Sampling and Analysis Plan/ Quality Assurance Project Plan Lower Duwamish Waterway Bank Sampling

Prepared for
Washington State Department of Ecology

May 9, 2011
17330-32

HARTCROWSER

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Prepared by
Hart Crowser, Inc.

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DRAFT SAMPLING AND ANALYSIS PLAN/ QUALITY ASSURANCE PROJECT PLAN LOWER DUWAMISH WATERWAY BANK SAMPLING

1.0 INTRODUCTION

This combined Sampling and Analysis Plan/Quality Assurance Project Plan (SAP/QAPP) was developed for the Washington State Department of Ecology (Ecology) Lower Duwamish Waterway (LDW) bank study. This SAP/QAPP describes sampling locations, field sampling procedures, laboratory analytical methods, data evaluation procedures, and quality control criteria to support the investigation.

2.0 BACKGROUND

The LDW is the 5.5-mile portion of the Duwamish River south of Harbor Island in Seattle, Washington. The Duwamish River is fed mainly by the Green River and smaller tributaries, and flows into Elliott Bay. The LDW was added to the US Environmental Protection Agency's (EPA) National Priorities List in 2001. Ecology added the site to the Washington State Hazardous Sites List in 2002.

Ecology and the EPA are working together to clean up contaminated sediment and control sources of recontamination in the LDW. Ecology is the lead agency responsible for source control in the LDW. Source control for the LDW is the process of finding and stopping or reducing, to the maximum extent practicable, releases of pollution to waterway sediment. The goal of source control is to stop ongoing sources and minimize post-remediation recontamination.

Previous investigations by others have included the collection and chemical analysis of over 1,200 surface sediment samples to characterize sediment contamination in the LDW. These investigations were summarized in the LDW Remedial Investigation Report (Windward 2010a). Since the intent of these investigations was to evaluate the sediment within the LDW, the vast majority of these samples were collected at or below 0 feet elevation. Very few are between 0 and +4 feet, and none were collected from the intertidal zone above +4 feet. A supplemental dioxin/furan investigation did include composite samples of select beach areas along the LDW (Windward 2010b).

There is little or no information on the nature of contamination in the high intertidal areas (approximately above +4 feet). The high intertidal areas include sand beaches with pilings, armored riprap, fill material of unknown origin, and suspected slag piles from industrial operations.

A summary of previous sediment and seep investigations in the vicinity of each bank sampling site is described in the Lower Duwamish Waterway Bank Sampling Reconnaissance Plan (Hart Crowser 2011). The sediment investigation results will be used for later comparison and to help assess the potential for sediment recontamination.

3.0 PROJECT OBJECTIVES AND SUMMARY

The objective of the bank sampling is to characterize the banks along the LDW at nine locations to aid in determining if they are potential sources of ongoing impacts to the LDW sediment. The locations were selected by Ecology based on their field observations, adjacent sediment contaminant levels, and proximity to known contaminated upland sites. The intent is to help characterize suspected and unknown materials and determine if there is a potential for sediment recontamination in these areas.

The samples collected will be analyzed for the following parameters:

- Semivolatile organic compounds (SVOCs);
- Polychlorinated biphenyls (PCBs);
- Pesticides;
- Total petroleum hydrocarbons (TPH) including gasoline, diesel, and heavy-oil ranges;
- Metals (As, Cd, Cr, Cu, Pb, Hg, Ag, Zn);
- Tributyltin;
- Total organic carbon (TOC);
- Dioxins and furans; and
- Polybrominated diethyl ethers (PBDEs).

Analytical results will be compared to:

- Washington State Sediment Management Standards (SMS) criteria;
- Soil screening levels protective of sediment (provided by Ecology);
- Most Stringent Screening Levels Without Potable Surface Water in Site (Provided by Ecology); and
- Model Toxics Control Act (MTCA) Method B.

A quality assurance data validation review will be performed on all analytical sample results. Validated data will be entered into Ecology's Environmental

Information Management (EIM) system. Sampling results and laboratory data will be compiled and evaluated. Sampling locations, procedures, analytical methods, and evaluation of results are discussed in subsequent sections of this SAP/QAPP.

4.0 PROJECT TEAM AND RESPONSIBILITIES

Key staff members and their project functions are listed below.

- Dan Cargill, Ecology Project Manager
- Mark Dagel, LHG, Program Manager
- Ross Stainsby, LHG, Project Manager
- Roger McGinnis, PhD, Project Chemist
- Kimberly Reinauer, EIT, Field Coordinator
- Field Geologist/Engineer – To Be Determined

Chemical analysis will be performed by Analytical Resources, Inc (ARI) located in Tukwila, Washington. ARI is accredited by the State of Washington. The ARI project manager will be Kelly Bottem.

5.0 SITE DESCRIPTIONS AND SAMPLING LOCATIONS

Ecology selected nine locations to further characterize the bank material and assess the potential for sediment recontamination. These areas were selected because visual observations indicated that there was suspected material present on the bank or there was information about past use at the site or upland areas. One of the identified locations, the South Park Street End, was selected to confirm there is no risk because it is in an area that is used by the public.

Table 1 summarizes access information for each bank site including the property owner information. Table 2 describes sampling activities related to each bank site including the type of sampling and number of samples collected per site. Sampling locations will be accessed by either boat or by land. In some instances, permission from landowners will be required to access specific locations. If access is not granted, the site will be removed from the list of sites to be characterized.

Unless otherwise noted, our understanding of each bank sampling site is based on conversations with Ecology, and site visits by boat on October 21, 2010, and by land on January 25, 2011. Each bank sampling site is described below. Actual sampling locations will be determined in the field based on site conditions and will be adjusted to target any suspected material. Sample locations will be documented in the field using a Trimble GPS with real-time corrections.

5.1 Riverside Marina

5.1.1 Site Description

The Riverside Marina Bank Sampling site is located at about River Mile (RM) 0.15 west (Figure 3). The site is currently owned by the Port of Seattle (Port) (Table 1). The site was a marina and has also been used for industrial activities. The site is now a mud bank/beach area with the remnants of wood piles. The site borders the Port's former Terminal 105 facility and is accessible by land from the Terminal 103 public access at low tide. The parcel is adjacent to Lipsett Company property but there is no access to the bank.

5.1.2 Proposed Sampling Activities

Bank samples will be collected from five locations. The samples will be collected in the area between high tide line and the vegetation. Samples will be collected to a depth of up to 10 cm using a hand auger (see Section 6.3). Proposed sample locations are shown on Figure 3.

5.2 T-107 CKD

5.2.1 Site Description

The T-107 CKD Bank Sampling site is located at RM 0.9 west (Figure 4). The site is owned by the Port (Table 1). A layer of unidentified white material, potentially cement kiln dust, is exposed in the vertical face of the bank. The site borders the Port's T-107 Park and a parking area that appears to be used for container storage. Lafarge Corporation is located to the southeast of the site. The site is accessible by boat.

5.2.2 Proposed Sampling Activities

Bank samples will be collected from five locations along the vertical face to characterize the unidentified white material. Proposed sample locations are shown on Figure 4. Actual sample locations will be determined in the field to

include the white material as part of the sample. Based on our field observations, the entire white layer is above high tide. To allow for access by boat, sample collection activities will be completed during high tide. A hand corer will be used to collect samples 10 cm into the vertical face (see Section 6.2).

5.3 SeaTac Marine

5.3.1 Site Description

The SeaTac Marine Bank Sampling site is located in Slip 3 at approximately RM 2.1 east (Figure 5). The upland area has been used as a shipyard and a hazardous waste storage area. The bank is a near vertical face and is partially covered by a pier. The site is owned by Fox Avenue LLC (Table 1) and is accessible by boat. A portion of the site is within the Port-managed waterway. Samples will be collected only from areas within the Port-managed waterway to eliminate the need for an access agreement.

5.3.2 Proposed Sampling Activities

Bank samples will be collected from three locations at two elevations per location for a total of six samples along the vertical face as indicated by Ecology. Proposed sample locations are shown on Figure 5. Samples will be collected from above MHHW. To allow for improved access, samples will be collected during high tide. A hand corer will be used to collect a sample from the outer 10 cm of the vertical face (see Section 6.2).

5.4 Boyer-Trotsky Street End

5.4.1 Site Description

The Boyer-Trotsky Street End Bank Sampling site is located at approximately RM 2.3 west. The site is bordered by Boyer Towing and Trotsky Property (Industrial Container Services – WA, LLC). The bank surface is rip-rap and is sometimes used as a public access point to the LDW. The site is located just south of Early Action Area 2 (Ecology 2007). The site is owned by the Port (Table 1) and is accessible by land at the end of 2nd Avenue South.

5.4.2 Proposed Sampling Activities

The site was selected by Ecology to further evaluate the extent of impacts associated with Early Action Area 2. Bank samples will be collected from four locations (Figure 6). The site is covered in large rip rap. A shovel will be used to

clear access between rip rap if needed. Samples will be collected to a depth of up to 10 cm using a hand auger (see Section 6.3). .

5.5 Seattle Iron & Metals

5.5.1 Site Description

The Seattle Iron & Metals Bank Sampling site is located at approximately RM 2.55 east. The bank at the southern end of the Seattle Iron & Metals property is covered by non-native material and debris, including brick. The site is owned by the Shalmar Group (Table 1) and is accessible by boat.

5.5.2 Proposed Sampling Activities

Bank samples will be collected from four locations at varying elevations along the vertical face to characterize the debris. Proposed sample locations are shown on Figure 7. Samples will be collected above MHHW and, to allow access by boat, will be collected at high tide. A hand corer will be used to collect samples from the vertical face (see Section 6.2).

5.6 Puget Sound Truck Lines

5.6.2 Site Description

The Puget Sound Truck Lines Bank Sampling sites are located from approximately RM 2.6 to 2.7 east. This upland site has been used for various industrial purposes including a drum reconditioning plant, concrete pipe company, and a truck company. The concrete company reportedly deposited concrete waste on the bank (Hart Crowser 2011a). A layer of white material is present along the vertical face of the bank above the MHHW line. Field observations indicate that the material is not uniform along the bank and may be from different sources.

