sediment in each catch basin (Equation 8).

$$D_{S-average} = D_{CB\ average} - D_{CB-S\ average}$$ Equation 8

Where:
$D_{S\text{-}average}$ = Average depth of sediment in each catch basin (inches)

- Calculate the average depth of sediment in the four catch basins at the test site and the four catch basins at the control site (Equation 9).

$$D_{S-TS\ or\ CS\ average} = \frac{\sum_{i=1}^{n} D_{S-average\ i}}{n}$$ Equation 9

Where:
$D_{S\text{-}TS\ average}$ = Average depth of sediment in catch basin at test site (inches)
$D_{S\text{-}CS\ average}$ = Average depth of sediment in catch basin at control site (inches)
n = number of catch basins at the test site (four) and at the control site (four)

- Calculate the rate of sediment accumulation in the catch basins by volume for the test site and then for the control site (Equation 10).

$$S_{AR-CB} = \frac{\frac{\frac{(D_{S-TS\ or\ CS\ average})A_{CB} \times A_S}{A_B}}{N}}{T}$$ Equation 10

Where:

$S_{AR\text{-}CBV}$ = Sediment accumulation rate $\left(\frac{\frac{in^3}{catch\ basin}}{day}\right)$

A_{CB} = cross sectional area of catch basin (in^2)

Calculation of Error in Measured Values

When using an instrument to measure data (e.g., catch basin sediment depth or sediment weight), there is a level of uncertainty (error) with each measured value. The propagation of uncertainty will be calculated for values that will be combined (e.g., calculate average values, sediment accumulation, etc.). This uncertainty will be quantified using Equation 11 when the measured values are added or subtracted. If the average value is calculated from multiple measured values, the uncertainty of the average value will be calculated by dividing the combined uncertainty (δR) by the number of individual values (n). The uncertainty of the final combined values will be used to determine the maximum and minimum values and compared to other measured values to determine whether the difference between values falls within the margin of measurement error.

$$\delta R = \sqrt{(\delta X_1)^2 + (\delta X_2)^2 + \cdots (\delta X_n)^2} \qquad \text{Equation 11}$$

Where:
δR = combined uncertainty of measured values
δX_n= uncertainty of a measured value

Weather Data

The weather data during the study will be evaluated to assess potential methods of sediment transport to the catch basins and washout from the catch basins to the sump. For example, runoff from rainfall event is known to transport sediment to catch basins however the winds in Ellensburg during the study are expected to range from 10-15 mph and may also transport sediment to catch basins. If there has been no rainfall events since the last day of data collection and there is measurable sediment in the catch basins that will indicate that wind is a significant source of sediment transport to the catch basins.

The representativeness of the weather during the study will also be evaluated by comparing the average monthly weather data collected at the weather station (wind, temperature, and precipitation) to the average monthly weather reported in historical records. The monthly averages and the percent difference (between the study and historical weather) will be reported in a table. The monthly averages (study and historical weather) will be displayed on bar graphs. Differences between the study weather and historical weather may also be used to understand the results of the statistical comparison.

Characterize Sediment Particle Size and Organic Content

The PSD and organic content analytical results will be averaged for each sample collection location (i.e., roadway, catch basins, and sump). The results will be used to compare changes in the organic content and the size and quantity of particles that are found in each sample location based on changes in the street sweeping frequency. These results will be displayed in tables and box plots.

14.2 Data Presentation

This section provides examples of how the data will be presented (i.e. tables, charts, and/or graphs) in the final reports to illustrate trends, relationships, and anomalies.

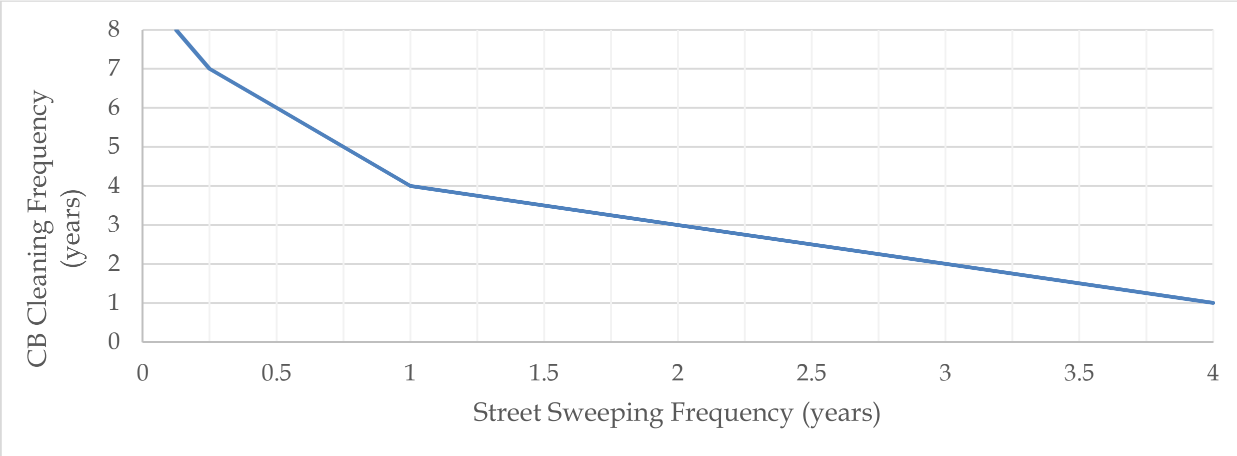


Figure 14.1 Forecast for Cleaning Catch Basins Based on Frequency of Street Sweeping

Table 14.1 Sediment Accumulation: Summary of Yearly Data Analysis Sheet

	Year:		**Location:**	Street Sweeping	Catch Basin Cleaning	Sump Socks	
	Month:		**April**	**June**	**August**	**October**	
	Date:						
	Data Collectors Name:						
	Time Data Was Collected:						
	Date of Last Cleaning:						
	Number of Days Since Last Cleaning:						
Test Site	Weight of Empty Basin or Sump	W_1					pounds
Test Site	Wet Weight of Sediments + Basin or Sump	W_2					pounds
Test Site	Wet Weight of Sediments $W_{s-w}=W_2-W_1$	W_{s-w}					pounds
Test Site	Sample 1 - Moisture Content of Sediments	w_1					%
Test Site	Sample 2 - Moisture Content of Sediments	w_2					%
Test Site	Sample 3 - Moisture Content of Sediments	w_3					%
Test Site	Average Moisture Content of Sediments $w_{average}=(w_1+w_2+w_3)/3$	$w_{average}$					%
Test Site	Dry Weight of Sediments per cleaning cycle $W_{s-d}=W/(1+w_{average}/100)$	W_{s-d}					pounds
Test Site	Average Dry Weight of Sediments per year	$W_{s-d\ average\ YR1}$					pounds
Control Site	Weight of Empty Basin or Sump	W_1					pounds
Control Site	Wet Weight of Sediments + Basin or Sump	W_2					pounds
Control Site	Wet Weight of Sediments $W_{s-w}=W_2-W_1$	W_{s-w}					pounds
Control Site	Sample 1 - Moisture Content of Sediments	w_1					%
Control Site	Sample 2 - Moisture Content of Sediments	w_2					%
Control Site	Sample 3 - Moisture Content of Sediments	w_3					%
Control Site	Average Moisture Content of Sediments $w_{average}=(w_1+w_2+w_3)/3$	$w_{average}$					%
Control Site	Dry Weight of Sediments per cleaning cycle $W_{s-d}=W_{s-w}/(1+w_{average}/100)$	W_{s-d}					pounds
Control Site	Average Dry Weight of Sediments per year	$W_{s-d\ average\ YR1}$					pounds

15.0 Reporting

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

15.1 Reporting

The following provides a summary of the reports that will be produced for this study as well as the party responsible for preparing the reports.

- Annual Reports (Permit Section S8.B8) – the lead entity will develop the annual reports which will describe the interim results and status of the study
- Final Technical Report (Permit Section S8.B10) – the principal investigator will produce the final technical report which will summarize the results of the study and recommend future actions based on the study findings. Table 15.1 provides an outline of the final technical report.
- A Video Fact Sheet – the lead entity will develop a video that summarizes the key points of the study along with the study findings.

Table 15.1 Proposed Final Technical Report Content

Final Report Sections	Effectiveness Studies
0.0 Cover Letter	✓
1.0 Executive Summary	✓
2.0 Introduction	See Note 1
3.0 Operational BMP Description	See Note 1
4.0 Sampling Procedures	See Note 1
5.0 Data Summaries and Analysis	✓
6.0 Discussion	✓
7.0 Conclusions	✓
8.0 Future Action Recommendations	✓
9.0 Appendices	✓

1. The Final Technical Report will reference these sections in the approved QAPP (in lieu of rewriting these sections in the Final Report). Any applicable changes made to the study since the QAPP was approved will be noted in these sections.

15.2 Dissemination of Project Documents

The Final Technical Report, will be shared with the participating agencies and posted to the City of Ellensburg website along with a video fact sheet about the study and study findings. https://www.ci.ellensburg.wa.us.

16.0 References

Amec Foster Wheeler Environment & Infrastructure, Inc. (2017). *PROPOSAL: Water Quality Regulatory Compliance Contract* (Proposal PQ15-01-01, Addendum 3). Arizona: Latimer, E., Sydnor, R.

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

City of Ellensburg. (2017). *Street Sweeping and Catch Basin Cleaning Pre Proposal*. Ellensburg, Washington.

City of Ellensburg. (2017). *Stormwater Management Plan Update 2016/2017*. Ellensburg, Washington. Retrieved from: https://ci.ellensburg.wa.us/DocumentCenter/View/9265

De Winter, J. C. (2013). *Using The Student's T-Test With Extremely Small Sample Sizes*. Practical Assessment, Research & Evaluation, *18*(10). Retrieved from: http://pareonline.net/getvn.asp?v=18&n=10

Ecology. (2013). Catch Basin Inspection Alternatives for Phase I and II Municipal Stormwater Permittees. Olympia, Washington. Retrieved from: https://fortress.wa.gov/ecy/publications/documents/1310019.pdf

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

Gautam, M. R., Acharya, K., & Stone, M. (2010). *Best Management Practices For Stormwater Management In The Desert Southwest*. Journal of Contemporary Water Research & Education, 146(1), 39-49.

Golder Associates. (2009). *Quantification of Catchpit Sediments and Contaminants* (1st ed.). Prepared for City of Auckland, NZ: Pennington, S., Kennedy, P.

Howard, A. (2010). *Use of Standard Sumps for Suspended Sediment Removal from Stormwater*.

Natural Resource Conservation Service. (1998). *Estimating Soil Moisture by Feel and Appearance.* Washington, D.C.: United States Department of Agriculture. Retrieved February 19, 2018, from https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_051845.pdf

Novotny, V. (2003). *Water Quality: Diffuse Pollution and Watershed Management*. John Wiley & Sons.

Pitt, R., Williamson, D., Voorhees, J., & Clark, S. (2004). *Review of Historical Street Dust and Dirt Accumulation and Wash-off Data*. Effective Modeling of Urban Water Systems, Monograph, 13, 43-54.

Rochfort, Q., et al., (2009). *Street Sweeping As A Method Of Source Control For Urban Stormwater Pollution.* Water Quality Research Journal, Canada, V. 44, No. 1, 48-58.

Sartor, J. D., & Gaboury, D. R. (1984). *Street Sweeping As A Water Pollution Control Measure: Lessons Learned Over The Past Ten Years*. Science of the Total Environment, 33(1-4), 171-183.

Sayre, J. M., J. S. Devinny, and J. P. Wilson. 2006. *Best management practices (BMPs) for the Treatment Of Stormwater Runoff In: Green Visions Plan For 21st Century Southern California: A Guide For Habitat Conservation, Watershed Health, And Recreational Open Space*. University of Southern California: GIS Research Laboratory and Center for Sustainable Cities, Los Angeles, California.

