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Technical Memorandum

TO:	Dan Cargill, WA State Department of Ecology Brad Helland, WA State Department of Ecology	**DATE:**	June 30, 2009
FROM:	Jonathan Nuwer, SAIC	**REF:**	01-0236-00-7901 Task 4
CC:	John Nakayama, SAIC		
SUBJECT:	Scoping of Lateral Loading Study		

1.0 Introduction

Science Applications International Corporation (SAIC) is assisting the Washington State Department of Ecology (Ecology) with the development of a study to measure contaminant concentrations and estimate lateral sediment loading from significant municipal storm drain outfalls in the Lower Duwamish Waterway (LDW).

A wide range of contaminants are present in a 5.5-mile reach of the LDW, a Federal Superfund site. These include polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and metals. Ecology leads source control efforts in coordination with local government and supports the Environmental Protection Agency (EPA) efforts on the remedial investigation/feasibility study (RI/FS) and early actions. Ecology and EPA are currently implementing a two-phase RI/FS with the Lower Duwamish Waterway Group (LDWG), listed as potentially responsible parties (PRPs) by EPA. The LDWG members are: City of Seattle, The Boeing Company, Port of Seattle, and King County.

The LDWG has estimated contaminant loading through stormwater runoff into the LDW based largely on data from catch basin and in-line solids samples. Ecology, in its oversight role, is evaluating these estimates. As part of this evaluation, Ecology plans to measure contaminant concentrations and loading in stormwater for significant municipal stormwater outfalls within the LDW study area.

The goals of the lateral loading study include:

- Collection of data to model contaminant loading from significant municipal stormwater outfalls;

- Estimation of maximum allowable concentrations of contaminants in stormwater that will not recontaminate sediments to concentrations above sediment cleanup levels; and
- Correlation of in-line sediment trap, storm drain solids, and catch basin solids data with stormwater data, to the extent feasible.

SAIC is assisting with scoping of the lateral loading study by identifying and recommending storm drain outfall sampling locations, reviewing existing stormwater and storm drain solids data for these outfalls, summarizing the methodology used in similar studies to calculate sediment loading, and preparing a sampling and analysis plan (SAP) and quality assurance project plan (QAPP) for conducting stormwater and solids sampling at the selected outfall locations. The purpose of this technical memorandum is to provide an estimate of costs associated with the work plan outlined in the LDW Lateral Loading SAP (SAIC 2009a) and to explain potential complications that may be involved in the sampling effort.

2.0 Sampling Objectives

The objective of the proposed sampling is to collect representative stormwater and storm drain solids samples from stormwater drain lines that empty into the LDW. Data collected during the investigation will be used to identify and quantify the contaminants discharged from municipal stormwater outfalls, model the pollutant loading to LDW sediment from these outfalls, and if possible, to assess the potential for sediment contamination due to stormwater discharges. Specific information regarding sample collection and handling is presented in the LDW Lateral Loading SAP. In addition, specific information summarizing models previously used to conduct stormwater loading calculations is presented in the LDW Lateral Loading Previous Study and Existing Data (SAIC 2009b).

3.0 Recommended Sampling Locations

After field evaluation of the 34 candidate outfalls and drain line access locations, 15 outfalls were deemed suitable for stormwater sampling under the scope of the lateral loading study (Figure 1). Detailed maps showing the outfall locations, drain lines, recommended access locations, and drainage basins, as well as photographs of the sites can be found in the LDW Lateral Loading Site Reconnaissance Report (SAIC 2009c). The 15 recommended drain line access locations met the following criteria:

- Allow minimally obstructed access to drain lines that empty to the LDW,
- Provide adequate conditions for the long-term installation of stormwater sampling equipment, and
- Are representative of a variety of industrial land use types and drainage basin sizes.

Criteria for rejecting outfalls from this study included:

- Inability to identify the outfall and drainage during field reconnaissance,
- Potential to discharge CSO effluent,

- Highly obstructed access to drain lines, or
- Drain line access located too far upgrade from the outfall to be representative of the total drainage basin.