The southern portion of the site is within the Port-managed waterway. The northern portion of the site is owned by R&A Properties, LLC. Samples will be collected only from areas from within the Port-managed waterway to eliminate the need for an access agreement with R&A Properties, LLC (Figure 8). The proposed sample locations are accessible by boat during high tides.

5.6.2 Proposed Sampling Activities

Banks samples will be collected from twenty-one locations along the vertical face to characterize the unknown materials. Samples will be collected at seven

locations along the length of the bank at three different elevations per location to evaluate the varying materials. A sample will be collected from the white material as well as above and below the white material.

Proposed sample locations are shown on Figure 8. Actual sample locations will be determined in the field. Samples will be collected above MHHW and collected at high tide. A hand corer will be used to collect a sample from the vertical face as described in Section 6.2.

5.7 South Park Street End

5.7.1 Site Description

The South Park Street End Bank Sampling site is located at approximately RM 3.3 west. The surrounding area is residential and this area has high public use. Little is known about the bank conditions in this area. The site is owned by the Port and is accessible by land at the end of South Rose Street. A street-use permit will be obtained from the city of Seattle to complete the work at this site.

5.7.2 Proposed Sampling Activities

The quality of the bank material will be determined from collecting subsurface samples using a push probe rig as close to the edge of the bank as practicable. The sample location was chosen by Ecology to help characterize bank soil in this area. Two push probes will be advanced to a depth of approximately 10 to 12 feet bgs to extend to the approximate elevation of high tide. Samples will be collected every 4 feet (see Section 6.1). Push probe locations are shown on Figure 9.

5.8 Sea King Industrial

5.8.1 Site Description

The Sea King Industrial Bank Sampling site is located at approximately RM 4.0 west (Figure 10). The upland area has been used for industrial activity and dumping of trash has been observed in the area. The site is owned by Sea King Industrial Park (Table 1). The site is accessible by boat and may also be accessible through the industrial park.

5.8.2 Proposed Sampling Activities

Bank samples will be collected from approximately six locations. The samples will be collected between the high tide line and the vegetation. Samples will be

typically collected above elevation +4 using a hand auger (see Section 6.3). Proposed sample locations are shown on Figure 10. Actual sample locations will be field located and may be moved to collect bank samples near stormwater outfalls identified during sampling activities.

5.9 Hamm Creek

5.9.1 Site Description

The Hamm Creek Bank Sampling site is located at approximately RM 4.4 west. The upland area was part of the Hamm Creek habitat restoration project. The site is owned by Seattle City Light (Table 1). The mud flat is accessible by boat and also may be accessible by land through Seattle City Light property.

5.9.2 Proposed Sampling Activities

Bank samples will be collected from up to three locations along one transect perpendicular to the shore in the pocket beach as specified by Ecology. The samples will be collected from the intertidal area above elevation +4. Samples will be collected using a hand auger (see Section 6.3). Proposed sample locations are shown on Figure 11. Samples will be collected at low tide.

6.0 FIELD SAMPLING METHODS

Proposed sample locations are presented on Figures 3 through 11. Actual sample locations will be determined in the field based on site conditions and will be adjusted to target any suspected material. Typically, samples will be collected at locations above elevation +4. Tides will be considered to make sure sample locations are accessible. Table 2 summarizes the number and type of samples at each bank sample site.

Sample locations will be documented in the field using a GPS. Sample elevations will be estimated by determining the approximate height above the water and using tide charts for the LDW.

Samples will generally be collected by one of three methods: push probe sampling in the area immediately upland of the site, hand auger surface sampling, or core sampling of a vertical face.

6.1 Push Probe Sampling Procedures

Subsurface soil samples may be collected using direct-push technology (also referred to as a push probe). A push probe is a truck-mounted, hydraulically powered hammer/ram sampling device. The hammer pushes 4-foot-long hollow steel samplers into the ground to collect soil. Several adjacent probes may be required to obtain sufficient soil samples for analysis.

The probe locations will be located and marked in the field by a Hart Crowser field representative. Each probe location will be cleared for underground utilities using existing records and "one-call" utility locating system. In addition, Hart Crowser will contract with a private utility locating service to locate utilities before probing.

Soil samples will be classified in general accordance with ASTM Method D 2488, and a soil log will be prepared. Soil samples will be collected in 4-foot intervals and soils will be continuously logged to document subsurface conditions beneath the property.

6.2 Vertical Face Sampling Procedures

Grab samples from the vertical face of banks will be collected using a hand corer or other hand tools. A rock hammer may be required to collect samples of hard or compacted material.

Samples collected will be representative of the targeted 0- to 10-cm depth profile. Care will be taken to collect all size fractions (smaller than 2 mm) and avoid loss of fine material.

6.3 Hand Auger Procedures

Shallow surface samples will be collected using a hand auger or other hand tools. Equipment will be cleaned between sample locations. Samples collected will be representative of the targeted 0- to 10-cm depth profile. Care will be taken to collect all size fractions (smaller than 2 mm) and avoid loss of fine material.

6.4 Soil Screening Analysis

Soil samples will be field screened for evidence of contamination using: (1) visual examination; (2) water sheen testing; and (3) headspace vapor screening using a PID. The effectiveness of field screening varies with temperature, moisture content, organic content, soil type, and age of the contaminant.

Visual Examination. Visual examination consists of observing the soil for stains. Visual screening is generally more effective when contamination is related to heavy petroleum hydrocarbons such as motor or hydraulic oil, or when hydrocarbon concentrations are relatively high.

Water Sheen Testing. Water sheen testing involves placing a small volume of soil in a pan of water and observing the water surface for sheen. Sheens are classified as follows:

No Sheen (NS)	No visible sheen on water surface.
Slight Sheen (SS)	Light colorless film, spotty to globular; spread is irregular, not rapid, areas of no sheen remain, film dissipates rapidly.
Moderate Sheen (MS)	Light to heavy film, may have some color or iridescence, globular to stringy, spread is irregular to flowing; few remaining areas of no sheen on water surface.
Heavy Sheen (HS)	Heavy colorful film with iridescence; stringy, spread is rapid; sheen flows off the sample; most of the water surface may be covered with sheen.

Headspace Vapor Screening. Headspace vapor screening is intended to indicate the presence of volatile organic vapors and involves placing a soil sample in a plastic sample bag. Air is captured in the bag and the bag is shaken to expose the soil to the air trapped in the bag. The probe of the PID is inserted in the bag and the instrument measures the concentration of organic vapors in the air from the sample headspace. The highest vapor reading is recorded for each sample. The PID measures concentrations in ppm (parts per million) and is calibrated to isobutylene. The PID is typically designed to screen total volatile organic vapor concentrations in the range of 0 to 1,000 ppm.

The results of field screening will be recorded in the field logs and will be used to select the samples to submit for chemical analysis.

6.5 Equipment Decontamination Procedures

Precleaned equipment will be used for all soil sampling. All reusable or non-dedicated field equipment (e.g., sampling spoons, mixing bowls, spade/shovel) will be decontaminated prior to reuse. Equipment will be decontaminated in the following manner:

- Nitrile gloves (or equivalent) must be worn during decontamination process.
- Excess soil will be removed using paper towels or by dry brushing.
- Rinse with potable water, collecting rinse water in one of the decontamination buckets.
- Wash with a spray bottle containing Liquinox™ (or equivalent nonphosphate detergent) and water and clean with the stiff-bristle brush until all evidence of soil or other material has been removed.
- Rinse with deionized or distilled water three times, ensuring that all detergent from the previous step has been removed.
- Place the equipment on a piece of aluminum foil to air dry.
- A trash bag will be provided for waste paper towels, aluminum foil, and used nitrile gloves.

6.6 Investigation-Derived Waste Management

Contaminated or potentially contaminated materials generated during field work will be managed in accordance with applicable federal, state, and local regulations. IDW will be handled in accordance with applicable regulations and in a manner consistent with ultimate disposition.

IDW is anticipated to include the following categories of waste:

- Non-hazardous solid waste, including personal protective equipment (PPE; e.g., gloves), paper towels, other disposable materials, etc.;
- Liquid IDW including decontamination wastewater; and
- Soil and Sediment IDW from sampling procedures.

Non-hazardous solid waste will be double-bagged in heavy duty garbage bags, sealed with duct tape, for solid waste disposal in a municipal landfill.

Liquid waste will be disposed of in the sanitary sewer.

6.7 Sample Containers and Labels

Sample container requirements vary according to analyte. Precleaned sample containers will be provided by the analytical laboratory. Sample containers shall be cleaned following the requirements described in Specifications and Guidance for Contaminant-Free Sample Containers (EPA 1992a, OSWER Directive 92.0-05a). Required sample containers, preservatives, and holding times are summarized in Table 3.

6.8 Field Documentation

Field notes will be maintained during sampling and processing operations. The following will be included in the field notes:

- Site name and location;
- Date and time;
- Name of the person collecting and logging the samples;
- Weather conditions;
- Date, time, and identification of each sample, including number of jars and tests requested;
- Details of sample collection, including GPS coordinates; actual sampling point locations will be recorded on a sketch map;
- Any deviation from the approved SAP; and
- General observations.

7.0 SAMPLE HANDLING PROCEDURES

7.1 Sample Preservation and Holding Times

Samples will be preserved according to the requirements of the specific analytical methods to be employed, and all samples will be extracted and analyzed within method-specified holding times. Required sample containers, preservatives, and holding times are summarized in Table 3.

7.2 Chain of Custody Procedures

Chain of custody forms will be used to document the collection, custody, and transfer of samples from their initial collection location to the laboratory, and their ultimate use and disposal. Entries for each sample will be made on the custody form after each sample is collected.

Sample custody procedures will be followed to provide a documented record that can be used to follow possession and handling of a sample from collection through analysis. A sample is considered to be in custody if it meets at least one of the following conditions:

- The sample is in someone's physical possession or view;
- The sample is secured to prevent tampering (i.e., custody seals); and/or
- The sample is locked or secured in an area restricted to authorized personnel.

