Lower Duwamish Waterway Group

Port of Seattle / City of Seattle / King County / The Boeing Company

QUALITY ASSURANCE PROJECT PLAN: SURFACE SEDIMENT CHEMICAL ANALYSES AND TOXICITY TESTING OF THE LOWER DUWAMISH WATERWAY

APPENDICES A-G

FINAL

For submittal to

The US Environmental Protection Agency
Region 10
Seattle, WA

The Washington State Department of Ecology
Northwest Regional Office
Bellevue, WA

January 14, 2005

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APPENDIX A: HEALTH AND SAFETY PLAN

TITLE AND APPROVAL PAGE
LDW SURFACE SEDIMENT SAMPLING
HEALTH AND SAFETY PLAN

By their signature, the undersigned certify that this Health and Safety Plan (HSP) is approved and that it will be used to govern health and safety aspects of fieldwork described in the Quality Assurance Project Plan to which it is attached.

Name Project Manager	Date
Name Corporate Health and Safety Manager	Date
Name Field Coordinator/Health and Safety Officer	Date

Acronyms

ACRONYM	Definition
CPR	cardiopulmonary resuscitation
EPA	US Environmental Protection Agency
FC	Field Coordinator
HSM	Corporate Health and Safety Manager
HSO	Field Health and Safety Officer
HSP	health and safety plan
LDW	Lower Duwamish Waterway
OSHA	Occupational Safety and Health Administration
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PFD	personal flotation device
PM	Project Manager
PPE	personal protective equipment
SIM	selected ion monitoring
TBT	tributyltin

A.1.0 Introduction

This site-specific health and safety plan (HSP) describes safe working practices for conducting field activities at potentially hazardous sites and for handling potentially hazardous materials/waste products. This HSP covers elements as specified in 29CFR1910§120. The procedures and guidelines contained in this plan are based on generally recognized health and safety practices. Any changes or revisions to this plan will be made by a written amendment, which will become a permanent part of this plan. The goal of the HSP is to establish procedures for safe working practices for all field personnel.

This HSP addresses all activities associated with collection and handling of surface sediment samples in the Lower Duwamish Waterway (LDW) for the surface sediment chemistry and toxicity study. During site work, this HSP will be implemented by the Field Coordinator (FC), who is also the designated site Health and Safety Officer (HSO), in cooperation with the Corporate Health and Safety Manager (HSM) and the Project Manager.

All personnel involved in fieldwork on this project are required to comply with this HSP. The contents of this HSP reflect anticipation of the types of activities to be performed, knowledge of the physical characteristics of the site, and consideration of chemical data from previous investigations at the site. The HSP may be revised based on new information and/or changed conditions during site activities. Revisions will be documented in the project records.

Observers for the sampling event who are not field personnel will be given a safety briefing by the HSO on physical and chemical hazards. Agency observers, or their designees, will be advised of chemicals that may be present at the site and where those chemicals may be located. In addition, appropriate attire and any precautions necessary while walking along the shoreline will be discussed.

A.2.0 Site Description and Project Scope

A.2.1 SITE DESCRIPTION

The sampling area is in the LDW (see Figures 3-1a to 3-1e in the QAPP). The area is affected by tidal fluctuations. The QAPP to which this HSP is attached provides complete details of the sampling program. The following section summarizes the types of work that will be performed during field activities.

A.2.2 SCOPE OF WORK

Specific tasks to be performed are as follows:

- collection of surface sediment grab samples from a boat (subtidal or intertidal) or on foot (intertidal)

Additional details on the sampling design and sampling methods are provided in Sections 3.1 and 3.2, respectively.

A.3.0 Health and Safety Personnel

Key health and safety personnel and their responsibilities are described below. These individuals are responsible for implementation of this HSP.

Windward Project Manager: The Windward project manager (PM) has overall responsibility for the successful outcome of the project. The PM will ensure that adequate resources and budget are provided for the health and safety staff to carry out their responsibilities during fieldwork. The PM, in consultation with the HSM, makes final decisions concerning implementation of the HSP.

Field Coordinator/Health and Safety Officer: Because of the limited scope and duration of fieldwork, the FC and HSO will be the same person. The FC/HSO will direct field sampling activities, coordinate the technical components of the field program with health and safety components, and ensure that work is performed according to the QAPP.

The FC/HSO will implement this HSP at the work location and will be responsible for all health and safety activities and the delegation of duties to a health and safety technician in the field, if appropriate. The FC/HSO also has stop-work authority, to be used if there is an imminent safety hazard or potentially dangerous situation. The FC/HSO or his designee shall be present during sampling and operations.

Corporate Health and Safety Manager: The HSM has overall responsibility for preparation, approval, and revisions of this HSP. The HSM will not necessarily be present during fieldwork, but will be readily available, if required, for consultation regarding health and safety issues during fieldwork.

Field Crew: All field crew members must be familiar with and comply with the information in this HSP. They also have the responsibility to report any potentially unsafe or hazardous conditions to the FC/HSO immediately.

A.4.0 Hazard Evaluation and Control Measures

This section covers potential physical and chemical hazards that may be associated with the proposed project activities, and presents control measures for addressing these hazards. The activity hazard analysis, Section A.4.3, lists the potential hazards associated with each site activity and the recommended site control to be used to minimize each potential hazard.

Confined space entry will not be necessary for this project. Therefore, hazards associated with this activity are not discussed in this HSP.

A.4.1 PHYSICAL HAZARDS

For this project, it is anticipated that physical hazards will present a greater risk of injury than chemical hazards. Physical hazards are identified and discussed below.

A.4.1.1 Slips, trips, and falls

As with all field work, caution should be exercised to prevent slips on slick surfaces. In particular, sampling from a boat or other floating platform requires careful attention to minimize the risk of falling down or of falling overboard. The same care should be used in rainy conditions or on the shoreline where slick rocks are found. Slips can be minimized by wearing boots with good tread, made of material that does not become overly slippery when wet.

Trips are always a hazard on the uneven deck of a boat, in a cluttered work area, or in the intertidal zone where uneven substrate is common. Personnel will keep work areas as free as possible from items that interfere with walking.

Falls may be avoided by working as far from exposed edges as possible, by erecting railings, and by using fall protection when working on elevated platforms. For this project, no work is anticipated that would present a fall hazard.

A.4.1.2 Sampling equipment deployment

A grab sampler will be used to collect sediment samples from the boat. The sampler will be deployed from the stern of the boat by a winch. Care will be taken to ensure that the sampler is safely guided from the stern over the railing and into the water. Before sampling activities begin, there will be a training session for all field personnel for the equipment that will be onboard the sampling vessel.

At some locations in the intertidal, sampling will be conducted by hand using stainless steel spoons.

A.4.1.3 Falling overboard

Most of the sampling activities will be done from a boat. As with any work from a floating platform, there is a chance of falling overboard. Personal flotation devices (PFDs) will be worn while working on the boat.

A.4.1.4 Manual lifting

Equipment and samples must be lifted and carried. Back strain can result if lifting is done improperly. During any manual handling tasks, personnel should lift with the load supported by their legs and not their backs. For heavy loads, an adequate number of people will be used, or if possible, a mechanical lifting/handling device will be used.

A.4.1.5 Heat stress, hypothermia, or frostbite

Sampling operations and conditions that might result in the occurrence of heat stress are not anticipated. The sampling will occur during the time of year when cold weather conditions may occur, making hypothermia or frostbite a concern. The FC/HSO will monitor all crew members for early symptoms of hypothermia (e.g., shivering, muscle incoordination, mild confusion). If such symptoms are observed, the FC/HSO will take immediate steps to reduce heat loss by providing extra layers of clothing or by temporarily moving the affected crew member to a warmer environment.

A.4.1.6 Weather

In general, field team members will be equipped for the normal range of weather conditions. The FC/HSO will be aware of current weather conditions, and of the potential for those conditions to pose a hazard to the field crew. Some conditions that might force work stoppage are electrical storms, high winds, or high waves resulting from winds. In the event of heavy rain, field team members will not sample near a flowing combined sewer overflow because of potentially high levels of fecal coliform bacteria.

A.4.1.7 Sharp objects

Sampling operations might result in exposure of field personnel to sharp objects on top of or buried within the sediment. If encountered, field personnel should not touch these objects. Also, field personnel should not dig in the sediment by hand.

A.4.1.8 Night sampling

There is a possibility that field sampling operations could occur at night. The FC/HSO will be aware of the sampling time(s) for each sampling day and will inform all field personnel. If night sampling is necessary, the FC will ensure all field personnel have headlamps/flashlights to avoid potential hazards associated with working in low light conditions.

A.4.2 VESSEL HAZARDS

Because of the high volumes of vessel and barge traffic on the LDW, precautions and safe boating practices will be implemented to ensure that the field boat does not interrupt vessel traffic. Additional potential vessel emergency hazards and responses are listed in Table A-1.

