Accelerated Source Tracing Study
Lower Duwamish Waterway, WA

Combined Sampling and Analysis Plan and Quality Assurance Project Plan

Prepared for

Washington State Department of Ecology
Toxics Cleanup Program
Northwest Regional Office
Bellevue,Washington

Prepared by

Science Applications International Corporation
18912 North Creek Parkway, Suite 101
Bothell, WA 98011

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List of Acronyms

ARI	Analytical Resources, Inc.
COC	chain of custody
CSL	Cleanup Screening Level
CSO	combined sewer overflow
DC	direct current
EAP	Environmental Assessment Program
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management
EPA	Environmental Protection Agency
FM	field manager
FS	feasibility study
gph	gallons per hour
GPM	government project manager
HSP	health and safety plan
LAET	lowest apparent effects threshold
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
LDW	Lower Duwamish Waterway
LDWG	Lower Duwamish Waterway Group
MDL	method detection limit
MS	matrix spike
MSD	matrix spike duplicate
MRL	method reporting limit
MTCA	Model Toxics Control Act
NBF-GTSP	North Boeing Field-Georgetown Steam Plant
NOAA	National Oceanic and Atmospheric Administration
OPR	ongoing precision and recovery
OPRD	ongoing precision and recovery duplicate
PAH	polycyclic aromatic hydrocarbon
PBDE	polybrominated diphenyl ether
PCB	polychlorinated biphenyl
PPE	personal protective equipment
QA	quality assurance
QC	quality control
QAPP	quality assurance project plan
RI	remedial investigation
RPD	relative percent difference
SAIC	Science Applications International Corporation
SAP	sampling and analysis plan
SD	storm drain
SOP	standard operating procedure
SQS	Sediment Quality Standard
SMS	Sediment Management Standards
SVOC	semi-volatile organic compound
TEF	toxic equivalency factor
TEQ	toxic equivalent

List of Acronyms (continued)

TOC	total organic carbon
WAC	Washington Administrative Code
WHO	World Health Organization

1.0 Introduction

Science Applications International Corporation (SAIC) is assisting the Washington State Department of Ecology (Ecology) with the development of a study to evaluate stormwater contaminant concentrations and identify potential sources in two Lower Duwamish Waterway (LDW) sub-basins. NewFields provides project support as a subcontractor to SAIC. The Accelerated Source Tracing Study consists of simultaneously measuring contaminant concentrations associated with stormwater discharges at multiple locations in two sub-basins of the Duwamish/Diagonal storm drain basin. This study assesses the practicality and effectiveness of an “up-the-pipe” approach, where stormwater sampling data throughout a drainage sub-basin will be used to prioritize the further investigation of potential contaminant sources. To facilitate this process, Ecology has tasked SAIC with the collection of stormwater, storm drain solids, and flow measurements from a total of eight locations along two different LDW storm drain lines. The Sampling and Analysis Plan/Quality Assurance Project Plan (SAP/QAPP) for this study was prepared in accordance with the requirements outlined in Washington Administrative Code (WAC) 173-340-820. Analytical procedures are also identified in the SAP/QAPP in accordance with WAC 173-340-830.

1.1 Background

A wide range of contaminants are present in a 5.5-mile reach of the LDW, including polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and metals. High concentrations of these contaminants have made this portion of the LDW a Federal Superfund and state Model Toxics Control Act (MTCA) site. Ecology supports the Environmental Protection Agency (EPA) efforts on the LDW Remedial Investigation/Feasibility Study (RI/FS) and is leading source control efforts in coordination with local governments. Ecology and EPA are currently implementing a two-phase RI/FS with the potentially responsible parties, collectively known as the Lower Duwamish Waterway Group (LDWG). The LDWG members are: City of Seattle, The Boeing Company, Port of Seattle, and King County.

In order to aid in the identification of contaminant sources to the LDW, Ecology plans to measure contaminant concentrations in stormwater and storm drain solids at multiple locations in two LDW sub-basins.

The objectives of the Accelerated Source Tracing Study include:

- Evaluation of the usefulness of the “up-the-pipe” source tracing approach;
- Collection of data necessary to trace and identify potential sources of LDW sediment contamination from two storm drain sub-basins of the LDW drainage basin;
- Correlation of in-line sediment trap, filtered suspended solids, and catch basin solids data with stormwater data, to the extent possible; and
- Comparison of different sampling methods to determine whether sediment traps or grab samples are useful and inexpensive tools to conduct source tracing at other locations.

2.0 Project Organization and Responsibilities

SAIC and its subcontractors will implement the SAP/QAPP under the direction of Ecology. The following sections describe the key roles and responsibilities of the project team.

2.1 Project Planning and Coordination

Dan Cargill of Ecology will serve as the Government Project Manager (GPM) who will conduct overall project coordination, supply government-furnished services, review reports, and coordinate with contractors. Glen Vedera will serve as the SAIC project manager and be responsible for executing the approved SAP/QAPP, overseeing the collection and analysis of field samples, and reporting analytical results.

SAIC
Glen Vedera
18912 North Creek Parkway, Suite 101
Bothell, WA
Phone: (425) 482-3329
Fax: (425) 487-1491
vederag@saic.com

2.2 Sample Collection

Dr. Jon Nuwer of NewFields will serve as field manager (FM) responsible for collecting and processing samples in accordance with the SAP/QAPP, and transporting samples to the analytical laboratories for analysis. The FM will oversee field preparation to ensure all sampling equipment is built to specifications. The FM will oversee the installation of the samplers and monitor the confined space subcontractors.

2.3 Laboratory Coordination and QA/QC Management

Dr. Will Hafner of NewFields will serve as laboratory coordinator responsible for subcontracting state-certified laboratories, and ensuring observation of established protocols for decontamination, sample preservation, holding times, chain-of-custody (COC) documentation, and laboratory reporting. The quality assurance/quality control (QA/QC) manager, Marina Mitchell of SAIC, will provide quality assurance oversight for the laboratory programs, ensuring that the laboratory analytical and QA/QC data are considered valid, and that procedures meet the required analytical quality control limits.

2.4 Health and Safety Manager

Preston Martin of NewFields will serve as the designated Project Health and Safety Manager. The Health and Safety Manager is responsible for ensuring that all personnel are properly trained, fully aware of potential site hazards, conduct all work in a safe manner, wear appropriate personal protective equipment (PPE), and abide by the conditions set forth in the Health and Safety Plan (HSP).

2.5 Subcontractor Support

The SAIC project team will consist of the following subcontractors to support the data collection activities, laboratory analytical services, and data reporting:

- Project Support

  NewFields
  John Nakayama
  4729 NE View Drive
  Port Gamble, WA 98364
  Phone: (360) 297-6040
  jnakayama@newfields.com

- Analytical Chemistry

  Analytical Resources, Incorporated
  Cheronne Oreiro
  4611 South 134th Place
  Tukwila, WA 98166
  Phone: (206) 695-6200
  cheronneo@arilabs.com

- Dioxin/Furan Congener and Polybrominated Diphenyl Ether (PBDE) Analysis

  Axys Analytical Services, Ltd.
  Georgina Brooks
  2045 Mills Road
  Sidney BC V8L 3S8
  CANADA
  Phone: (250) 655-5801
  Fax: (250) 655-5811
  gbrooks@axys.com

- ISCO Sampler Support

  Whitney Equipment Co., Inc.
  Laura Haggard
  21222 30th Dr. SE, Suite. 110
  Bothell, WA 98021
  Phone: (425)486-9499
  Fax: (425)485-7409
  lhaggard@weci.com

- Analytical Data Validation

  EcoChem, Inc.
  Christine Ransom
  710 Second Avenue, Suite 660
  Seattle, WA 98104
  Phone: (206)233-9332
  cransom@ecochem.net

- Confined Space Entry and Sampler Installation

  Clearcreek Contractors
  Jay Wilcox
  3203 15th Street
  Everett, WA 98201
  Phone: (425)252-5800
  JayW@clearcreekcon.com

2.6 Project Schedule

Field preparation and mobilization will begin in November following approval of the SAP/QAPP. Sampling and analysis will begin in November 2010 and will continue until April 30, 2011. During this time period, samples will be collected during up to five storm events and one base flow event. Samples will be analyzed after each event and the analytical results will be validated as the data become available. Given the anticipated end date for stormwater sampling (April 2011) and the time required for analysis and data evaluation, completion of the data report may not meet the June 30, 2011, deadline. Following completion of the stormwater sampling program, SAIC will coordinate with Ecology to determine and obtain a no-cost period of performance extension to complete the report, if possible and deemed necessary.

3.0 Field Sampling Plan

The purpose of the field sampling plan is to describe the manner and methods by which data collection efforts will be performed to measure contaminant concentrations in selected LDW storm drains. Each location will be sampled during five storm events over the course of the rainy season (November 2010 – April 2011) in order to estimate the seasonal variability in contaminant concentrations. Samples will also be collected during a base flow period, if conditions permit. Sampling activities will include collection of stormwater (whole water), filtered suspended solids, sediment trap solids, and catch basin solids samples, as well as measurement of stormwater flow. Whole water and filtered suspended solids samples will consist of one composite per individual storm event. Sediment trap samples will be composited over a period of several months to provide enough material for chemical analysis. Catch basin solids grab samples will be collected once at each location over the course of the sampling season.

3.1 Sampling Locations

The eight locations to be sampled as a part of the Accelerated Source Tracing Study are located along storm drain lines that flow to the Diagonal Avenue S combined sewer overflow/storm drain (CSO/SD) outfall, owned by the City of Seattle. Four sampling locations each are located in the S Snoqualmie Street sub-basin and the S Dakota Street sub-basin (Figure 1). Sampling within a sub-basin will take place at drain line access locations (manholes) staggered along the main drain line. Field reconnaissance conducted during September and October 2010 identified access locations appropriate for sampling (Table 1). All sampling locations were observed during base flow conditions and during different tidal heights. Figures 2 and 3 display the drain lines and sampling access locations for the S Snoqualmie Street and S Dakota Street sub-basins, respectively. Sub-basins that were evaluated but not considered suitable for use in this study can be found in NewFields (2010).

3.1.1 S Snoqualmie Street Sub-basin

The S Snoqualmie Street sub-basin is almost entirely industrial (Figure 2). The most upstream sampling location (SQ1) incorporates stormwater draining from Airport Way S. Sampling locations SQ2, SQ3, and SQ4 each integrate stormwater drainage from different industrial properties located along 7th Avenue S, 6th Avenue S, and 4th Avenue S, respectively.

3.1.2 S Dakota Street Sub-basin

The S Dakota Street sub-basin is located just north of the S Snoqualmie Street sub-basin (Figure 1). Sampling of this sub-basin will help differentiate contaminant concentrations associated with residential, I-5, and industrial stormwater. The most upstream sampling location (DK1) incorporates stormwater drainage from a section of the Beacon Hill neighborhood, including the VA Medical Center (Figure 3). Sample location DK2 is located downstream from an I-5 drain line connection. Sample locations DK3 and DK4 integrate drainage from two different industrial areas located along S Dakota Street and 6th Avenue S, respectively.