A chain of custody form will be completed in the field as samples are packaged. At a minimum, the information on the custody form shall include the sample number, date and time of sample collection, sampler, analysis, and number of containers. Two copies of the custody form will be placed in the cooler prior to sealing for delivery to the laboratory with the respective samples. The other copy will be retained and placed in the project files after review by the Project Chemist. Custody seals will be placed on each cooler or package containing samples so the package cannot be opened without breaking the seals.

7.3 Delivery of Samples to Analytical Laboratory

After sample containers have been filled, they will be packed on ice in coolers. The coolers will be transferred to Analytical Resources Inc. (ARI) in Tukwila, WA, for chemical analysis. Specific procedures are as follows:

- Samples will be packaged and shipped in accordance with U.S. Department of Transportation regulations as specified in 49 CFR 173.6 and 49 CFR 173.24;
- Individual sample containers will be packed to prevent breakage;
- The coolers will be clearly labeled with sufficient information (name of project, time and date container was sealed, person sealing the cooler, and the Hart Crowser office name and address) to enable positive identification;

- A sealed envelope containing custody forms will be enclosed in a plastic bag and taped to the inside lid of the cooler;

- Signed and dated custody seals will be placed on all coolers prior to shipping;

- Samples will either be shipped by overnight courier or will be hand delivered to the laboratory by Hart Crowser personnel; and

- Upon transfer of sample possession to the testing laboratories, the custody form will be signed by the persons transferring custody of the coolers. Upon receipt of samples at the laboratory, the shipping container custody seal will be broken and the laboratory sample-receiving custodian will compare samples to information on the chain of custody form and record the condition of the samples received.

8.0 LABORATORY ANALYTICAL METHODS

Samples will be analyzed according to EPA methods as described in Update III to Test Methods for Evaluating Solid Waste; Physical/Chemical Methods, SW-846 (EPA 1986) and EPA Method 1613B. Tetra- through Octa-Chlorinated Dioxins and Furans by Isotope Dilution HRGC/HRMS (EPA 1994) as summarized below.

Samples will be analyzed for:

- SVOCs by EPA Method 8270D;
- Polycyclic Aromatic Hydrocarbons (PAHs) by EPA Method 8270D-SIM;
- PCBs by EPA Method 8082;
- PBDEs by EPA Method 8082;
- Polychlorinated dioxins and furans by EPA Method 1613B;
- Pesticides by EPA Method 8081;
- Petroleum hydrocarbons by Ecology's NWTPH-Gx (using 5035A collection methods for soil) and NWTPH-Dx methods;
- Total metals including arsenic, cadmium, chromium, copper, lead, silver, and zinc by EPA Method 6010B;
- Total mercury by EPA Method 7471;
- Tributyltin by the method developed by Krone (REF) as modified for the Puget Sound Dredge Disposal Analysis (PSDDA) program; and
- TOC by EPA Method 9060.

Laboratory methods, practical quantitation limits (PQL; reporting limits) and method detection limits are presented in Table 4. The individual analytes requested for the different tests are also listed in Table 4.

9.0 QUALITY ASSURANCE AND QUALITY CONTROL

The quality of analytical data generated is assessed by the frequency and type of internal QC checks developed for analysis type. The quality of laboratory measurements will be assessed by reviewing results for analysis of method blanks, matrix spikes, duplicate samples, laboratory control samples, surrogate compound recoveries, instrument calibrations, performance evaluation samples, interference checks, etc., as specified in the analytical methods to be used. The following general procedures will be followed for all laboratory analyses:

- Laboratory blank measurements at a minimum frequency of 5 percent or one per batch of 20 samples or fewer for each matrix;
- Matrix spike (MS) analysis to assess accuracy at a minimum frequency of 5 percent or one per batch of 20 samples or fewer for each matrix;
- Matrix spike duplicate or laboratory duplicate to assess precision at a minimum frequency of 5 percent or one per batch of 20 samples or fewer for each matrix;
- Surrogate or labeled compound spikes in each sample for organics analysis to assess accuracy;
- Laboratory control sample analysis or a certified reference material (CRM), if appropriate CRM is available, with each analytical batch to assess accuracy in the absence of any matrix effect at a minimum frequency of 5 percent or one per batch of 20 samples or fewer for each matrix. Acceptance criteria for the CRM results (based on the 95 percent confidence interval) must be provided by the laboratory. If results fall outside the acceptance range, the laboratory may be required to re-extract and reanalyze the associated samples; and
- A trip blank will be submitted for analysis with each cooler that contains NWTPH-Gx samples.

Laboratory quality control procedures, criteria, and corrective action are summarized in Tables 5 through 13 for the various analyses.

9.1 Data Quality Indicators

The overall quality assurance objectives for field sampling, field measurements, and laboratory analysis are to produce data of known and appropriate quality. The procedures and quality control checks specified herein will be used so that known and acceptable levels of accuracy and precision are maintained for each data set. This section defines the objectives for accuracy and precision for measurement data. These goals are primarily expressed in terms of acceptance criteria for the quality control checks performed.

The quality of analytical data generated is controlled by the frequency and type of internal quality control checks developed for analysis type. Laboratory results will be evaluated by reviewing results for analysis of method blanks, matrix spikes, duplicate samples, laboratory control samples, calibrations, performance evaluation samples, interference checks, etc., as specified in the analytical methods to be used.

9.1.1 Precision

Precision is the degree of reproducibility or agreement between independent or repeated measurements. Analytical variability will be expressed as the relative percent difference (RPD) between laboratory replicates and between matrix spike and matrix spike duplicate analyses. RPD will be used to measure precision for this investigation and is defined as follows:

$$RPD = \frac{(D_1 - D_2)}{(D_1 + D_2)/2} \times 100$$

Where,

D_1 = Sample value
D_2 = Duplicate sample value

9.1.2 Accuracy

Accuracy is the agreement between a measured value and its true or accepted value. While it is not possible to determine absolute accuracy for environmental samples, the analysis of standards and spiked samples provides an indirect assessment of accuracy.

Laboratory accuracy will be assessed as the percent recovery of matrix spikes, matrix spike duplicates, surrogate spiked compounds (for organic analyses), and

laboratory control samples. Accuracy will be defined as the percentage recoverable from the true value and is defined as follows:

$$\%\text{Recovery} = \frac{(\text{SSR-SR})}{\text{SA}} \times 100$$

Where,

SSR = spiked sample result
SR = sample results (not applicable for surrogate recovery)
SA = amount of spike added

9.1.3 Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition. Care will be taken in the design of the sampling program to confirm sample locations are selected properly, sufficient numbers of samples are collected to accurately reflect conditions at the site, and samples are representative of sampling locations. A sufficient volume of sample will be collected at each sampling point to minimize bias or errors associated with sample particle size and heterogeneity.

9.1.4 Completeness

Completeness is the percentage of measurements made that are judged to be valid. Completeness will be calculated separately for each analytical group, e.g., metals or PAHs. Results must also contain all quality control check analyses required to verify the precision and accuracy of results to be considered complete. Data qualified as estimated during the validation process will be considered complete. Nonvalid measurements will be results that are rejected during the validation review or samples for which no analytical results were obtained. Completeness will be calculated for each analysis using the following equation:

$$\text{Completeness} = \frac{\text{valid data points obtained}}{\text{total data points planned}} \times 100$$

The target goal for completeness is a minimum of 95 percent. Completeness will be monitored on an ongoing basis so that archived sample extracts can be reanalyzed, if required, without remobilization.

9.1.5 Comparability

Comparability is the degree to which data from separate data sets may be compared. For instance, sample data may be compared to data from background locations, to established criteria or guidance, or to data from earlier sampling events. There has been little consistency among historical studies used to estimate background chemical concentrations. For example, intervals defined as surface soil have varied often ranging from 1 inch to 6 or more inches in depth. In addition, analytical methods have not been consistent across studies.

As discussed in Section 6.0, sample collection will be performed in a consistent manner by field personnel at all sampling locations to confirm all data collected as part of this study are comparable. Comparability is attained by careful adherence to standardized sampling and analytical procedures, based on rigorous documentation of sample locations (including depth, time, and date).

The use of standardized methods to collect and analyze samples, along with instruments calibrated against National Institute for Standards and Technology (NIST) and US EPA traceable standards will also confirm comparability, particularly for comparison of data collected from this study (within-study comparability).

Comparability also depends on other data quality characteristics. Only when data are judged to be representative of the environmental conditions, and when precision and accuracy are known, can data sets be compared with confidence.

9.2 Data Quality Assurance Review

A project chemist at Hart Crowser will perform an independent data quality review of the chemical analytical results provided by ARI. This report will assess the adequacy of the reported detection limits in achieving the project screening levels for soil; the precision, accuracy, representativeness, and completeness of the data; and the usability of the analytical data for project objectives. Exceedances of analytical control limits will be summarized and evaluated.

A data evaluation review will be performed on all results using QC summary sheet results provided by the laboratory for each data package. The data evaluation review is based on the Quality Control Requirements previously described and follows the format of the EPA National Functional Guidelines for Inorganic (EPA 2010) Superfund Data Review, EPA National Functional Guidelines for Organic (EPA 2008) Superfund Data Review, and EPA Contract Laboratory Program Functional Guidelines for Chlorinated Dioxin/Furan Data Review (EPA 2005) modified to include specific criteria of individual analytical

methods. Raw data (instrument tuning, calibrations, instrument printouts, bench sheets, and laboratory worksheets) will be available for review if any problems or discrepancies are discovered during the routine evaluation. The following is an outline of the data evaluation review format:

- Verify that sample numbers and analyses match the chain of custody request;
- Verify sample preservation and holding times;
- Verify that instrument tuning, calibration, and performance criteria were achieved;
- Verify that laboratory blanks were performed at the proper frequency and that no analytes were present in the blanks;
- Verify that laboratory duplicates, matrix spikes, surrogate compounds, and laboratory control samples were run at the proper frequency and that control limits were met; and
- Verify that required detection limits have been achieved.