Table A-1 Potential vessel emergency hazards and responses

POTENTIAL EMERGENCY HAZARD	RESPONSE
Fire or explosion	If manageable, attempt to put out a small fire with a fire extinguisher. Otherwise, call the Coast Guard or 911 and evacuate the area (by rescue boat or swimming) and meet at a designated area. The FC/HSO will take roll call to make sure everyone evacuated safely. Emergency meeting places will be determined in the field during the daily safety briefing.
Medical emergency/ personal injury	At least one person with current first aid and cardiopulmonary resuscitation (CPR) training will be aboard the vessel at all times. This person will attempt to assess the nature and severity of the injury, call 911 immediately, and apply CPR if necessary. Stop work and wait for medical personnel to arrive. Fill out a site accident report.
Person overboard	All persons aboard the sampling vessel will wear a PFD at all times. Have one person keep an eye on the person and shout the distance (boat lengths) and direction (o'clock) of the person from the vessel. Stop work and use the vessel to retrieve the person in the water.
Sinking vessel	Call the Coast Guard immediately. If possible, wait for a rescue boat to arrive to evacuate vessel personnel. See fire/explosion section for emergency evacuation procedures. The FC/HSO will take a roll call to make sure everyone is present.
Lack of visibility	If the navigation visibility or personal safety is compromised because of smoke, fog, or other unanticipated hazards, stop work immediately. The vessel operator and FC/HSO will assess the hazard and, if necessary, send out periodic horn blasts to mark vessel location to other vessels potentially in the area, move to a secure location (i.e., berth), and wait for the visibility to clear.
Loss of power	Stop work and call Coast Guard for assistance. Use oars to move vessel towards the shoreline. Vessel personnel should watch for potential collision hazards and notify vessel operator if hazards exist. Secure vessel to a berth, dock, or mooring as soon as possible.
Collision	Stop work and call Coast Guard for assistance. The FC/HSO and vessel operator will assess damage and potential hazards. If necessary, vessel will be evacuated and secured until repairs can be made.

A.4.3 CHEMICAL HAZARDS

Previous investigations have shown that some chemicals are present at higher-than-background concentrations in the sampling area. For the purposes of discussing potential exposure to chemicals in sediments, the chemicals of concern are metals, tributyltin (TBT), petroleum hydrocarbons, polycyclic aromatic hydrocarbons (PAHs), and polychlorinated biphenyls (PCBs).

A.4.3.1 Exposure routes

Potential routes of chemical exposure include inhalation, dermal contact, and ingestion. Exposure will be minimized by using safe work practices and by wearing the appropriate personal protective equipment (PPE). Further discussion of PPE requirements is presented in Section A.7.

Inhalation —Inhalation is not expected to be an important route of exposure.

Dermal exposure — Dermal exposure to hazardous substances associated with sediments, surface water, or equipment decontamination will be controlled by the use of PPE and by adherence to detailed sampling and decontamination procedures.

Ingestion — Ingestion is not considered a major route of exposure for this project. Accidental ingestion of surface water is possible. However, careful handling of equipment and containers aboard the boat should prevent the occurrence of water splashing or spilling during sample collection and handling activities.

A.4.3.2 Description of chemical hazards

Metals and tributyltin — Exposure to metals may occur via ingestion or skin contact. As mentioned above, neither is likely as an exposure route. Metal fumes or metal-contaminated dust will not be encountered during field and sample handling activities. Large amounts of sediment would need to be ingested for any detrimental effects to occur. Momentary skin contact allows little, if any, opportunity for passage of any of these metals into the body. Field procedures require immediate washing of sediments from exposed skin.

Petroleum hydrocarbons and PAHs — Exposure to petroleum hydrocarbons and PAHs may occur via ingestion or skin contact. The most important human health exposure pathway for this group of chemicals, inhalation, is not expected to occur at this site. Animal studies have also shown that PAHs can cause harmful effects on the skin, body fluids, and ability to fight disease after both short- and long-term exposure, but these effects have not been seen in people. Some PAHs may reasonably be expected to be carcinogens. Large amounts of sediment would need to be ingested for any detrimental effects to occur. Momentary skin contact allows little, if any, opportunity for passage of any of these compounds into the body. Field procedures require immediate washing of sediments from exposed skin.

PCBs — Prolonged skin contact with PCBs may cause acne-like symptoms known as chloracne. Irritation to eyes, nose, and throat may also occur. Acute and chronic exposure can damage the liver, and cause symptoms of edema, jaundice, anorexia, nausea, abdominal pains, and fatigue. PCBs are a suspected human carcinogen. Skin absorption may substantially contribute to the uptake of PCBs. Large amounts of sediment would need to be ingested for any detrimental effects to occur. Momentary skin contact allows little, if any, opportunity for passage of any of the compounds into the body. Field procedures require immediate washing of sediments from exposed skin.

A.4.4 ACTIVITY HAZARD ANALYSIS

The activity hazard analysis summarizes the field activities to be performed during the project, outlines the hazards associated with each activity, and presents controls that can reduce or eliminate the risk of the hazard occurring.

Table A-2 presents the activity hazard analysis for sediment sampling.

Table A-2. Activity hazard analysis

ACTIVITY	HAZARD	CONTROL
Sediment sampling from a boat	Falling overboard	Use care in boarding/departing from vessel. Deploy and recover the sampler from the back deck of the boat. Wear PFD.
	Skin contact with contaminated sediments or liquids	Wear modified Level D PPE.
	Back strain	Use appropriate lifting technique when deploying and retrieving heavy equipment, or seek help.
Sediment sampling by hand in intertidal zone	Skin contact with contaminated sediments or liquids	Wear modified Level D PPE.

A.5.0 Work Zones and Shipboard Access Control

During sampling and sample handling activities, work zones will be established to identify where sample collection and processing are actively occurring. The intent of the zone is to limit the migration of sample material out of the zone and to restrict access to active work areas by defining work zone boundaries.

A.5.1 WORK ZONE

The work zone on the boat or the beach will encompass the area where sample collection and handling activities are performed. Only persons with appropriate training, PPE, and authorization from the FC/HSO will be allowed to enter the work zone while work is in progress.

A.5.2 DECONTAMINATION STATION

A decontamination station will be set up, and personnel will clean soiled boots or PPE prior to leaving the work zone. The station will have the buckets, brushes, soapy water, rinse water, or wipes necessary to clean boots, PPE, or other equipment leaving the work zone. Plastic bags will be provided for expendable and disposable materials. If the location does not allow the establishment of a decontamination station, the FC/HSO will provide alternatives to prevent the spread of contamination.

Decontamination of the boat will also be completed at the end of each work day. Cockpit and crew areas will be rinsed down with LDW water to minimize accumulation of sediment.

A.5.3 ACCESS CONTROL

Security and control of access to the boat will be the responsibility of the FC/HSO and boat captain. Boat access will be granted only to necessary project personnel and authorized visitors. Any security or access control problems will be reported to the client or appropriate authorities.

A.6.0 Safe Work Practices

Following common sense rules will minimize the risk of exposure or accidents at a work site. These general safety rules will be followed on site:

- Do not climb over or under obstacles of questionable stability.
- Do not eat, drink, smoke, or perform other hand-to-mouth transfers in the work zone.
- Work only in well-lighted spaces.
- Never enter a confined space without the proper training, permits, and equipment.
- Make eye contact with equipment operators when moving within the range of their equipment.
- Be aware of the movements of shipboard equipment when not in the operator's range of vision.
- Get immediate first aid for all cuts, scratches, abrasions, or other minor injuries.
- Use the established sampling and decontamination procedures.
- Always use the buddy system.
- Be alert to your own and other workers' physical condition.
- Report all accidents, no matter how minor, to the FC/HSO.
- Do not do anything dangerous or unwise even if ordered by a supervisor.

A.7.0 Personal Protective Equipment and Safety Equipment

Appropriate PPE will be worn as protection against potential hazards. In addition, a PFD will be required when working aboard the boat. Prior to donning PPE, the field crew will inspect their PPE for any defects that might render the equipment ineffective.

Fieldwork will be conducted in Level D or modified Level D PPE, as discussed below in Sections A.7.1 and A.7.2. Situations requiring PPE beyond modified Level D are not anticipated. Should the FC/HSO determine that PPE beyond modified Level D is necessary, the HSM will be notified, and an alternative selected.