4.0 Sampling Duration

The total recommended duration of stormwater and storm drain solids sampling is one year. This sampling period would encompass a variety of storm conditions and severity, as well as land surface conditions that affect stormwater runoff. Stormwater samples are recommended to be collected at each sampling location during individual storm events. The specific criteria that a rain event must meet to be classified as a storm event are outlined in the LDW Lateral Loading SAP. According to these criteria, the Seattle metropolitan area received an annual average of 36 individual storm events (SAIC 2009a; Table 1). All storm events are not expected to be sampled due to such issues as the availability of field personnel and the unreliable prediction of storm events. Storm drain solids will be sampled less frequently than stormwater. Two separate sediment traps are recommended to be deployed at each sampling location for a 6-month period, after which they will be replaced for a second 6-month deployment.

5.0 Cost Estimate

The estimated costs involved with the proposed stormwater and storm drain solids sampling, sample analysis and validation, outfall modeling, and data reporting are provided in Table 1.

5.1.1 Stormwater Sampling

It is recommended that simultaneous stormwater sampling occur at 15 different outfall drain lines, during 15 separate storm events, over the course of one year. Prior to the sampling of each storm event, the 15 individual Isco samplers will need to have a fully charged battery installed and be programmed with sampling time intervals specific to the predicted storm event. After the conclusion of the storm event, the stormwater samples will need to be retrieved from the sampler and properly stored until analysis. Specific costs associated with stormwater sampling of 15 storm events can be found in Table 1. In general, these costs include:

- Purchase of sampling equipment for continuous deployment,
- Confined space installation, monitoring, removal, and oversight labor,
- Sample analysis and data validation, and
- Data reporting.

5.1.2 Storm Drain Solids Sampling

It is recommended that two sediment traps be installed at each of the 15 drain line access locations for the period of one year for the collection of storm drain solids. Two trap deployments are recommended, requiring the replacement of bottles after 6 months. The specific costs associated with storm drain solids sampling for two 6-month sediment trap deployments can be found in Table 1. In general, these costs include:

- Purchase of sampling equipment;
- Confined space installation, monitoring, removal, and oversight labor;
- Sample analysis and data validation; and
- Data reporting.

5.1.3 Modeling, Loading Calculations, and Evaluation of Results

The stormwater and storm drain solids data collected during the investigation will be used to identify and quantify the contaminants discharged from the studied stormwater outfalls. Loading calculations will require flow modeling of the watersheds in order to estimate the total discharge from the outfalls sampled. Additional modeling may be used to assess the potential for lateral loading from stormwater discharges to cause sediment contamination in the vicinity of the outfalls.

5.1.4 Total Project Costs

The total cost of the LDW Lateral Loading Study is estimated to be $1,230,000, assuming the specifics details outlined in the LDW Lateral Loading SAP (SAIC 2009a) are followed (Table 1).

6.0 Impediments and Complications

Although the SAP outlines the most appropriate methodology for successfully acquiring the needed samples for the lateral loading study, several possible impediments exist that have the potential to either interfere with sample collection, create uncertainty in the results, or add additional labor costs not included in the cost estimate (Table 1). Lessons learned from similar stormwater studies, including the biases involved in stormwater and storm drain solids sampling, are discussed in the LDW Lateral Loading Previous Study and Existing Data (SAIC 2009b). This section describes various impediments and complications specific to the LDW lateral loading study.

6.1 Worker Safety

Because LDW main stormwater drain lines are generally located underneath roadways, many of the recommended drain line access locations are found either in or adjacent to roadways. While more highly protected access locations were scouted during field reconnaissance, these manholes generally allow access to drain lines receiving runoff from small sub-basins that are not representative of the stormwater discharged from the outfall. The proximity of the access locations to moving traffic poses a safety hazard to field workers during equipment installation and monitoring activities. Proximity to traffic does not jeopardize the sampling equipment because all of the field equipment proposed to be used in the study remains subsurface throughout deployment.