3.2 Sampling Events

3.2.1 Storm Event Sampling

Whole water and filtered suspended solids samples will be collected during five storm events over the course of 2010 – 2011 sampling season. Targeted storm events will meet the following criteria (Ecology 2007):

- Wet Season: October 1st through April 30th
- Rainfall volume: 0.20" minimum, no fixed maximum
- Rainfall duration: No fixed minimum or maximum
- Antecedent dry period: Less than or equal to 0.02" rain in the previous 24 hours
- Inter-event dry period: 6 hours

Each sampling event will be evaluated relative to these criteria. Due to the time and effort required to deploy sampling gear immediately prior to a sampling event, a flexible interpretation of storm event criteria is suggested for this project. It is anticipated that storm event volume may not meet the minimum requirement for all sampled events. In the case that the above criteria cannot be met for a targeted storm event, Ecology will be contacted to discuss whether to proceed with sampling.

3.2.2 Base Flow Sampling

Contaminants may enter the storm drain system during base flow conditions via groundwater infiltration or as a result of unidentified connections to the storm drain system. Whole water and filtered suspended solids will be collected during a base flow event in order to assess the presence of contaminants in base flow and the contribution of contaminants in base flow to outfall discharges. Collection of base flow samples will occur during a period of little or no precipitation between typical storm events. It is anticipated that some of the sampling locations may not have enough base flow to collect a representative sample volume.

3.3 Sampler Design and Installation

This section describes specifications of the samplers being used and the methodology for positioning these devices in the storm drains. The installation and potential maintenance of both the whole water sampling equipment and sediment traps will require confined space entry. Certain components of the sampling systems will remain installed at each sampling location through the entire duration of the sampling season. Sampler installation will vary between locations due to site-specific characteristics (pipe shape, diameter, vault depth, etc.). The whole water sample reservoir and stormwater filtration apparatus for each sampling location will be installed for the duration of the sampled storm event only, and will be removed between sampling events.

3.3.1 Stormwater Sampler and Sensors

The general methods outlined in this section for collecting automated stormwater samples are taken from Ecology's Environmental Assessment Program's (EAP) standard operating procedures (SOPs) (Ecology 2009). Specific details on installation and programming of the stormwater samplers can be found in the *6712 Portable Samplers Installation and Operation Guide* (Teledyne ISCO 2009), and the *750 Area Velocity Module Installation and Operation Guide* (Teledyne ISCO 2007). All field personnel will be familiar with these documents.

Stormwater samples will be collected at each location using an ISCO 6712c automated sampler (Figure 4). Each stormwater sample will be a flow-weighted composite collected in a 2.5-gallon glass carboy located in the base of the ISCO unit. The sample collected in the carboy will consist of equal volume aliquots sampled at predetermined runoff volume intervals. This sampling scheme samples more frequently at higher flow rates, and less frequently at lower flow rates. At two locations (DK3 and DK4) whole water samples will be time-weighted rather than flow weighted. Due to a narrow tidal window, time-weighted sampling will be required at these stations in order to ensure the collection of sufficient sample volume.

Each sampler will be equipped with a Model 750 area velocity flow module capable of measuring flow where submerged, full-pipe, surcharged, and reverse flow conditions may occur. Area velocity flow measurements require the collection of water level, water velocity, and pipe dimensions. The Model 750 module measures water level and velocity (Teledyne ISCO 2007). Pipe dimensions will be measured during sampler deployment by the confined space entry crew. At locations with a suspected tidal influence, a YSI 600 Sonde with a conductivity probe will be connected to the ISCO sampler to measure salinity. Salinity readings will aid in the differentiation of stormwater flow from LDW tidal inflow. However, salinity will not be used as the primary criterion for identifying tidal inflow, as tidal water moving up the storm drain from the LDW will generally be low salinity surface water.

During sampling, the sampler's peristaltic pump will pull the stormwater though a Teflon® suction line connected to a stainless steel strainer. Inside the sampler container, the suction line feeds into a small section of silicone line prior to the stormwater being deposited into the carboy.

The strainer and area velocity flow sensor will all be attached to an anchored mounting plate or a scissors ring with a diameter matching the pipe dimensions. Installation will require confined space entry. The flow sensor will be installed so it faces upstream and will be located away from items that may interfere with flow velocity, such as the pump for the collection of filtered suspended solids. The strainer will also be installed facing upstream and situated so that the intake screen is near but not touching the surface of the pipe to avoid excess sediment accumulation.

The strainer must be positioned so that it is completely underwater during storm events, otherwise improper aliquot volumes may be collected due to the presence of air. The suction line and electrical cords will be secured to the side of the pipe using concrete bolts or plastic ties. Care will be taken to make sure the suction line will not kink under higher velocity flows and that no loops are present in the line that can hold residual water or cause disturbances in flow that may affect the flow sensor. Flow through the strainer and suction line will be checked periodically to make sure that neither has become plugged with debris.

While the flow sensor and sample collection strainer will remain installed in the drain line throughout the entire sampling season, the conductivity probe will only be deployed during sampling events. The conductivity probe needs to remain wet to function properly. The probe will be secured inside a small, wide mouth jar that will be deployed along with the suspended solids filtration pump (Section 3.3.2). The jar will continually flush when there is sufficient flow through the drain line, and retain enough residual water to prevent damage to the sensor when flow subsides.

3.3.2 Stormwater Solids Filtration

A stormwater filtered suspended solids collection system will be installed at all sampling locations during sampling events. The design of the filtration system is a condensed version of that used by SAIC for collecting stormwater filtered solids at the North Boeing Field/Georgetown Steam Plant Site (NBF-GTSP) (SAIC 2009). The filtration units are designed to be deployed at the beginning of each sampling event within the storm drain line, fully contained beneath the manhole cover. The system consists of a direct current (DC) powered bilge pump and float switch connected to a frame which supports two parallel filtration housings and batteries (Figure 5). The weighted pump will sit on the bottom of the storm drain vault while the filtration apparatus will be tethered to the vault access ladder, out of the flowing stormwater.

For each storm event, the 2,000-gph submersible bilge pump will be positioned in the drain line downstream of the flow sensor and strainer of the ISCO sampler. Positioning the pump too close to the flow sensor may interfere with flow measurements. The pump will be well secured in a weighted cage to prevent movement during high flow events.

Unlike the ISCO sampler, the filtration system does not flow-weight samples. Prior to each sampling event, a DC timer on each unit will be set to ensure that filtration only occurs when tidal water is not backed up in the drain line. During the periods when the timer closes the electrical circuit, stormwater flowing along the bottom of the storm drain line will trigger the float switch, activating the bilge pump. The float switch will be situated high enough off of the bottom of the drain line so that it does not activate during base flow conditions. Stormwater will be pushed through the pump hose where the flow is split and forced through two independent filter canisters. Flow totalizers connected to the outflow side of each filter canister will measure the volume of water passing through each filter. Filtered stormwater exits the system through a hose positioned several feet downstream of the pump to avoid re-sampling water. As the filter bags accumulate solids, flow velocity through the system will eventually diminish to the point where fine-grained materials will preferentially be collected. In order to prevent the over-sampling of fine-grained material, an adjustable in-line pressure relief valve is located upstream of the filtration housings.

The filtration housings are each equipped with a 20-inch long, 4-inch diameter filter bag. All bags are made of 5 micron polypropylene felt, pressure rated to 15 psi. This parallel system allows for the concurrent collection of two discrete storm drain solids samples representative of the storm event. Each of the filter bags will be restricted in the compound classes which can be analyzed, as independent whole bag extractions are required for PCB Aroclor, semi-volatile organic compounds (SVOC), dioxin/furan congener, and PBDE analysis.

3.3.3 Suspended Sediment Trap

A modified Ecology-designed sediment trap (Figure 6) will be used for this study to collect stormwater suspended solids. The trap consists of a stainless steel bracket which holds a one-liter Teflon® sample bottle. The traps will be mounted to the wall of the drain line pipe or vault. Ideally the bracket should be installed at a height at which the top of the bottle is above water level due to tides or base flow. Due to the low elevations of the drain lines being sampled, it may not be possible to ensure the traps do not become submerged during high tidal stages.

The trap bracket will be attached to the drain pipe or the vault wall using either epoxy or by mounting it to studs installed by the confined space entry crew (Figure 7). If neither of these installation options is feasible, the bracket may be attached to the scissors ring that holds the ISCO flow meter and suction line. Two sediment traps will be installed per location to ensure sufficient quantity of sediment is collected in a timely manner. The traps will be deployed for the entire sampling season.

3.3.4 Bedload Sediment Trap

Ecology-designed bed load sediment traps will also be used during this study. These traps are constructed of stainless steel and are designed to be placed in the bottom of a storm drain line (Figure 8). Unlike the bottle sediment traps, their low profile allows them to collect bed load solids rather than just suspended solids. The traps will be attached to the bottom of the drain pipe using either epoxy or by mounting them to studs installed by the confined space entry crew. A total of two sediment traps will be installed for this study, one within each sub-basin. The traps will be deployed for the entire sampling season.

3.4 Preliminary Data Collection

After confined space entry equipment installation has occurred, but before the first sampling event, a preliminary data collection period will take place. The deployed sensors will be allowed to collect drain line water depth, velocity, and conductivity data over the course of multiple days and at least one storm event. These data will be used to determine:

- The tidal height at which the drain line becomes inundated with tidal water,
- The expected flow volume for a known storm event, and
- A rainfall/runoff relationship for each outfall sub-basin.

This information will aid in programming both the ISCO whole water samplers (Section 3.5.3) and filtered suspended solids samplers (Section 3.5.4).

3.5 Sample Collection and Handling Methods

This section describes the methodology for equipment decontamination and sample collection for the proposed field investigation.

3.5.1 Equipment Decontamination

Prior to field mobilization, all sampling equipment and utensils will be thoroughly decontaminated. Analytical Resources, Inc. (ARI) will be responsible for the decontamination of the whole water sample carboys. After each sampling event, field staff will complete the Equipment Cleaning Sheet and submit it to ARI with the filled carboy. Decontamination will be in accordance with Puget Sound Estuary Program (PSEP 1997) protocols (i.e., washed with Liquinox™ soap and water, rinsed with fresh water, and rinsed with distilled water). The Teflon® suction line, strainer, filter bags, and sediment trap bottles will be all new materials. The suction lines will not be decontaminated between storm events because they are dedicated to a location and semi-permanently installed. Prior to each sampling event the ISCO will automatically purge the suction line with site water. Stormwater filtration equipment will be flushed with tap water between sampling events to remove any residual solids from the system.

All hand work will be conducted with phthalate-free disposable gloves, which will be changed after handling each individual sample, as appropriate, and between sampling locations to prevent cross contamination between samples.

3.5.2 Storm Tracking

The sample collection process begins with precipitation monitoring. Precipitation can be tracked online through the Seattle Boeing Field (KBFI) rain gauge at http://www.wrh.noaa.gov/mesowest/getobext.php?wfo=sew&sid=KBFI&num=48&raw=0&dbn=m. Once the required 24-hour dry period is achieved, the stormwater sampling team will begin to monitor for potential storm conditions. The National Oceanic and Atmospheric Administration (NOAA) website offers a Quantitative Precipitation Forecast for 6-hour increments: http://www.wrh.noaa.gov/forecast/wxtables/index.php?lat=47.5405059&lon=-122.3045438&table=custom&duration=7&interval=6. When the forecasts indicate that a storm is coming that is likely to meet the 0.2-inch criterion, the sampling team will begin preparations for sampling.