A.7.1 LEVEL D PERSONAL PROTECTIVE EQUIPMENT

Workers performing general activities in which skin contact with contaminated materials is unlikely will wear Level D PPE. Level D PPE includes the following:

- cotton overalls or rain gear

- chemical-resistant steel-toed boots
- chemical-resistant gloves
- sunglasses
- hard hats (when operating onboard sampling vessel and the grab sampler is raised above the deck)

A.7.2 MODIFIED LEVEL D PERSONAL PROTECTIVE EQUIPMENT

Workers performing activities where skin contact with contaminated materials is possible and in which inhalation risks are not expected will be required to wear an impermeable outer suit. The type of outerwear will be chosen according to the types of chemical contaminants that might be encountered. Modified Level D PPE includes the following:

- impermeable outer garb such as rain gear
- chemical-resistant steel-toed boots
- chemical-resistant outer gloves

A.7.3 SAFETY EQUIPMENT

In addition to PPE that will be worn by shipboard personnel, basic emergency and first aid equipment will also be provided. Equipment for the field team will include:

- a copy of this HSP
- first aid kit adequate for the number of personnel
- emergency eyewash

The FC/HSO will ensure that the safety equipment is aboard. Equipment will be checked daily to ensure its readiness for use.

A.8.0 Monitoring Procedures for Site Activities

A monitoring program that addresses the potential site hazards will be maintained. For this project, air, dust, and noise monitoring will not be necessary. No volatile organic compounds have been identified among the expected contaminants, the sampled media will be wet and will not pose a dust hazard, and none of the equipment emits high-amplitude (>85 dBA) sound. For this project, the monitoring program will consist of all workers monitoring themselves and their co-workers for signs that might indicate physical stress or illness.

All personnel will be instructed to look for and inform each other of any deleterious changes in their physical or mental condition during the performance of all field activities. Examples of such changes are as follows:

- headaches
- dizziness
- nausea
- symptoms of heat stress
- blurred vision
- cramps
- irritation of eyes, skin, or respiratory system
- changes in complexion or skin color
- changes in apparent motor coordination
- increased frequency of minor mistakes
- excessive salivation or changes in papillary response
- changes in speech ability or speech pattern
- shivering
- blue lips or fingernails

If any of these conditions develop, work shall be halted immediately and the affected person(s) evaluated. If further assistance is needed, personnel at the local hospital will be notified, and an ambulance will be summoned if the condition is thought to be serious. If the condition is the direct result of sample collection or handling activities, procedures will be modified to address the problem.

A.9.0 Decontamination

Decontamination is necessary to prevent the migration of contaminants from the work zone(s) into the surrounding environment and to minimize the risk of exposure of personnel to contaminated materials that might adhere to PPE. The following sections discuss personnel and equipment decontamination. The following supplies will be available to perform decontamination activities:

- wash buckets
- rinse buckets
- long-handled scrub brushes
- clean water sprayers
- paper towels
- plastic garbage bags
- Alconox® or similar decontamination solution

A.9.1 MINIMIZATION OF CONTAMINATION

The first step in addressing contamination is to prevent or minimize exposure to existing contaminated materials and the spread of those materials. During field activities, the FC/HSO will enforce the following measures:

Personnel:

- Minimize walking through areas of obvious or known contamination.
- Do not handle, touch, or smell contaminated materials directly.
- Make sure PPE has no cuts or tears prior to use.
- Fasten all closures on outer clothing, covering with tape if necessary.
- Protect and cover any skin injuries.
- Stay upwind of airborne dusts and vapors.
- Do not eat, drink, chew tobacco, or smoke in the work zones.

Sampling equipment and boat:

- Place clean equipment on a plastic sheet or aluminum foil to avoid direct contact with contaminated media.
- Keep contaminated equipment and tools separate from clean equipment and tools.
- Clean boots before entering the boat.

A.9.2 PERSONNEL DECONTAMINATION

The FC/HSO will ensure that all site personnel are familiar with personnel decontamination procedures. Personnel will perform decontamination procedures, as appropriate, before eating lunch, taking a break, or before leaving the work location. Following is a description of these procedures.

Decontamination procedure:

1. If outer suit is heavily soiled, rinse it off.
2. Wash and rinse outer gloves and boots with water.
3. Remove outer gloves; inspect and discard if damaged.
4. Wash hands if taking a break.
5. Don necessary PPE before returning to work.

Dispose of soiled, expendable PPE before leaving for the day.

A.9.3 SAMPLING EQUIPMENT DECONTAMINATION

Before use at each sampling location, the sampler will be rinsed in river water to dislodge and remove any sediment, washed with detergent, rinsed again with LDW water, and rinsed with deionized water.

A.9.4 VESSEL DECONTAMINATION

Most sampling will be conducted from a boat. Care will be taken not to spill any sediment collected in the sampler in the vessel, so vessel decontamination should not be necessary. In the event that any sediment is spilled, the vessel will be rinsed with LDW water at the end of the sampling day to remove sediment from cockpit and crew areas.

A.10.0 Disposal of Contaminated Materials

Contaminated materials that may be generated during field activities include PPE, decontamination fluids, and excess sample material. These contaminated materials will be disposed of as an integral part of the project.

A.10.1 PERSONAL PROTECTIVE EQUIPMENT

Gross surface contamination will be removed from PPE. All disposable sampling materials and PPE, such as disposable coveralls, gloves, and paper towels used in sample processing, will be placed in heavyweight garbage bags. Filled garbage bags will be placed in a normal refuse container for disposal as solid waste.

A.10.2 EXCESS SAMPLE MATERIALS

At each sampling location, excess sediment collected will be returned to the water.

A.11.0 Training Requirements

Individuals performing work at locations where potentially hazardous materials and conditions may be encountered must meet specific training requirements. It is not anticipated that hazardous concentrations of contaminants will be encountered in sampled material, so training will consist of site-specific instruction for all personnel and oversight of inexperienced personnel by an experienced person for one working day. The following sections describe the training requirements for this fieldwork.

A.11.1 PROJECT-SPECIFIC TRAINING

In addition to HAZWOPER training, as described in Section 2.5 of the QAPP, field personnel will undergo training specifically for this project. All personnel must read this HSP and be familiar with its contents before beginning work. They shall acknowledge reading the HSP by signing the field team HSP review form contained in Attachment A1. The form will be kept in the project files.

The boat captain and FC/HSO or a designee will provide project-specific training prior to the first day of fieldwork and whenever new workers arrive. Field personnel will not be allowed to begin work until project-specific training is completed and documented by the FC/HSO. Training will address the HSP and all health and safety issues and procedures pertinent to field operations. Training will include, but not be limited to, the following topics:

- activities with the potential for chemical exposure
- activities that pose physical hazards, and actions to control the hazard
- ship access control and procedure
- use and limitations of PPE
- decontamination procedures
- emergency procedures
- use and hazards of sampling equipment
- location of emergency equipment on the vessel
- vessel safety practices
- vessel evacuation and emergency procedures

A.11.2 DAILY SAFETY BRIEFINGS

The FC/HSO or a designee and the boat captain will present safety briefings before the start of each day's activities. These safety briefings will outline the activities expected for the day, update work practices and hazards, address any specific concerns associated with the work location, and review emergency procedures and routes. The FC/HSO or designee will document safety briefings in the field logbook.

A.11.3 FIRST AID AND CPR

At least one member of the field team must have first-aid and CPR training. Documentation of which individuals possess first-aid and CPR training will be kept in the project health and safety files.

A.12.0 Medical Surveillance

A medical surveillance program conforming to the provisions of 29 CFR 1910§120(f) is not necessary for field team members because they do not meet any of the four criteria outlined in the regulations for implementation of a medical surveillance program:

- Employees who are or may be exposed to hazardous substances or health hazards at or above permissible exposure levels for 30 days or more per year (1910.120(f)(2)(I).

- Employees who must wear a respirator for 30 days or more per year (1910.120(f)(2)(ii)).
- Employees who are injured or become ill due to possible overexposures involving hazardous substances or health hazards from an emergency response or hazardous waste operation (1910.120(f)(2)(iii)).
- Employees who are members of HAZMAT teams (1910.120(f)(2)(iv)).

As described in Section A.8, employees will monitor themselves and each other for any deleterious changes in their physical or mental condition during the performance of all field activities.

A.13.0 Reporting and Record Keeping

Each member of the field crew will sign the HSP review form (see Attachment A1). If necessary, accident/incident report forms and OSHA Form 200s will be completed by the FC/HSO.

The FC/HSO or a designee will maintain a health and safety field logbook that records health- and safety-related details of the project. Alternatively, entries may be made in the field logbook, in which case a separate health and safety logbook will not be required. The logbook must be bound and the pages must be numbered consecutively. Entries will be made with indelible blue ink. At a minimum, each day's entries must include the following information:

- project name or location
- names of all personnel onboard
- weather conditions
- type of fieldwork being performed

The person maintaining the entries will initial and date the bottom of each completed page. Blank space at the bottom of an incompletely filled page will be lined out. Each day's entries will begin on the first blank page after the previous workday's entries.