Data qualifier flags, beyond any applied by the laboratory, will be added to sample results that fall outside the QC acceptance criteria. An explanation of data qualifiers to be applied during the review is provided below:

U The compound was analyzed for but was not detected. The associated numerical value is the sample reporting limit.

J The associated numerical value is an estimated quantity because QC criteria were slightly exceeded.

UJ The compound was analyzed for, but not detected. The associated numerical value is an estimated reporting limit because QC criteria were not met.

T The associated numerical value is an estimated quantity because reported concentrations were less than the practical quantitation limit (lowest calibration standard).

K Ion ratios do not meet identification criteria acceptance limits for positive identification.

R Data are not usable because of significant exceedance of QC criteria. The analyte may or may not be present; resampling and/or reanalysis are necessary for verification.

10.0 DATA ANALYSIS AND REPORTING

10.1 Evaluation of Chemistry Data

Soil chemistry results will be compared to SMS criteria and MTCA Method B criteria. Soil chemistry results will also be compared to soils screening levels that are protective of sediments and most stringent screening levels to protect potable groundwater (without potable surface water). These screening levels were provided by Ecology in Draft LDW Preliminary Screening Levels v12r7.xls on April 13, 2011. Screening levels are derived from conservation assumptions and in some cases will be below the PQLs (see Table 4). Results in will be compared to the PQL in these situations.

10.2 Laboratory Reports

The laboratory data reports will consist of complete data packages that will contain complete documentation and all raw data to allow independent data reduction and verification of analytical results from laboratory bench sheets, and instrument raw data outputs. Each laboratory data report will include the following:

- Case narrative identifying the laboratory analytical batch number, matrix and number of samples included, analyses performed and analytical methods used, and description of any problems or exceedance of QC criteria and corrective action taken. The laboratory manager or their designee must sign the narrative.

- Copy of chain of custody forms for all samples included in the analytical batch.

- Tabulated sample analytical results with units, data qualifiers, percent solids, sample weight or volume, dilution factor, laboratory batch and sample number, Hart Crowser sample number, and dates sampled, received, extracted, and analyzed all clearly specified.

- All calibration, quality control, and sample raw data including quantitation reports and other instrument output data.

- Blank summary results indicating samples associated with each blank.
- MS/MSD result summaries with calculated percent recovery and relative percent differences.
- Surrogate compound recoveries, when applicable, with percent recoveries.
- Laboratory control sample results, when applicable, with calculated percent recovery.
- Performance evaluation or certified reference material sample results, if applicable, with acceptance limits.
- Electronically formatted data deliverable (CD) results.

10.3 Hart Crowser Reports

Hart Crowser will prepare a draft report summarizing sampling procedures and laboratory testing results. The report will include a map(s) with sampling locations, tabulated analytical testing data, and laboratory analytical documentation. The report will also include an assessment of sediment recontamination potential. A final report will be completed following discussions with Ecology.

11.0 REFERENCES

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Windward, 2010a. Remedial Investigation Report. Prepared by Windward Environmental LLC for the Lower Duwamish Waterway Group. July 2010.

Windward, 2010b. Technical Memorandum: 2009/2010 Surface Sediment Sampling Results for Dioxins and Furnas and Other Chemicals. Prepared by Windward Environmental LLC for the Lower Duwamish Waterway Group. July 2010.

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Table 1 - Bank Sampling Site Taxpayer Information

Site Name	King County Parcel Number	Site Address	Taxpayer Name	Taxpayer Mailing Address			
Riverside Marina	7666703532	4100 West Marginal Way SW	Port of Seattle	PO BOX 1209	Seattle	WA	98111
T-107 CKD	1924049103	5402 West Marginal Way SW	Port of Seattle	PO BOX 1209	Seattle	WA	98111
Seattle Iron & Metals	2924049089	620 South Othello St	Shalmar Group	601 South Myrtle Street	Seattle	WA	98108
SeaTac Marine	0001800104	6701 Fox Ave South	Fox Avenue LLC	C/O Booth Creek Management Corp 950 Red Sandstone Road #43	Vail	CO	81657
PS Truck Lines	2136200670	7401 8TH Ave South	Cleanscapes	5939 4th Avenue South	Seattle	WA	98108
			Port of Seattle	PO BOX 1209	Seattle	WA	98111
South Park Street End	322404HYDR	South Rose Street	Port of Seattle	PO BOX 1209	Seattle	WA	98111
Boyer -Trotsky Street End	292404HYDR	South Orchard St & 2nd Ave South	Port of Seattle	PO BOX 1209	Seattle	WA	98111
Sea King Industrial	0001600060	1620 South 92nd Place	Sea King Industrial Park	1849 Green Bay Road - 4th Floor	Highland Park	IL	60035
Hamm Creek	5624200931	9850 W Marginal Pl South	Seattle City Light	PO BOX 34023	Seattle	WA	98124

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Table 2 - Proposed Bank Sampling and Analysis

Site Name	Rationale	Sample Access	Type of Sampling	Number of Samples	Analytes
Riverside Marina	Old marina, industrial history, pilings	Land - T-105 park	Hand auger	5	Semivolatile organic compounds (SVOCs) Polychlorinated biphenyls (PCBs) Pesticides Total petroleum hydrocarbons (TPH) including gasoline, diesel, and heavy oil-ranges Metals (As, Cd, Cr, Cu, Pb, Hg, Ag, Zn) Total organic carbon (TOC) Dioxins and furans Polybrominated diethyl ethers (PBDEs) Tributyltin
T-107 CKD	Unknown white material, potential cement kiln	Boat	Vertical face/ hand tools	5	
SeaTac Marine	Shipyard, industrial activity	Boat	Vertical face/ hand tools	6	
Boyer -Trotsky Street End	Industrial activity	Land - street end	Hand auger	4	
Seattle Iron & Metals	Industrial activity, brick and debris	Boat	Vertical face/ hand tools	4	
PS Truck Lines	Former Seattle concrete, white/grey material	Boat	Vertical face/ hand tools	21	
South Park Street End	High public use area	Land - street end	Push probe	6	
Sea King Industrial	Dumping, industrial activity	Boat	Hand auger	6	
Hamm Creek	Transfer station, dredge spoils	Boat	Hand auger	3	

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Table 3 - Storage Temperatures and Maximum Holding Times for Physical/Chemical Analysis

Sample Type	Sample Container	Sample Preservation Technique	Maximum Holding Time
Total solids	Included in metals or organics container	Cool, < 6°C Freeze, -18°C	14 days 6 months
Total organic carbon	Included in organics container	Cool, < 6°C Freeze, -18°C	14 days 6 months
Gasoline-range petroleum hydrocarbons	Soil – 2-40 mL VOC vials preweighed each with 5 grams of soil Sediment – 1-2 oz VOA jar	Methanol; Cool, < 6°C Minimize headspace; Cool to < 6°C	14 days 7 days
Diesel and heavy oil-range petroleum hydrocarbons	1-4 oz wide mouth glass jar	Cool to < 6°C	14 days
Metals (except mercury)	1-4 oz wide mouth glass jar	Cool, < 6°C Freeze, -18°C	6 months 2 years
Mercury	Included in metals container	Freeze, -18°C	28 days
Tributyltin - after extraction	1-8 oz wide mouth glass jar	Cool, < 6°C Freeze, -18°C Cool, < 6°C	14 days 1 year 40 days
Semivolatile organic compounds; pesticides; PCBs; PBDEs; PCDDs/PCDFs - after extraction	1-16 oz wide mouth glass jar	Cool, < 6°C Freeze, -18°C Cool, < 6°C	14 days 1 year 40 days

Note:
PCB - polychlorinated biphenyl
PCDD - polychlorinated dibenzo-p-dioxin
PCDF - polychlorinated dibenzofuran
PBDE – polybrominated diphenylether

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Table 4 - Sample Preparation, Analytical Methods, and Quantitation Limits