3.5.3 Whole Water Sample Collection

Flow-weighted whole water samples (six locations) and time-weighted whole water samples (two locations) will be collected by ISCO samplers based on computer programs specific to both the sampling location and predicted storm event. Because some of the proposed sampling locations are tidally influenced, sample aliquots should only be collected when the tidal height is less than the elevation of the drain line at the sampling location. Elevations of drain lines were determined for each sampling location during field reconnaissance (Table 1). ISCO samplers will be programmed to initiate/terminate sampling based on these drain line elevations and predicted daily tidal levels in the LDW. Additionally, sensors will be used as a safeguard to ensure tidal water is not sampled. The ISCO programs will enable sampling when water in the drain line is below both conductivity and depth thresholds. These threshold values will be determined during the preliminary data collection period (Section 3.4). Time-weighted rather than flow-weighted sampling will ensure sufficient sample volume is collected at the two lowest elevation locations, due to the narrow sampling tidal window.

Whole water composite samples will be collected during five storm events and a single base flow event. Efforts will be made to sample at least 75% of the storm event hydrograph, or at least 75% of the first 24 hours if the storm event lasts longer than 24 hours. This may not be possible at all locations due to tidal conditions. Necessary parameters for flow-weighted sampling include: predicted amount of precipitation, expected runoff volume, expected storm duration, minimum volume required for analysis, minimum number of aliquots, sample aliquot size, and maximum carboy volume (Ecology 2009). Each program will be set up to meet the aliquot size and frequency requirements and the analytical volume requirements without overfilling the carboy.

At the initiation of a sampling event, each ISCO sampler will be tested for proper operation by pumping stormwater and then purging the suction line. The samplers will then be programmed on site with the event-specific sampling program. The program will include rinsing and purging of the suction line before the collection of each aliquot. Next, the decontaminated 2.5-gallon carboy will be installed in the sample base, and the sample base packed with ice. The suction line and flow sensor cord will be retrieved from below the manhole and connected to the ISCO sampler. The conductivity sensor will be lowered to the bottom of the drain line along with the stormwater filtration pump (Section 3.5.4). The sampler will then be plugged into the DC power source on the stormwater solids filtration housing and lowered into the manhole vault, aided by a tripod with pulley system. The sampler will be suspended in the vault from a harness, supported by a bracket designed to fit securely below the manhole cover. The sampler will remain in this configuration throughout the sampling event.

The sampling team will retrieve the carboy within 12 hours after the storm event has concluded. At this point, the flow data from the ISCO samplers will be downloaded for analysis. The carboys will be capped and labeled with the date, collection time of the last aliquot, and location name. All information will be recorded in the field logbook. The filled carboys will be heavy and fragile. To avoid damage, special totes with handles will be used to move the carboys. During transit to the analytical laboratory, carboys will be packed in appropriately sized coolers.

3.5.4 Filtered Solids Collection

A stormwater filtration system will be deployed at every sampling location prior to each sampling event. Filtration units are dedicated systems, and will be labeled with location names to ensure they always sample the same drain line. The frame containing the two filter housings will be loaded with two fully-charged 12-volt batteries. Each unit's timer will be manually set to prevent sampling when tidal water is backed up in the drain line. The sampling time intervals will be specific to the drain line being sampled and the predicted tidal heights during the storm event. Pre-weighed and numbered filter bags will be installed in each of the filter housings and digital flow totalizers will be set to zero immediately before deployment.

Installation of the in-line filtration system within the storm drain vault will require a minimum of two people. A tripod and pulley system set over the access manhole will aid in lowering the filtration system components. After connecting the bilge pump to the timer, the weighted pump cage will be lowered by hand to the bottom of the drain line using a rope. The deployment rope will be tied securely to the manhole access ladder. The filter frame (attached to the pump cage by the pump hose, electrical leads, and tether line) will simultaneously be lowered into the vault using the tripod setup. The filter frame will be secured to the manhole access ladder with a 4-

point harness. The position of the filter frame will be low enough in the vault so that it does not interfere with the installation of the ISCO sampler, and high enough in the vault to not impede stormwater flow through the drain line.

At the completion of the sampling event, the sampling team will retrieve the filtration system along with the ISCO sampler. The filtration system will be completely removed from the drain line at the completion of sampling. Residual water in the filtration housings following sampling adds approximately 70 lbs to the weight of the filter frame. The surface tripod and pulley system will be used to lift the filtration system out of the vault. Drain valves in the bottom of the filtration housings will then be opened to allow remaining filtrate to drain down the manhole into the drain line. Filter bags will be removed from the filter housings, squeezed of their excess water, and placed into the same labeled sample bags that they were removed from prior to sampling. These bags will be labeled with the sample location name, filtered volume, and date. All information will be recorded in the field logbook. Collected filters will be stored on ice until delivery to the analytical laboratory. Following sampling, the filtration systems will be taken back to SAIC's warehouse to be flushed and have their batteries recharged.

3.5.5 Suspended Sediment Trap Sample Collection

Two sediment traps will be installed at each location by a confined space entry crew at the beginning of the sampling and left to collect sediment until the end of the final sampling event. At the end of the final sampling event, the confined space entry crew will be utilized to cap the collection bottles with a Teflon® lined caps, remove the bottles from the mounting bracket, and remove the brackets from the drain lines. Sample bottles will be labeled with the location name and recovery date. Sediment trap samples will be sent to the analytical laboratory where sediment from a single location will be composited and homogenized.

3.5.6 Bed Load Sediment Trap Sample Collection

A total of two bed load sediment traps will be installed for this study, one within each of the sampled sub-basins. The sediment traps will be installed at each location by a confined space entry crew at the beginning of the sampling event, and will collect sediment until the end of the final sampling event. A confined space entry crew will be utilized to recover the traps. Once a trap is brought to the surface, the field crew will use decontaminated stainless steel spoons to transfer the captured solids to a stainless steel pan. After the sample has been homogenized, aliquots will be transferred to glass sample jars using stainless steel spoons. Sample jars will be labeled with the location name and recovery date.

3.5.7 Catch Basin Solids Grab Sample Collection

Up to eight catch basin solids grab samples will be collected during the sampling season. These samples will be collected at opportunistic times when there is limited water flow through the drain lines. Sampling will likely occur during mobilization/demobilization of a sampling event. Catch basin solids grab samples will be collected once at each of the sampling locations. If catch basin solids are not present at a designated sampling location, an attempt will be made to collect the sample from an alternate access location along the drain line.

Catch basin solids grab samples will be collected with a decontaminated stainless steel scoop at the end of a long arm. Once brought to the surface, material greater than 2 centimeters in diameter will be removed. The remaining solids will be transferred from the scoop to glass sample jars using stainless steel spoons. If possible, solids from multiple locations in each catch basin (corners, depressions, etc.) will be composited to form a sample representative of the location. Sample jars will be labeled with the location name and recovery date.

3.6 Sample Identification, Containers, and Labels

Samples will be identified by project, sampling location, date of collection, and sample type. All samples collected during the investigation will be labeled clearly and legibly. Each sample will be labeled with a unique alpha-numeric sample identification name that identifies characteristics of the sample as follows:

Project	Location Identifier	Date	Sample Type
LDW/AST-	SQ1-	112410-	S

Where:

- *Project* consists of characters describing the project (Lower Duwamish Waterway/ Accelerated Source Tracing).

- *Location Identifier* consists of alpha-numeric characters identifying the sample location (SQ1, SQ2, SQ3, SQ4, DK1, DK2, DK3, and DK4), where SQ1 = the furthest upstream sampling location along the Snoqualmie St. drain line, and DK4 = the furthest downstream sampling location along the Dakota St. drain line.

- *Date* consists of six numeric characters indicating the date of sample collection in *mmddyy* format 112410 = November 24, 2010.

- *Sample Type* consists of characters indicating the sample type where S = filtered solids, W = stormwater composite, ST = suspended sediment trap, BT = bed load sediment trap, and CB = catch basin solids composite. Sample type is indicated for quality assurance/quality control (QA/QC) samples with ER = equipment rinseate and RB = rinseate blank.

Sample labels will be self-adhering, waterproof material. An indelible pen will be used to fill out each label. Labels will be affixed to carboys, bags containing the filters, sediment trap bottles, and grab sample jars before delivery to the laboratory. ARI will use the same nomenclature when splitting the samples and reporting analytical results.

3.7 Sample Storage and Delivery

After collection, all samples will be stored in insulated coolers and preserved by cooling with ice or frozen gel-packs to a temperature of 4ºC. Because the samples are being delivered to ARI within 12 hours of collection, sample temperatures may be warmer than 4ºC upon delivery.

Maximum sample holding and extraction times will be strictly adhered to by field personnel and the analytical laboratories. Holding times for the stormwater samples will begin when the samples are split at ARI. Preparation of carboys and filter bags for delivery will be performed in the following manner:

- Filter bags will be placed inside the laboratory-provided Ziploc (or similar) bag and labeled.
- An empty insulated cooler will be prepared by placing three to four ice packs at the bottom of the cooler. The wrapped filter bags will be placed in the cooler before transit to ARI for analysis.
- ARI will process and deliver filter bags to Axys Analytical Services Ltd., of Sydney, BC for dioxin/furan congener and PBDE analysis. Prior to shipping the filter bags to Axys, the headspace in the cooler will be packed with bubble wrap. COC forms will be enclosed in a plastic bag and taped to the inside lid of the cooler. The cooler will be wrapped with strapping tape, and signed COC seals will be taped across the cooler lid.
- Sample carboys will be carried using totes with handles. When in transit, carboys will be placed in a well padded cooler or similar hard-bodied protective structure.
- Samples for chemical analysis will be hand-couriered to ARI upon completion of sampling. The COC will be signed by the individual relinquishing samples to the onsite laboratory representative. Upon receipt of samples at the laboratory, the condition of the samples will be recorded by the receiver. The field personnel will be responsible for the following:
    - Packaging the samples,
    - Signing the COC before placing inside the cooler or delivering to ARI staff, and
    - Notifying the laboratory of when the samples are being delivered.

3.8 Documentation

This section describes the record of field activities and documentation associated with the transfer of samples that will be maintained throughout the study.

3.8.1 Field Logbooks

Documentation necessary to meet QA objectives for this project include field notes and field forms, sample container labels, and COC forms. The field documentation will provide descriptions of all sampling activities, sampling personnel, and weather conditions, and will record all modifications, decisions, and/or corrective actions to the study design and procedures identified in this SAP.

Field logbook(s) will be kept on site during field operations. Daily activities will be recorded in a bound field logbook of water-resistant paper. All entries will be made legibly, in indelible ink, and will be signed and dated. Information recorded will include the following:

- Date, time, place, and location of sampling;
- Onsite personnel and visitors;
- Daily safety discussion and any safety issues;

- Field measurements (depth to base flow conditions, etc.) and their units;
- Observations about site, location, and samples (weather, odors, appearance, etc.);
- Equipment decontamination verification;
- Identification names of samples collected; and
- For filtered suspended solids, a record of the filter number (assigned by ARI) used at each location, the volume of water passed through the filter, and the time program used to collect filtered suspended solids.