A.14.0 Emergency Response Plan

As a result of the hazards onboard and the conditions under which operations will be conducted, the potential exists for an emergency situation to occur. Emergencies may include personal injury, exposure to hazardous substances, fire, explosion, or release of toxic or non-toxic substances (spills). OSHA regulations require that an emergency response plan be available for use onboard to guide actions in emergency situations.

Onshore organizations will be relied upon to provide response in emergency situations. The local fire department and ambulance service can provide timely response. Field personnel will be responsible for identifying an emergency situation, providing first aid if applicable, notifying the appropriate personnel or agency, and evacuating any hazardous area. Shipboard personnel will attempt to control only very minor hazards that could present an emergency situation, such as a small fire, and will otherwise rely on outside emergency response resources.

The following sections identify the onboard individual(s) who should be notified in case of emergency, provide a list of emergency telephone numbers, offer guidance for particular types of emergencies, and provide directions for getting from any sampling location to a hospital.

A.14.1 PRE-EMERGENCY PREPARATION

Before the start of field activities, the FC/HSO will ensure that preparation has been made in anticipation of emergencies. Preparatory actions include the following:

- Meeting with the FC/HSO and equipment handlers concerning the emergency procedures in the event that a person is injured.
- A training session given by the FC/HSO informing all field personnel of emergency procedures, locations of emergency equipment and their use, and proper evacuation procedures.
- A training session given by senior staff operating field equipment, to apprise field personnel of operating procedures and specific risks associated with that equipment.
- Ensuring that field personnel are aware of the existence of the emergency response plan in the HSP and ensuring that a copy of the HSP accompanies the field team.

A.14.2 PROJECT EMERGENCY COORDINATOR

The FC/HSO will serve as the Project Emergency Coordinator in the event of an emergency. He will designate his replacement for times when he is not onboard or is not serving as the Project Emergency Coordinator. The designation will be noted in the field logbook. The Project Emergency Coordinator will be notified immediately when an emergency is recognized. The Project Emergency Coordinator will be responsible for evaluating the emergency situation, notifying the appropriate emergency response units, coordinating access with those units, and directing interim actions onboard before the arrival of emergency response units. The Project Emergency Coordinator will notify the HSM and the Project Manager as soon as possible after initiating an emergency response action. The Project Manager will have responsibility for notifying the client.

A.14.3 EMERGENCY RESPONSE CONTACTS

All onboard personnel must know whom to notify in the event of an emergency situation, even though the FC/HSO has primary responsibility for notification.

Table A-3 lists the names and phone numbers for emergency response services and individuals.

Table A-3. Emergency response contacts

CONTACT	TELEPHONE NUMBER
Emergency Numbers	
Ambulance	911
Police	911
Fire	911
Harborview Medical Center	(206) 323-3074
Emergency Responders	
U.S. Coast Guard Emergency General information	(206) 286-5400 (206) 442-5295 UHF Channel 16
National Response Center	(800) 424-8802
EPA	(908) 321-6660
Washington State Department of Ecology – Northwest Region Spill Response (24-hour emergency line)	(206) 649-7000
Emergency Contacts	
Project Manager	
Kathy Godtfredsen	(206) 577-1283
Corporate Health and Safety Manager	
Tad Deshler	(206) 577-1285
Field Coordinator/ Field Health and Safety Officer	Site cellular telephone:
Bob Complita	(206) 465-7886

A.14.4 RECOGNITION OF EMERGENCY SITUATIONS

Emergency situations will generally be recognizable by observation. An injury or illness will be considered an emergency if it requires treatment by a medical professional and cannot be treated with simple first-aid techniques.

A.14.5 DECONTAMINATION

In the case of evacuation, decontamination procedures will be performed only if doing so does not further jeopardize the welfare of site workers. If an injured individual is also heavily contaminated and must be transported by emergency vehicle, the emergency response team will be told of the type of contamination. To the extent possible, contaminated PPE will be removed, but only if doing so does not exacerbate the injury. Plastic sheeting will be used to reduce the potential for spreading contamination to the inside of the emergency vehicle.

A.14.6 FIRE

Field personnel will attempt to control only small fires, should they occur. If an explosion appears likely, personnel will follow evacuation procedures specified during the training session. If a fire cannot be controlled with a fire extinguisher on board that is part of the required safety equipment, personnel will either withdraw from the vicinity of the fire or evacuate the boat as specified in the training session.

A.14.7 PERSONAL INJURY

In the event of serious personal injury, including unconsciousness, possibility of broken bones, severe bleeding or blood loss, burns, shock, or trauma, the first responder will immediately do the following:

- Administer first aid, if qualified.
- If not qualified, seek out an individual who is qualified to administer first aid, if time and conditions permit.
- Notify the Project Emergency Coordinator of the incident, the name of the individual, the location, and the nature of the injury.

The Project Emergency Coordinator will immediately do the following:

- Notify the boat captain and the appropriate emergency response organization.
- Assist the injured individual.
- Follow the emergency procedures for retrieving or disposing equipment reviewed in the training session and leave the site en route to the predetermined land-based emergency pick-up.
- Designate someone to accompany the injured individual to the hospital.
- If a life-threatening emergency occurs, i.e., injury where death is imminent without immediate treatment, the FC/HSO or boat captain will call 911 and arrange to meet the Medic One unit at the nearest accessible dock. Otherwise, for emergency injuries that are not life-threatening (i.e., broken bones, minor lacerations, etc.) the Project Emergency Coordinator will follow the procedures outlined above and proceed to the Harbor Island Marina or to an alternative location of his choice if that would be more expedient.
- Notify the HSM and the Project Manager.

If the Project Emergency Coordinator determines that emergency response is not necessary, he or she may direct someone to decontaminate and transport the individual by vehicle to the nearest hospital. Directions showing the route to the hospital are in Section A.14.10.

If a worker leaves the boat to seek medical attention, another worker should accompany them to the hospital. When in doubt about the severity of an injury or exposure, always seek medical attention as a conservative approach, and notify the Project Emergency Coordinator.

The Project Emergency Coordinator will have responsibility for completing all accident/incident field reports, OSHA Form 200s, and other required follow-up forms.

A.14.8 OVERT PERSONAL EXPOSURE OR INJURY

If an overt exposure to toxic materials occurs, the first responder to the victim will initiate actions to address the situation. The following actions should be taken, depending on the type of exposure.

A.14.8.1 Skin contact

- Wash/rinse the affected area thoroughly with copious amounts of soap and water.
- If eye contact has occurred, eyes should be rinsed for at least 15 minutes using the eyewash that is part of the emergency equipment onboard.
- After initial response actions have been taken, seek appropriate medical attention.

A.14.8.2 Inhalation

- Move victim to fresh air.
- Seek appropriate medical attention.

A.14.8.3 Ingestion

- Seek appropriate medical attention.

A.14.8.4 Puncture wound or laceration

- Seek appropriate medical attention.

A.14.9 SPILLS AND SPILL CONTAINMENT

No bulk chemicals or other materials subject to spillage are expected to be used during this project. Accordingly, no spill containment procedure is required for this project.

A.14.10 EMERGENCY ROUTE TO THE HOSPITAL

The name, address, and telephone number of the hospital that will be used to provide medical care is as follows:

Harborview Medical Center
325 - 9th Ave
Seattle, WA
(206) 323-3074

Directions from the vicinity of LDW to Harborview Medical Center are described below.

From the 1st Ave S boat launch:

- Drive east on S River Street.
- Turn left on Occidental Ave S.
- Turn left on E Marginal Way S.
- Turn right on S Michigan Street.
- Look for entrance ramps to I-5 Northbound.
- Head north on I-5.
- Take the James Street exit.
- Head east on James Street to 9th Avenue.
- Turn right on 9th Avenue.
- Emergency entrance will be two blocks south on the right.

From the Harbor Island Marina:

- From marina parking lot, turn sharp right onto Klickitat Way SW
- Turn slight right onto SW Spokane St.
- Turn slight left to take the ramp toward WA-99 N/I-5/Columbian Way
- Keep left at the fork in the ramp
- Stay straight to go onto West Seattle Bridge
- Merge onto I-5 North via the ramp on the left
- Take the James Street exit.
- Head east on James Street to 9th Avenue.
- Turn right on 9th Avenue.
- Emergency entrance will be two blocks south on the right.

Attachment A1. Field Team Health and Safety Plan Review

I have read a copy of the Health and Safety Plan, which covers field activities that will be conducted to investigate potentially contaminated areas in the LDW. I understand the health and safety requirements of the project, which are detailed in this Health and Safety Plan.