SPU. (2009). *Seattle Street Sweeping Pilot Study Monitoring Report*. Seattle Public Works (SPU), Drainage and Wastewater Division. Seattle, WA

Tang, Y. (2016). *Sediment Study in Storm Sewer Catch Basins and Submerged Pipes.* Doctoral Dissertation, University of Alberta.

Tetra Tech. (2001). *Quantifying the Impact of Catch Basin and Street Sweeping on Storm Water Quality for a Great Lakes Tributary: A Pilot Study* (1st ed.). Prepared for Grand River Inter-County Drainage Board. Retrieved From: http://www.uppergrandriver.org/files/Street%20Sweeping%20Study.pdf

Tyagi, A., Chongtoua, B., & Medina, D. (2008). *Meeting Challenges of Stormwater Management in Semi Arid Climates with Low Impact Development*. In World Environmental and Water Resources Congress 2008: Ahupua'A (pp. 1-10).

United States Environmental Protection Agency (EPA). (1999). *Storm Water O&M Fact Sheet: Catch Basin Cleaning.* (Publication No. 832-F-99-011). EPA Office of Water. Washington, D.C.

United States Environmental Protection Agency (EPA) & American Society of Civil Engineers (ASCE). (2002). *Urban Stormwater BMP Performance Monitoring*. EPA Office of Environmental Information. Washington, D.C.

United States Environmental Protection Agency (EPA). (2002). *Guidance for Quality Assurance Project Plans*. (Publication No. EPA QA/G-8). EPA Office of Environmental Information. Washington, D.C.

Washington State Department of Ecology (Ecology). (no date (nd)). *Catch Basin Inspection Alternatives for Phase I and II Municipal Stormwater Permittee*s. Olympia, Washington. Retrieved from: https://fortress.wa.gov/ecy/publications/documents/1310019.pdf

Washington State Department of Ecology (Ecology). (2004). *Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies*: Olympia, WA.

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

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

Wilson, B. N. (2012). Lecture on Settling Velocity of Sediment. Personal Collection of B. Wilson, University of Minnesota, St. Paul, Minnesota.

WRCC. (no date). *Climate of Washington: Eastern Washington and Central Basin*. Washington Regional Climate Center. Retrieved from: http://www.wrcc.dri.edu/narratives/WASHINGTON.htm

17.0 Appendices

Appendix A. Ecology Proposal Approval Letter and Comments

Navickis-Brasch, Aimee

From:	Jon Morrow <morrowj@ci.ellensburg.wa.us>
Sent:	Wednesday, November 8, 2017 4:59 PM
To:	Navickis-Brasch, Aimee
Subject:	FW: Approval of Street Sweeping and Catch Basin Cleaning Comparison effectiveness study outline
Attachments:	Street Sweeping Study RL Review.docx; 170720 Comments on BMP Insp & Maintenance Submittals DCH (002).docx

FYI, THIS JUST IN

From: Latham, Ray (ECY) [mailto:RLAT461@ECY.WA.GOV]
Sent: Wednesday, November 8, 2017 4:11 PM
To: Jon Morrow <morrowj@ci.ellensburg.wa.us>
Cc: Dinicola, Karen (ECY) <KDIN461@ECY.WA.GOV>; Howie, Douglas (ECY) <doho461@ECY.WA.GOV>; Stockwell, Abbey (ECY) <abst461@ECY.WA.GOV>
Subject: Approval of Street Sweeping and Catch Basin Cleaning Comparison effectiveness study outline

Ecology approves and authorizes the preparation of a Quality Assurance Project Plan (QAPP) and detailed study proposal for *Street Sweeping and Catch Basin Cleaning Comparison* effectiveness study. Attached are comments on the initial study design, asking for clarification. Please feel free to call whoever provided the comment to discuss them further.

Permit condition S8.B.6 requires that:

> "…Lead entities shall submit a Quality Assurance Project Plan (QAPP) for each study within six months of Ecology's written approval of each detailed proposal..."

The subsequent evaluation will be very helpful in promoting effective street sweeping. We look forward to working with you to provide a meaningful project.

****

Ray Latham, CPSWQ
Municipal Stormwater Permit Manager
Water Quality Section
509.575.2807

DEPARTMENT OF ECOLOGY
State of Washington

To: Karen Dinicola, Department of Ecology

From: Douglas C. Howie, P.E., Department of Ecology

Cc: Abbey Stockwell, Department of Ecology

Date: July 20, 2017

Subject: Comments on Eastern Washington Effectiveness Study Proposals

Here are my comments on the eight Eastern Washington Effectiveness Studies submitted to Ecology on July 11 and following days. The proposals follow a common format with significant portions of the documents left for later completion. There is still adequate information in each proposal to identify what the author intends to complete.

Documents Reviewed:

Detailed Study Design Proposal: BMP Inspection and Maintenance Responsibilities, by HDR, Inc. and Drummond Carpenter, PLLC, June 30, 2017

General Comments on Proposals

1. There are still a number of significant issues left to fill in when producing the QAPP for these studies. I will probably have more comments when they submit the QAPP.

Comments on Street Sweeping and Catch Basin Cleaning Comparison

1. There are a several places where sentences suddenly end, there are missing words, or text doesn't make sense. The proposal is still understandable and I assume the next edit will correct these issues.
2. Section 3.3, add a bullet that discusses the potential that sediment in the catch basin could re-suspend and flow out of the catch basin during a large storm. A catch basin could catch some sediment, at least for a short time, and then discharge to the swale. The sediment bags should catch this sediment.
3. You are vacuuming the street with a hand held vacuum to collect samples. How will this work with the street sweeper volumes of sediment removed?

If you have any further questions, please contact me by email at douglas.howie@ecy.wa.gov or by phone at (360) 407-6444.

Effectiveness Monitoring Project 03-15:
Street Sweeping and Catch Basin Cleaning Comparison

Sponsor: City of Ellensburg
Reviewer: Ray Latham
Date: Aug. 2, 2017

3.0 Background:

3.1 Introduction to the Operational BMP.

- How many CBs are cleaned each year?
- Is the amount collected just the street sweeping, or includes CBs. Relates to the baseline annual load expected from street sweeping interception.
- Is the 1,200 tons the amount of dry material removed to the landfill? What is the target % moisture? Using a set % moisture will take out variability.
- Is the % organics of sediments known? Dry season is more likely to contribute wind-blown dust, while winter deposits are sand, gravel and salt. Be consistent with protocols in study.

3.2 Problem Description:

Identifies variability of conditions between dry summer and wet winter deposits, with the study focus on dry weather conditions.

4.0 Project Overview:

4.2 Study Description

Sweep both sides at the beginning to start with a clean slate.

Is gravel, sand, salt or deicer applied on this street during the winter? This provides information about how much the city is contributing to the overall load.

Gather and weigh the winter accumulation in late Feb. to provide an annual sediment load. This provides a break point for data analysis between summer and winter deposition. Must be collected from both sides to prevent skewing the data. Will socks be left in place during the winter?

Would any useful information be gathered by sweeping and collecting both sides at the start of the study? Significant differences might indicate a preferential deposition pattern

4.5 Data collection:

Sediment Collection: Provide protocols on method for random selection for sediment accumulations on roadway strip.

4.6 Potential Constraints:

Provide a contingency plan for local construction projects or adjacent property maintenance. At a minimum, document the activity.

Equipment breakdown: Identify availability of similar equipment from participating municipalities in case of malfunction or breakdown.

5.0 Organization and Schedule

5.1 Key Project Team Member: Roles and Responsibilities

5.3 Budget and Funding Sources

Is Ellensburg acknowledging any roles or participation by others?

7.0 Experimental Design

7.4 Type of Data to be Collected:

For consistency sake follow the sampling and analytical procedures of the *Stormwater Sampling Manual: A guide for the Industrial Stormwater General Permit*. These are standard protocols for select parameters i.e. Stormdrain solids sampling, TSS and Settable Solids

Appendix B. Proposal: Responses to Ecology's Comments

#	Commenter Initials	Section	Comment	Response
1	DCH	General	There are still a number of significant issues left to fill in when producing the QAPP for these studies. I will probably have more comments when they submit the QAPP.	Comment Noted
2	DCH	General	There are a several places where sentences suddenly end, there are missing words, or text doesn't make sense. The proposal is still understandable and I assume the next edit will correct these issues.	Comment Noted
3	DCH	3.3	Add a bullet that discusses the potential that sediment in the catch basin could re-suspend and flow out of the catch basin during a large storm. A catch basin could catch some sediment, at least for a short time, and then discharge to the swale. The sediment bags should catch this sediment.	Added
4	DCH		You are vacuuming the street with a hand held vacuum to collect samples. How will this work with the street sweeper volumes of sediment removed?	The study was modified since the proposal was written. Instead of using a vacuum to collect roadway sediments, the street sweeper will be used.
5	RL	3.1	How many CBs are cleaned each year?	600 catch basins are cleaned per year
6	RL	3.1	Is the amount collected just the street sweeping, or includes CBs. Relates to the baseline annual load expected from street sweeping interception.	The amount is actually 760 tons (corrected in the draft QAPP) which is the combined total of what is collected between both street sweeping and catch basin cleaning. This study will help answer how much is collected by each O & M practice.
7	RL	3.1	Is the 1,200 tons the amount of dry material removed to the landfill? What is the target % moisture? Using a set % moisture will take out variability.	The amount is actually 760 tons (corrected in the draft QAPP) which is an estimated quantity of dry materials removed from both the roads and catch basins. The moisture content is unknown. Using a set moisture content is not relevant to this study.
8	RL	3.1	Is the % organics of sediments known? Dry season is more likely to contribute wind-blown dust, while winter deposits are sand, gravel and salt. Be consistent with protocols in study.	The organic content of the sediment is unknown. For this study, characterization of the sediment content will focus on particle size distribution.
9	RL	3.2	Identifies variability of conditions between dry summer and wet winter deposits, with the study focus on dry weather conditions.	Comment noted

10	RL	4.2	Sweep both sides at the beginning to start with a clean slate.	That is the plan, to sweep both sides of the street in April
11	RL	4.2	Is gravel, sand, salt or deicer applied on this street during the winter? This provides information about how much the city is contributing to the overall load.	Added to study objectives
12	RL	4.2	Gather and weigh the winter accumulation in late Feb. to provide an annual sediment load. This provides a break point for data analysis between summer and winter deposition. Must be collected from both sides to prevent skewing the data. Will socks be left in place during the winter?	Sediment from the catch basins will be collected and weighted on April 1st for the purpose of measuring the winter sediment load. Socks are no longer being used. Sumps will be used instead which will be left in place through the winter.
13	RL	4.2	Would any useful information be gathered by sweeping and collecting both sides at the start of the study? Significant differences might indicate a preferential deposition pattern	The streets were swept at the end of September and they will be swept again on April 1st so the winter sediment accumulation can be quantified.
14	RL	4.5	Sediment Collection: Provide protocols on method for random selection for sediment accumulations on roadway strip.	The roadway sediment collection method has changed from using a vacuum to using the street sweeper. Comment no longer applies to the study.
15	RL	4.6	Provide a contingency plan for local construction projects or adjacent property maintenance. At a minimum, document the activity.	Comment noted
16	RL	4.6	Equipment breakdown: Identify availability of similar equipment from participating municipalities in case of malfunction or breakdown.	The city has 2 street sweepers and 2 vactor trucks both are the same age and model. In the event of equipment breakdown the city can use the other street sweeper or vactor truck. Reference Appendix E
17	RL	5.1	Key Project Team Member: Roles and Responsibilities	Roles and responsibilities are defined in the table and footnotes below the table.
18	RL	5.3	Budget and Funding Sources: Is Ellensburg acknowledging any roles or participation by others?	The City of Ellensburg is funding this study
19	RL	7.4	Type of Data to be Collected: For consistency sake follow the sampling and analytical procedures of the Stormwater Sampling Manual: A guide for the Industrial Stormwater General Permit. These are standard protocols for select parameters i.e. Stormdrain solids sampling, TSS and Settable Solids	Comment noted. Procedures were applied where applicable.