Parameter	Prep Method	Analysis Method	Practical Quantitation Limits[a]	SQS Criteria	Vadose Zone Soil Protective of SQS[b]	Saturated Zone Soil Protective of SQS[b]	Most Stringent Soil Standard to Protect Potable Ground Waters[c]
CONVENTIONALS:							
Total Solids in %	---	PSEP	0.1% (wet weight)				
Total Organic Carbon in %	---	EPA 9060/Ecology	0.0				
PETROLEUM HYDROCARBONS			**mg/kg (dry weight)**				**mg/L**
Gasoline-range hydrocarbons	NWTPH-Gx	NWTPH-Gx	5.0				30/100[d]
Diesel-range hydrocarbons	NWTPH-Dx	NWTPH-Dx	5.0				200
Heavy oil-range hydrocarbons	NWTPH-Dx	NWTPH-Dx	5.0				2000
METALS			**mg/kg (dry weight)**				**ug/L**
Arsenic	PSEP/ EPA 3050B	EPA 6010B	5.0	57			1.58E-04
Cadmium	PSEP/ EPA 3050B	EPA 6010B	0.2	5.1	26	1.3	0.001
Chromium	PSEP/ EPA 3050B	EPA 6010B	0.5	260	5201	260	42
Copper	PSEP/ EPA 3050B	EPA 6010B	0.2	390	780	39	0.053
Lead	PSEP/ EPA 3050B	EPA 6010B	2.0	450	1133	57	5.4
Mercury	EPA 7471A	EPA 7471A	0.05	0.41	0.41	0.02	2.70E-04
Silver	PSEP/ EPA 3050B	EPA 6010B	0.3	6.1	12	0.61	0.013
Zinc	PSEP/ EPA 3050B	EPA 6010B	0.6	410	327	16	2.029
ORGANOMETALLICS			**ug/kg (dry weight)**				
Tributyltin (ion)	PSEP (Krone)	PSEP (Krone)	4				
SEMIVOLATILE ORGANICS (SVOC)			**ug/kg (dry weight)**				**ug/kg**
LPAH							
Naphthalene	EPA 3540C	EPA 8270D-SIM	5	2,100	2197	114	0.47
Acenaphthylene	EPA 3540C	EPA 8270D-SIM	5	1,300	1363	69	69.09
Acenaphthene	EPA 3540C	EPA 8270D-SIM	5	500	330	17	16.75
Fluorene	EPA 3540C	EPA 8270D-SIM	5	540	468	24	23.56
Phenanthrene	EPA 3540C	EPA 8270D-SIM	5	1,500	2019	101	101.38
Anthracene	EPA 3540C	EPA 8270D-SIM	5	960	4443	223	223.09
2-Methylnaphthalene	EPA 3540C	EPA 8270D-SIM	5	670	833	43	43.21
Total LPAH	EPA 3540C	EPA 8270D-SIM		5,200			
HPAH							
Fluoranthene	EPA 3540C	EPA 8270D-SIM	5	1,700	3209	161	160.53
Pyrene	EPA 3540C	EPA 8270D-SIM	5	2,600	20058	1004	684.43
Benzo(a)anthracene	EPA 3540C	EPA 8270D-SIM	5	1,300	2201	110	0.00
Chrysene	EPA 3540C	EPA 8270D-SIM	5	1,400	2202	110	0.27
Benzofluoranthenes (b,k, j)	EPA 3540C	EPA 8270D-SIM	5	3,200			0.042
Benzo(a)pyrene	EPA 3540C	EPA 8270D-SIM	5	1,600	1981	99	0.01
Indeno(1,2,3-c,d)pyrene	EPA 3540C	EPA 8270D-SIM	5	600	680	34	0.06
Dibenzo(a,h)anthracene	EPA 3540C	EPA 8270D-SIM	5	230	240	12	0.07
Benzo(g,h,i)perylene	EPA 3540C	EPA 8270D-SIM	5	670	620	31	31.00
Benzo(b)fluoranthene	EPA 3540C	EPA 8270D-SIM	5		4601	230	0.04
Benzo(k)fluoranthene	EPA 3540C	EPA 8270D-SIM	5		4601	230	0.04
Total HPAH	EPA 3540C	EPA 8270D-SIM		12,000			
CHLORINATED HYDROCARBONS							
1,3-Dichlorobenzene	EPA 3540C	EPA 8270D	20				275.20
1,4-Dichlorobenzene	EPA 3540C	EPA 8270D	20	110	92.0	5.1	0.41
1,2-Dichlorobenzene	EPA 3540C	EPA 8270D	20	35	67.6	3.8	3.79
1,2,4-Trichlorobenzene	EPA 3540C	EPA 8270D	20	31			0.40
PHTHALATES							
Dimethyl phthalate	EPA 3540C	EPA 8270D	20	71	1631	94	40.95
Diethyl phthalate	EPA 3540C	EPA 8270D	20	200	3157	200	199.78
Di-n-butyl phthalate	EPA 3540C	EPA 8270D	20	1,400	5003	263	81.36
Butyl benzyl phthalate	EPA 3540C	EPA 8270D	20	63	100	5.1	3.95
Bis(2-ethylhexyl)phthalate	EPA 3540C	EPA 8270D	20	1,300	941	47	47.08
Di-n-octyl phthalate	EPA 3540C	EPA 8270D	20	6,200	1161	58	0.55
ACID EXTRACTABLES							
Phenol	EPA 3540C	EPA 8270D	20	420	733	43	23.88
2 Methylphenol	EPA 3540C	EPA 8270D	20	63	91	5.2	2.69
4 Methylphenol	EPA 3540C	EPA 8270D	20	670	979	56	22.13
2,4-Dimethylphenol	EPA 3540C	EPA 8270D	20	29	37	2.0	2.03
2,4,6-Trichlorophenol	EPA 3540C	EPA 8270D	100				0.82
Pentachlorophenol	EPA 3540C	EPA 8270D	100	360	381	20	2.56
Benzyl alcohol	EPA 3540C	EPA 8270D	100	57	785	55	55.02
Benzoic acid	EPA 3540C	EPA 8270D	200	650	9622	675	644.32
MISCELLANEOUS EXTRACTABLES							
Dibenzofuran	EPA 3540C	EPA 8270D	20	540			15.37
N-Nitrosodiphenylamine	EPA 3540C	EPA 8270D	20	28			9.54
PCBs			**ug/kg (dry weight)**				**ug/kg**
Aroclor 1016	EPA 3540C	EPA 8082	4		242	12	1.77
Aroclor 1221	EPA 3540C	EPA 8082	4				0.24
Aroclor 1232	EPA 3540C	EPA 8082	4				120.00
Aroclor 1242	EPA 3540C	EPA 8082	4				0.02
Aroclor 1248	EPA 3540C	EPA 8082	4		241	12	1.02
Aroclor 1254	EPA 3540C	EPA 8082	4		241	12	0.42
Aroclor 1260	EPA 3540C	EPA 8082	4		240	12	4.77
Aroclor 1262	EPA 3540C	EPA 8082	4				
Aroclor 1268	EPA 3540C	EPA 8082	4				
Total PCBs	EPA 3540C	EPA 8082	4	130	241	12	0.71
PDBEs			**ug/kg (dry weight)**				**ug/kg**
2,2',4-Tribromodiphenyl ether (PBDE-17)	EPA 3540C	EPA 8082	0.5				
2,4,4'-Tribromodiphenyl ether (PBDE-28)	EPA 3540C	EPA 8082	0.5				
2,3',4',6-Tetrabromodiphenyl ether (PBDE-71)	EPA 3540C	EPA 8082	0.5				
2,2',4,4'-Tetrabromodiphenyl ether (PBDE-47)	EPA 3540C	EPA 8082	0.5				
2,3',4,4'-Tetrabromodiphenyl ether (PBDE-66)	EPA 3540C	EPA 8082	0.5				
2,2',4,4',6-Pentabromodiphenyl ether (PBDE-100)	EPA 3540C	EPA 8082	0.5				
2,2',4,4',5-Pentabromodiphenyl ether (PBDE-99)	EPA 3540C	EPA 8082	0.5				
2,2,3,4,4-Pentabromodiphenyl ether (PBDE-85)	EPA 3540C	EPA 8082	0.5				
2,2',3,4,4',5'-Hexabromodiphenyl ether (PBDE-138)	EPA 3540C	EPA 8082	0.5				
2,2',4,4',5,6'-Hexabromodiphenyl ether (PBDE-154)	EPA 3540C	EPA 8082	0.5				
2,2',4,4',5,5'-Hexabromodiphenyl ether (PBDE-153)	EPA 3540C	EPA 8082	0.5				
2,2',3,4,4',5',6-Heptabromodiphenyl ether (PBDE-183)	EPA 3540C	EPA 8082	0.5				

Table 4 - Sample Preparation, Analytical Methods, and Quantitation Limits

Parameter	Prep Method	Analysis Method	Practical Quantitation Limits[a]	SQS Criteria	Vadose Zone Soil Protective of SQS[b]	Saturated Zone Soil Protective of SQS[b]	Most Stringent Soil Standard to Protect Potable Ground Waters[c]
CHLORINATED DIOXIN/FURAN CONGENERS			**ng/kg (dry weight)**				**ng/kg**
1,2,3,4,6,7,8-HpCDD	EPA 1613B	EPA 1613B	1				
1,2,3,4,6,7,8-HpCDF	EPA 1613B	EPA 1613B	5				
1,2,3,4,7,8,9-HpCDF	EPA 1613B	EPA 1613B	5				
1,2,3,4,7,8-HxCDD	EPA 1613B	EPA 1613B	5				
1,2,3,4,7,8-HxCDF	EPA 1613B	EPA 1613B	5				
1,2,3,6,7,8-HxCDD	EPA 1613B	EPA 1613B	5				
1,2,3,6,7,8-HxCDF	EPA 1613B	EPA 1613B	10				
1,2,3,7,8,9-HxCDD	EPA 1613B	EPA 1613B	1				
1,2,3,7,8,9-HxCDF	EPA 1613B	EPA 1613B	5				
1,2,3,7,8-PeCDD	EPA 1613B	EPA 1613B	5				
1,2,3,7,8-PeCDF	EPA 1613B	EPA 1613B	5				
2,3,4,6,7,8-HxCDF	EPA 1613B	EPA 1613B	5				
2,3,4,7,8-PeCDF	EPA 1613B	EPA 1613B	5				
2,3,7,8-TCDD	EPA 1613B	EPA 1613B	5				3.02E-05
2,3,7,8-TCDF	EPA 1613B	EPA 1613B	5				
OCDD	EPA 1613B	EPA 1613B	5				
OCDF	EPA 1613B	EPA 1613B	10				
PESTICIDES							
Hexachlorobenzene (HCB)	EPA 3540C	EPA 8081	1	22	8.1	0.4	0.24
Hexachlorobutadiene	EPA 3540C	EPA 8081	1	11	97	5.0	1281.15
Aldrin	EPA 3540C	EPA 8081	1				0.61
alpha-BHC (Benzene HexaChloride)	EPA 3540C	EPA 8081	1				2.47
beta-BHC	EPA 3540C	EPA 8081	1				10.23
gamma-BHC (Lindane)	EPA 3540C	EPA 8081	1				0.36
Chlordane	EPA 3540C	EPA 8081	1				10.32
4,4'-DDT	EPA 3540C	EPA 8081	1				36.74
4,4'-DDE	EPA 3540C	EPA 8081	1				4.70
4,4'-DDD	EPA 3540C	EPA 8081	1				3.54
Dieldrin	EPA 3540C	EPA 8081	1				0.34
alpha-Endosulfan	EPA 3540C	EPA 8081	1				20.24
beta-Endosulfan	EPA 3540C	EPA 8081	2				20.24
Endosulfan Sulfate	EPA 3540C	EPA 8081	2				20.24
Endrin	EPA 3540C	EPA 8081	2				22.20
Endrin Aldehyde	EPA 3540C	EPA 8081	2				22.20
Heptachlor	EPA 3540C	EPA 8081	1				0.19
Heptachlor Epoxide	EPA 3540C	EPA 8081	1				0.81
Toxaphene	EPA 3540C	EPA 8081	100				0.06