Signature	Date
Signature	Date
Signature	Date
Signature	Date
Signature	Date
Signature	Date
Signature	Date
Signature	Date
Signature	Date
Signature	Date

APPENDIX B. FIELD COLLECTION FORMS

SURFACE SEDIMENT COLLECTION FORM

PROTOCOL MODIFICATION FORM

CORRECTIVE ACTION FORM

Windward environmental LLC

SURFACE SEDIMENT COLLECTION FORM

Project Name: ______________________ Project no. ______________________

Date: ______________________ Station: ______________________

Start/Stop time: ______________________ X: ______________________

Sampling Method: ______________________ Y: ______________________

Weather: ______________________ Sample ID: ______________________

Crew: ______________________

Subsample #:	Sample depth:	Penetration depth		Time:
Sampling gear:				Acceptable sample (circle) yes no
type:	color:	odor:		Biota in sample:
cobble	drab olive	none	H_2S	
gravel	gray	slight	petroleum	Comments:
sand C M F	black	moderate	other:	
silt clay	brown	strong		
organic matter	brown surface	overwhelming		
Subsample #:	Sample depth:	Penetration depth		Time:
Sampling gear:				Acceptable sample (circle) yes no
type:	color:	odor:		Biota in sample:
cobble	drab olive	none	H_2S	
gravel	gray	slight	petroleum	Comments:
sand C M F	black	moderate	other:	
silt clay	brown	strong		
organic matter	brown surface	overwhelming		
Subsample #:	Sample depth:	Penetration depth		Time:
Sampling gear:				Acceptable sample (circle) yes no
type:	color:	odor:		Biota in sample:
cobble	drab olive	none	H_2S	
gravel	gray	slight	petroleum	Comments:
sand C M F	black	moderate	other:	
silt clay	brown	strong		
organic matter	brown surface	overwhelming		

PROTOCOL MODIFICATION FORM

Project Name and Number:

Material to be Sampled:

Measurement Parameter:

Standard Procedure for Field Collection & Laboratory Analysis (cite reference):

Reason for Change in Field Procedure or Analysis Variation:

Variation from Field or Analytical Procedure:

Special Equipment, Materials or Personnel Required:

Initiator's Name: Date:

Project Officer: Date:

QA Officer: Date:

Windward environmental LLC

CORRECTIVE ACTION FORM

Project Name and Number:

Sample Dates Involved:

Measurement Parameter:

Acceptable Data Range:

Problem Areas Requiring Corrective Action:

Measures Required to Correct Problem:

Means of Detecting Problems and Verifying Correction:

Initiator's Name: Date:

Project Officer: Date:

QA Officer: Date:

APPENDIX C. RISK-BASED ANALYTICAL CONCENTRATION GOALS FOR SEDIMENT

Acronyms

ACRONYM	Definition
2,3,7,8-TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
ACG	analytical concentration goal
BW	body weight
DFC	daily food consumption
DMMP	Dredged Material Management Program
dw	dry weight
Ecology	Washington State Department of Ecology
EPA	US Environmental Protection Agency
ERA	ecological risk assessment
LDW	Lower Duwamish Waterway
LOAEL	lowest-observed-adverse-effect level
MDL	method detection limit
MTCA	Model Toxics Control Act
NOAEL	no-observed-adverse-effect level
OC	organic carbon
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
QAPP	quality assurance project plan
RBC	risk-based concentration
RL	reporting limit
SIM	selective ion monitoring
SL	screening level of DMMP
SMS	Washington State Sediment Management Standards
SQS	sediment quality standards of SMS
SVOC	semivolatile organic compound
TEQ	toxic equivalent
Windward	Windward Environmental LLC

C.1.0 Introduction

This appendix addresses the following question:

> Are standard analytical methods proposed for the chemical analysis of sediment samples sufficiently sensitive to meet the needs of the Phase 2 ecological and human health risk assessments?

To answer this question, laboratory reporting limits (RLs) were compared to analytical concentration goals (ACGs) for sediment.[1] To determine ACGs for this quality assurance project plan (QAPP), sediment risk-based concentrations (RBCs) were identified or derived for the protection of benthic invertebrates, spotted sandpipers, and humans. RBCs in sediment are not relevant for other ecological receptors because sediment is generally a very small dietary component for the fish and other wildlife receptor species that will be evaluated in the Phase 2 ecological risk assessment (ERA). The risk-based ACGs for sediment are equal to the lowest RBC for each chemical. For example, if RBCs are identified or calculated for benthic invertebrates, spotted sandpipers, and humans for cadmium, the risk-based ACG for cadmium in sediment is set by the RBC for the receptor most sensitive to cadmium (the lowest of the three RBCs).

For the protection of benthic invertebrates, RBCs are defined as the concentration of a chemical in sediment corresponding to numerical criteria found in the Washington State Sediment Management Standards (SMS). The SMS include numerical criteria for 47 chemicals or groups of chemicals. The lowest numerical criterion for each chemical is called the Sediment Quality Standard (SQS). The Dredged Material Management Program (DMMP) also includes criteria for chemicals in sediment. The lowest guideline in that program is called the Screening Level (SL). RBCs are set equal to the SQS or to the SLs if no SQS is available for a given chemical.

Sediment RBCs are defined for the protection of wildlife receptors as the concentration of a chemical in sediment incidentally ingested by that receptor that is associated with no adverse effects on growth, reproduction, or survival.[2] For the protection of human health, RBCs are defined by two methods. In one method, which was applied to all chemicals, RBCs are defined as the concentration of a chemical in sediment incidentally ingested or directly contacted that has been identified as having an acceptable risk level (e.g., excess cancer risk of 10^{-6}). In the other method, which was applied for chemicals likely to bioaccumulate in fish and shellfish consumed by humans, sediment RBCs presented in the LDW benthic invertebrate QAPP (Windward

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[1] Other sediment ACGs and ACGs for tissue were presented in the benthic invertebrate QAPP (Windward 2004a) or in the fish and crab tissue QAPP (Windward 2004b).

[2] The lowest concentration associated with adverse effects was used if data were not available for a concentration associated with no effects.

2004) that were based on a back-calculation[3] from clam tissue RBCs are included in this QAPP as well.

Sediment RBCs have not been developed by EPA Region 10 or Ecology for the protection of avian wildlife or humans. Therefore, sandpiper and human RBCs were calculated by using information from the toxicological literature for avian wildlife and by reviewing human health guidance documents. Although information from the toxicological literature is used in this document, the objective of this memo is not to establish the toxicity reference values (TRVs) to be used for the Phase 2 risk assessments. The TRVs to be used in those assessments will be determined during Phase 2, in consultation with EPA and Ecology.

The remainder of this appendix is organized as follows:

- Section C.2.0 – RBC derivation methods for benthic invertebrates, spotted sandpipers, and humans
- Section C.3.0 – Comparison of ACGs to RLs
- Tables C-1 through C-5 (located at the end of this appendix) summarize RBCs for all receptors for each chemical, provide background information for RBC selection, and compare ACGs and RLs.

C.2.0 Risk-based Concentrations

For this QAPP, RBCs are sediment concentrations associated with an acceptable risk level as derived from state standards, the toxicity literature, or human health guidance documents. In this appendix, sediment RBCs are derived for the protection of the following receptors through several exposure pathways:

- Benthic invertebrates exposed to chemicals via direct contact with sediment
- Spotted sandpipers exposed to chemicals via incidental ingestion of sediment
- Humans exposed to chemicals via direct contact or incidental ingestion of sediment
- Humans exposed to chemicals via seafood consumption

The following sections describe how RBCs were derived for each receptor. The specific chemicals for which RBCs were derived are discussed in the sections below for each receptor, and are summarized in Table C-1.

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[3] Sediment RBCs were calculated from clam tissue RBCs using a biota-sediment accumulation factor, as described in Windward (2004a). The clam tissue RBCs were calculated using the total seafood consumption rate rather than the consumption rate of clams.