Appendix C. QAPP: TAG Comments and Responses to Comments

#	Commenter Initials	Section	Page	Comment	Suggested Revision	HDR Response to Comment
1	JS	3.1	2		Recommend removing the "s" on "years" in the third sentence of the second paragraph.	revision made
2	JS	4.6	14	If there is an equipment breakdown is there a procedure for notifying the Principal Investigator (PI)?	I would suggest including in the training for the operators a list of what should be reported and a procedure for reporting to the PI.	revision made
3	JS	7.1	24	In the first paragraph, it states that the road will be swept on April 1st. This date falls on Sunday. Do the street crews work on this day?	Perhaps it should be the first business day in April.	See footnote 4 under Table 5.2: '*4. Data collection activities will occur on the first day working day of the month*'. The note was also added to section 7.1.
4	JS	7.3.2	28		Recommend removing the word "with" in the first sentence of the first paragraph.	revision made
5	NP	General		Does the crown of the road exactly split the total road area into exactly equal parts? Some field surveying checks would confirm this.		See section 7 "The roadway crown is located in the center of the highway….". Surveying was done, see section 7.2, Figure 7.3
6	NP	General		How do you plan to control runon and runoff from the site? There are a number of roads joining the highway and a number of road stubs leaving it. There are also grassed verges with sidewalks.		Information about the slope from adjacent areas has been added to section 7.2
7	NP	General		What is the bottom material of the CBs? Are they solid or are they leaching CBs?		It is a standard CB type 1 which have solid concrete bottoms. 'Type 1' was added to QAPP (Section 7.1)
8	NP	General		Is the size of the CB and sump adequate to **fully contain** the sediment from a very large storm? I estimated that the combined CB/sump size would have to be about 6-12 ft^3 for a 100-year 24-hour storm with 100-200 mg/l TSS.		Typically it takes between 3-5 years for a catch basin sump to fill. The sediment volume you estimated seems extremely high for a single 100 year event from a 0.3AC basin.

9	NP	General		Maybe the CB sampling should be done after each significant storm in the summer instead of monthly. That will mean it is less likely that the sediment in the CB will overflow into the sump.		The city staff are collecting the data and the data collection dates need to be schedule in advance.
10	NP	General		Maybe the CB sampling could be done with a large shop vacuum if the sediment quantities are small. That approach might result in less error due to cross-contamination from residual sediment in the vactor truck when used for repeated sampling.		The vactor truck will be sprayed out with water before and after sample collection. Since we are not collecting analytical data, we should not have an issue with cross contamination.
11	NP	General		Perhaps a field weight (say 50 lb) should be used for field- verifying the weight measurements with the scale since it is going to be moved around. That would provide an additional check.		The scale will not be moved around. It will be installed in the spring and moved in the fall. Once the scale is setup, it will be calibrated by the vendor. The SOPs include information about calibration.
12	NP	General		The formulas in the back of the document need to be fully documented with appropriate units.		Formulas were updated
13	NP	General		Is the 1-micron felt filter fabric adequate to prevent significant loss of sediment fines?		Standard methods for analyzing TSS are greater than 1.5-micron, so a 1-micron should be sufficient.
14	NP	General		The ultimate goal of the permit is to improve downstream WQ conditions, reduce sediment ant TP. So you might want to add a few composite samples for TP testing. It seems a shame to waste the opportunity. Lab cost would be minimal for the project if samples are pooled, say one per month for the two treatments i.e. 8 samples or about $250 total. There might be some interesting outcomes since the two methods of sediment removal		Testing for total phosphorus will not answer the research questions for this project and funding is limited so it is not possible to add additional tests at this time.

				target different sediment sizes and hence different TP concentrations.		
15	DH	8.1.4	38	You identify sizes of the bucket. Is this adequate for the amount of material you will have to deal with?		Methods for collecting sediment at the discharge point in the swale have been updated as well as the sample collection methods. A bucket is no longer used.
16	DH	8.1.1	38	The rod is in hundredths of a foot, not tenths of an inch.		revision made
17	DH	8.1.5	39	Correct word from "not" to "no". There should still be some dewatering occurring after the standing water is gone. Is that the correct time to measure, or do you need to go longer.		revision made and additional guidance was added regarding dewatering
18	DH	9.2	44	I am having difficulty coming up with the number of samples you propose to get. Can you show the calculation process?		footnote added under Table 9.2 that explains calculation process
19	DH	14.1	51 plus	You need to identify the units for the various calculated numbers (for example equation 3, 4, 5, 6). You have a value of Lm with no discussion. You should include the descriptor for each item in the equation with each equation and not force the reader to research it.		revision made
20	DH	14.2	Figure 14.1	I think the graph should go up to the right instead of down. If you sweep twice a year your CB cleaning frequency should be less than if you sweep once a year, and with this graph, it goes from a 4 year cleaning frequency for once a year to a 3 year frequency for twice a year.		Units are graph were not correct and have been revised

Appendix D. Ecology QAPP Approval Letter, Comments, and Responses to Comments

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
1250 W Alder St • Union Gap, WA 98903-0009 • (509) 575-2490

June 6, 2018

Mr. Jon Morrow, Stormwater Manager
City of Ellensburg
Public Works Department
501 N Anderson Street
Ellensburg, WA 98926

RE: Comments on Effectiveness Monitoring Quality Assurance Project Plan (QAPP)

Dear Mr. Morrow:

The Street Sweeping QAPP has been reviewed by Brandi Lubliner, Doug Howie and myself. Some of these comments are editorial, others are recommendations for your consideration.

Required edits:
Revise section 11.6 title and paragraph to remove references to EIM from the QAPP. The Environmental Information Management (EIM) database wasn't designed to hold the data for the Effectiveness Studies.

> For this project, data storage and delivery will be submitted to the municipal stormwater permit manager in an electronic spreadsheet format with the final report. This spreadsheet will contain all of the data from the study including all of the useable quality assured data used for the analysis and the rejected or un-useable data gathered as part of the study. The rejected data, along with annotation as to the reason for its exclusion, can be included in a separate file or different tab.

Revise section 8.1.1 Standard Operating Procedures - Measuring Catch Basin Sediment Depth
Step 3: Remove the references to the word "random". The method for selection of location for the depth measurement is not truly random. See below for recommendation.

8.1.4 Catch Basin Sediment Washout Collection
Clarify first bullet.

- "Prior to field work, the sump sock will be weighed… to the hundredth gram." Are socks weighed to nearest 100 g or 0.01 g? (I'm sure I know, but the SOPs are not for me.)

  The level of accuracy of 100 g. will be overwhelmed by the gross weight and loss of both material and moisture content during collection, processing and handling. A precision level of 500 g. (or 1 lb.) is sufficient.

14.1 Data Analysis Method:
Complete the half sentence above Equation 1. pg. 58.

The multiple incremental errors for the weights of sample should be estimated as part of data analysis. It is likely that the residual fines left in the sock are within the 500 g. (or 1 lb.) precision of the scale.

Recommendations:

8.1.4 Catch Basin Sediment Washout Collection

Recommendation: The depth sampling method may be replicated by using a grid placed over the catch basin and measurements taken at specified points.

9.4 Special Method Requirements:

Recommendation:

If the sump sock holds too much material to be sent to the lab, revise the procedure 8.1.6. for subsampling the sock.

Include the procedures for removing sediment from the socks, weighing the empty wet socks, drying process and reweighing dry socks.

As with most projects, Murphy's Law can be invoked at any time. If further changes are necessary please contact me and we will collectively discuss mitigations and alternatives.

With these changes incorporated, the QAPP is conditionally approved. The original signature page will be circulated and signed by Doug, Brandi and myself. Please submit the updated QAPP for the file.

Good job.

Sincerely,

Ray Latham

Ray Latham
Municipal Stormwater Permit Planner

cc: Brandi Lubliner, Ecology-HQ
Doug Howie, Ecology-HQ

#	Section & Page	Comment & Required Revision	HDR Response to Comment
1	11.6	Revise section 11.6 title and paragraph to remove references to EIM from the QAPP. The Environmental Information Management (EIM) database wasn't designed to hold the data for the Effectiveness Studies. Replace section 11.6 with the following: *For this project, data storage and delivery will be submitted to the municipal stormwater permit manager in an electronic spreadsheet format with the final report. This spreadsheet will contain all of the data from the study including all of the useable quality assured data used for the analysis and the rejected or un-useable data gathered as part of the study. The rejected data, along with annotation as to the reason for its exclusion, can be included in a separate file or tab. At the end of the study, the data collected will be uploaded to the International BMP database.*	Section 11.6 was updated as requested.
2	8.1.1	Revise section 8.1.1 Standard Operating Procedures - Measuring Catch Basin Sediment Depth Step 3: Remove the references to the word "random". The method for selection of location for the depth measurement is not truly random.	References to the word random have been removed.
3	8.1.4	Catch Basin Sediment Washout Collection Clarify first bullet. • *"Prior to field work, the sump sock will be weighed... to the hundredth gram." Are socks weighed to nearest 100 g or 0.01 g? (I'm sure I know, but the SOPs are not for me)* The level of accuracy of 100 g. will be overwhelmed by the gross weight and loss of both material and moisture content during collection, processing and handling. A precision level of 500 g. (or 1 lb.) is sufficient.	Section was updated to the nearest 2-grams. Socks weigh approximately 280-grams each, and the scale used to weigh the sock is accurate to 2-grams.
4	14.1	Data Analysis Method: Complete the half sentence above Equation 1. pg. 58.	Sentence was completed to reference applicable form for calculating and tracking the dry sediment weight.
5	14.1	The multiple incremental errors for the weights of the sample should be estimated as part of data analysis. It is likely that the residual fines left in the sock are within the 500 g. (or 1 lb.) precision of the scale.	A subsection titled *Calculation of Error in Measured Values* was added to section 14. Also, see response to comment 8 regarding how the sediment weight in the socks is determined.
#	**Section & Page**	**Comment & Recommended Revision**	**HDR Response to Comment**
6	8.1.4	Catch Basin Sediment Washout Collection Recommendation: The depth sampling method may be replicated by using a grid placed over the catch basin and measurements taken at specified points.	Additional language was added to SOP 8.1.1 to clarify where catch basin depth measurements are taken.
7	9.4	Special Method Requirements: If the sump sock holds too much material to be sent to the lab, revise the procedure 8.1.6 for subsampling the sock.	A copy of the sock cut-sheet was added to Appendix G. Note the socks have a 7-inch

			diameter and are 31.5-inches long. Considering the maximum time the sock will remain in place is 6-months (October to April), it is unlikely that the sock will fill with sediment during this study. As such, no procedures for subsampling were added to the QAPP.
8	9.4	Special Method Requirements: Include the procedures for removing sediment from the socks, weighing the empty wet socks, drying process and reweighing dry socks.	Sediment will not be removed from the sock unless the PSD testing will be conducted on the sediment. Reference SOP 8.1.4, Catch Basin Sediment Washout Collection. The dry weight of sediment will be determined by subtracting the weight of the sock prior to installation in the sump by the weight of the sock after the sock has been removed from the sump and completely dried. Each time a sock is removed from the sump, it is replaced with a new sock.