Notes:

a) default reporting limits may apply depending upon extraction methods

b) Soil screening levels protective of sediment provided by Ecology in Draft LDW Preliminary Screening Levels v12r7.xls on April 13, 2011

c) Most stringent soil standard to protect potable ground waters without potable surface water screenling levels provided by Ecology in Draft LDW Preliminary Screening Levels v12r7.xls on April 13,

d) 30mg/kg with benzene, 100mg/kg without benzene

Table 5 – Quality Control Procedures for Conventional Parameters

	Suggested Control Limits						
Analyte	**Initial Calibration**	**Continuing Calibration**	**Calibration Blanks**	**Laboratory Control Samples**	**Matrix Spikes**	**Laboratory Replicates**	**Method Blank**
Total organic carbon	Correlation coefficient ≥0.995	90 to 110 percent recovery	Analyte concentration ≤ PQL	80 to 120 percent recovery	75 to 125 percent recovery	20 % RSD	Analyte concentration ≤ PQL
Total solids	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	20 % RSD	Not applicable

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Table 6 – Quality Control Procedures, Criteria, and Corrective Actions for NWTPH-Gx Analysis

Gasoline-Range Hydrocarbons NWTPH-Gx			
Laboratory Quality Control			
Quality Control Check	**Frequency**	**Acceptance Criteria**	**Corrective Action**
Method blank	1 per batch of every 20 or fewer samples	All analytes < reporting limit	Re-extract and reanalyze associated samples unless concentrations are > 5 x blank level
Initial calibration	4-point external calibration prior to analysis of samples	%RSD < 25%	Recalibrate instrument
Continuing calibration	Every 10 samples with mid-range standard	% Difference < 20% of initial calibration	Recalibrate instrument and re-analyze affected samples
System monitoring compounds (surrogates)	Bromofluorobenzene; Every lab and field sample	Soil- 50 – 150% recovery	Evaluate data for useability
Laboratory duplicates	1 per batch of every 10 or fewer samples	None specified	Evaluate data for useability
Retention time windows	All samples and continuing calibration checks	±0.06 relative retention time units (sample and standard)	Reanalyze affected samples

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Table 7 – Quality Control Procedures, Criteria, and Corrective Actions for NWTPH-Dx Analysis

Hydrocarbons NWTPH-Dx			
Laboratory Quality Control			
Quality Control Check	**Frequency**	**Acceptance Criteria**	**Corrective Action**
Method blank	1 per batch of every 20 or fewer samples	All analytes < reporting limit	Re-extract and reanalyze associated samples unless concentrations are > 5 x blank level
Initial calibration	4-point external calibration prior to analysis of samples	%RSD < 25%	Recalibrate instrument
Continuing calibration	Every 10 samples with mid-range standard	% Difference < 20% of initial calibration	Recalibrate instrument and re-analyze affected samples
System monitoring compounds (surrogates)	o-Terphenyl; Every lab and field sample	Soil- 50 – 150% recovery	Evaluate data for useability
Laboratory duplicates	1 per batch of every 10 or fewer samples	None specified	Evaluate data for useability
Retention time windows	All samples and continuing calibration checks	±0.06 relative retention time units (sample and standard)	Reanalyze affected samples

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Table 8 - Quality Control Procedures for Metals Analysis

Quality Control Procedure	Frequency	Control Limit	Corrective Action
Instrument Quality Assurance/Quality Control			
Initial Calibration	Daily	Correlation coefficient ≥0.995	Laboratory to optimize and recalibrate the instrument and reanalyze any affected samples
Initial Calibration Verification	Immediately after initial calibration	90 to 110 % recovery for ICP-AES, ICP-MS, and GFAA (80 to 120 % for mercury), or performance-based intralaboratory control limits, whichever is lower	Laboratory to resolve discrepancy prior to sample analysis
Continuing Calibration Verification	After every 10 samples or every 2 hours, whichever is more frequent, and after the last sample	90 to 110 % recovery for ICP-AES and GFAA, 85 to 115 % for ICP-MS (80 to 120 % for mercury)	Laboratory to recalibrate and reanalyze affected samples
Initial and Continuing Calibration Blanks	Immediately after initial calibration, then 10 percent of samples or every 2 hours, whichever is more frequent, and after the last sample	Analyte concentration < PQL	Laboratory to recalibrate and reanalyze affected samples
ICP Interelement Interference Check Samples	At the beginning and end of each analytical sequence or twice per 8 hour shift, whichever is more frequent	80 to 120 percent of the true value	Laboratory to correct problem, recalibrate, and reanalyze affected samples
Method Quality Assurance/Quality Control			
Holding Times	Not applicable	See Table 3	Qualify data or collect fresh samples
Detection Limits	Not applicable	See Table 4	Laboratory must initiate corrective actions and contact the QA/QC coordinator and/or the project manager immediately
Method Blanks	One per sample batch or every 20 samples, whichever is more frequent	Analyte concentration ≤ PQL	Laboratory to redigest and reanalyze samples with analyte concentrations < 10 times the highest method blank
Analytical (Laboratory) Replicates and Matrix Spike Duplicates	One duplicate analysis with every sample batch or every 20 samples, whichever is more frequent	RPD ≤ 35 % applied when the analyte concentration is > PQL	Laboratory to redigest and reanalyze samples if analytical problems suspected, or to qualify the data if sample homogeneity problems suspected and the project manager consulted

Table 8 - Quality Control Procedures for Metals Analysis

Quality Control Procedure	Frequency	Control Limit	Corrective Action
Matrix Spikes	One per sample batch or every 20 samples, whichever is more frequent	75 to 125 % recovery applied when the sample concentration is < 4 times the spiked concentration for a particular analyte	Laboratory may be able to correct or minimize problem; or qualify and accept data
Laboratory Control Samples, Certified or Standard Reference Material	Overall frequency of 5 percent of field samples	80 to 20 % recovery, or performance based intralaboratory control limits, whichever is lower	Laboratory to correct problem to verify the analysis can be performed in a clean matrix with acceptable precision and recovery; then reanalyze affected samples

Table 9 - Quality Control Procedures for Tributyltin Analysis

Quality Control Procedure	Frequency	Control Limit	Corrective Action
Instrument Quality Assurance/Quality Control			
Initial Calibration	As needed	Coefficient of determination ≥0.990	Laboratory to optimize and recalibrate the instrument and reanalyze any affected samples
Continuing Calibration Verification	At the beginning of every analytical sequence	RSD 20%	Laboratory to recalibrate and reanalyze affected samples
Method Quality Assurance/Quality Control			
Holding Times	Not applicable	See Table 3	Qualify data or collect fresh samples
Detection Limits	Not applicable	See Table 4	Laboratory must initiate corrective actions and contact the QA/QC coordinator and/or the project manager immediately
Method Blanks	One per sample batch or every 20 samples, whichever is more frequent	Analyte concentration ≤ PQL	Laboratory to redigest and reanalyze samples with analyte concentrations < 10 times the highest method blank
Analytical (Laboratory) Replicates and Matrix Spike Duplicates	One duplicate analysis with every sample batch or every 20 samples, whichever is more frequent	RPD ≤ 20 % applied when the analyte concentration is > PQL	Laboratory to redigest and reanalyze samples if analytical problems suspected, or to qualify the data if sample homogeneity problems suspected and the project manager consulted
Matrix Spikes	One per sample batch or every 20 samples, whichever is more frequent	75 to 125 % recovery applied when the sample concentration is < 4 times the spiked concentration for a particular analyte	Laboratory may be able to correct or minimize problem; or qualify and accept data
Surrogate Spikes	All samples	Performance based intralaboratory control limits	Re-extract and reanalyze sample unless interferences are present
Laboratory Control Samples, Certified or Standard Reference Material	Overall frequency of 5 percent of field samples	80 to 20 % recovery, or performance based intralaboratory control limits, whichever is lower	Laboratory to correct problem to verify the analysis can be performed in a clean matrix with acceptable precision and recovery; then reanalyze affected samples

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Table 10 – Quality Control Procedures for Semivolatile Organic Compound Analysis

Quality Control Procedure	Frequency	Control Limit	Corrective Action
Instrument Quality Assurance/Quality Control			
Instrument Tuning	Prior to initial calibration and every 12 hours	See Method 8270D: Sections 11.3.1 and 11.4.1 and Table 3	Retune and recalibrate instrument
Initial Calibration	See Method 8270D: Sections 11.3	< 20% relative percent difference	Laboratory to recalibrate and reanalyze affected samples
Continuing Calibration	Every 12 hours	See Method 8270D: Sections 11.4 < 20% percent difference	Laboratory to recalibrate if correlation coefficient or response factor does not meet method requirements
Method Quality Assurance/Quality Control			
Holding Times	Not applicable	See Table 3	Qualify data or collect fresh samples in cases of extreme holding time or temperature exceedance
Detection Limits	Annually	See Table 4	Laboratory must initiate corrective actions (which may include additional cleanup steps as well as other measures, see Table 3) and contact the QA/QC coordinator and/or project manager immediately.
Method Blanks	One per sample batch or every 20 samples, whichever is more frequent, or when there is a change in reagents	Analyte concentration < PQL	Laboratory to eliminate or greatly reduce laboratory contamination due to glassware or reagents or analytical system; reanalyze affected samples
Analytical (Laboratory) Replicates and Matrix Spike Duplicates	One duplicate analysis with every sample batch or every 20 samples, whichever is more frequent; Use analytical replicates when samples are expected to contain target analytes. Use matrix spike duplicates when samples are not expected to contain target analytes	Compound- and matrix-specific RPD ≤ 35 % applied when the analyte concentration is > PQL	Laboratory to redigest and reanalyze samples if analytical problems suspected, or to qualify the data if sample homogeneity problems suspected and the project manager consulted
Matrix Spikes	One per sample batch or every 20 samples, whichever is more frequent; spiked with the same analytes at the same concentration as the LCS	Performance based intralaboratory control limits	Matrix interferences should be assessed and explained in case narrative accompanying the data package.
Surrogate Spikes	Added to every organics sample as specified in analytical protocol	Performance based intralaboratory control limits	Follow corrective actions specified in Method 8270.
Laboratory Control Samples (LCS), Certified or Standard Reference Material	One per analytical batch or every 20 samples, whichever is more frequent	Compound-specific, recovery and relative standard deviation for repeated analyses should not exceed the control limits specified in the method or performance-based intralaboratory control limits, whichever is lower	Laboratory to correct problem to verify the analysis can be performed in a clean matrix with acceptable precision and recovery; then reanalyze affected samples