Table C-1. Receptor-specific RBCs for sediment

ANALYTE	RECEPTOR-SPECIFIC RBC (mg/kg dw)				
	HUMAN HEALTH[A]		BENTHIC INVERTEBRATES[B]	SPOTTED SANDPIPER	
	INDIRECT EXPOSURE	DIRECT EXPOSURE		LOAEL-BASED	NOAEL-BASED
PAHs					
Acenaphthylene	na	na	**0.33**	na	na
Benzo(a)anthracene	**0.0052**	0.62	0.55	na	na
Benzo(a)pyrene	**0.00076**	0.062	0.50	na	na
Benzo(b)fluoranthene	**0.0047**	0.62	na	na	na
Benzo(k)fluoranthene	**0.047**	6.2	na	na	na
Benzofluoranthenes (total)	na	na	**1.2**	na	na
Benzo(g,h,i)perylene	na	na	**0.16**	na	na
Chrysene	**0.48**	62	0.50	na	na
Dibenzo(a,h)anthracene	0.062	c	**0.06**	na	na
Fluoranthene	2.1	230	**0.80**	na	na
Indeno(1,2,3-cd)pyrene	**0.0029**	0.62	0.17	na	na
Phenanthrene	na	na	**0.50**	na	na
Pyrene	8.9	230	**5.0**	na	na
Acenaphthene	370	c	**0.08**	na	na
Anthracene	900	2,200	**1.1**	na	na
Fluorene	270	c	**0.12**	na	na
Naphthalene	5.6	na	**0.50**	na	na
2-Methylnaphthalene	na	na	**0.19**	na	na
Dibenzofuran	29	na	**0.075**	nd	nd
Total LPAHs	na	na	**1.9**	na	na
Total HPAHs	na	na	**4.8**	na	na
Total PAHs	na	na	na	**1,410**	na
Other SVOCs					
1,2,4-Trichlorobenzene	65	c	**0.0041**	nd	nd
1,2-Dichlorobenzene	12	370	**0.012**	na	na
1,3-Dichlorobenzene	1.6	c	**0.17**	nd	nd
1,4-Dichlorobenzene	0.073	3.4	**0.016**	nd	nd
2,4,5-Trichlorophenol	**610**	na	na	nd	nd
2,4,6-Trichlorophenol	**0.61**	na	na	nd	nd
2,4-Dichlorophenol	**18**	na	na	nd	nd
2,4-Dimethylphenol	120	na	**0.029**	nd	nd
2,4-Dinitrophenol	**12**	na	na	nd	nd
2,4-Dinitrotoluene	**12**	na	na	nd	nd
2,6-Dinitrotoluene	**6.1**	na	na	nd	nd
2-Chloronaphthalene	**490**	na	na	nd	nd
2-Chlorophenol	**6.3**	na	na	nd	nd
2-Methylphenol	310	na	**0.063**	na	na
3,3'-Dichlorobenzidine	**1.1**	na	na	nd	nd
4-Chloroaniline	**24**	na	na	nd	nd
4-Methylphenol	31	na	**0.67**	nd	nd

Analyte	Receptor-Specific RBC (mg/kg dw)				
	Human Health[A]		Benthic Invertebrates[B]	Spotted Sandpiper	
	Indirect Exposure	direct Exposure		LOAEL-based	NOAEL-based
Aniline	**85**	na	na	nd	nd
Benzoic acid	100,000	na	**0.65**	na	na
Benzyl alcohol	1,800	na	**0.057**	na	na
Bis(2-chloroethyl)ether	**0.21**	na	na	nd	nd
Bis(2-ethylhexyl)phthalate	35	na	**0.24**	12,400	53
Bis-chloroisopropyl ether	**2.9**	na	na	na	na
Butyl benzyl phthalate	1,200	na	**0.025**	na	na
Di-ethyl phthalate	4,900	na	**0.31**	nd	nd
Dimethyl phthalate	100,000	na	**0.27**	nd	nd
Di-n-butyl phthalate	610	na	**1.1**	na	na
Di-n-octyl phthalate	240	na	**0.29**	nd	nd
Hexachlorobenzene	0.30	na	**0.0019**	110	na
Hexachlorobutadiene	0.023	6.2	**0.02**	na	166
Hexachloroethane	**0.12**	35	1.4	nd	nd
Isophorone	**510**	na	na	nd	nd
Nitrobenzene	**2.0**	na	na	nd	nd
N-Nitrosodimethylamine	**0.0095**	na	na	nd	nd
N-Nitrosodi-n-propylamine	**0.069**	na	na	nd	nd
N-Nitrosodiphenylamine	99	na	**0.055**	nd	nd
Pentachlorophenol	3.0	na	**0.36**	2,220	775
Phenol	3,700	na	**0.42**	na	na
PCBs					
Aroclor 1016	**0.0061**	0.39	na	na	na
Aroclor 1221	**0.00021**	0.22	na	na	na
Aroclor 1232	**0.00021**	0.22	na	na	na
Aroclor 1242	**0.00021**	0.22	na	na	na
Aroclor 1248	**0.00021**	0.22	na	na	14.5
Aroclor 1254	**0.00021**	0.22	na	33.2	na
Aroclor 1260	**0.00021**	0.22	na	na	na
Total PCBs	**0.00021**	0.22	0.06	na	na
PCB-77 [d]	**0.0035**	0.039	na	0.70	0.070
PCB-81 [d]	**0.0035**	0.039	na	0.35	0.035
PCB-105 [d]	**0.0035**	0.039	na	352	35
PCB-114 [d]	**0.00070**	0.0078	na	352	35
PCB-118 [d]	**0.0035**	0.039	na	3520	352
PCB-123 [d]	**0.0035**	0.039	na	3520	352
PCB-126 [d]	**0.0000035**	0.000039	na	0.35	0.035
PCB-156 [d]	**0.00070**	0.0078	na	352	35
PCB-157 [d]	**0.00070**	0.0078	na	352	35
PCB-167 [d]	**0.035**	0.39	na	3520	352
PCB-169 [d]	**0.000035**	0.00039	na	35	3.5
PCB-189 [d]	**0.0035**	0.039	na	3520	352
Dioxins/furans					

	Receptor-Specific RBC (mg/kg dw)				
	Human Health[A]			Spotted Sandpiper	
Analyte	Indirect Exposure	direct Exposure	Benthic Invertebrates[B]	LOAEL-based	NOAEL-based
2,3,7,8-TCDD	**3.5E-07**	3.9E-06	na	0.0352	0.00352
1,2,3,7,8-PeCDD[d]	**3.5E-07**	3.9E-06	na	0.0352	0.00352
1,2,3,4,7,8-HxCDD[d]	**7.0E-07**	7.8E-06	na	0.0352	0.00352
1,2,3,6,7,8-HxCDD[d]	**3.5E-06**	3.9E-05	na	0.352	0.0352
1,2,3,7,8,9-HxCDD[d]	**3.5E-06**	3.9E-05	na	0.352	0.0352
1,2,3,4,6,7,8-HpCDD[d]	**3.5E-06**	3.9E-05	na	0.704	0.0704
OCDD[d]	**3.5E-06**	3.9E-05	na	0.352	0.0352
2,3,7,8-TCDF[d]	**3.5E-06**	3.9E-05	na	3.52	0.352
1,2,3,7,8-PeCDF[d]	**3.5E-06**	3.9E-05	na	0.352	0.0352
2,3,4,7,8-PeCDF[d]	**3.5E-06**	3.9E-05	na	0.352	0.0352
1,2,3,4,7,8-HxCDF[d]	**3.5E-06**	3.9E-05	na	0.0352	0.00352
1,2,3,6,7,8-HxCDF[d]	**7.0E-06**	7.8E-05	na	0.352	0.0352
1,2,3,7,8,9-HxCDF[d]	**3.5E-05**	3.9E-04	na	3.52	0.352
2,3,4,6,7,8-HxCDF[d]	**3.5E-05**	3.9E-04	na	3.52	0.352
1,2,3,4,6,7,8-HpCDF[d]	**3.5E-05**	3.9E-04	na	35.2	3.52
1,2,3,4,7,8,9-HpCDF[d]	**0.0035**	0.039	na	352	35.2
OCDF[d]	**0.0035**	0.039	na	352	35.2
Metals					
Antimony	**3.1**	na	150	na	na
Arsenic	**0.006**	0.39	57	1,374	705
Cadmium	**0.003**	3.7	5.1	1,656	705
Chromium	**100**	210	260	3,700	271
Cobalt	**900**	na	na	na	na
Copper	**1.3**	310	390	2,185	1,656
Lead	**40**	c	450	707	70.5
Molybdenum	**39**	na	na	1248	na
Nickel	160	c	**140**	3,771	2,714
Selenium	39	c	na	29	**14.9**
Silver	39	c	**6.1**	na	na
Thallium	**0.52**	na	na	nd	nd
Vanadium	**55**	na	na	na	na
Zinc	**16**	2,300	410	4,335	2,890
Mercury	**0.016**	2.3	0.41	3.2	na
Tri-n-butyltin	**0.00028**	1.8	0.0085	598	241
Pesticides					
DDD	**0.0083**	2.4	na	31.8	na
DDE	**0.0026**	1.7	na	9.9	4.6
DDT	**0.00092**	1.7	na	35.4	31.8
Total DDT	**0.00092**	1.7	0.0069	na	na
Aldrin	**0.000063**	0.029	0.01	1.41	na
alpha-BHC	**0.09**	c	na	na	na
beta-BHC	**0.00063**	0.32	na	na	na
alpha-Chlordane	**na**	na	0.01	na	na

Analyte	Receptor-Specific RBC (mg/kg dw)				
	Human Health[a]			Spotted Sandpiper	
	Indirect Exposure	direct Exposure	Benthic Invertebrates[b]	LOAEL-based	NOAEL-based
Chlordane[e]	**0.0017**	1.6	na	1,938	49.3
Dieldrin	**0.000033**	0.030	0.01	16.6	8.46
Endosulfan	**0.50**	37	na	na	743
Endrin	**0.027**	1.8	na	9.9	5.66
gamma-BHC (Lindane)	**0.00083**	0.44	0.01	127	56.6
Heptachlor	**0.00025**	0.11	0.01	nd	nd
Heptachlor epoxide	**0.053**	c	na	nd	nd
Methoxychlor	**0.44**	31	na	na	na
Mirex	**0.27**	c	na	1,202	636
Toxaphene	**0.44**	c	na	nd	nd

NOTE: Values in **BOLD** were used as ACGs in Table C-5.

na – toxicity data not available or not applicable

nd – not determined because human health or SQS/SL values were not available, or it was not considered a chemical of interest for spotted sandpipers, as discussed in Section C.2.2

[a] The RBC for a given chemical may be derived from either carcinogenic or non-carcinogenic endpoints. For chemicals with both endpoints, the lower RBC is shown.