Appendix E. Equipment Specifications and Interview Notes Regarding the City's Existing O&M Practices

Notes from October 5th 2017 interview with the City of Ellensburg's about typical street sweeping and catch basin cleaning procedures.

CB Cleaning Equipment	Vehicle #1 Typically used for storm only	Vehicle #2 Typically used for sewer only
Model	VacCon	VacCon
Make	V311/1000 Combination Truck, International Chassis	V311/1000 Combination Truck, International Chassis
Model Year	2012	2012
Downtime in the last year	Multiple occasions; fairly frequently	Multiple occasions; fairly frequently
Equipment Life	About 15 years	About 15 years

CB Cleaning Procedures	
What is the typical number of CBs cleaned per event and the frequency of those events?	Approximately 600 catch basins are cleaned per season (beginning March or April, through September or October). Within a season, the frequency of catch basin cleaning is variable. One of the reasons for the variability is the use of the trucks by other City departments.
Are any alternate procedures used during inclement weather (i.e., postpone cleaning, etc.)?	Catch basin cleaning begins in March or April and ends in September or October; cleaning does not occur during the winter season which depends primarily on weather. Once the winter season starts, the catch basin cleaning vehicle is used to clean sanitary sewers.
How does cleaning occur for a typical CB (i.e. standard practices, tasks required to clean); what length of time is required to clean one CB?	The catch basin cleaning vehicle pulls up so the front of the truck and vactor arm are in line with the catch basin. The catch basin grate is removed, and the vactor end is lowered into the catch basin by use of a remote control. The vacuum is started and a high pressure water hose is used to flush material off from the vertical catch basin walls below the grate. Once all material and water is removed from the catch basin, the vactor end is removed and the grate is replaced over the catch basin.
What conditions trigger the need to clean a catch basin (including and in addition to permit requirements)?	According to the EWA Phase II Municipal Permit, all catch basins owned or operated by a municipality must be inspected and cleaned if necessary every three years; following December 31st 2018, all catch basins must be inspected and cleaned if necessary every two years. Aside from permit requirements, catch basins are cleaned if complaints of flooding or full catch basins are received, or if a business requests that catch basins be cleaned. Complaints/requests do not occur often.
How are CB cleaning practices tracked (i.e. date of last cleaning, name/location of CB cleaned)?	Catch basin cleaning practices are tracked in an ESRI ArcGIS map: which catch basin, date of inspection or cleaning, and whether the catch basin could be accessed for cleaning (occasionally, parked cars or other obstacles prevent personnel from accessing catch basins).
How is CB cleaning waste disposed of; where are the locations of disposal?	Waste material is disposed of at the City's decant facility off of Industrial Way. Vehicle #1 has its own bay, in which the material is placed and allowed to decant. The decant water is allowed to flow into a grate and is directed to a pump, which routes it to the sanitary sewer. Solids are transported to a waste facility in Wenatchee.
Describe any deviations from typical practices during Effectiveness Study.	During catch basin cleaning, high pressure water will be used to wash off any material on the rim of the catch basin (in addition to the catch basin walls). Waste material will be allowed to decant in a tank, and solids will be collected for analysis.

Street Sweeping Equipment	Vehicle #160	Vehicle #161
Model	Elgin	Elgin
Make	Crosswind J Street Sweeper, Freightliner Chassis	Crosswind J Street Sweeper, Freightliner Chassis
Model Year	2016	2016
Downtime in the last year	None	None
Equipment Life	About 15 years	About 15 years
Street Sweeping Procedures		
What are the typical routes during sweeping events and the frequency of those events?	Main arterials are swept twice per month; secondary arterials are swept once per month; and collectors are swept once per year.	
Are any alternate sweeping procedures used during inclement weather (i.e. lower speeds, postpone routes, etc.)?	Chip seal is performed once per year and during that time (approximately one week) sweeping is not performed. Sweeping is also not performed during the winter season (for street sweeping, typically about Thanksgiving Day - Valentines Day).	
What are the typical characteristics of public street sweeping (i.e. typical forward speeds, when is broom raised and lowered)?	The street sweeper vehicle pulls up as close to the curb as possible at the high point of the street. Once at the high point, a small amount of water starts to flow from a manifold at the front of the truck, the broom starts to rotate and is lowered, and the vacuum is started. The vehicle drives from the high point to just beyond the catch basin at the low point of the street.	
What width of road can each vehicle cover in a pass; what section/lanes of the road are covered in a pass?	Typically, curb and gutter (plus the width of the truck) are swept during a street sweeping event. On the major arterials, the center median is swept once per year following the winter season.	
What are the procedures for parked car interference?	The sweeper pulls around the parked car and returns to driving along the curb and gutter once the car is passed.	
How are street sweeping practices tracked (i.e. speed of sweeper, frequency, and location)?	Street sweeping practices, such as speed, frequency, and location are tracked in online software called PreCise. The software provides tabular data for each sweeper as well as mapping of street sweeper locations.	
How is street sweeping waste disposed of; where are the locations of disposal?	Waste material is disposed of at the City's decant facility off of Industrial Way. Vehicle #160 has its own bay, in which the material is placed and allowed to decant. The decant water is allowed to flow into a grate and is directed to a pump, which routes it to the sanitary sewer. Solids are transported to a waste facility in Wenatchee.	
Describe any deviations from typical practices during Effectiveness Study.	Street sweeping will occur once every other month and immediately following catch basin cleaning. Sweeping will begin at Sta 0+00 (CB-4 or CB-8) and will end at CB-1 or CB-5, depending on the side of the road. Sweeping will only occur along the curb and gutter. Material collected will be allowed to decant in a tank at the City's decant facility, and solids will be collected for analysis.	

Purchase Order

City of Ellensburg
501 N Anderson St.
Ellensburg WA 98926

OWEN EQUIPMENT CO	
Vendor ID	02847
On Hold?	
Purchase Order No.	PO0082528
Date	7/23/2015
Buyer ID	malellat

Vendor:

OWEN EQUIPMENT CO
PO BOX 30959
PORTLAND OR 97294

Ship To:

City of Ellensburg
501 N Anderson St.
Ellensburg WA 98926

^ Changed Since the Previous Revision

Shipping Method	Payment Terms	Confirm With	Page
			1

L/N Item Number / Budget Number	Description / Project Number	Req. Date / FOB	U/M	Ordered	Unit Price	Ext. Price
1 2015 ELGIN CROSSWINI		7/23/2015	Each	1.0	$249,191.10	$249,191.10
500-531-594-48-64-404-000	**SH594.48150160**					
EQUIP/MACHINERY	2015 ELGIN CROSSWIND J SWEEF	None				
2 2015 ELGIN CROSSWINI		7/23/2015	Each	1.0	$249,191.10	$249,191.10
500-531-594-48-64-404-000	**SH594.48150161**					
EQUIP/MACHINERY	2015 ELGIN CROSSWIND J SWEEF	None				

Subtotal	$498,382.20
Trade Discount	$0.00
Freight	$0.00
Miscellaneous	$0.00
Tax	$0.00
Order Total	$498,382.20

Authorized Signature

OWEN EQUIPMENT COMPANY
WSDOT CONTRACT 02613
Crosswind J Sweeper

	Company	Owen Equipment Company		
	Contract #	WSDOT 02613 - Regenerative Vacuum Pickup - Crosswin J		
	Municipality	City of Ellensburg		
	Address	501 North Anderson Street		
	City, State, Zip	Ellensburg, WA. 98926		
	Contact Name	Tony Malella		
	Contact Phone #	(509) 962-7134		
	Contact Fax #			
	PO Number			
Sales Representative		Dave Armstrong	Quote Date:	7/14/2015
Qty	Part #	DESCRIPTION	8/28/2013	Ext
1		Crosswind J Sweeper/M2 Convnetional Chassis	$ 196,016.00	$ 196,016.00
	General Specifications (See Bid Specs for More Detail)			
		Crosswind J Sweeper/M2 Convnetional Chassis		
		John Deere T 3 115hp Aux Engine (Now Replaced by Tier 4i)		
		Dual Gutter Brooms		
		Total Sweeping Path = 120inches		
		2700 Sq In Pickup Head		
		20,000 CFM Blower		
		8 Cubic Yard Debris Body		
		240 Gallons Water		
		Spray Nozzles (16 Total)		
		M2 Conventional Chassis (2013 Emissions)		
		Non Standard Options Included in Price (With Deduction Amounts Listed)		
	1061652	Anti Siphon 2-1/2" Air Gap	$ (120.00)	
1	1059209	Hopper Deluge	$ (642.00)	$ (642.00)
	1075400	AM/FM CD	$ (554.00)	
	1087729	SB Tilt Left	$ (716.00)	
	1087730	SB Tilt Right	$ (716.00)	
	1092227	Lifeliner Hopper System w/Warranty	$ (4,936.00)	
	1081364	Heated Remote Mirrors	$ (1,939.00)	
	1078045	Turbo II Precleaner	$ (317.00)	
1	1082931	In Cab Air Cleaner Restriction Guage-Chassis	$ (631.00)	$ (631.00)
1	1086456	Variable Speed Side Brooms	$ (2,218.00)	$ (2,218.00)
	1078204	Air Filter Restriction Indicator Light in Cab	$ (405.00)	
	1090157	(2) Rear Bumper Mounted Strobes- LED	$ (547.00)	
	1090458	(2) Rear 7" Alternating Flashers- LED	$ (508.00)	
1	1088219	Two Rear Strobe Guards	$ (684.00)	$ (684.00)
1	1088229	Rear LED Arrowboard	$ (1,707.00)	$ (1,707.00)
		M2 Conventional Chassis (2013 Emissions)	$ (66,000.00)	
1	1032484	25' Water Fill Hose	$ (109.00)	$ (109.00)
	702430	Crosswind Service Manual	$ (85.00)	
	702216	Crosswind Parts Book	$ (85.00)	
1	704050	John Deere Parts Manual	$ (42.00)	$ (42.00)
1	704052	John Deere Service Manual	$ (127.00)	$ (127.00)
1	704005	M2 Parts Book	$ (271.00)	$ (271.00)
1	704007	M2 Service Manual	$ (219.00)	$ (219.00)

OWEN EQUIPMENT COMPANY
WSDOT CONTRACT 02613
Crosswind J Sweeper

		TOTAL DEDUCTIONS		$ (6,650.00)
		Available Options (With Pricing)		
1		Tier 4i Shared Power System	$ 7,000.00	$ 7,000.00
1	1087829	PM10 Water System	$ 3,047.00	$ 3,047.00
1	1086441	Hydraulic Wandering Hose	$ 4,333.00	$ 4,333.00
1	1070639	LED/Stop/Tail/Turn	$ 626.00	$ 626.00
1	1086602	Front Spray Bar	$ 549.00	$ 549.00
1	1096151	Auto Lube (Midwest)	$ 7,419.00	$ 7,419.00
1	1095548	Camera / Rear and Passenger Side Pickup Head	$ 604.00	$ 604.00
1	1090604	Flow Blocker	$ 2,089.00	$ 2,089.00
1	1040094	Water fill Quick Disconnect	$ 504.00	$ 504.00
1	1084463	Left Fender Mirror	$ 532.00	$ 532.00
1	1110027	Auxillary Hydraulic Pump	$ 1,208.00	$ 1,208.00
1	1085882	Left hand door	$ 432.00	$ 432.00
1	1085883	Right hand door & step	$ 715.00	$ 715.00
1	1081748	High back air ride seat (Curbside)	$ 1,064.00	$ 1,064.00
1	110434	Additional 140 gallon water (top Fill) 3.75" catwalk	$ 6,588.00	$ 6,588.00
1	1088582	Hopper water nozzles	$ 525.00	$ 525.00
1	1070059	Air purge for water system	$ 349.00	$ 349.00
		In cab hopper dump, individual water switches, wisker switch on rear axle		
		TOTAL ADDITIONS		$ 37,584.00
		Total Tag Price (Before Applicable Taxes)		$ 226,950.00
		Sales Tax 9.8%	9.80%	$ 22,241.10
		Total Tag Price		$ 249,191.10