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Table 11 – Quality Control Procedures for PCB Analysis

Quality Control Procedure	Frequency	Control Limit	Corrective Action
Instrument Quality Assurance/Quality Control			
Initial Calibration	See Method 8082, Section 11.4	See Method 8082, Section 11.4	Laboratory to recalibrate and reanalyze affected samples
Continuing Calibration	Every 12 hours or every 20 samples See Method 8082, Section 11.6.2	+ 20 % difference See Method 8082, Section 11.6.2	Laboratory to recalibrate if correlation coefficient or response factor does not meet method requirements
Method Quality Assurance/Quality Control			
Holding Times	Not applicable	See Table 3	Qualify data or collect fresh samples in cases of extreme holding time or temperature exceedance
Detection Limits	Annually	See Table 4	Laboratory must initiate corrective actions (which may include additional cleanup steps as well as other measures, see Table 3) and contact the QA/QC coordinator and/or project manager immediately.
Method Blanks	One per sample batch or every 20 samples, whichever is more frequent, or when there is a change in reagents	Analyte concentration < PQL	Laboratory to eliminate or greatly reduce laboratory contamination due to glassware or reagents or analytical system; reanalyze affected samples
Analytical (Laboratory) Replicates and Matrix Spike Duplicates	One duplicate analysis with every sample batch or every 20 samples, whichever is more frequent; Use analytical replicates when samples are expected to contain target analytes. Use matrix spike duplicates when samples are not expected to contain target analytes	Compound- and matrix-specific RPD ≤ 35 % applied when the analyte concentration is > PQL	Laboratory to redigest and reanalyze samples if analytical problems suspected, or to qualify the data if sample homogeneity problems suspected and the project manager consulted
Matrix Spikes	One per sample batch or every 20 samples, whichever is more frequent; spiked with the same analytes at the same concentration as the LCS	Compound- and matrix-specific	Matrix interferences should be assessed and explained in case narrative accompanying the data package.
Surrogate Spikes	Added to every organics sample as specified in analytical protocol; See Method 8082, Section 7.10	Tetrachloro-m-xykene recovery - 30 to 150% Decachlorobiphenyl recovery - 30 to 150%	Re-extract and reanalyze sample unless interferences are present
Laboratory Control Samples (LCS), Certified or Standard Reference Material	One per analytical batch or every 20 samples, whichever is more frequent	Compound-specific, recovery and relative standard deviation for repeated analyses should not exceed the control limits specified in the method or performance-based intralaboratory control limits, whichever is lower	Laboratory to correct problem to verify the analysis can be performed in a clean matrix with acceptable precision and recovery; then reanalyze affected samples

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Table 12 – Quality Control Procedures for Chlorinated Pesticide Analysis

Quality Control Procedure	Frequency	Control Limit	Corrective Action
Instrument Quality Assurance/Quality Control			
Initial Calibration	See Method 8081, Section 11.4	< 20% relative standard deviation See Method 8081, Section 11.4	Laboratory to recalibrate and reanalyze affected samples
Continuing Calibration	Every 12 hours or every 20 samples See Method 8081, Section 11.5	+ 20 % difference See Method 8081, Section 11.5	Laboratory to recalibrate if correlation coefficient or response factor does not meet method requirements
DDT/Endrin Breakdown	Prior to analysis and every 12 hours	< 15% breakdown	Clean injector and recalibrate instrument
Analyte confirmation	Second, disimilar GC column confirmation for all detected analytes	Concentration percent difference < 15%	Qualify data
Method Quality Assurance/Quality Control			
Holding Times	Not applicable	See Table 3	Qualify data or collect fresh samples in cases of extreme holding time or temperature exceedance
Detection Limits	Annually	See Table 4	Laboratory must initiate corrective actions (which may include additional cleanup steps as well as other measures, see Table 3) and contact the QA/QC coordinator and/or project manager immediately.
Method Blanks	One per sample batch or every 20 samples, whichever is more frequent, or when there is a change in reagents	Analyte concentration < PQL	Laboratory to eliminate or greatly reduce laboratory contamination due to glassware or reagents or analytical system; reanalyze affected samples
Analytical (Laboratory) Replicates and Matrix Spike Duplicates	One duplicate analysis with every sample batch or every 20 samples, whichever is more frequent; Use analytical replicates when samples are expected to contain target analytes. Use matrix spike duplicates when samples are not expected to contain target analytes	Compound- and matrix-specific RPD ≤ 35 % applied when the analyte concentration is > PQL	Laboratory to redigest and reanalyze samples if analytical problems suspected, or to qualify the data if sample homogeneity problems suspected and the project manager consulted
Matrix Spikes	One per sample batch or every 20 samples, whichever is more frequent; spiked with the same analytes at the same concentration as the LCS	Compound- and matrix-specific	Matrix interferences should be assessed and explained in case narrative accompanying the data package.
Surrogate Spikes	Added to every organics sample as specified in analytical protocol; See Method 8081, Section 7.10	Tetrachloro-m-xykene recovery - 30 to 150% Decachlorobiphenyl recovery - 30 to 150%	Re-extract and reanalyze sample unless interferences are present

Table 12 – Quality Control Procedures for Chlorinated Pesticide Analysis

Quality Control Procedure	Frequency	Control Limit	Corrective Action
Laboratory Control Samples (LCS), Certified or Standard Reference Material	One per analytical batch or every 20 samples, whichever is more frequent	Compound-specific, recovery and relative standard deviation for repeated analyses should not exceed the control limits specified in the method or performance-based intralaboratory control limits, whichever is lower	Laboratory to correct problem to verify the analysis can be performed in a clean matrix with acceptable precision and recovery; then reanalyze affected samples

Table 13 – Quality Control Procedures for Polybrominated Diphenyl Ether Analysis

Quality Control Procedure	Frequency	Control Limit	Corrective Action
Instrument Quality Assurance/Quality Control			
Initial Calibration	See Method 8082, Section 11.4	See Method 8082, Section 11.4	Laboratory to recalibrate and reanalyze affected samples
Continuing Calibration	Every 12 hours or every 20 samples See Method 8082, Section 11.6.2	+ 20 % difference See Method 8082, Section 11.6.2	Laboratory to recalibrate if correlation coefficient or response factor does not meet method requirements
Method Quality Assurance/Quality Control			
Holding Times	Not applicable	See Table 3	Qualify data or collect fresh samples in cases of extreme holding time or temperature exceedance
Detection Limits	Annually	See Table 4	Laboratory must initiate corrective actions (which may include additional cleanup steps as well as other measures, see Table 3) and contact the QA/QC coordinator and/or project manager immediately.
Method Blanks	One per sample batch or every 20 samples, whichever is more frequent, or when there is a change in reagents	Analyte concentration < PQL	Laboratory to eliminate or greatly reduce laboratory contamination due to glassware or reagents or analytical system; reanalyze affected samples
Analytical (Laboratory) Replicates and Matrix Spike Duplicates	One duplicate analysis with every sample batch or every 20 samples, whichever is more frequent; Use analytical replicates when samples are expected to contain target analytes. Use matrix spike duplicates when samples are not expected to contain target analytes	Compound- and matrix-specific RPD ≤ 35 % applied when the analyte concentration is > PQL	Laboratory to redigest and reanalyze samples if analytical problems suspected, or to qualify the data if sample homogeneity problems suspected and the project manager consulted
Matrix Spikes	One per sample batch or every 20 samples, whichever is more frequent; spiked with the same analytes at the same concentration as the LCS	Compound- and matrix-specific	Matrix interferences should be assessed and explained in case narrative accompanying the data package.
Surrogate Spikes	Added to every organics sample as specified in analytical protocol; See Method 8082, Section 7.10	Tetrachloro-m-xykene recovery - 30 to 150% Decachlorobipheyl recovery - 30 to 150%	Re-extract and reanalyze sample unless interferences are present
Laboratory Control Samples (LCS), Certified or Standard Reference Material	One per analytical batch or every 20 samples, whichever is more frequent	Compound-specific, recovery and relative standard deviation for repeated analyses should not exceed the control limits specified in the method or performance-based intralaboratory control limits, whichever is lower	Laboratory to correct problem to verify the analysis can be performed in a clean matrix with acceptable precision and recovery; then reanalyze affected samples

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Table 14 – Quality Control Procedures for Polychlorinated Dioxins/Furans Analysis

Quality Control Procedure	Frequency	Control Limit	Corrective Action
Instrument Quality Assurance/Quality Control			
Initial Calibration	See Method 1613B, Section 10	See Method 1613B, Section 10 and Table 4	Laboratory to recalibrate and reanalyze affected samples
Continuing Calibration	Every 12 hours See Method 1613B, Section 15	See Method 1613B: Section 15 and Tables 4, 5, and 6	Laboratory to recalibrate if method requirements not met
Method Quality Assurance/Quality Control			
Holding Times	Not applicable	See Table 3	Qualify data or collect fresh samples in cases of extreme holding time or temperature exceedance
Detection Limits	Annually	See Table 4	Laboratory must initiate corrective actions (which may include additional cleanup steps as well as other measures, see Table 3) and contact the QA/QC coordinator and/or project manager immediately.
Method Blanks	One per sample batch or every 20 samples, whichever is more frequent, or when there is a change in reagents	Analyte concentration < PQL	Laboratory to eliminate or greatly reduce laboratory contamination due to glassware or reagents or analytical system; reanalyze affected samples
Analytical (Laboratory) Replicate	One duplicate analysis with every sample batch or every 20 samples, whichever is more frequent	Compound- and matrix-specific RPD ≤ 35 % applied when the analyte concentration is > PQL	Laboratory to redigest and reanalyze samples if analytical problems suspected, or to qualify the data if sample homogeneity problems suspected and the project manager consulted
Surrogate Spikes	Added to every organics sample as specified in analytical protocol	See Method 1613B Table 3	Follow corrective actions specified in Method 1613B .
Laboratory Control Samples (LCS), Certified or Standard Reference Material	One per analytical batch or every 20 samples, whichever is more frequent	Compound-specific, recovery and relative standard deviation for repeated analyses should not exceed the control limits specified in the method or performance-based intralaboratory control limits, whichever is lower	Laboratory to correct problem to verify the analysis can be performed in a clean matrix with acceptable precision and recovery; then reanalyze affected samples

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Source: Base map prepared from DeLorme Topo 7.0, 2007.