Field logbooks are intended to provide sufficient data and observations to enable participants to reconstruct events that occur during project field activities. Entries will be factual, detailed, and objective. Unless restricted by weather conditions, all original data recorded in field logbooks and on sample identification tags, COC records, and field forms will be written in waterproof ink. If an error is made, the individual responsible may make corrections simply by crossing out the error and entering the correct information. The erroneous information will not be obliterated. All corrections must be initialed and dated. All documentation, including voided entries, must be maintained within project files.

3.8.2 Chain-of-Custody Procedures

The field crew will retain samples at all times until contractor personnel deliver samples to the appropriate laboratory. COC forms will be initiated at the time of sample collection to ensure that all collected samples are properly documented and traceable through storage, transport, and analysis. When all line items on the form are completed or when the samples are relinquished, the sample collection custodian will sign and date the form, list the time, and confirm the completeness of all descriptive information contained on the form. Each individual who subsequently assumes responsibility for the sample will sign the COC form and provide the reason for assuming custody. The field chain-of-custody terminates when the laboratory receives the samples. The field manager will retain a copy of the completed, signed, COC form(s) for project files.

3.9 Laboratory Analyses

All of the chemical and physical analytical procedures used in this program will be performed by subcontracted laboratories in accordance with Ecology guidelines as outlined below. The laboratory analysis for storm drain solids will be consistent with Ecology's Sediment Sampling and Analysis Plan Appendix (Ecology 2008). Each laboratory participating in this program will institute internal QA/QC plans. Analyses will be required to conform to accepted standard methods and internal QA/QC checks prior to final approval. Table 2 presents the number of samples to be analyzed for each sampling event.

3.9.1 Whole Water Analyses

Using a churn splitter or similar device, ARI laboratory staff will distribute proper volumes of homogenized stormwater to bottles for preservation or immediate analysis. At the laboratory, water for the dissolved metals sample will be drawn through a 0.45 µm filter. Should there be an event where sample volume is insufficient, SAIC will direct ARI in the priority of analysis. If, during the planning phase, it seems likely a sampling event will end on a weekend or during non-business hours, arrangements will be made with ARI staff to ensure that a technician is present to process the samples

Table 3 presents the specific analytes to be measured in the stormwater samples. The analytical methods, method detection limits (MDLs), and acute and chronic marine surface water criteria are also included. The MDLs listed may be subject to modification due to elevated sample concentrations and potential matrix interferences that may preclude obtaining the desired quantification limit. In the event the laboratory is unable to meet the MDLs, the reasons for the deviation will also be reported.

3.9.2 Filtered Suspended Solids Analyses

Two filter bags will be collected at each sampling location for every sampling event. When received by ARI, the wet filter bags will be weighed. Sample splits of the solids will be removed and weighed for metals and grain size analysis. Next, the bags and remaining solids will be dried and weighed again, with and without the filter bag ring. The filter bags and solids, minus the ring, will be extracted for either PCB Aroclors, dioxin/furan congeners, or PBDEs. In the case of SVOC analysis, filter bags will not be dried due to their volatility. Analytical results for these compounds will be reported in units of µg/filter bag and will have to be back calculated to µg/kg sediment based on the dry weight of the filter bag. Results will not be organic carbon-normalized, as total organic carbon (TOC) cannot be measured in the filtered suspended solids due to interference from the polypropylene filter bag.

Table 4 presents the specific chemical analytes and conventional parameters to be measured in the filtered suspended solids along with the associated sample preparation methods, analytical methods, and MDLs. In Table 4, Sediment Management Standards (SMS) numeric criteria (Sediment Quality Standards [SQS] and Cleanup Screening Levels [CSL]) (Chapter 173-204 WAC) are listed for metals and ionizable organic compounds, and the lowest apparent effects threshold (LAET), which is functionally equivalent to the SQS, or the second lowest apparent effects threshold (2LAET), which is functionally equivalent to CSL, are listed for PCB Aroclors and SVOCs (Barrick et al. 1988). As with the whole water analysis, the MDLs listed may be subject to modification due to elevated sample concentrations, heterogeneous samples, and potential matrix interferences that may preclude obtaining the desired quantification limit.

In addition to the analytes listed in Table 4, dioxin/furan congeners and PBDEs will also be analyzed in selected storm event samples (Table 2). At the direction of SAIC, ARI will ship dried filter bags to Axys Analytical of Sydney, British Columbia for these analyses. Analysis of dioxins/furans will follow EPA Method 1613B for 2,3,7,8-substituted chlorinated dioxins and furans (Table 5) and PBDEs will be analyzed by EPA Method 1614 (Table 6). The concentration of dioxin/furan compounds will be normalized to the toxicity of 2,3,7,8-TCDD (tetrachlorodibenzo-p-dioxin) using toxic equivalency factors (TEFs) updated by the World Health Organization (WHO) in 2005 (Van den Berg et al. 2006). The toxic equivalent (TEQ) is equal to the sum of the concentrations of individual congeners multiplied by their TEF (potency relative to 2,3,7,8-TCDD). Non-detected values will be assessed as 0, ½, and 1 times the method detection limit for data evaluation purposes.

3.9.3 Suspended Sediment Trap Solids Analyses

In addition to the analytes listed in Tables 4 through 6, additional analytes that will be quantified in suspended sediment trap solids samples are presented in Table 7. Chemistry data results will be compared to SMS criteria when TOC is greater than 0.5 percent and less than 4.0 percent. When TOC is outside of this range, chemistry data results will be compared to the LAET and 2LAET.

3.9.4 Bed Load Sediment Trap Solids Analyses

Bed load sediment trap solids samples will undergo all of the same analyses as suspended sediment trap samples (Section 3.9.3).

3.9.5 Catch Basin Solids Sample Analyses

Catch basin solids grab samples will undergo all of the same analyses as suspended and bedload sediment trap samples (Section 3.9.3).

3.9.6 Analytical Laboratory Reporting

Analytical laboratory reports will be accompanied by sufficient backup data and QC results to enable independent reviewers to evaluate the quality of the data results. Analytical data will be reported in the units specified by the MDLs listed in Tables 3 through Table 7.

The analytical laboratory deliverables will include the following:

- MDLs and method reporting limits (MRLs) for each sample;
- Laboratory qualifier codes appended to analyte concentrations and a summary of code definitions;
- Case narrative (including any problems encountered, protocol modifications, and/or corrective actions taken);
- Sample analytical and QA/QC results with units;
- All protocols used during analyses;
- Any protocol deviations from the approved sampling plan;
- Surrogate recovery results;
- Matrix spike/matrix spike duplicate (MS/MSD) results when analyzed;
- Laboratory duplicate/triplicate results;
- Blank results;
- Sample custody records (including original COC forms); and
- Analytical results in Environmental Information Management (EIM) format.

4.0 Quality Assurance Project Plan

The purpose of the project QAPP is to provide confidence in the project data results through a system of quality control performance checks with respect to data collection methods, laboratory analysis, data reporting, and appropriate corrective actions to achieve compliance with established performance, and data quality criteria. This section presents the QA/QC procedures to ensure that the investigation data results are defensible and usable for their intended purpose.

4.1 Measurements of Data Quality

The tolerable limits for the data reported by the laboratory will be measured with precision, accuracy, representativeness, completeness, and comparability as described below.

Precision is a measure of mutual agreement among individual measurements of the same property under prescribed conditions. Precision will be assessed by the analysis of MS/MSDs, ongoing precision and recovery/ongoing precision and recovery duplicates (OPR/OPRD), and laboratory control sample/laboratory control sample duplicates (LCS/LCSD). The calculated relative percent differences (RPDs) for MS/MSD pairs will provide information on the precision of sampling and analytical procedures, and the RPDs for OPR/OPRD and LCS/LCSD pairs will provide information on precision of the analytical procedures. MS/MSD samples cannot be run on the filtered suspended solids because the filter bag must be extracted as one sample (subsamples cannot be cut from the filter bag).

Accuracy is the degree to which an observed measurement agrees with an accepted reference or true value. Accuracy is a measure of the bias in the system and is expressed as the percent recoveries of spiked analytes in MS/MSD and LCS/LCSD samples. Accuracy will also be evaluated through the surrogate spikes in each sample. The laboratory control limits for surrogates will be used for the project.

Representativeness expresses the degree to which data accurately and precisely represent an actual condition or characteristic at a particular sampling point. Representativeness is achieved by collecting samples representative of the matrix at the time of collection. Representativeness is generally evaluated through the analysis of field replicates and laboratory blanks. Field replicates will not be collected as a part of this study due to the addition equipment that would be required for their collection. Therefore, only blanks will be used to assess representativeness.

Completeness refers to the amount of measurement data collected relative to that needed to assess the project's technical objectives. It is calculated as the number of valid data points achieved divided by the total number of data points requested by virtue of the study design.

Comparability is based on the use of established USEPA-approved methods for the analysis of the selected parameters. The quantification of the analytical parameters is based on published methods, supplemented with well-documented procedures used in the laboratory to ensure reproducibility of the data.

4.2 QA/QC for Chemistry Samples

Field and laboratory QA/QC samples will be used to evaluate the data precision, accuracy, representativeness, and comparability of the analytical results. The field QA/QC samples to be collected are described in Section 4.2.1. The laboratory QA/QC samples are discussed in Section 4.2.2.

4.2.1 Field QA/QC for Water and Sediment Chemistry

Field QA/QC samples will be collected during sampling to quantitatively measure and ensure the quality of the sampling effort and the analytical data. QA/QC samples are to be handled in the same manner as the environmental samples collected. Field QA/QC samples include equipment rinseate and rinseate blanks. Equipment rinseates provide a quality control check on the potential for cross contamination by measuring the effectiveness of the sampling and decontamination procedures. The equipment rinseate sample consists of reagent grade water provided by ARI rinsed across sample collection and processing equipment. An equipment rinseate sample will be collected from the stormwater sampling equipment (Teflon® suction line, pump, and sample carboy).

4.2.2 Laboratory QA/QC for Water and Sediment Chemistry

MS/MSD samples for each analytical batch of samples will be analyzed SVOCs, pesticides, PCBs, metals, and TOC. The combination of these spiked samples will provide information on the accuracy and precision of the chemical analysis, and to verify that the extraction and measured concentrations are acceptable. The MS/MSDs will be analyzed in accordance with USEPA methods for each respective analyte.

One laboratory method blank and LCS will be analyzed for all constituents (except water quality parameters and grain size) for each analytical batch to assess potential laboratory contamination and accuracy. An LCSD will be analyzed if required by the method, or if the laboratory does not have enough sample volume to prepare an MS/MSD.

Laboratory control samples, certified reference material, and surrogate spikes will be used as defined by the analytical methods and equipment calibration requirements. One certified reference material will be analyzed for dioxin/furan congeners.

4.3 Data Validation

The data generated as part of this investigation will undergo an independent Level III quality assurance review and data validation by EcoChem, Inc., of Seattle, WA. If data fail the review, the laboratory will be contacted and the data will be (a) reanalyzed, (b) qualified, or (c) unqualified with an explanation. For each data type, the quality of the data will be summarized in validation memos.

The analytical laboratory will provide Level III validation data packages that will allow for the examination of the complete analytical process from calculation of instrument and method detection limits, practical quantification limits, final dilution volumes, sample size, and wet-to-dry ratios to quantification of calibration compounds and all analytes detected in blanks and environmental samples (PTI 1989).