Delivery per the contract is 120 days after receipt of order

[signature] 7-23-15

Customer Approval Date

Sales Representative Approval Date

SOLID WASTE SYSTEMS, INC. *"Waste Equipment Specialists"*

P.O. BOX 13040 • SPOKANE, WA 99213-3040 • PHONE (509) 533-9000 • FAX (509) 533-1050 • 1-800-U WASTE 1

WA State "Catch Basin Contract" # 07005

For VAC-CON Combination Truck

Washington State Contract Price (Base Unit) $281,963.94

Chassis: 2012 IH 7600 6X4 MAXX 410HP/4500 RDS 66000 GVWR
Model: V311 / 1000 (11 yard with 1000 Gallons of Fresh Water)

Deductions:

Standard 6' Long Boom with 8" Boom Diameter & Inlet	$7,034.00
8" x 6" Reducer	$154.37
Ball Valves @ hydraulic filters	$1,756.00
6" tube handle	$172.27
6" x 3' CB Tube	$86.03
Handgun shutoff each location	$400.00
40' pendant mounted on retractable reel	$2,789.00
Flush out connection for rear door valve	$401.00
Heavy reinforced elbow	$852.00
Rear splash guard	$1,462.00
Rear hand gun connection	$230.00
Front bumper hand gun connection	$268.00
pre-tank water filter (Y-type)	$717.00
pinch roller no automatic level wind	$1,641.00
Hydraulic Folding pipe rack drivers side	$2,239.00
Hydraulic Folding pipe rack curb side	$2,239.00
Additional hand light connection	$91.00
Low water alarm with light	$389.00
Circular Operator handle	$204.00
Aluminum storm Nozzle 1" 80 gpm	$296.00
6" quick clamp	$39.00
6" adjustable air gap	$329.00
Total deducts at List Price	$23,788.67

SOLID WASTE SYSTEMS, INC. *"Waste Equipment Specialists"*

P.O. BOX 13040 • SPOKANE, WA 99213-3040 • PHONE (509) 533-9000 • FAX (509) 533-1050 • 1-800-U WASTE 1

Additions:

10' Aluminum Telescoping Boom with 10" Diameter Boom & Inlet	$14,289.00
Winter Recirculation	$795.00
Air Purge	$645.00
Hose Reel on Front of Truck	$1581.00
Level Wind Guide Light	$239.00
Chassis Air Dryer	$1107.00
1/4" Turn Ball Valve	$350.00
160 CC Hydrostatic Drive Upgrade	$1500.00
3/4" hose 200' extra	
Rear hydraulic pump off system 575 gpm	
Variable Flow	$686.00
Lazy Susan pipe rack	$9,810.00
(2) Roll out shelves	$330.00
(2) Side mtd tool boxes 35"x14"x24" ($611.00 ea)	$2,140.00
(2) Dry decking side tool boxes	$1,230.00
Dry decking behind cab tool box	$1,222.00
LED 4 Strobes (2) front (2) rear bumpers	$334.00
Led Arrow board	$410.00
Wireless remote with hi-dump controls	$1,523.00
Back up alarm	$1,990.00
Hydro-Excavation Package	$3,582.00
Hose guide spare	$210.00
Manhole cover lifting hook	$4,568.00
Centrifugal compressor quiet package	$137.00
Auxiliary engine remote oil drain	$81.00
Remote debris tank zerk assembly	$2,814.00
Remote boom grease zerk assembly	$213.00
3/4" 30 gpm standard nozzle spare	$1,984.00
3/4" 30 gpm penetrator chisel spare	$1,840.00
3/4" 50 gpm Rotating spinning nozzle	$257.00
	$297.00
	$753.00

P.O. BOX 13040 • SPOKANE, WA 99213-3040 • PHONE (509) 533-9000 • FAX (509) 533-1050 • 1-800-U WASTE 1

3/4" 10' leader hose	$206.00
Total Additions	**$57,123.00**
Total Additions	**$57,123.00**
Total Deductions	**$23,788.67**
Special Discount	**-$1,971.08**
Total Sales Price off State Contract	**$313,327.19**
Sales Tax (8.0%)	$25,066.18
Total Truck Pricing with Sales Tax	**$338,393.37**

Purchase Order

City of Ellensburg
501 N Anderson St.
Ellensburg WA 98926

Solid Waste Systems, Inc	
Vendor ID	03943
On Hold?	
Purchase Order No.	PO0055784
Date	8/19/2011
Buyer ID	malellat

Vendor:

Solid Waste Systems, Inc
P.O. Box 13040
Spokane WA 99213-3040

Ship To:

City of Ellensburg
501 N Anderson St.
Ellensburg WA 98926

^ Changed Since the Previous Revision

Shipping Method	Payment Terms	Confirm With	Page
			1

L/N Item Number / Budget Number	Description / Project Number	Req. Date / FOB	U/M	Ordered	Unit Price	Ext. Price
1 AUX ENGINE HYDRAULI		8/19/2011	Each	1.0	$1,782.00	$1,782.00
400-431-594-38-64-000-000	**SS594.38115440**					
EQUIP/MACHINERY	AUX ENGINE HYDRAULICS	None				
^2 CHASSIS ENGINE REMC		8/19/2011	Each	1.0	$3,960.37	$3,960.37
400-431-594-38-64-000-000	**SS594.38115440**					
EQUIP/MACHINERY	CHASSIS ENGINE REMOTE START	None				

Subtotal	$5,742.37
Trade Discount	$0.00
Freight	$0.00
Miscellaneous	$0.00
Tax	$0.00
Order Total	$5,742.37

Authorized Signature

SOLID WASTE SYSTEMS, INC.
P.O. BOX 13040
SPOKANE VALLEY, WA 99213-3040
Phone: (509) 533 - 9000
Fax: (509) 533-1050

Page	Invoice Number	Order Number	Order Date
1 of 1	0054243-IN	0120259	1/12/12
	Invoice Date	**Cust No:**	
	1/2/12	09-C1063	

INVOICE

Sold To:

City of Ellensburg
501 N Anderson St
Ellensburg, WA 98926-3147

Ship To:

City of Ellensburg
501 N Anderson St
Ellensburg, WA 98926-3147

Buyer: Tony Malella

Salesperson: Phil Davison

Customer P.O.	Ship VIA	F.O.B.	Terms
PO0055784	BESTWAY	origin	Net on Delivery

Item No.	Description	Unit	Ordered	Shipped	Back Ordered	Price	Amount
	City of Ellensburg z35287 Ref: 2012 International 7600SFA w/ V3-11 LXHA Vin: 1HJGRSJT1CJ076904 S/n: 12116061						
*	Auxiliary Engine Hydraulics	EACH	1.00	1.00	0.00	1,650.00	1,650.00 TX
*	Remote Start for Chassis Engine	EACH	1.00	1.00	0.00	3,667.00	3,667.00 TX

SWS will accept Visa, Mastercard and American Express.
Any charges above $1000.00 will have a service fee.

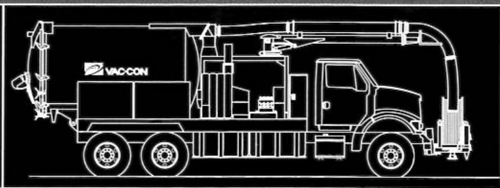
1.5% (18% per Annum) Interest Charge on all Past Due Accounts

Net Invoice:	5,317.00
Less Discount:	0.00
Sales Tax:	425.37
Invoice Total:	5,742.37

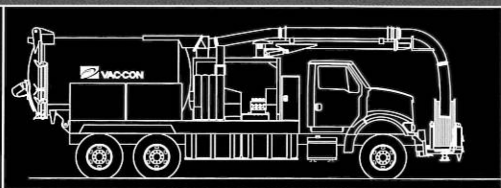
Invoice No.: 0054243-IN

VAC-CON MODELS AND SPECS:

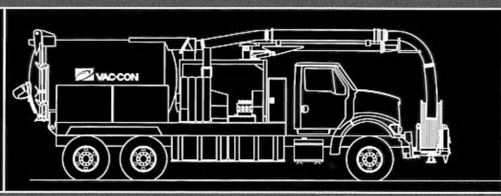
16 YARD



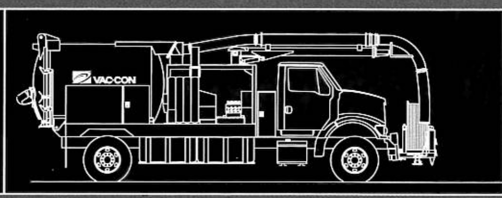
12 YARD



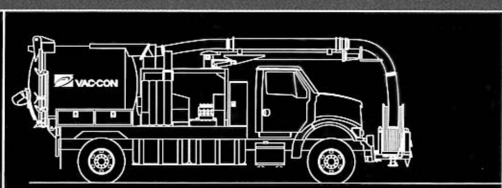
11 YARD



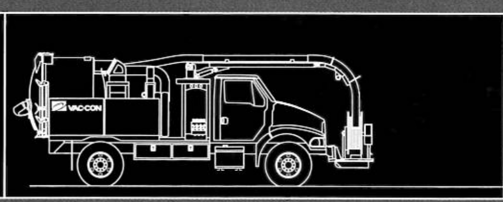
9 YARD



5 YARD



3.5 YARD



		16 YARD	12 YARD	11 YARD	9 YARD	5 YARD	3.5 YARD
SAFETY	Automatic Vacuum Breaker	•	•	•	•	•	•
	Vacuum Breaker/Relief in Pendant Control Station	•	•	•	•	•	•
	Emergency Shut Down	•	•	•	•	•	•
	Hydraulic Safety Interlock	•	•	•	•	•	•
	Circuit Breakers	•	•	•	•	•	•
	Available Fan Silencer	•	•	•	•	•	•
	Hydraulic Rear Door Locks	•	•	•	•	•	•
	Boom Travel Tie Down	•	•	•	•	•	•
	Protected Hose Reel Drive Components	•	•	•	•	•	•
	Footage Counter	•	•	•	•	•	•
	Low Water Alarm/Light	•	•	•	•	•	•
	Strobe Lights	•	•	•	•	•	•
	ICC Lighting	•	•	•	•	•	•
	Reflective Striping	•	•	•	•	•	•
DURABILITY	Corten® Steel Debris Body	•	•	•	•	•	•
	Deflector Shield in Debris Body	•	•	•	•	•	•
	Welded Fan Components	•	•	•	•	•	•
	Centrifugal Separator with Cleanout	•	•	•	•	•	•
	Water Pump Drain	•	•	•	•	•	•
	Winter Recirculation	•	•	•	•	•	•
	Centrifugal Compressor Flush Out	•	•	•	•	•	•
	12 Month Warranty	•	•	•	•	•	•
	Polyethylene Water Tanks from 500 to 1500 gallons	•	•	•	•	•	•
	Polyurethane Paint	•	•	•	•	•	•
PERFORMANCE	Available Hi Dump	•	•	•	•		
	Hydraulic Scissor Lift	•	•	•	•	•	
	Body Pump Off	•	•	•	•	•	•
	Street Flusher	•	•	•	•	•	
	Full Opening Rear Door	•	•	•	•	•	•
	Water Pump with Smooth Continuous Pressure	•	•	•	•	•	•
	Front Tow Hooks	•	•	•	•	•	•
	2-Stage Compressor	•	•	•	•	•	•
	Available 3-Stage Centrifugal Compressor	•	•	•	•	•	
	27″ Corten® Steel Fans in Compressor	•	•	•	•	•	•
	2 Engine Design: Vacuum System powered by Chassis Engine and Water System by Auxiliary Engine	•	•	•	•	•	
	Portable Video Inspection	•	•	•	•	•	•
	Boom Lights	•	•	•	•	•	•
	Grate Lifting Hook on Boom	•	•	•	•	•	•
	Front Mounted Hydraulic Hose Reels from 500′ to 800′ Capacity	•	•	•	•	•	•
	Articulating Hose Reel	•	•	•	•	•	
	Hand Gun Reel	•	•	•	•	•	•
	Manual Level Wind Guide	•	•	•	•	•	•
	Available Positive Displacement Blower	•	•	•	•	•	•
	6″ Vac Intake Hose						•
	8″ Vac Intake Hose	•	•	•	•	•	•
	4 Way Boom With 270° Rotation	•	•	•	•	•	•
	Water Systems up to 3000 PSI and 120 GPM	•	•	•	•	•	
	Water Systems up to 4000 PSI and 30 GPM	•	•	•	•	•	•
EASE OF OPERATION	Hydrostatic Blower Drive	•	•	•	•	•	•
	Available Automatic Level Wind Guide	•	•	•	•	•	
	Telescoping Boom, Extendable Boom	•	•	•	•	•	•
	Joystick for Boom	•	•	•	•	•	•
	Available Wireless Remote	•	•	•	•	•	•
	Coated Body/Body Wash Out	•	•	•	•	•	•
	Hand Gun Wash Down System	•	•	•	•	•	•
	Tachometer for Chassis Engine at Operator Station	•	•	•	•	•	•
	Gravity Drain Systems	•	•	•	•	•	•
	5″ Butterfly Valve	•	•	•	•	•	•
	Rear Door Pipe Rack	•	•	•	•	•	•
	Rotary Pipe Rack	•	•	•	•	•	
	Tool Boxes / Tool Storage	•	•	•	•	•	•