6.2 Additional Field Reconnaissance

Additional site reconnaissance is highly recommended before the installation of sampling equipment. Because initial field reconnaissance of the outfalls and access sites took place during a dry period (SAIC 2009c), flowing water was not observed in many of the drain lines. Before installation of sampling equipment, it would be prudent to inspect drain lines at the recommended access locations during a storm event to ensure adequate flow. It is possible that some of the sampling drainage basins are too small to provide sufficient sampling volume even during a large storm event.

Although the diameter of the outfall pipes were determined during field reconnaissance, the diameter of drain lines at the access locations are unknown. Such a determination would require confined space entry to the drain lines. Due to the height of the sediment traps and their mounting configuration, they cannot be installed in drain lines with a diameter smaller than 24 inches. Even if the chamber beneath the manhole provides sufficient vertical clearance for sediment trap installation, the mouth of the trap will not be submerged during high flow events unless the drain line emptying into the chamber has a diameter greater than approximately 24 inches.

6.3 Intertidal Drain Lines

Approximate elevations of the drain lines at the access locations are reported relative to MLLW (SAIC 2009c; Table 2). However, uncertainty associated with the determination of surface elevation at manhole level leads to substantial error in these values. Drain lines at elevations less than the high tide level are expected to experience LDW water backing up the drain line during high tidal stages. During additional field reconnaissance activities, storm drain access locations should also be observed during high tidal stages to determine if they become inundated during high tides. Although drain line access locations further upgradient from the outfall are less susceptible to inundation at high tide, stormwater flow becomes less representative of the entire drainage basin further upgrade. Because the goal of this study is to estimate contaminant loading to the LDW from stormwater runoff, drain line sampling is recommended in close proximity to the outfall.

Data from both the flow sensor and conductivity sensor will be used to ensure that only stormwater and not LDW surface water is sampled. The stormwater sampler should be programmed to collect water samples only when flow is down-grade toward the LDW and the conductivity value of the water is below a threshold level that would exclude LDW surface water. Although this methodology helps to ensure that only stormwater is collected, it also may reduce the fraction of a storm event that will be sampled.

When intertidal water is present in the drain line, data collected by the flow sensor are not representative of unimpeded stormwater flow. Therefore, flow data collected throughout the deployment of the sampler cannot be used to determine the annual stormwater discharge for an outfall. Instead, storm event and drainage basin modeling will likely be required to estimate the quantity of water discharged from each outfall. These total discharge volume calculations are essential for chemical loading calculations.

6.4 Storm Event Prediction

Twelve discrete stormwater samples will be collected during a storm event that will later be composited based on flow rate to create a single sample representative of the storm event. Stormwater samplers will need to be programmed with sampling time intervals based on the predicted timing of the storm event prior to each sampling event. Because of the large volume of stormwater required for analysis, effort should be taken to minimize sampling intervals outside the storm event window while ensuring sample collection during both the leading and tailing ends of the storm event. For example, the sampling time intervals for a storm event predicted to last 16 hours may begin 4 hours before the storm's predicted beginning, sampling every 2 hours, and concluding 4 hours after the storm's predicted end.

An accurate prediction of the size and duration of a rain event is imperative in determining whether it is likely to meet the criteria for classification as a storm event, and therefore whether or not sampling should take place. A great deal of resources and effort may be wasted mobilizing for and sampling a rain event that does not meet storm event criteria, or by not programming sampling to occur for an adequate duration to encompass the event.

6.5 Additional Monitoring Activities

Drain line access locations will require frequent monitoring over the course of sampler deployment. Labor costs involved in sampler installation, programming of samplers before storm events, recovering samples after sampling, and final sampler removal are estimated in Table 1. Substantial additional labor costs could be incurred if confined space entry crews are required during sampler deployment to reposition equipment or remove obstructions interfering with sampling.