[b] RBCs for benthic invertebrates are equivalent to the SQS/SL for chemicals with standards expressed on a dry weight basis. For chemicals with standards expressed on an organic-carbon normalized basis, an average LDW organic carbon content of 0.5% was assumed to convert the standards to dry weight.

[c] This chemical was identified as an important bioaccumulative chemical by EPA (2000), but no BSAF is available from the sources listed in Section C.2.3.2, so no RBC for indirect exposure was calculated.

[d] Dioxin-like PCB and dioxin/furan congeners will be evaluated as toxic equivalents (TEQs) in the risk assessments, rather than as individual congeners. However, because TEQs are calculated, rather than measured by the laboratory, RBCs for individual congeners are presented to facilitate comparison with RLs for those congeners. In reality, risks will be assessed based on sums of these congeners (normalized per their relative toxicity to TCDD), and thus comparison to RLs on a congener-specific basis is somewhat uncertain.

[e] RBCs for chlordane for human health and spotted sandpiper are based on toxicity of mixtures of chlordane-related compounds (e.g., alpha- and gamma-chlordane, cis- and trans-nonachlor).

C.2.1 RBC DERIVATION FOR THE PROTECTION OF BENTHIC INVERTEBRATES

RBCs for the protection of benthic invertebrates are expressed as chemical concentrations in sediment, to which benthic invertebrates are directly exposed. The benthic invertebrate RBCs are derived from the SQS or from DMMP SLs when SQS are not available. There are 14 chemicals that have SLs but do not have an SQS value. The SQS and SL values are presented in Table C-2. The RBCs in Table C-1 for benthic invertebrates are equivalent to the SQS/SL for chemicals where the SQS is expressed on a dry weight basis. For chemicals with standards expressed on an organic-carbon (OC) normalized basis, a lower-than-average OC content of 0.5% was assumed to convert the SQS to its dry weight equivalent.

No sediment-based SQS or SL is available for TBT. The benthic invertebrate sediment RBC for TBT is calculated for the purposes of this appendix using a tissue effect value along with a modified bioaccumulation factor (BAF), as described below.

The tissue effect value was obtained from a review of effects data associated with TBT in benthic invertebrate tissues. The lowest LOEC (lowest-observed-effect concentration; the lowest concentration at which an adverse effect was observed) was 2.4 mg/kg dry weight (dw) associated with reduced growth of the polychaete *Armandia brevis* (Meador and Rice 2001). The highest NOEC (no-observed-effect concentration; the highest concentration at which no adverse effect was observed) found in a laboratory study was 0.85 mg/kg dw (reduced condition index in Pacific oysters, assuming a moisture content of 80% [Davies et al. 1988]). The LOEC and NOEC are 0.48 and 0.17 mg/kg ww, respectively. The NOEC of 0.17 mg/kg ww was used as the tissue effect concentration for calculating the RBC only for the purposes of this appendix (the NOECs and LOEC to be used in the Phase 2 remedial investigation will be developed as part of the Phase 2 ERA).

The modified bioaccumulation factor was derived as described in the Phase 1 ERA (Windward 2003b; see Section A.3.1.2.2) using a wet weight tissue concentration and a sediment concentration expressed on an organic carbon-normalized basis, as follows:

$$\text{Modified BAF for TBT} = \frac{\text{Biota (mg/kg ww)}}{\text{Sediment (mg/kg OC)}}$$

Equation 1

The modified BAF used in this appendix is 0.10, which was calculated in the Phase 1 ERA using limited site-specific data from Kellogg Island[4] (Windward 2003b; Section A.3.1.2.2). The sediment RBC was then calculated using Equation 2:

$$\text{Sediment (mg/kg dw)} = \frac{\text{Tissue effect concentration (mg/kg ww)}}{\text{Modified BAF for TBT}} \times 0.5\%\text{OC in sediment} \times 0.01$$

Equation 2

Using this approach, the sediment RBC for benthic invertebrates for TBT is 0.0085mg/kg dw (Table C-1).

Table C-2. Chemical criteria used to derive sediment RBCs for benthic invertebrates

CHEMICAL	SQS	SL	UNITS
1,2,4-Trichlorobenzene	0.81	sa	mg/kg OC
1,2-Dichlorobenzene	2.3	sa	mg/kg OC
1,3-Dichlorobenzene	ns	170	µg/kg dw
1,4-Dichlorobenzene	3.1	sa	mg/kg OC
2,4-Dimethylphenol	29	sa	µg/kg dw
2-Methylnaphthalene	38	sa	mg/kg OC
2-Methylphenol	63	sa	µg/kg dw
4-Methylphenol	670	sa	µg/kg dw
Acenaphthene	16	sa	mg/kg OC
Acenaphthylene	66	sa	mg/kg OC

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[4] Note that additional site-specific data will be available for Phase 2 to assess the relationship between concentrations of TBT in sediment and benthic invertebrate tissue.

CHEMICAL	SQS	SL	UNITS
Aldrin	ns	10	µg/kg dw
alpha-Chlordane	ns	10	µg/kg dw
Anthracene	220	sa	mg/kg OC
Antimony	ns	150	mg/kg dw
Arsenic	57	sa	mg/kg dw
Benzo(a)anthracene	110	sa	mg/kg OC
Benzo(a)pyrene	99	sa	mg/kg OC
Benzo(g,h,i)perylene	31	sa	mg/kg OC
Benzofluoranthenes (total-calc'd)	230	sa	mg/kg OC
Benzoic acid	650	sa	µg/kg dw
Benzyl alcohol	57	sa	µg/kg dw
bis(2-ethylhexyl)phthalate	47	sa	mg/kg OC
Butyl benzyl phthalate	4.9	sa	mg/kg OC
Cadmium	5.1	sa	mg/kg dw
Chromium	260	sa	mg/kg dw
Chrysene	100	sa	mg/kg OC
Copper	390	sa	mg/kg dw
DDTs (total-calc'd)	ns	6.9	µg/kg dw
Dibenzo(a,h)anthracene	12	sa	mg/kg OC
Dibenzofuran	15	sa	mg/kg OC
Dieldrin	ns	10	µg/kg dw
Diethyl phthalate	61	sa	mg/kg OC
Dimethyl phthalate	53	sa	mg/kg OC
Di-n-butyl phthalate	220	sa	mg/kg OC
Di-n-octyl phthalate	58	sa	mg/kg OC
Ethylbenzene	ns	10	µg/kg dw
Fluoranthene	160	sa	mg/kg OC
Fluorene	23	sa	mg/kg OC
gamma-BHC	ns	10	µg/kg dw
Heptachlor	ns	10	µg/kg dw
Hexachlorobenzene	0.38	sa	mg/kg OC
Hexachlorobutadiene	3.9	sa	mg/kg OC
Hexachloroethane	ns	1,400	µg/kg dw
Indeno(1,2,3-cd)pyrene	34	sa	mg/kg OC
Lead	450	sa	mg/kg dw
Mercury	0.41	sa	mg/kg dw
Naphthalene	99	sa	mg/kg OC
Nickel	ns	140	mg/kg dw
N-Nitrosodiphenylamine	11	sa	mg/kg OC
PCBs (total-calc'd)	12	sa	mg/kg OC
Pentachlorophenol	360	sa	µg/kg dw
Phenanthrene	100	sa	mg/kg OC
Phenol	420	sa	µg/kg dw
Pyrene	1,000	sa	mg/kg OC
Silver	6.1	sa	mg/kg dw
Tetrachloroethene	ns	57	µg/kg dw

CHEMICAL	SQS	SL	UNITS
Total HPAH (calc'd)	960	sa	mg/kg OC
Total LPAH (calc'd)	370	sa	mg/kg OC
Trichloroethene	ns	160	µg/kg dw
Xylene (total)	ns	40	µg/kg dw
Zinc	410	sa	mg/kg dw

OC – organic carbon

dw – dry weight

ns – SQS not available

sa – SQS available and used as the preferred criterion

C.2.2 RBC DERIVATION FOR THE PROTECTION OF SPOTTED SANDPIPERS

RBCs for the protection of spotted sandpipers are expressed as chemical concentrations in sediment, which may be ingested incidentally while foraging. RBCs were derived for the chemicals of interest presented in Table C-3. This list was developed using three criteria: 1) detection in at least 5% of LDW Phase 1 surface sediment samples, 2) identification as a bioaccumulative chemical by EPA (2000), and 3) detection in historical fish or shellfish tissue samples collected from the LDW (Windward 2003a). Chemicals were selected if they were identified by EPA (2000) as bioaccumulative chemicals of concern and if they were also detected in sediments or tissues (or both). Chemicals detected in both media were also selected regardless of their inclusion in EPA (2000).