VAC-CON

MORE POWER TO YOU

How does your machine stack up?
To request a demonstration call
904-284-4200 or visit www.vac-con.com

SOLID WASTE SYSTEMS, INC.
"WASTE EQUIPMENT SPECIALISTS"
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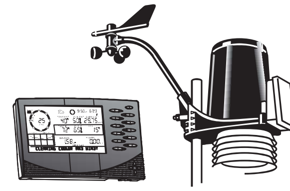
FAX 509-533-1050

691-0548

Appendix F. Weather Station Specifications

Cabled Vantage Pro2™ & Vantage Pro2 Plus™ Stations

6152C
6162C



Vantage Pro2™

The Vantage Pro2™ (# 6152C) and Vantage Pro2™ Plus (# 6162C) cabled weather stations include two components: the Integrated Sensor Suite (ISS) and the console. The ISS contains the sensor interface module (SIM), rain collector, an anemometer, and a passive radiation shield. The Vantage Pro2 console provides the user interface, data display, and calculations. The Vantage Pro2 Plus weather station includes two additional sensors that are optional on the Vantage Pro2 and purchased separately: the UV Sensor and the Solar Radiation Sensor. The console and ISS are powered by an AC-power adapter connected to the console. Batteries can be installed in the console to provide a backup power supply. Use WeatherLink® to let your weather station interface with a computer, log data, and upload weather information to the Internet. The 6152C and 6162C models rely on passive shielding to reduce solar-radiation induced temperature errors in the outside temperature sensor readings.

Integrated Sensor Suite (ISS)

Operating Temperature	-40° to +150°F (-40° to +65°C)
Non-operating Temperature	-40° to +158°F (-40° to +70°C)
Current Draw	5 mA (average) at 4 to 6 VDC for ISS only. 10 mA average for both console and ISS
Connectors, Sensor	Modular RJ-11
Cable Type	4-conductor, 26 AWG
Cable Length, Anemometer	40' (12 m) (included); 240' (73 m) (maximum recommended)

Note: Maximum displayable wind decreases as the length of cable increases. at 140' (42 m) of cable, the maximum wind speed displayed is 135 mph (60 m/s); at 240' (73 m), the maximum wind speed displayed is 100 mph (34 m/s).

Wind Speed Sensor	Solid state magnetic sensor
Wind Direction Sensor	Wind vane with potentiometer
Rain Collector Type	Tipping bucket, 0.01" per tip (0.2 mm with metric rain adapter), 33.2 in^2 (214 cm^2) collection area
Temperature Sensor Type	PN Junction Silicon Diode
Relative Humidity Sensor Type	Film capacitor element
Housing Material	UV-resistant ABS plastic
Sensor Inputs	
RF Filtering	RC low-pass filter on each signal line

ISS Dimensions(not including anemometer or bird spikes):

Vantage Pro2 with Standard Rad Shield	14.0" x 9.4" x 14.5" (356 mm x 239 mm x 368 mm)
Vantage Pro2 with Fan-Asprated Rad Shield	20.8" x 9.4" x 16.0" (528 mm x 239 mm x 406 mm)
Vantage Pro2 Plus with Standard Rad Shield	14.3" x 9.7" x 14.5" (363 mm x 246 mm x 368 mm)
Vantage Pro2 Plus with Fan-Aspirated Rad Shield	21.1" x 9.7" x 16.0" (536 mm x 246 mm x 406 mm)

Davis Instruments 3465 Diablo Ave., Hayward, CA 94545-2778 USA
(510) 732-9229 • FAX (510) 670-0589 • sales@davisnet.com • www.davisnet.com

Barometric Pressure

Resolution and Units	0.01" Hg, 0.1 mm Hg, 0.1 hPa/mb (user-selectable)
Range	16.00" to 32.50" Hg, 410 to 820 mm Hg, 540 to 1100 hPa/mb
Elevation Range	-999' to +15,000' (-600 m to 4570 m) (Note that console screen limits entry of lower elevation to -999' when using feet as elevation unit.)
Uncorrected Reading Accuracy	±0.03" Hg (±0.8 mm Hg, ±1.0 hPa/mb) (at room temperature)
Sea-Level Reduction Equation Used	United States Method employed prior to use of current "R Factor" method
Equation Source	Smithsonian Meteorological Tables
Equation Accuracy	±0.01" Hg (±0.3 mm Hg, ±0.3 hPa/mb)
Elevation Accuracy Required	±10' (3m) to meet equation accuracy specification
Overall Accuracy	±0.03" Hg (±0.8 mm Hg, ±1.0 hPa/mb)
Trend (change in 3 hours)	Change 0.06" (2 hPa/mb, 1.5 mm Hg) = Rapidly Change 0.02" (.7hPa/mb,.5 mm Hg)= Slowly
Trend Indication	5 position arrow: Rising (rapidly or slowly), Steady, or Falling (rapidly or slowly)
Update Interval	1 minute or when console BAR key is pressed twice
Current Display Data	Instant
Current Graph Data	Instant, 15-min., and Hourly Reading; Daily, Monthly, High and Low
Historical Graph Data	15-min. and Hourly Reading; Daily, Monthly Highs and Lows
Alarms	High Threshold from Current Trend for Storm Clearing (Rising Trend Low Threshold from Current Trend for Storm Warning (Falling Trend)
Range for Rising and Falling Trend Alarms	0.01 to 0.25" Hg (0.1 to 6.4 mm Hg, 0.1 to 8.5 hPa/mb)

Clock

Resolution	1 minute
Units	Time: 12 or 24 hour format (user-selectable)
Date	US or International format (user-selectable)
Accuracy	±8 seconds/month
Adjustments	Time: Automatic Daylight Savings Time (for users in North America and Europe that observe it in AUTO mode, MANUAL setting available for all other areas) Date: Automatic Leap Year
Alarms	Once per day at set time when active

Dewpoint (calculated)

Resolution and Units	1°F or 1°C (user-selectable) °C is converted from °F rounded to nearest 1°C
Range	-105° to +130°F (-76° to +54°C)
Accuracy	±2°F (±1°C) (typical)
Update Interval	10 to 12 seconds
Source	World Meteorological Organization (WMO)
Equation Used	WMO Equation with respect to saturation of moist air over water
Variables Used	Instant Outside Temperature and Instant Outside Relative Humidity
Current Display Data	Instant Calculation
Current Graph Data	Instant Calculation; Daily, Monthly High and Low
Historical Graph Data	Hourly Calculations; Daily, Monthly Highs and Lows
Alarms	High and Low Threshold from Instant Calculation

Moon Phase

Console Resolution	1/8 (12.5%) of a lunar cycle, 1/4 (25%) of lighted face on console
WeatherLink Resolution	0.09% of a lunar cycle, 0.18% of lighted face maximum (depends on screen resolution)
Range	New Moon, Waxing Crescent, First Quarter, Waxing Gibbous, Full Moon, Waning Gibbous, Last Quarter, Waning Crescent
Accuracy	±38 minutes

Rainfall

Resolution and Units	0.01" or 0.2 mm (user-selectable) (1 mm at totals ≥ 2000 mm)
Daily/Storm Rainfall Range	0 to 99.99" (0 to 999.8 mm)
Monthly/Yearly/Total Rainfall Range	0 to 199.99" (0 to 6553 mm)
Accuracy	For rain rates up to 4"/hr (100 mm/hr): ±4% of total or ± one tip of the bucket (0.01" /0.2 mm), whichever is greater.
Update Interval	20 to 24 seconds
Storm Determination Method	0.02" (0.5 mm) begins a storm event, 24 hours without further accumulation ends a storm event
Current Display Data	Totals for Past 15-min
Current Graph Data	Totals for Past 15-min, Past 24-hour, Daily, Monthly, Yearly (start date user-selectable) and Storm (with begin date); Umbrella is displayed when 15-minute total exceeds zero
Historical Graph Data	Totals for 15-min, Daily, Monthly, Yearly (start date user-selectable) and Storm (with begin and end dates)
Alarms	High Threshold from Latest Flash Flood (15-min. total, default is 0.50", 12.7 mm), 24-Hour Total, Storm Total,
Range for Rain Alarms	0 to 99.99" (0 to 999.7 mm)

Rain Rate

Resolution and Units	0.01" or 0.1mm (user-selectable) at typical rates (see Fig. 3 and 4)
Range	0, 0.04"/hr (1 mm/hr) to 96"/hr (0 to 2438 mm/hr)
Accuracy	±5% for rates less than 5" per hour (127 mm/hr)
Update Interval	20 to 24 seconds
Calculation Method	Measures time between successive tips of rain collector. Elapsed time greater than 15 minutes or only one tip of the rain collector constitutes a rain rate of zero.
Current Display Data	Instant
Current Graph Data	Instant and 1-min. Reading; Hourly, Daily, Monthly and Yearly High
Historical Graph Data	1-min Reading; Hourly, Daily, Monthly and Yearly Highs
Alarm	High Threshold from Instant Reading

Solar Radiation (requires solar radiation sensor)

Resolution and Units	1 W/m^2
Range	0 to 1800 W/m^2
Accuracy	±5% of full scale (Reference: Eppley PSP at 1000 W/m^2)
Drift	up to ±2% per year
Cosine Response	±3% for angle of incidence from 0° to 75°
Temperature Coefficient	-0.067% per °F (-0.12% per °C); reference temperature = 77°F (25 °C)
Update Interval	50 seconds to 1 minute (5 minutes when dark)
Current Graph Data	Instant Reading and Hourly Average; Daily, Monthly High
Historical Graph Data	Hourly Average, Daily, Monthly Highs
Alarm	High Threshold from Instant Reading