Deep-cycle marine batteries are generally recommended to power Isco samplers during long-term sampling events because of their long lifetime. Unfortunately the size and weight of these batteries would prevent installation of the samplers beneath the access manholes within drain lines. Instead, Isco nickel/cadmium batteries with a shorter lifetime (approximately 7 days) must be used. This short lifetime would require the batteries to be recharged or replaced shortly before the beginning of a sampled storm event. If flow data are to be collected continuously during the entire 1-year deployment period, these batteries will need to be replaced more frequently.

6.6 Sample Representativeness

It is anticipated that the two sample types (stormwater and storm drain solids) will result in different predictions of mass loading at most locations. The reason for having two independent methods to estimate loading is that each method has intrinsic measurement artifacts that will lead to varying load estimates. The advantages and disadvantages of each method are to some extent complementary. By using two approaches, the disadvantages of each method can be better understood and the two loading estimates provide a better overall sense of the potential range of chemical loads. The generic advantages and disadvantages of both methods are discussed in the LDW Lateral Loading Previous Study and Existing Data (SAIC 2009b). Additional complications involving the representativeness of stormwater and storm drain solids samples specific to the LDW lateral loading study are discussed below.

6.6.1 Stormwater Samples

Composited stormwater samples collected from drain lines that experience substantial tidal influence may not be representative of the entire storm event. Because samplers will be programmed not to collect samples during periods of tidal influence, some storm events will be incompletely sampled.

6.6.2 Storm Drain Solids Samples

In contrast to the composited stormwater samples that are representative of a single storm event, sediment trap samples integrate material deposited over the entire deployment. However, particles only have the chance to settle into the sediment trap during periods when the mouth of the trap is submerged. Because of this, storm drain solids are not likely to be collected during both the leading and tailing ends of a storm event.

Sediment traps located within intertidal drain lines will collect suspended particulates carried in LDW water that backs up into the drain line during high tidal heights. While LDW water traveling upgradient in the drain line may resuspend and transport storm drain solids to the sediment trap, upgradient flow may also introduce COCs originating from outside of the outfall's watershed.

7.0 Conclusions

Details presented in the LDW Lateral Loading SAP (SAIC 2009a) outline the recommended methodology for accomplishing stormwater and storm drain solids sampling under the scope of the lateral loading study. This sampling is recommended to take place at 15 manhole locations where stormwater drain lines are readily accessible and whose drainages are likely representative of stormwater loading to the LDW from municipal outfalls. The total cost associated with sampling over the recommended 1-year period, sample analysis and validation, modeling, and data reporting is estimated to be $1,230,000. However, the scope of the work is logistically complicated and may involve pitfalls beyond what is presented in the LDW Lateral Loading SAP. These pitfalls have the potential to impede sampling efforts, create uncertainty in the representativeness of the samples collected, and add additional labor costs not included in the cost estimate.

8.0 References

SAIC. 2009a. Scoping of Lateral Loading Study, Combined Sampling and Analysis Plan and Quality Assurance Project Plan. Prepared for Washington State Department of Ecology. Prepared by Science Applications International Corporation, Bothell, WA. June 30, 2009.

SAIC. 2009b. Scoping of Lateral Loading Study, Previous Study and Existing Data. Prepared for Washington State Department of Ecology. Prepared by Science Applications International Corporation, Bothell, WA. June 30, 2009.

SAIC. 2009c. Scoping of Lateral Loading Study, Site Reconnaissance Report. Prepared for Washington State Department of Ecology. Prepared by Science Applications International Corporation, Bothell, WA. June 30, 2009.