Lower Duwamish Waterway
Seattle, Washington

Vicinity Map

17330-32 5/11

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Figure
1

EAL 05/9/11 173303205-001.dwg

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Source: Base map prepared from Google Earth Pro, 2010.

0 2500 5000

Scale in Feet

N

Lower Duwamish Waterway
Seattle, Washington

Lower Duwamish Waterway Bank Sampling Sites

17330-32 5/11

HARTCROWSER

Figure
2

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Source: Base map prepared from Google Earth Pro, 2010.

⊕ Proposed Bank Sample Location

Previous Investigation Sample Location and Number

LDW-SS503-G ● Dioxin/Furan Composite Subsample (Windward 2010b)

LDW-SSC1 ◑ Surface Sediment (Windward 2010a)

LDW-SC5 ▲ Subsurface Sediment (Windward 2010a)

SP-71 ○ Seep (Windward 2010a)

0 100 200

Scale in Feet

N

Lower Duwamish Waterway
Seattle, Washington

Riverside Marina Bank Sampling Site Plan

17330-32 5/11

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Figure **3**

EAL 05/9/11 173303205-002.dwg

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Source: Base map prepared from Google Earth Pro, 2010.

⊕ Proposed Bank Sample Location

Previous Investigation Sample Location and Number

LDW-SS29 ◑ Surface Sediment (Windward 2010a)

0 150 300

Scale in Feet

N

Lower Duwamish Waterway
Seattle, Washington

T-107 CKD Bank Sampling Site Plan

17330-32 5/11

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Figure
4

EAL 05/9/11 173303205-003.dwg

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Source: Base map prepared from Google Earth Pro, 2010.

⊕ Proposed Bank Sample Location*

Previous Investigation Sample Location and Number

LDW-SSC1 ◑ Surface Sediment (Windward 2010a)

LDW-SC37 ◭ Subsurface Sediment (Windward 2010a)

Property Line

0 100 200

Scale in Feet

N

* Samples will be collected at two elevations at each location for a total of six samples.

Lower Duwamish Waterway
Seattle, Washington

SeaTac Marine Bank Sampling Site Plan

17330-32 5/11

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Figure
5

EAL 05/9/11 173303205-004.dwg

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Source: Base map prepared from Google Earth Pro, 2010.

⊕ Proposed Bank Sample Location

Previous Investigation Sample Location and Number

LDW-SS85 ◑ Surface Sediment (Windward 2010a)

0 100 200

Scale in Feet

N

Lower Duwamish Waterway
Seattle, Washington

Boyer-Trotsky Street End Bank Sampling Site Plan

17330-32 5/11

HARTCROWSER

Figure 6

EAL 05/9/11 173303205-005.dwg

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Source: Base map prepared from Google Earth Pro, 2010.

⊕ Proposed Bank Sample Location

Previous Investigation Sample Location and Number

LDW-SS333 ◑ Surface Sediment (Windward 2010a)

0 60 120

Scale in Feet

N

Lower Duwamish Waterway
Seattle, Washington

Seattle Iron & Metal Bank Sampling Site Plan

17330-32 5/11

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Figure
7

EAL 05/9/11 173303205-006.dwg

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Source: Base map prepared from Google Earth Pro, 2010.

⊕ Proposed Bank Sample Location*

Previous Investigation Sample Location and Number

LDW-SS333 ◑ Surface Sediment (Windward 2010a)

Property Line

0 120 240

Scale in Feet

N

* Samples will be collected at three elevations to evaluate the varying materials.

Lower Duwamish Waterway
Seattle, Washington

Puget Sound Truck Lines
Bank Sampling Site Plan

17330-32 5/11

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Figure
8

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Source: Base map prepared from Google Earth Pro, 2010.

⊕ Proposed Bank Sample Location

Previous Investigation Sample Location and Number

WST332 ◑ Surface Sediment (Windward 2010a)

SB-5 ▲ Subsurface Sediment (Windward 2010a)

0 100 200

Scale in Feet

N

Lower Duwamish Waterway
Seattle, Washington

South Park Street End Bank Sampling Site Plan

17330-32 5/11

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Figure **9**

EAL 05/9/11 173303205-008.dwg

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Source: Base map prepared from Google Earth Pro, 2010.

⊕ Proposed Bank Sample Location

Previous Investigation Sample Location and Number

LDW-SSC1 ◑ Surface Sediment (Windward 2010a)

SP-41 ○ Seep (Windward 2010a)

0 100 200

Scale in Feet

N

Lower Duwamish Waterway
Seattle, Washington

Sea King Industrial Bank Sampling Site Plan

17330-32 5/11

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Figure
10

EAL 05/9/11 173303205-009.dwg

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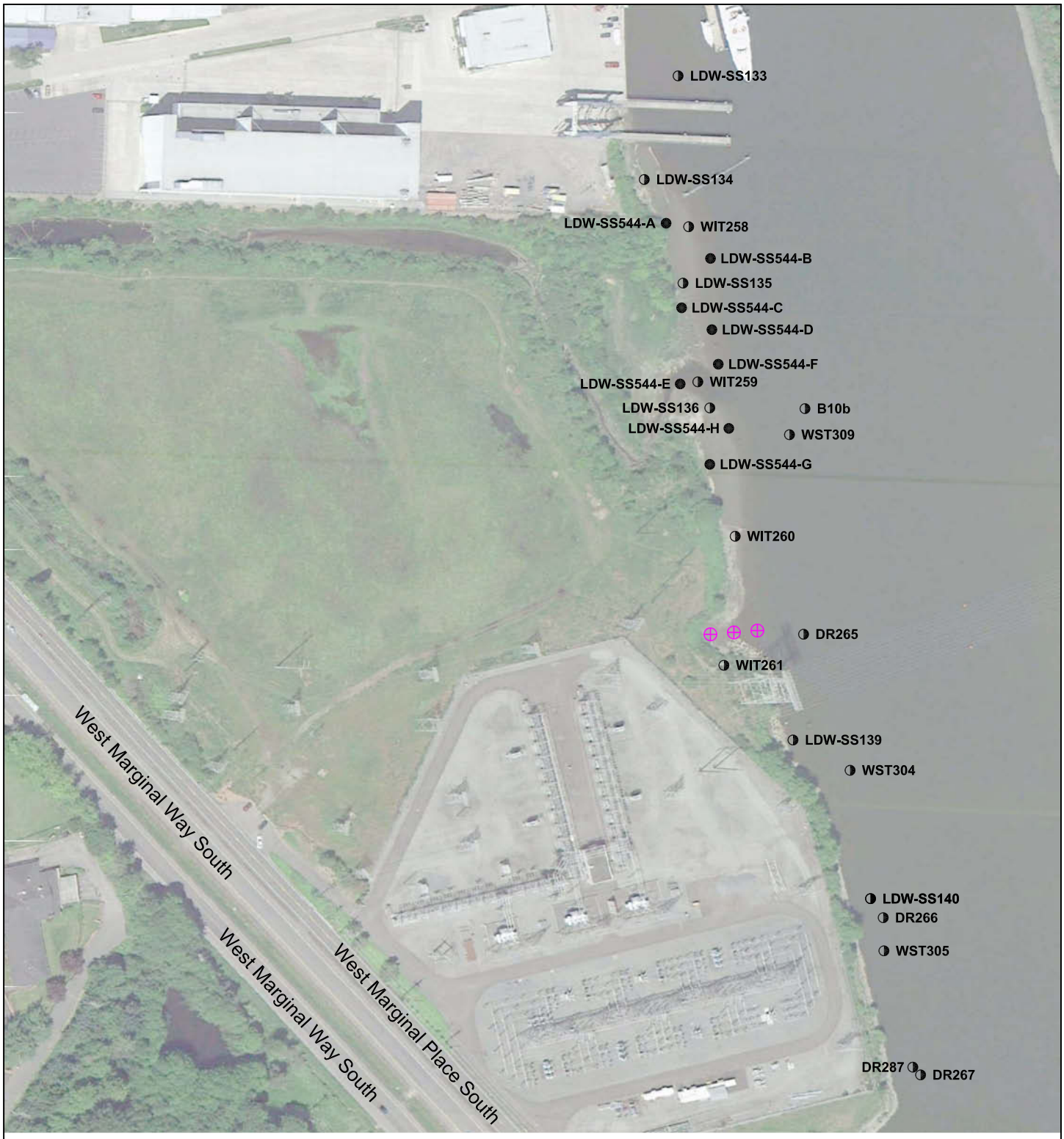

Source: Base map prepared from Google Earth Pro, 2010.

⊕ Proposed Bank Sample Location

Previous Investigation Sample Location and Number

LDW-SS544-B ● Dioxin/Furan Composite Subsample (Windward 2010b)

LDW-SS140 ◑ Surface Sediment (Windward 2010a)

0 200 400

Scale in Feet

N

Lower Duwamish Waterway
Seattle, Washington

Hamm Creek Bank Sampling Site Plan

17330-32 5/11

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Figure **11**

EAL 05/9/11 173303205-010.dwg

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