Sunrise and Sunset

Resolution	1 minute
Accuracy	±1 minute
Reference	United States Naval Observatory

Temperature

Inside Temperature (sensor located in console)

Resolution and Units	Current Data: 0.1°F or 1°F or 0.1°C or 1°C (user-selectable) °C is converted from °F rounded to nearest 1°C Historical Data and Alarms: 1°F or 1°C (user-selectable)
Range	+32° to +140°F (0° to +60°C)
Sensor Accuracy	±1°F (±0.5°C) (typical) See. Fig. 2
Update Interval	1 minute
Current Display Data	Instant (user-adjustable offset available)
Current Graph Data	Instant Reading; Daily and Monthly High and Low
Historical Graph Data	Hourly Readings; Daily and Monthly Highs and Lows
Alarms	High and Low Thresholds from Instant Reading

Outside Temperature (sensor located in ISS)

Resolution and Units	Current Data: 0.1°F or 1°F or 0.1°C or 1°C (user-selectable) nominal °C is converted from °F rounded to nearest 1°C Historical Data and Alarms: 1°F or 1°C (user-selectable)
Range	-40° to +150°F (-40° to +65°C)
Sensor Accuracy	±0.5°F (±0.3°C) See Fig. 1
Radiation Induced Error (Passive Shield)	+4°F (2°C) at solar noon (insolation = 1040 W/m^2, avg. wind speed ≤ 2 mph (1 m/s)) (reference: RM Young Model 43408 Fan-Aspirated Radiation Shield)
Radiation Induced Error (Fan-Aspirated Shield)	+0.6°F (0.3°C) at solar noon (insolation = 1040 W/m^2, avg. wind speed ≤ 2 mph (1 m/s)) (reference: RM Young Model 43408 Fan-Aspirated Radiation Shield)
Update Interval	10 to 12 seconds
Current Display Data	Instant (user-adjustable offset available)
Current Graph Data	Instant; Daily, Monthly, Yearly High and Low
Historical Graph Data	Hourly Readings; Daily, Monthly, Yearly Highs and Lows
Alarms	High and Low Thresholds from Instant Reading

Temperature Humidity Sun Wind Index (requires solar radiation sensor)

Resolution and Units	1°F or 1°C (user-selectable) °C is converted from °F rounded to nearest 1°C
Range	-90° to +165°F (-68° to +74°C)
Accuracy	±4°F (±2°C) (typical)
Update Interval	10 to 12 seconds
Sources and Formulation Used	United States National Weather Service (NWS)/NOAA Steadman (1979) modified by US NWS/NOAA and Davis Instruments to increase range of use and allow for cold weather use
Variables Used	Instant Outside Temperature, Instant Outside Relative Humidity, 10-minute Average Wind Speed, 10-minute Average Solar Radiation
Formulation Description	Uses Heat Index as base temperature, affects of wind and solar radiation are either added or subtracted from this base to give an overall effective temperature
Current Graph Data	Instant and Hourly Calculation; Daily, Monthly High
Historical Graph Data	Hourly Calculation; Daily, Monthly Highs
Alarm	High Threshold from Instant Reading

Ultra Violet (UV) Radiation Dose (requires UV sensor)

Resolution and Units	0.1 MEDs to 19.9 MEDs; 1 MED above 19.9 MEDS
Range	0 to 199 MEDs
Accuracy	±5% of daily total
Drift	up to ±2% per year
Update Interval	50 seconds to 1 minute (5 minutes when dark)
Current Graph Data	Latest Daily Total (user resetable at any time from Current Screen)
Historical Graph Data	Hourly, Daily Totals (user reset from Current Screen does not affect these values)
Alarm	High Threshold from Daily Total
Alarm Range	0 to 19.9 MEDs

Ultra Violet (UV) Radiation Index (requires UV sensor)

Resolution and Units	0.1 Index
Range	0 to 16 Index
Accuracy	±5% of full scale (Reference: Yankee UVB-1 at UV index 10 (Extremely High))
Cosine Response	±4% FS (0° to 90° zenith angle)
Update Interval	50 seconds to 1 minute (5 minutes when dark)
Current Graph Data	Instant Reading and Hourly Average; Daily, Monthly High
Historical Graph Data	Hourly Average, Daily, Monthly Highs
Alarm	High Threshold from Instant Calculation

Wind

Wind Chill (Calculated)

Resolution and Units	1°F or 1°C (user-selectable); °C is converted from °F and rounded to the nearest 1°C
Range	-110° to +135°F (-79° to +57°C)
Accuracy	±2°F (±1°C) (typical)
Update Interval	10 to 12 seconds
Source	United States National Weather Service (NWS)/NOAA
Equation Used	Osczevski (1995) (adopted by US NWS in 2001)
Variables Used	Instant Outside Temperature and 10-min. Avg. Wind Speed
Current Display Data	Instant Calculation
Current Graph Data	Instant Calculation; Hourly, Daily and Monthly Low
Historical Graph Data	Hourly, Daily and Monthly Lows
Alarm	Low Threshold from Instant Calculation

Wind Direction

Range	0 - 360°
Display Resolution	16 points (22.5°) on compass rose, 1° in numeric display
Accuracy	±3°
Update Interval	2.5 to 3 seconds
Current Graph Data	Instant Reading (user adjustable); 10-min. Dominant; Hourly, Daily, Monthly Dominant
Historical Graph Data	Past 6 10-min. Dominants on compass rose only; Hourly, Daily, Monthly Dominants

Wind Speed

Resolution and Units	1 mph, 1 km/h, 0.4 m/s, or 1 knot (user-selectable) Measured in mph; other units are converted from mph and rounded to nearest 1 km/hr, 0.1 m/s, or 1 knot.
Range	1 to 200 mph, 1 to 173 knots, 0.5 to 89 m/s, 1 to 322 km/h
Update Interval	Instant Reading: 2.5 to 3 seconds, 10-minute Average: 1 minute
Accuracy	±2 mph (2 kts, 3 km/h, 1 m/s) or ±5%, whichever is greater
Maximum Cable Length	540' (165 m) (Note that maximum wind speed reading decreases as length of cable from anemometer to ISS increases.)
Current Display Data	Instant
Current Graph Data	Instant Reading; 10-minute and Hourly Average; Hourly High; Daily, Monthly and Yearly High with Direction of High
Historical Graph Data	10-min. and Hourly Averages; Hourly Highs; Daily, Monthly and Yearly Highs with Direction of Highs
Alarms	High Thresholds from Instant Reading and 10-minute Average

Appendix G. Sediment Accumulation: Basin and Sock Cut-Sheet

Agrimaster Poly Stock Tank by Behlen Country

Blain # 747144 | Mfr # 52112187

★★★★★ Write a review

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Today's Price

$199.99

Capacity:

65 Gallon 70 Gallon 100 Gallon

150 Gallon 300 Gallon

Quantity: - 1 +

Ship This Item In Stock

Usually ships within 4-5 days

Check Store Availability

Add To Cart

About This Item Product Q & A

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About This Item

Features

- Durable seamless design resists breakage.
- All round - end tanks have an extra heavy duty, molded rim and an extra - deep sidewall rib design for additional strength.
- Heavy duty, molded - in aluminum drain fitting and 1 1/4" poly drain plug ensure a long - life.
- FDA food - grade approved poly, tested to -20°F, corrosion - free impact resistant and recyclable.
- Premium UV Protection assures long life and resistance to color fade in outdoor use.

Specifications

Cross Brace:2
Dimensions:3' x 2' x 8'
Weight: 77 lb
Color: Blue
Capacity: 300 Gallon

PARKER

Felt Filter Bag, Polyester Material, 160 gpm Max. Flow, 1 Microns

Item # **4NVE6** Mfr. Model # **G2PE1-Q** Catalog Page # **2703** UNSPSC # **40161508**

Web Price
$104.50 / pkg. of 10

One Time Delivery
Auto Reorder

1

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Shipping Pickup

Expected to arrive **Fri. Jul 20**.

Ship To **68101** (Change)

Be the first to write a review

Shipping Weight
7.31 lbs.

How can we improve our Product Images?

Compare

Country of Origin **USA** | *Country of Origin is subject to change.*

Note: Product availability is real-time updated and adjusted continuously. The product will be reserved for you when you complete your order. More

PRODUCT DETAILS

Polyester felt bag features a top-sealing plastic ring that provides positive sealing in standard vessels. Glazed surface effectively keeps fibers from migrating into filtered product.

TECHNICAL SPECS

Not today Please don't invite me again

Item	**Filter Bag**
Basic Material	**Felt**
Material	**Polyester**
Max. Flow	**160 gpm**
Microns	**1**
Filter Size	**2**
Height	**31-1/2"**
Diameter	**7"**

Max. Temp.	**275 Degrees F**
Finish	**Glazed**
Ring Material	**Polyester**
Seam Type	**Welded**
Collar Type	**Ring**
Area	**4-1/2 ft.**
Reduces	**Particulate**

Appendix H. Field Data Collection Forms

Catch Basin Sediment Depth Measurements

CB Cleaning Month:		**Data Collector Name:**	
Date:		**Data Collection Time:**	
Location (Circle One):		**Test-Site**	**Control-Site**
Comments:			

Catch Basin #:	**Depth Measurement Location in CB:**		**1**	**2**	**3**	**4**	**5**	**Units**
Depth of CB Empty:	**Measure from the bottom of CB to CB rim in 5 different locations in the CB**	D_{CB}						**inches**
Depth of CB Empty to Pipe Invert:	**Measure from the bottom o CB to bottom of the inside of the pipe**	D_{invert}						**inches**
Depth to Top of Sediment in CB:	**Measure from top of sediment in CB to CB rim in 5 different locations in the CB**	D_{CB-S}						**inches**
Catch Basin #:	**Depth Measurement Location in CB:**		**1**	**2**	**3**	**4**	**5**	**Units**
Depth of CB Empty:	**Measure from the bottom of CB to CB rim in 5 different locations in the CB**	D_{CB}						**inches**
Depth of CB Empty to Pipe Invert:	**Measure from the bottom o CB to bottom of the inside of the pipe**	D_{invert}						**inches**
Depth to Top of Sediment in CB:	**Measure from top of sediment in CB to CB rim in 5 different locations in the CB**	D_{CB-S}						**inches**
Catch Basin #:	**Depth Measurement Location in CB:**		**1**	**2**	**3**	**4**	**5**	**Units**
Depth of CB Empty:	**Measure from the bottom of CB to CB rim in 5 different locations in the CB**	D_{CB}						**inches**
Depth of CB Empty to Pipe Invert:	**Measure from the bottom o CB to bottom of the inside of the pipe**	D_{invert}						**inches**
Depth to Top of Sediment in CB:	**Measure from top of sediment in CB to CB rim in 5 different locations in the CB**	D_{CB-S}						**inches**
Catch Basin #:	**Depth Measurement Location in CB:**		**1**	**2**	**3**	**4**	**5**	**Units**
Depth of CB Empty:	**Measure from the bottom of CB to CB rim in 5 different locations in the CB**	D_{CB}						**inches**
Depth of CB Empty to Pipe Invert:	**Measure from the bottom o CB to bottom of the inside of the pipe**	D_{invert}						**inches**
Depth to Top of Sediment in CB:	**Measure from top of sediment in CB to CB rim in 5 different locations in the CB**	D_{CB-S}						**inches**