EcoChem will validate the data as analysis is completed and submit the validated data to SAIC in an electronic deliverable. The final validation report including all events will be issued after the completion of the last round of sampling.

5.0 Data Analysis

The purpose of this section is to describe the methods which will be used to evaluate data collected as a part of this study.

5.1 Analysis of Water and Solids Chemistry Data

The chemical data results for stormwater and solids will include comparison of the results to the marine water quality criteria (Table 3) and SMS numeric criteria (Table 4), respectively. The water and sediment chemistry data will be summarized and presented in tables indicating locations, detected contaminants, and any detection limits that exceed numeric criteria, along with any data qualifiers assigned by the laboratory or during the data validation efforts.

5.2 Comparison of Solids Sampling Methods

The chemical results for storm drain solids collected by stormwater filtration, suspended sediment traps, bed load sediment traps, and catch basin solids grab samples will be compared to determine their similarity. Each of the solids collection methods is not only representative of a different sampling interval, but also different physical properties that allow the sample material to accumulate.

Filtered suspended solids will be collected for individual storm events, where particle entrainment by the pump is likely to be unrelated to particle settling characteristics. The suspended sediment trap samples integrate particles traversing the drain lines for the entire sampling season. Due to the height of the sediment trap bottle mouth above the drain line bottom, particles will only be deposited in the traps during deep water conditions caused by high stormwater flow volume or tidal inundation. Bed load sediment traps are likely to predominantly collect coarse sediment. Although these sediment traps are to be deployed for the entire sampling season, the solids retained by the traps may not necessarily be representative of the entire sampling period due to scouring that may occur during large storm events. Catch basin solids grab samples are likely to reflect intermittent deposition between large flushing events.

Comparing the results of the different sampling methods will allow an assessment of whether sediment traps or grab samples are useful and inexpensive tools for collecting storm drain solids for use in source tracing.

5.3 Sub-basin Source Tracing

The data collected as a part of this study will be used to evaluate the practicality and effectiveness of an “up-the-pipe” methodology for identifying potential contaminant sources to the LDW. Within each of the studied sub-basins, similar sample types collected for the same sampling event will be compared to determine where in the drainage contaminants may be entering the system. Some of the samples within a sub-basin will be collected from lateral connections to a main drain line, while other samples will be collected along the main drain line itself. In either case, a downstream increase in contaminant concentrations between two adjacent sampling locations suggests a source entering the system between the locations. A downstream decrease in contaminant concentration between two adjacent sampling locations can likely be attributed to particle dilution between the sites. Such a drop in concentration would suggest either the lack of a contaminant source between the sites or a more dilute source than what is located upstream of both sampling locations.

6.0 Data Reporting

SAIC, with assistance from NewFields, will prepare a draft and final Accelerated Source Tracing Report documenting all activities associated with collection, transportation, and chemical analysis of stormwater and storm drain solids samples. The analytical and QA/QC reports will be included as appendices. The written report will summarize the analytical results and data evaluation.

At a minimum, the following will be included in the report:

- Description of sampling and analysis activities,
- Protocols used during sampling and testing and an explanation of any deviations from the sampling plan protocols or the approved SAP,
- Physical descriptions of samples,
- Results of data comparisons to regulatory criteria (marine water quality criteria [WAC 173-201A-240] and SMS criteria [WAC 173-204]),
- COC records,
- Chemistry testing results and laboratory reports,
- QA/QC summary and data compliance reports,
- Comparison of chemical results for different solids sampling methods, and
- Comparison of chemical concentrations within each sub-basin as a means of “up-the-pipe” source tracing.

In addition, the validated analytical data from the investigation will be entered into Ecology’s EIM database. Information for entering environmental data into EIM can be found on Ecology’s website: http://www.ecy.wa.gov/eim/.

Given the anticipated end date for stormwater sampling (April 2011) and the time required for analysis, data evaluation, completion of the data deliverable and report, and EIM data entry, completion of the study may require additional time and may not meet the June 30, 2011, deadline. Following completion of the stormwater sampling program, SAIC will coordinate with Ecology to determine and obtain a no-cost period of performance extension to complete the report, if possible and deemed necessary.

7.0 References

Anchor and Integral. 2007. Portland Harbor RI/FS, Round 3A Field Sampling Plan: Stormwater Sampling. Prepared for the Willamette Group by Anchor Environmental, LLC and Integral Consulting Inc. March 1, 2007.

Barrick, R.C., D.S. Becker, L.B. Brown, H. Beller, and R. Pastorak. 1988. Sediment Quality Values Refinement: 1988 Update and Evaluation of Puget Sound AET. Volume I. Final Report. Prepared for tetra tech, Inc., Bellevue, WA, and the U.S. Environmental Protection Agency, Region 10, Seattle, WA. Prepared by PTI Environmental Services, Bellevue, WA.

Ecology. 2007. Phase I Municipal Stormwater Permit. National Pollutant Elimination System and State Waste Discharge General Permit for discharges from Large and Medium Municipal Separate Storm Sewer Systems. Washington State Department of Ecology. Revised September 2010.

Ecology. 2008. Sediment Sampling and Analysis Plan Appendix. Guidance on the Development of Sediment Sampling and Analysis Plans Meeting the Requirements of the Sediment Management Standards (Chapter 173-204 WAC). Washington State Department of Ecology. Publication No. 03-09-043. Revised February 2008.

Ecology. 2009. Standard Operating Procedure for Automatic Sampling for Stormwater Monitoring. Washington State Department of Ecology. Version 1.0

PSEP. 1997. Recommended Protocols for Measuring Selected Environmental Variables in Puget Sound. U.S. Environmental Protection Agency, Region 10, Seattle, WA, for Puget Sound Estuary Program. April 1997.

PTI. 1989. Data validation guidance manual for selected sediment variable. Prepared for the Washington State Department of Ecology, Olympia, WA. PTI Environmental Services, Bellevue, WA.

SAIC. 2009. North Boeing Field/Georgetown Steam Plant Site Remedial Investigation/Feasibility Study, Sampling and Analysis Plan for Preliminary Stormwater and Filtered Suspended Solids Sampling. Prepared for Washington State Department of Ecology by SAIC, Bothell, Washington; August 2009.

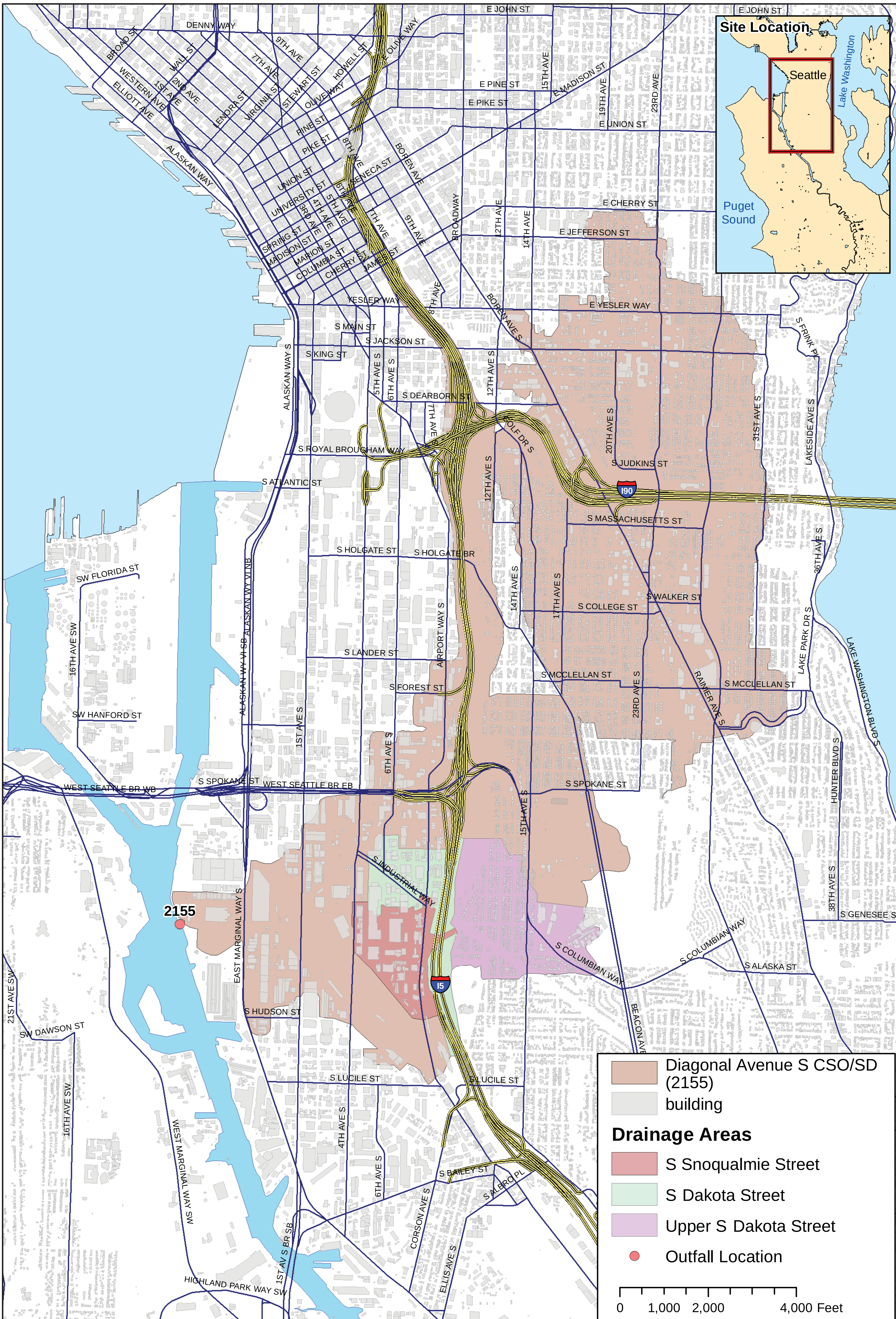
SAIC. 2010. Sub-basin Evaluation for use in the Accelerated Source Tracing Study, Technical Memorandum. Prepared for Washington State Department of Ecology by Science Applications International Corporation, Bothell, Washington. December 2010.

Teledyne ISCO. 2007. 750 Area Velocity Module Installation and Operation Guide. Teledyne ISCO, Lincoln, NE. May 2007. http://www.isco.com/pcfiles/PartPDF4/UP000ZX3.pdf

Teledyne ISCO. 2009. 6712 Portable Samplers Installation and Operation Guide. Teledyne ISCO, Lincoln, NE. March 2009. http://www.isco.com/pcfiles/PartPDF4/UP00130Z.pdf

Van den Berg, M., L.S. Bimbaum, M. Denison, M. De Vito, W. Farland, M. Feeley, H. Fiedler, H. Hakansson, A. Hanberg, L. Haws, M. Rose, S. Safe, D. Schrenk, C. Tohyama, A. Tritscher, J. Tuomisto, M. Tysklind, N. Walker, and R. Peterson. 2005. The 2005 World Health Organization Re-Evaluation of Human and Mammalian Toxic Equivalency Factors for Dioxins and Dioxin-like Compounds. Prepared for the World Health Organization (WHO). ToxSci Advance Access published July 7, 2006. Published by Oxford University Press on behalf of the Society of Toxicology.