Figures

Tables

Figures

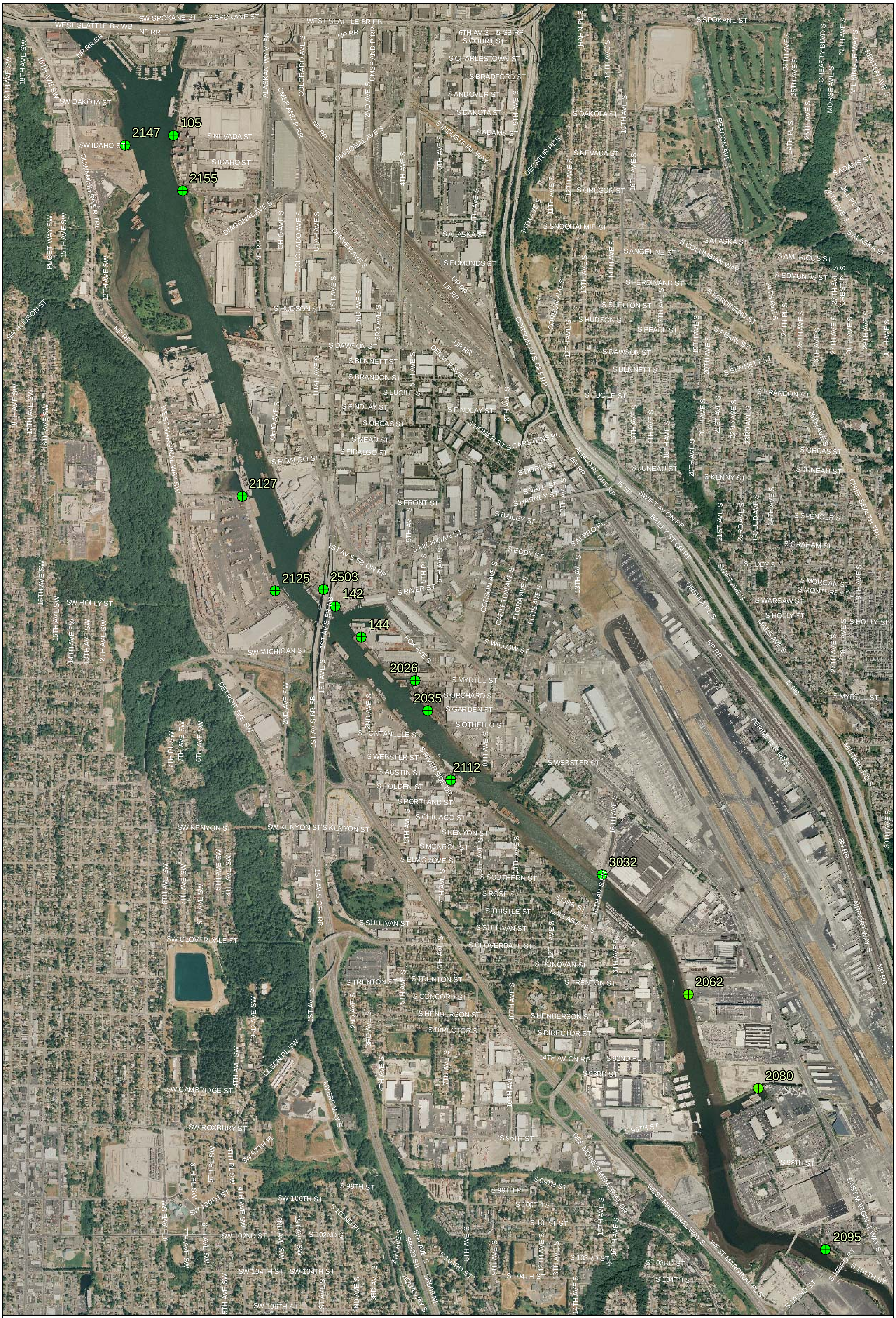

Figure 1. Stormwater Outfalls Recommended for Stormwater and Storm Drain Solids Sampling