Sediment Weight Field Data Collection Form: Roadway and Catch Basins

	Location (Circle One):	Street Sweeping				Catch Basin Cleaning		
	Date of Data Collection:				**Time of Data Collection:**			
	Data Collectors Name:							
Test Site	**Comments:**							
	Weight of Empty Basin:	W_1						pounds
	Wet Weight of Sediments + Basin:	W_2						pounds
	Wet Weight of Sediments: $W=W_2-W_1$	W						pounds
	Duration Sediment Dewatered (Before Weighing)	T						time
	Cone & Quartering Technique Followed to Collect Samples for:	Moisture Content:			Organic Content:		Particle Size Distribution:	
	Number of Samples Collected:	Moisture Content:			Organic Content:		Particle Size Distribution:	
	Chain of Custody Form Completed:	Moisture Content:			Organic Content:		Particle Size Distribution:	
Control Site	**Comments:**							
	Weight of Empty Basin:	W_1						pounds
	Wet Weight of Sediments + Basin:	W_2						pounds
	Wet Weight of Sediments: $W=W_2-W_1$	W						pounds
	Duration Sediment Dewatered (Before Weighing)	T						time
	Cone & Quartering Technique Followed to Collect Samples for:	Moisture Content:			Organic Content:		Particle Size Distribution:	
	Number of Samples Collected:	Moisture Content:			Organic Content:		Particle Size Distribution:	
	Chain of Custody Form Completed:	Moisture Content:			Organic Content:		Particle Size Distribution:	

Sump Sock Sediment Collection and Dry Weight Analysis Field Data Collection Form

CB Cleaning Month:			Data Collector Name:		
Date:			Data Collection Time:		
Location (Circle One):	Test-Site		Control-Site		
Comments:					
Catch Basin #:					
Any holes or tears present in used sock?	☐	Describe damage:			
Used Sock Removed?	☐	Sock Label:			
Used Sock Shipping Prep	Used Sock Sealed?		☐	Used Sock Placed in Plastic Bag?	☐
Used Sock Plastic Bag Labeled?	☐	Bag Label:			
New Sock Weighed Pre-Install?	☐	Weight:		pounds	
New Sock Installed and Labeled?	☐	Sock Label:			
Comments:					
Catch Basin #:					
Any holes or tears present in used sock?	☐	Describe damage:			
Used Sock Removed?	☐	Sock Label:			
Used Sock Shipping Prep	Used Sock Sealed?		☐	Used Sock Placed in Plastic Bag?	☐
Used Sock Plastic Bag Labeled?	☐	Bag Label:			
New Sock Weighed Pre-Install?	☐	Weight:		pounds	
New Sock Installed and Labeled?	☐	Sock Label:			
Comments:					
Catch Basin #:					
Any holes or tears present in used sock?	☐	Describe damage:			
Used Sock Removed?	☐	Sock Label:			
Used Sock Shipping Prep	Used Sock Sealed?		☐	Used Sock Placed in Plastic Bag?	☐
Used Sock Plastic Bag Labeled?	☐	Bag Label:			
New Sock Weighed Pre-Install?	☐	Weight:		pounds	
New Sock Installed and Labeled?	☐	Sock Label:			
Comments:					
Catch Basin #:					
Any holes or tears present in used sock?	☐	Describe damage:			
Used Sock Removed?	☐	Sock Label:			
Used Sock Shipping Prep	Used Sock Sealed?		☐	Used Sock Placed in Plastic Bag?	☐
Used Sock Plastic Bag Labeled?	☐	Bag Label:			
New Sock Weighed Pre-Install?	☐	Weight:		pounds	
New Sock Installed and Labeled?	☐	Sock Label:			
Comments:					

Appendix I. Chain of Custody Form

Anatek Labs, Inc.

1282 Alturas Drive, Moscow ID 83843 (208) 883-2839 FAX 882-9246

504 E Sprague Ste D, Spokane WA 99202 (509) 838-3999 FAX 838-4433

Chain of Custody Record

Anatek Log-In #

Company Name:	Project Manager:
Address:	Project Name & # :
City: State: Zip:	Email Address :
Phone:	Purchase Order #:
Fax:	Sampler Name & phone:

Turn Around Time & Reporting

Please refer to our normal turn around times at:
http://www.anateklabs.com/services/guidelines/reporting.asp

__Normal
__Next Day*
__2nd Day*
__Other*______

*All rush order requests must be prior approved.

__Phone
__Mail
__Fax
__Email

Provide Sample Description				**List Analyses Requested**												**Note Special Instructions/Comments**
				Preservative:												
Lab ID	Sample Identification	Sampling Date/Time	Matrix	# of Containers	Sample Volume											

	Printed Name	Signature	Company	Date	Time
Relinquished by					
Received by					
Relinquished by					
Received by					
Relinquished by					
Received by					

Inspection Checklist

Received Intact?	Y	N
Labels & Chains Agree?	Y	N
Containers Sealed?	Y	N
VOC Head Space?	Y	N

Temperature (°C):____________________

Preservative:____________________

____

Date & Time:____________________

Inspected By:____________________

Form COC01.00 - Eff 1 Mar 2015

Samples submitted to Anatek Labs may be subcontracted to other accredited labs if necessary. This message serves as notice of this possibility. Sub-contracted analyses will be clearly noted on the analytical report.

Appendix J. Summary of QAPP Revisions Table

Revision #	Revised By	Section and Page	Status of Revision (Draft/Approved)	Summary of Revision
1	ASNB	Multiple locations	Approved	The lab was changed from Test America to Anatek and Budinger. As such all locations in the document that reference the lab, have been changed accordingly

Appendix K. Corrective Action Plan Table

#	Date Need for Corrective Action Was Identified	Issue Identified	Summary of Corrective Action	Implementation Date of Corrective Action

Appendix L. Sediment Scale and Digital Indicator

COTI GLOBAL 4' X 4' FLOOR SCALE, 10,000# CAPACITY WITH INDICATOR

Digital Indicator

TI-500RF	$1395.00
TI-500 E SS	$1415.00
TI-1680	$1435.00

TI-500ESS

INDICATOR

The TI-500ESS is an NTEP and Canadian certified rugged industrial digital indicator housed in a stainless steel NEMA 4X enclosure. It comes with a large 0.6" LED display for easy readout of up to 50,000 display divisions, and has power for up to 4-350Ω load cells. All setup parameters may be entered via the front panel keys and are shared with other TI series indicators for consistently easy and trouble free use and maintenance. The TI-500ESS uses full duplex RS-232 serial format for communication with many types of attached support equipment. The unit can transmit data on demand, or continuously in a popular data protocol to match a wide variety of printers, remote displays, or personal computers. A piece counting function is also included.

TRANSCELL TECHNOLOGY, INC.

TI-500ESS

Standard Features & Benefits:

- **DIVISIONS-** NTEP certified for 5,000 Divisions
- **CERTIFIED FOR USE IN CANADA**
- **SERIAL PORT-** Full duplex RS-232 Serial Port - demand or continuous
- **CONSTRUCTION-** Stainless Steel swivel stand
- **MULTI-POINT DIGITAL CALIBRATION**
- **FULL FRONT PANEL CONFIGURATION**
- **DISPLAYS-** Up to 50,000 Graduations
- **ENCLOSURE-** Stainless Steel NEMA 4x / IP65
- **STAND-** Stainless steel swivel stand
- **LOAD CELLS-** Drives up to four 350 Ω Load Cells
- **DISPLAY- Easy to read** LED
- **SIMPLE PIECE COUNTING FUCTION**
- **HIGH QUALITY/LOW COST**
- **SPECIAL APPLICATIONS-** Piece Counting, Remote Display, Peak Hold, Animal Hold

Specifications:

Load Cell Excitation: +5 VDC

Load Cell Current: Drives up to four 350 Ω Load Cells

Analog Signal Input Range: +/- 3.125 mV/V max

Analog Sensitivity: 0.3 µV/grad, minimum
0.6 µV/grad, recommended minimum for Legal-for-Trade

A/D Conversion Rate: 10 Hz / 80 Hz Selectable

A/D Resolution: Up to 260,000 Internal Counts @ 2 mV/V

Display: 0.6", 6 Digit LED Display

Display Resolution: Up to 50,000 external grads

NIST Classification: H-44 Class III at 5,000 Divisions
NTEP CC 94-080A3

Canadian Approval No.: AM-5800C

Keyboard Functions: Units, Zero, Net/Gross, Tare, Print

Annunciators: Gross, Net. kg, lb, Center of Zero, Stable, Tare, Negative, PCS

Serial Port: Full Duplex RS-232C Format

Power Requirement: 110/220 VAC, 50/60 Hz

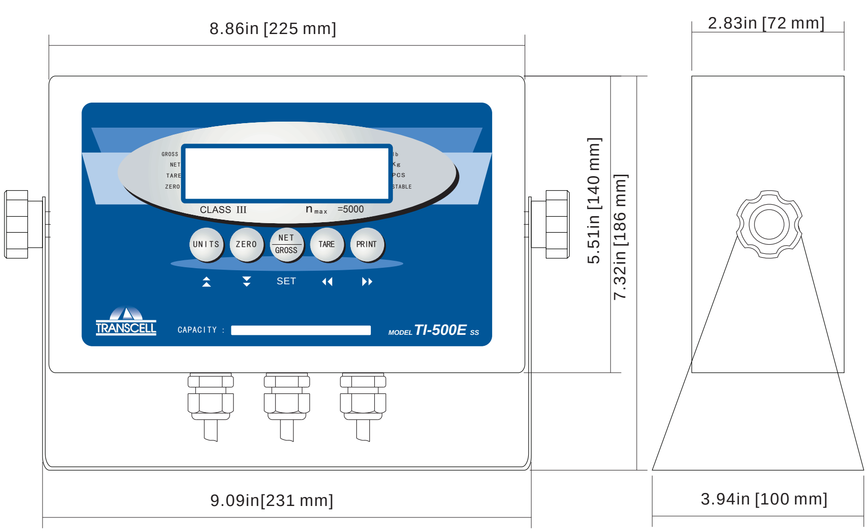
DC Power Consumption: 200 mA + 15 mA/350 ohm Load Cell

Indicator Dimensions: 9.0" x 5.5" x 2.9" (231mm x 140mm x 72mm)

Operating Temperature: 14ºF to 104ºF (-10ºC to 40ºC)

Warranty: 1 year

Dimensions:



Options:

Analog output: 16-Bit, 0-5 VDC (active), 4-20 mA (passive)

Communication: Bluetooth or RS-485

Time/Date & Programmable print format

TRANSCELL TECHNOLOGY, INC.
975 Deerfield Pkwy, Buffalo Grove, IL 60089
Tel (847) 419-9180 Fax (847) 419-1515
(800) 503-9180
www.transcell.net

Version 1.9, 01/26/11

YOUR AUTHORIZED TRANSCELL DEALER IS:

Specifications and features subject to change without notice.

Appendix M. Sediment Settling Time Calculations

The 1-hour time to settle provided in Section 8.1.5 was determined by dividing the depth to the row of valves by the settling velocity for a 1 µm particle (lower limit of TSS particle size range) and 10 µm particle. The settling velocity is obtained by applying Stoke's Law to small particles (less than or equal to 0.01mm) with a density of 2.65 g/cm^3 falling at terminal velocity through water (Wilson, 2012). Assuming a density of 2.65 g/cm3 for sediment and a water temperature of 68°F, the settling velocity for the lower limit TSS particle is determined from the following equation.

$$\omega_s = \left(\frac{2}{9}\right)\frac{(\rho_p - \rho_f)}{v} g d^2$$

Where
$\omega_s = settling\ velocity$
$g = gravity$
$d = particle\ diameter$
$v = viscosity\ of\ fluid$
$\rho_p = density\ of\ soil$
$\rho_f = density\ of\ fluid$

From this formula, the settling velocity for a 1 µm particle size is approximately 0.000003 ft/s. Instead of waiting for a 1 µm particle to fall, 1 µm filter fabric will be used on the valves to prevent particles from leaving the basin. Additionally, the time required to settle 10 µm particles (0.0003 ft/s) will be used to determine when a row of valves can be opened.