Figures



SAIC From Science to Solutions

Figure 1. Duwamish Diagonal and Proposed Drainage Areas for Stormwater Sampling

DEPARTMENT OF ECOLOGY State of Washington

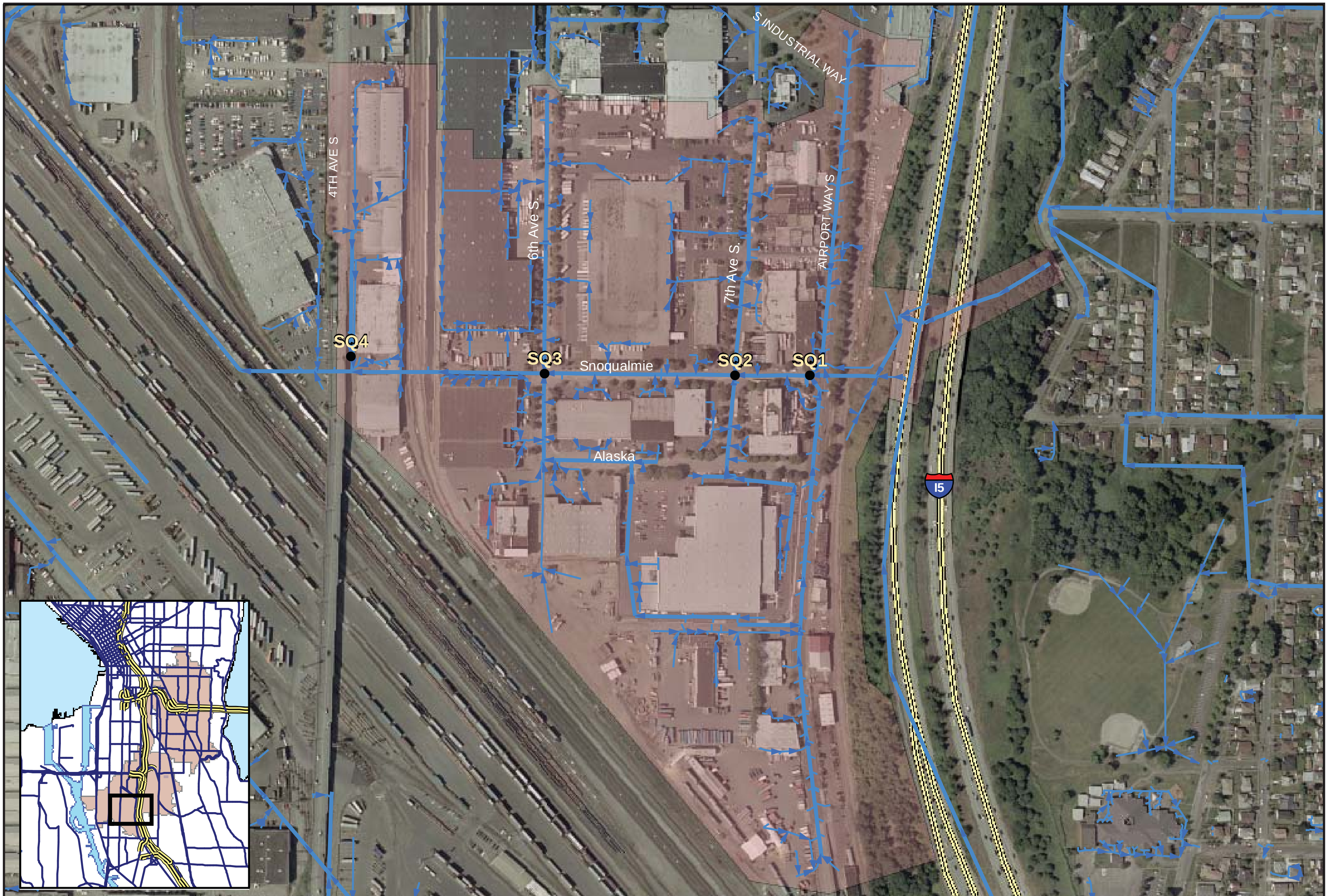


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Figure 2. S Snoqualmie Street Drainage Area and Sampling Locations

0 200 400 800 Feet

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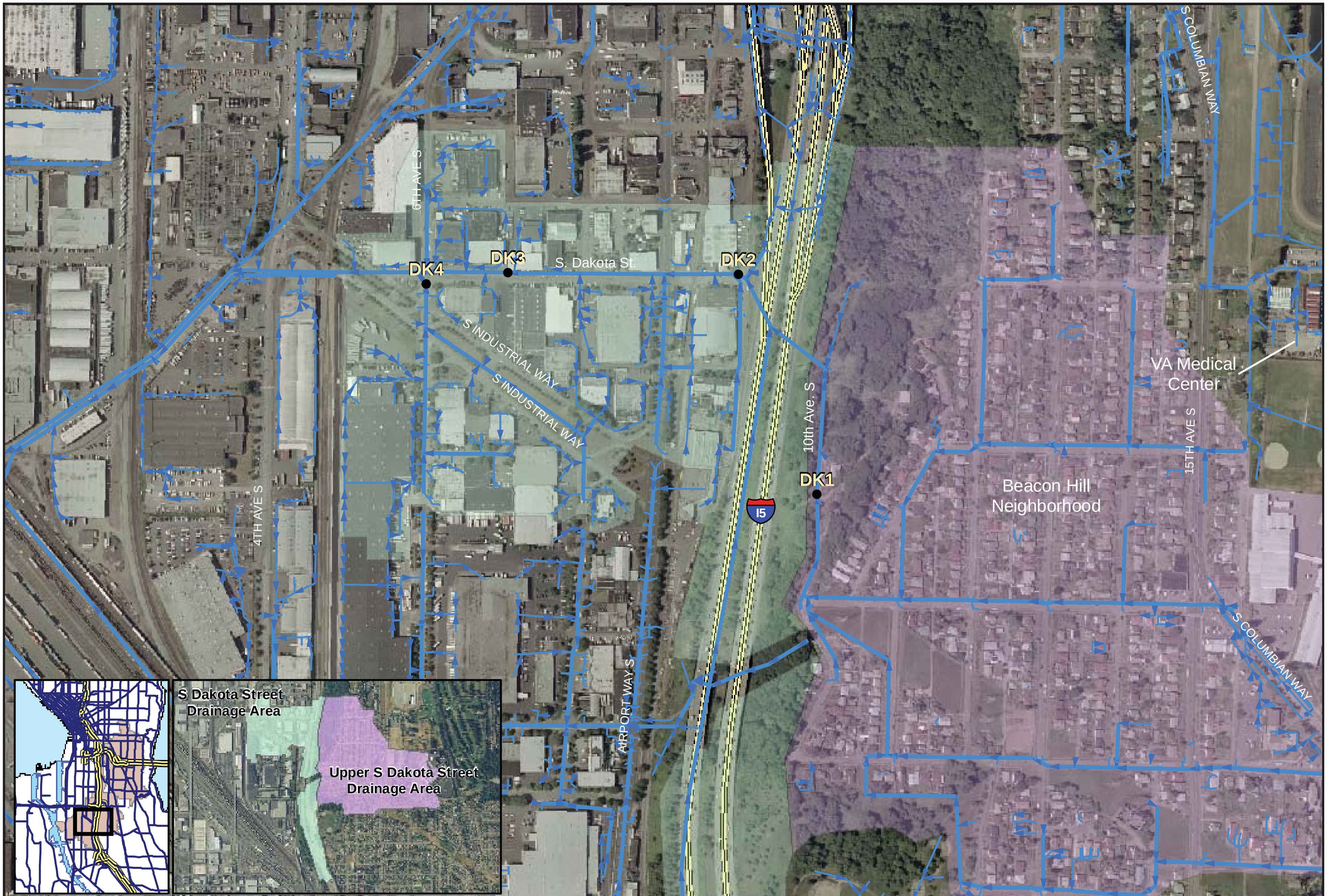

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Figure 3. S Dakota Street Drainage Area and Sampling Locations

0 200 400 800 Feet

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Figure 4. ISCO Whole Water Sampler

Figure 5. Suspended Solids Filtration Unit

Figure 6. Modified Ecology Sediment Trap

Figure 7. Sediment Traps Installed
in a Storm Drain Line

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Figure 8. Ecology Bedload Sediment Trap

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Tables

Table 1
Storm Drain Access Location Information

Location Description	Location ID	Easting[1]	Northing[1]	Elevation of Drain Bottom (feet MLLW)	Depth to Drain Bottom (feet)
Diagonal Ave S CSO/SD Snoqualmie St. Sub-basin					
S Snoqualmie St & Airport Ave S	SQ1	1272599.1	208570.6	11.3	11.1
S Snoqualmie St & 7th Ave S	SQ2	1272356.6	208570.1	9.7	9.6
S Snoqualmie St & 6th Ave S	SQ3	1271741.8	208576.2	8.8	9.5
S Snoqualmie St & 4th Ave S	SQ4	1271123.5	208610.4	10.8	6.5
Diagonal Ave S CSO/SD Dakota St. Sub-basin					
10th Ave S Dead End	DK1	1273410.6	209545.9	128.3	8.3
S Dakota St & 9th Ave S	DK2	1273080.5	210472.8	10.2	13.3
S Dakota St & 7th Ave S	DK3	1272108.1	210432.5	3.2	8.6
6th Ave S & S Industrial Way	DK4	1271764.9	210432.5	4.8	10.8

Notes:

1. Washington State Plane North, NAD 83, feet

MLLW = mean lower low water

Table 2
Event-based Sample Collection

Analyte	Event 1	Event 2	Event 3	Event 4	Event 5	Baseflow	Seasonal Composite	Equipment Rinseate	Sample Totals
Stormwater									
TOC	8	8	8	8	8	8	--	--	48
DOC	8	8	8	8	8	8	--	--	48
TSS	8	8	8	8	8	8	--	--	48
Hardness	8	8	8	8	8	8	--	--	48
pH	8	8	8	8	8	8	--	--	48
Alkalinity	8	8	8	8	8	8	--	--	48
Anions (CL, NO3, SO4)	8	8	8	8	8	8	--	--	48
VOCs	8	8	8	8	8	8	--	--	48
SVOCs	8	8	8	8	8	8	--	1	49
SIM SVOCs	8	8	8	8	8	8	--	1	49
Pesticides	8	8	8	8	8	8	--	1	49
PCB Aroclors	8	8	8	8	8	8	--	1	49
Metals Total	8	8	8	8	8	8	--	1	49
Metals Dissolved	8	8	8	8	8	8	--	1	49
Filtered Suspended Solids									
Grain Size	8	8	8	8	8	8	--	--	48
Total Solids	8	8	8	8	8	8	--	--	48
SMS Metals	8	8	8	8	8	8	--	--	48
PCB Aroclors	8	--	8	--	8	--	--	--	24
SVOCs		8	--	8	--	8	--	--	24
Dioxin/Furan Congeners	8	--	--	8	--	8	--	--	24
PBDEs	--	8	8	--	8	--	--	--	24
Suspended Sediment Trap Solids									
TOC	--	--	--	--	--	--	8	--	8
Total Solids	--	--	--	--	--	--	8	--	8
Grain Size	--	--	--	--	--	--	8	--	8
SMS Metals	--	--	--	--	--	--	8	--	8
PCB Aroclors	--	--	--	--	--	--	8	--	8
SVOCs	--	--	--	--	--	--	4*	--	4*
SIM SVOCs	--	--	--	--	--	--	4*	--	4*
Pesticides	--	--	--	--	--	--	4*	--	4*
Dioxin/Furan Congeners	--	--	--	--	--	--	4*	--	4*
PBDEs	--	--	--	--	--	--	4*	--	4*
Bedload Sediment Trap Solids									
TOC	--	--	--	--	--	--	4	--	4
Total Solids	--	--	--	--	--	--	4	--	4
Grain Size	--	--	--	--	--	--	4	--	4
SMS Metals	--	--	--	--	--	--	4	--	4