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1 inch = 1,500 feet

0 1,750 3,500 7,000 Feet

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Tables

Table 1. Cost Estimate for LDW Lateral Loading Study

STORMWATER SAMPLING - 15 STORM EVENTS		1 Site	15 sites
Isco 6712c Compact Portable Sampler	1 per site	$3,000	$45,000
Glass Sample Bottles and Carrier	24 bottles per site	$800	$12,000
Suction Line with Strainer	1 per site	$300	$4,500
Connection Cable	1 per site	$100	$1,500
750 Module Velocity Sensor	1 per site	$3,500	$52,500
Scissor Ring Sensor Mount	1 per site	$500	$7,500
YSI 600 Conductivity Sonde and Cable	1 per site	$4,000	$60,000
Nickel/Cadmium Battery	2 per site	$400	$6,000
Manhole Hanger	1 per site	$200	$3,000
Software	1 license	$2,000	$2,000
Labor: Installation	1 supervisor, 1 crew, 8 hrs each per site	$1,600	$24,000
Confined Space Subcontractor: Installation	2 crew+equipment, 8 hrs each per site	$2,000	$30,000
Miscellaneous Equipment/Supplies (e.g., manhole lifter, gloves, safety glasses, cones, flagging tape, log books, etc.)	Approximately $500	$500	$500
Labor: Sampler Programming and Battery Replacement	1 supervisor, 2 hrs per site, one visit per storm event	$3,000	$45,000
Labor: Sample Collection	1 supervisor, 2 hrs per site, one visit per storm event	$3,000	$45,000
Analytical Cost	1 sample per site, 15 storm events, $1500 per sample	$22,500	$337,500
Data Validation	1 sample per site, 15 storm events	$1,800	$27,000
Subcontractor Labor: Removal (confined space)	2 crew+equipment, 8 hr per day, 3 sites per day, $2000 per day	$2,000	$10,000
Labor: Data Report	200 hours, 5 hours per location, 5 hours per storm event	$28,000	$35,000
Project Manager	10% of total labor	$3,960	$18,900
Total		**$79,200**	**$748,000**
STORM DRAIN SOLIDS SAMPLING - 2 INSTALLATIONS		**1 Site**	**15 sites**
Labor: Installation	1 supervisor, 8 hrs each per site	$1,600	$24,000
Confined Space Subcontractor: Installation	2 crew+equipment, 8 hrs each per site	$4,000	$60,000
Labor: Monthly Monitoring	1 supervisor, 2 hrs per site, 12 visits	$2,400	$36,000
Sediment Sampler	$350 each; two samplers per site	$1,400	$21,000
Equipment/Supplies	Consumable supplies, assumes $100/site	$100	$3,000
Labor: Sampling and Removal	1 supervisor, 2 hrs per site	$400	$6,000

Table 1. Cost Estimate for LDW Lateral Loading Study

STORM DRAIN SOLIDS SAMPLING - 2 INSTALLATIONS		**1 Site**	**15 sites**
Subcontractor Labor: Sampling and Removal (confined space)	2 crew+equipment, 8 hr per day, 3 sites per day, $2000 per day	$4,000	$20,000
Analytical Cost	1 sample per site, $1500 per sample	$3,000	$45,000
Data Validation	1 sample per site	$400	$3,000
Labor: Data Report	100 hours plus 1 hours per site	$20,200	$23,000
Project Manager	10% of total labor	$3,260	$16,900
Total		**$37,500**	**$241,000**
MODELING, LOADING CALCULATIONS, AND EVALUATION OF RESULTS		**1 Site**	**15 sites**
Labor: Flow Modeling/ Loading Calculations	100 hours, 5 hours per location, 5 hours per storm event	$18,000	$25,000
Labor: Technical Memorandum	100 hours, 1 hours per location, 1 hours per storm event	$11,600	$13,000
Total		**$29,600**	**$38,000**
TOTAL PROJECT COSTS		**1 Site**	**15 sites**
Total Tasks		$146,300	$1,027,000
Contingency (20%)		$29,260	$205,400
Total		**$175,560**	**$1,232,400**