Table 2
Event-based Sample Collection

Analyte	Event 1	Event 2	Event 3	Event 4	Event 5	Baseflow	Seasonal Composite	Equipment Rinseate	Sample Totals
PCB Aroclors	--	--	--	--	--	--	4	--	4
SVOCs	--	--	--	--	--	--	2*	--	2*
SIM SVOCs	--	--	--	--	--	--	2*	--	2*
Pesticides	--	--	--	--	--	--	2*	--	2*
Dioxin/Furan Congeners	--	--	--	--	--	--	2*	--	2*
PBDEs	--	--	--	--	--	--	2*	--	2*
Catch Basin Solids									
TOC	--	--	--	--	--	--	8	--	8
Total Solids	--	--	--	--	--	--	8	--	8
Grain Size	--	--	--	--	--	--	8	--	8
SMS Metals	--	--	--	--	--	--	8	--	8
PCB Aroclors	--	--	--	--	--	--	8	--	8
SVOCs	--	--	--	--	--	--	8	--	8
SIM SVOCs	--	--	--	--	--	--	8	--	8
Pesticides	--	--	--	--	--	--	8	--	8
Dioxin/Furan Congeners	--	--	--	--	--	--	8	--	8
PBDEs	--	--	--	--	--	--	8	--	8

Notes:
* Parameter will be analyzed if sufficient material is collected.

Table 3
Whole Water Sample Analytes

Analyte	Analytical Method	MDL	Acute	Chronic
Conventionals				
Total Suspended Solids (TSS) (mg/L)	EPA160.2	2	---	---
pH	150.1	0.01 Units[2]	---	---
Hardness	6010B	0.332	---	---
Alkalinity	310.1	0.37	---	---
Chloride	300	0.1	---	---
Nitrate	300	0.01	---	---
Sulfate	300	0.13	---	---
Total Organic Carbon (TOC)	415.1	0.15	---	---
Dissolved Organic Carbon (DOC)	415.1	0.12	---	---
TSS	160.2	1.02	---	---
Metals		**µg/L**	**µg/L**	
Arsenic	EPA200.8	0.07	691	361
Arsenic (dissolved)	EPA200.8	0.1	69	36
Cadmium	SW6010B	0.3	42.31	9.31
Cadmium (dissolved)	SW6010B	0.2	42	9.3
Chromium	SW6010B	2.4	---	---
Chromium (dissolved)	SW6010B	3.4	---	---
Copper	SW6010B	0.6	5.81	3.71
Copper (dissolved)	SW6010B	0.3	4.8	3.1
Lead	SW6010B	1	2201	8.51
Lead (dissolved)	SW6010B	1	210	8.1
Mercury	SW7470A	0.02	2.11	---
Mercury (dissolved)	SW7470A	0.01	1.8	0.025
Nickel	SW6010B	3	74.71	8.31
Nickel (dissolved)	SW6010B	4	74	8.2
Selenium	EPA200.8	0.1	2911	711
Selenium (dissolved)	EPA200.8	0.33	290	71
Silver	SW6010B	0.4	2.21	---
Silver (dissolved)	SW6010B	0.4	1.9	---
Zinc	SW6010B	0.4	951	861
Zinc (dissolved)	SW6010B	7	90	81
Pesticides		**µg/L**	**µg/L**	
Alpha-BHC	SW8081	0.014	---	---
Beta-BHC	SW8081	0.033	---	---
Gamma-BHC (Lindane)	SW8081	0.015	0.16	---
Delta-BHC	SW8081	0.021	---	---
Heptachlor	SW8081	0.011	0.053	*0.00363*
Aldrin	SW8081	0.02	0.71	*0.00193*
Heptachlor Epoxide	SW8081	0.008	---	---
Gamma Chlordane	SW8081	0.008	0.09	*0.0043*
Alpha Chlordane	SW8081	0.027	0.09	*0.0043*
Endosulfan I	SW8081	0.008	0.034	0.0087
4,4'-DDE	SW8081	0.018	0.13	*0.0013*
Dieldirin	SW8081	0.014	0.71	*0.00193*
Endrin	SW8081	0.052	*0.0373*	*0.00233*
Endosulfan II	SW8081	0.027	0.034	*0.00873*
4,4'-DDD	SW8081	0.031	0.13	*0.0013*
Endrin Aldehyde	SW8081	0.033	---	---
4,4'-DDT	SW8081	0.031	0.13	*0.0013*

Table 3
Whole Water Sample Analytes

Analyte	Analytical Method	MDL	Acute	Chronic
Endosulfan Sulfate	SW8081	0.022	0.034	*0.00873*
Endrin Ketone	SW8081	0.025	---	---
Methoxychlor	SW8081	0.131	---	---
Hexachlorobutadiene	SW8081	0.01	---	---
Hexachlorobenzene	SW8081	0.009	---	---
Toxaphene	SW8081	0.22	*0.213*	*0.00023*
Low Molecular Weight Polycyclic Aromatic Hydrocarbons (PAHs)		**µg/L**	**µg/L**	
Naphthalene	SW8270D[4]	0.42	---	---
Acenaphthylene	SW8270D[4]	0.45	---	---
Acenaphthene	SW8270D[4]	0.49	---	---
Fluorene	SW8270D[4]	0.5	---	---
Phenanthrene	SW8270D[4]	0.45	---	---
Anthracene	SW8270D[4]	0.46	---	---
2-Methylnaphthalene	SW8270D[4]	0.32	---	---
High Molecular Weight PAHs		**µg/L**	**µg/L**	
Fluoranthene	SW8270D[4]	0.59	---	---
Pyrene	SW8270D[4]	0.34	---	---
Benzo(a)anthracene	SW8270D[4]	0.58	---	---
Chrysene	SW8270D[4]	0.51	---	---
Benzofluoranthenes	SW8270D[4]	0.41	---	---
Benzo(a)pyrene	SW8270D[4]	0.48	---	---
Indeno(1,2,3-c,d)pyrene	SW8270D[4]	0.39	---	---
Dibenzo(a,h)anthracene	SW8270D[4]	0.38	---	---
Benzo(g,h,i)perylene	SW8270D[4]	0.3	---	---
Chlorinated Benzenes		**µg/L**	**µg/L**	
1,2-Dichlorobenzene	SW8270D[4]	0.42	---	---
1,4-Dichlorobenzene	SW8270D[4]	0.42	---	---
1,2,4-Trichlorobenzene	SW8270D[4]	0.44	---	---
Hexachlorobenzene	SW8270D[4]	0.61	---	---
Phthalate Esters		**µg/L**	**µg/L**	
Dimethyl phthalate	SW8270D[4]	0.49	---	---
Diethyl phthalate	SW8270D[4]	0.49	---	---
Di-n-butyl phthalate	SW8270D[4]	0.46	---	---
Butyl benzyl phthalate	SW8270D[4]	0.4	---	---
Bis(2-ethylhexyl)phthalate	SW8270D[4]	0.45	---	---
Di-n-octyl phthalate	SW8270D[4]	0.51	---	---
Ionizable Organic Compounds		**µg/L**	**µg/L**	
Phenol	SW8270D[4]	0.39	---	---
2 Methylphenol	SW8270D[4]	0.4	---	---
4 Methylphenol	SW8270D[4]	0.34	---	---
2,4-Dimethylphenol	SW8270D[4]	0.35	---	---
Pentachlorophenol	SW8270D[4]	2.4	---	---
Benzyl alcohol	SW8270D[4]	1.3	---	---
Benzoic acid	SW8270D[4]	3.7	---	---
Volatile Organic Compounds		**µg/L**	**µg/L**	
Trichloroethene	SW8260C	0.076	---	---
1,1,1,2-Tetrachloroethane	SW8260C	0.068	---	---
1,1,2,2-Tetrachloroethane	SW8260C	0.067	---	---
Ethylbenzene	SW8260C	0.094	---	---
m, p-Xylene	SW8260C	0.144	---	---

Table 3
Whole Water Sample Analytes

Analyte	Analytical Method	MDL	Acute	Chronic
o-Xylene	SW8260C	0.057	---	---
Vinyl Chloride	SW8260C	0.075	---	---
Methylene Chloride	SW8260C	0.391	---	---
Chloroform	SW8260C	0.081	---	---
1,2-Dichloroethane	SW8260C	0.075	---	---
Bromodichloromethane	SW8260C	0.053	---	---
1,2-Dichloropropane	SW8260C	0.093	---	---
cis-1,3-Dichloropropene	SW8260C	0.058	---	---
Dibromochloromethane	SW8260C	0.212	---	---
1,1,2-Trichloroethane	SW8260C	0.035	---	---
Benzene	SW8260C	0.056	---	---
Tetrachloroethene	SW8260C	0.088	---	---
Toluene	SW8260C	0.058	---	---
Chlorobenzene	SW8260C	0.042	---	---
Polychlorinated Biphenyl Aroclors (PCBs)		**µg/kg**	**µg/L**	
Aroclor-1221	8082	0.01	—	—
Aroclor-1232	8082	0.01	—	—
Aroclor-1242	8082	0.01	—	—
Aroclor-1016	8082	0.01	—	—
Aroclor-1248	8082	0.01	—	—
Aroclor-1254	8082	0.01	—	—
Aroclor-1260	8082	0.01	—	—
Aroclor-1262	8082	0.01	—	—
Aroclor-1268	8082	0.01	—	—
Total PCBs	SW8082	0.01	10	0.03
Miscellaneous Compounds		**µg/L**	**µg/L**	
Dibenzofuran	SW8270D[4]	0.31	---	---
Hexachlorobutadiene	SW8270D[4]	0.59	---	---
N-Nitrosodiphenylamine	SW8270D[4]	0.46	---	---

Notes:

1. WAC 173-201A-240 Table 240(3) only provides criteria for dissolved metals. Criteria presented for total metals in the above table were back calculated using the provided conversion factors. Total metals criteria should be used only as estimates.

2. Reporting limit listed in place of method detection limit.

3. Marine surface water criteria are less than ARI standard MDLs

4. Selected ion monitoring may improve the sensitivity of USEPA Method 8270D and is recommended in cases when detection limits must be lowered to human health criteria levels or when TOC levels elevate detection limits above ecological criteria levels. See PSEP Organics Chapter, Appendix B – Guidance for Selected Ion Monitoring (1997d).

Table 4
Stormwater Solid Sample SMS Analytes

Analyte	Prep Method[1]	Analytical Method[2]	MDL [3,4]	SQS	CSL
Conventional Parameters					
Total Solids (%)	---	160.3	0.1	---	---
Grain Size	---	ASTM/Sedigraph	---	---	---
Metals			**mg/kg**	**mg/kg**	
Arsenic	PSEP/3050B	6010B/6020	19	57	93
Cadmium	PSEP/3050B	6010B/6020	1.7	5.1	6.7
Chromium	PSEP/3050B	6010B/6020	87	260	270
Copper	PSEP/3050B	6010B/6020	130	390	390
Lead	PSEP/3050B	6010B/6020	150	450	530
Mercury	---	7471A /245.5	0.14	0.41	0.59
Silver	PSEP/3050B	6010B/6020	2	6.1	6.1
Zinc	PSEP/3050B	6010B/6020	137	410	960
Ionizable Organic Compounds			**µg/kg**	**µg/kg**	
Phenol	3540C/3550B	8270D	20	420	1200
2 Methylphenol	3540C/3550B	8270D	6	63	63
4 Methylphenol	3540C/3550B	8270D	20	670	670
2,4-Dimethylphenol	3540C/3550B	8270D	6	29	29
Pentachlorophenol	3540C/3550B	8270D	61	360	690
Benzyl alcohol	3540C/3550B	8270D	6	57	73
Benzoic acid	3540C/3550B	8270D	100	650	650
				LAET	**2LAET**
Low Molecular Polycyclic Aromatic Hydrocarbons (LPAH)			**µg/kg**	**µg/kg**	
Naphthalene	3540C/3550B	8270D	20	2100	2100
Acenaphthylene	3540C/3550B	8270D	20	1300	1300
Acenaphthene	3540C/3550B	8270D	20	500	500
Fluorene	3540C/3550B	8270D	20	540	540
Phenanthrene	3540C/3550B	8270D	20	1500	1500
Anthracene	3540C/3550B	8270D	20	960	960
2-Methylnaphthalene	3540C/3550B	8270D	20	670	670
Total LPAH				5200	5200
High Molecular Polycyclic Aromatic Hydrocarbons (HPAH)			**µg/kg**	**µg/kg**	
Fluoranthene	3540C/3550B	8270D	20	1700	2500
Pyrene	3540C/3550B	8270D	20	2600	3300
Benzo(a)anthracene	3540C/3550B	8270D	20	1300	1600
Chrysene	3540C/3550B	8270D	20	1400	2800
Benzofluoranthenes	3540C/3550B	8270D	20	—	—
Benzo(a)pyrene	3540C/3550B	8270D	20	1600	1600
Indeno(1,2,3-c,d)pyrene	3540C/3550B	8270D	20	600	690
Dibenzo(a,h)anthracene	3540C/3550B	8270D	20	230	230
Benzo(g,h,i)perylene	3540C/3550B	8270D	20	670	720
Total HPAH				12000	17000
Chlorinated Benzenes			**µg/kg**	**µg/kg**	
1,2-Dichlorobenzene	3540C/3550B	8270D	3.2	35	50
1,4-Dichlorobenzene	3540C/3550B	8270D	3.2	110	110
1,2,4-Trichlorobenzene	3540C/3550B	8270D	6	31	51
Hexachlorobenzene	3540C/3550B	8270D	12	22	70
Phthalate Esters			**µg/kg**	**µg/kg**	
Dimethyl phthalate	3540C/3550B	8270D	20	71	160
Diethyl phthalate	3540C/3550B	8270D	20	200	1200

Table 4
Stormwater Solid Sample SMS Analytes

Analyte	Prep Method[1]	Analytical Method[2]	MDL [3,4]	SQS	CSL
Di-n-butyl phthalate	3540C/3550B	8270D	20	1400	5100
Butyl benzyl phthalate	3540C/3550B	8270D	20	63	900
Bis(2-ethylhexyl)phthalate	3540C/3550B	8270D	20	1300	3100
Di-n-octyl phthalate	3540C/3550B	8270D	20	6200	6200
Polychlorinated Biphenyl Aroclors (PCBs)			**µg/kg**	**µg/kg**	
Aroclor-1221	3540C/3550B	8082	20	—	—
Aroclor-1232	3540C/3550B	8082	20	—	—
Aroclor-1242	3540C/3550B	8082	20	—	—
Aroclor-1016	3540C/3550B	8082	20	—	—
Aroclor-1248	3540C/3550B	8082	20	—	—
Aroclor-1254	3540C/3550B	8082	20	—	—
Aroclor-1260	3540C/3550B	8082	20	—	—
Aroclor-1262	3540C/3550B	8082	20	—	—
Aroclor-1268	3540C/3550B	8082	20	—	—
Total PCBs	3540C/3550B	8082	67	130	1000
Miscellaneous Compounds			**µg/kg**	**µg/kg**	
Dibenzofuran	3540C/3550B	8270D	20	540	540
Hexachlorobutadiene	3540C/3550B	8270D	20	11	120
N-Nitrosodiphenylamine	3540C/3550B	8270D	12	28	40

Notes:

1. Recommended sample preparation methods are: PSEP (1997a,b) and USEPA Method 3050B and 3500 series (sample preparation methods from SW-846 [USEPA 1986] and subject to changes by USEPA updates).

2. Recommended sample cleanup methods are: Sample extracts subjected to gel permeation chromatography (GPC) cleanup follow the procedures specified by USEPA SW-846 Method 3640A. Special care should be used during GPC to minimize loss of analytes. If sulfur is present in the samples (as is common in most marine sediments), cleanup procedures specified by USEPA SW-846 Method 3660B should be used. All PCB extracts should be subjected to sulfuric acid/permanganate cleanup as specified by USEPA SW-846 Method 3665A. Additional cleanup procedures may be necessary on a sample-by-sample basis. Alternative cleanup procedures are described in PSEP (1997a,b) and USEPA (1986).

3. MDL, SQS, CSL, LAET, and 2LAET are on a dry weight basis.

4. The recommended MDL is based on a value equal to one third of the 1988 dry weight lowest apparent effects threshold (LAET) value (Barrick et al. 1988) except for the following chemicals: 1,2-dichlorobenzene, 1,2,4-trichlorobenzene, hexachlorobenzene, hexachlorabutadiene, n-nitrosodiphenylamine, 2-methylphenol, 2,4-dimethylphenol, and benzyl alcohol, for which the recommended MDL is equal to the full value of the 1988 dry weight LAET.

Table 5
Dioxin/Furan Congeners and Method Detection Limits

Analyte	Analysis Method[1]	Sediment MDL[2]
2,3,7,8-TCDD	1613B	0.2 to 0.5
1,2,3,7,8-PeCDD	1613B	0.2 to 0.5
1,2,3,4,7,8-HxCDD	1613B	1 to 5
1,2,3,6,7,8-HxCDD	1613B	1 to 5
1,2,3,7,8,9-HxCDD	1613B	1 to 5
1,2,3,4,6,7,8-HpCDD	1613B	1 to 5
OCDD	1613B	10
Total Tetra-Dioxins (TCDD)	1613B	0.2 to 0.5
Total Penta-Dioxins (PeCDD)	1613B	1 to 5
Total Hexa-Dioxins (HxCDD)	1613B	1 to 5
Total Hepta-Dioxins (HpCDD)	1613B	1 to 5
2,3,7,8-TCDF	1613B	1 to 5
1,2,3,7,8-PeCDF	1613B	1 to 5
2,3,4,7,8-PeCDF	1613B	1 to 5
1,2,3,4,7,8-HxCDF	1613B	1 to 5
1,2,3,6,7,8-HxCDF	1613B	1 to 5
1,2,3,7,8,9-HxCDF	1613B	1 to 5
2,3,4,6,7,8-HxCDF	1613B	1 to 5
1,2,3,4,6,7,8-HpCDF	1613B	1 to 5
1,2,3,4,7,8,9-HpCDF	1613B	1 to 5
OCDF	1613B	10
Total Tetra-Furans (TCDF)	1613B	0.2 to 0.5
Total Penta-Furans (PeCDF)	1613B	1 to 5
Total Hexa-Furans (HxCDF)	1613B	1 to 5
Total Hepta-Furans (HpCDF)	1613B	1 to 5

Notes:

1. Method 1613 Tetra- through Octa-Chlorinated Dioxins and Furans by Isotope Dilution HRGC/HRMS. U.S. Environmental Protection Agency, Office of Water, Engineering and Analysis Division. October 1994.

2. MDL is on a dry weight basis in pg/g.

Table 6
PBDE Congeners and Method Detection Limits

Analyte	Analysis Method[1]	Sediment MDL[2]
BR2-DPE-7	1614	1.3
BR2-DPE-8/11	1614	1.5
BR2-DPE-10	1614	0.8
BR2-DPE-12/13	1614	2.6
BR2-DPE-15	1614	0.5
BR3-DPE-17/25	1614	1.2
BR3-DPE-28/33	1614	1.4
BR3-DPE-30	1614	1.8
BR3-DPE-32	1614	0.8
BR3-DPE-35	1614	0.6
BR3-DPE-37	1614	0.6
BR4-DPE-47	1614	2.8
BR4-DPE-49	1614	0.8
BR4-DPE-51	1614	0.8
BR4-DPE-66	1614	1.0
BR4-DPE-71	1614	0.8
BR4-DPE-75	1614	1.7
BR4-DPE-77	1614	0.8
BR4-DPE-79	1614	1.3
BR5-DPE-85	1614	0.5
BR5-DPE-99	1614	2.6
BR5-DPE-100	1614	0.9
BR5-DPE-105	1614	1.3
BR5-DPE-116	1614	1.4
BR5-DPE-119/120	1614	1.3
BR5-DPE-126	1614	0.7
BR6-DPE-128	1614	1.3
BR6-DPE-138/166	1614	1.6
BR6-DPE-140	1614	1.0
BR6-DPE-153	1614	0.6
BR6-DPE-154	1614	0.8
BR6-DPE-155	1614	0.7
BR7-DPE-181	1614	1.0
BR7-DPE-183	1614	0.5
BR7-DPE-190	1614	1.4
BR8-DPE-203	1614	2.0
BR9-DPE-206	1614	12.3
BR9-DPE-207	1614	11.0
BR9-DPE-208	1614	8.8
BR10-DPE-209	1614	124

Notes:

1. Method 1614 Brominated Diphenyl Ethers in Water, Soil, Sediment and Tissue by HRGC/HRMS. U.S. Environmental Protection Agency, Office of Water, Engineering and Analysis Division. August 2007.

2. MDL is on a dry weight basis in pg/g.

Table 7
Sediment Trap and Catch Basin Solid Analytes

Analyte	Prep Method	Analytical Method	Sediment MDL	LAET	2LAET
Conventional Parameters					
Total Organic Carbon (%)	---	Plumb 1981	0.1	---	---
Pesticides µg/kg					
4,4'-DDE	3540C/3550B	8081	2.3.	9	15
4,4'-DDD	3540C/3550B	8081	3.3	2	43
4,4'-DDT	3540C/3550B	8081	6.7	3.9	6
Aldrin	3540C/3550B	8081	1.7	---	---
Gamma Chlordane	3540C/3550B	8081	2	---	---
Alpha Chlordane	3540C/3550B	8081	2	---	---
Dieldirin	3540C/3550B	8081	2.3	---	---
Heptachlor	3540C/3550B	8081	1.7	---	---
Gamma-BHC (Lindane)	3540C/3550B	8081	1.7	---	---