Table C-3. Chemicals of interest in tissue based on draft tissue analyte approach memorandum

Metals	**PAHs**
Antimony	Acenaphthene
Arsenic	Acenaphthylene
Cadmium	Anthracene
Chromium	Benzo(a)anthracene
Cobalt	Benzo(a)pyrene
Copper	Benzo(b)fluoranthene
Lead	Benzo(g,h,i)perylene
Mercury	Benzo(k)fluoranthene
Molybdenum	Chrysene
Nickel	Dibenzo(a,h)anthracene
Selenium	Fluoranthene
Silver	Fluorene
Vanadium	Indeno(1,2,3-cd)pyrene
Zinc	Phenanthrene
Butyltins	Pyrene
Dibutyltin as ion	**PCBs**
Tributyltin as ion	Total PCBs
Pesticides	**SVOCs**
4,4'-DDD	1,2-Dichlorobenzene
4,4'-DDE	1,4-Dichlorobenzene
4,4'-DDT	2-Methylphenol
alpha-BHC	Benzoic acid
alpha-Chlordane	Benzyl alcohol
Chlordane	Bis(2-ethylhexyl)phthalate
Dieldrin	Di-n-butyl phthalate
gamma-BHC	Hexachlorobenzene
gamma-chlordane	Pentachlorophenol
Methoxychlor	Phenol

Source: Windward (2003a)

SVOC - semivolatile organic compound

Toxicity data identified for bird species were no-observed-adverse-effect levels (NOAELs), which are the highest doses at which no adverse effects were observed, and lowest-observed-adverse-effect levels (LOAELs), which are the lowest doses at which adverse effects were observed. Effects endpoints included growth, reproduction, and survival.[5]

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[5] These assessment endpoints will be used in the Phase 2 risk assessments for wildlife, as discussed in the Phase 2 work plan (Windward 2004c).

The NOAELs and LOAELs derived from the literature are expressed as dietary doses in mg/kg body weight (BW)/day. These dietary doses were converted to RBCs in sediment in mg/kg dry weight using the receptor's sediment ingestion rate and BW (as described in Section C.2.3.2). Table C-1 summarizes spotted sandpiper RBCs, including both NOAELs and LOAELs, if available. The NOAEL-based RBC is the most relevant concentration; LOAEL-based RBCs are presented in case the NOAEL-based RBC is less than the RL. Table C-4 presents summary information for the studies selected to derive RBCs for spotted sandpipers. The summary information in Table C-4 includes the endpoint, test species, exposure pathway, and reference for each NOAEL and LOAEL shown. The following sections describe the literature search process and the conversion of dietary doses to dietary RBCs relevant for sediment ingestion.

C.2.2.1 Literature search

Studies relating dietary concentrations to adverse effects in birds were identified from a search of the following electronic databases: ECOTOX, BIOSIS, TOXNET, and IRIS. In addition, reviews of the following summary reports were used to identify original studies for avian toxicity data:

- Agency for Toxic Substances and Disease Registry (ATSDR)
- US Fish and Wildlife Service Contaminant Review series (Eisler 2002)
- Oak Ridge National Laboratory database (Sample et al. 1996)

Toxicity studies were reviewed for methods, relevance, and interpretation to ensure that RBCs were derived appropriately. Studies were excluded if there was no control group for comparison to treated groups, or if test species were exposed to more than one chemical. Exceptions were made for certain mixtures of related chemicals such as a mixture of DDT and its metabolites, or a mixture of polychlorinated biphenyl (PCB) Aroclors. In addition, the polycyclic aromatic hydrocarbon (PAH) RBC for the protection of spotted sandpipers was derived from an aromatic hydrocarbon chemical mixture including individual PAHs, because no other dietary studies were available. These requirements eliminated most field studies from consideration in the development of RBCs, because field studies generally lack suitable controls, and organisms are typically exposed to a mixture of different types of chemicals in the field.

Table C-4. Studies selected to derive RBCs in prey items of birds

ANALYTE	NOAEL (MG/KG BW/DAY)	LOAEL (MG/KG BW/DAY)	ENDPOINT[A]	TEST SPECIES	EXPOSURE PATHWAY	REFERENCE
2,3,7,8-TCDD	0.0001	0.001	mortality	white leghorn, cockerels	gavage	Schwetz et al. 1973
Aroclor 1254	na	0.94	reproduction	ringed turtledove	food	Peakall et al. 1972
Aroclor 1248	0.41	na	reproduction	screech owl	food	McLane and Hughes 1980
Arsenic	20	39	mortality	mallard	food	USFWS 1964
Cadmium	na	47	growth	mallard	food	DiGiulio and Scanlon 1984
Cadmium	20	na	growth	mallard	food	White and Finley 1978
Chromium	na	105	growth	chicks	food	Chung et al. 1988
Chromium	7.7	na	growth	chicks	food	Romoser et al. 1961
Copper	47	62	growth/ mortality	chicks	food	Mehring et al. 1960
Lead	2	20	reproduction	Japanese quail	food	Edens et al. 1976
Mercury	na	0.091	growth	great egret (1 day old)	food	Spalding et al. 2000
Molybdenum	na	35.3	reproduction	chicken	food	Lepore and Miller 1965
Nickel	77	107	growth/ mortality	mallard	food	Cain and Pafford 1981
Selenium	0.42	0.82	reproduction	mallard	food	Heinz et al. 1989
Zinc	82	123	growth	white rock chicks	food	Roberson and Schaible 1960
Tributyltin	6.8	16.9	reproduction	Japanese quail	food	Schlatterer et al. 1993
PAHs[b]	na	40	growth	mallard	food	Patton and Dieter 1980
Aldrin	na	0.040	mortality	quail	food	DeWitt 1956
Chlordane[c]	na	55	mortality	bobwhite- juvenile	food	Hill et al. 1975
Chlordane[d]	1.4	na	growth/ mortality	bobwhite quail	food	Ludke 1976
DDD	na	0.90	reproduction	mallard	food	Heath et al. 1969
DDE	na	0.28	reproduction	barn owl	food	Mendenhall et al. 1983
DDE	0.13	na	reproduction	American kestrel	food	Lincer 1975
DDT	na	1.0	reproduction	Mallard	food	Kolaja 1977
DDT	0.90	na	reproduction	Mallard	food	Heath et al. 1969

ANALYTE	NOAEL (MG/KG BW/DAY)	LOAEL (MG/KG BW/DAY)	ENDPOINT[a]	TEST SPECIES	EXPOSURE PATHWAY	REFERENCE
Dieldrin	0.24	0.47	mortality	bobwhite quail	food	Fergin and Shafer 1977
Endosulfan	21	na	reproduction	gray partridge	food	Abiola 1992
Endrin	na	0.28	reproduction	screech owl	food	Fleming et al. 1982
Endrin	0.16	na	reproduction	Pheasant	food	DeWitt 1956
Hexachlorobenzene	na	3.1	reproduction	Japanese quail	food	Schwetz et al. 1974
Hexachlorobutadiene	4.7	na	growth/ reproduction	Japanese quail	food	Schwetz et al. 1974
gamma-BHC (Lindane)	1.6	3.6	reproduction	Mallard	gavage	Chakravarty and Lahiri 1986; Chakravarty et al. 1986
Mirex	18	34	reproduction	Chicken	food	Naber and Ware 1965
Pentachlorophenol	22	63	growth	broiler chicks	food	Prescott et al. 1982
Bis(2-ethylhexyl) phthalate	na	350	reproduction	Chicken	food	Ishida et al. 1982
Bis(2-ethylhexyl) phthalate	1.5	na	reproduction	ringed turtledove	food	Peakall 1974

na – NOAEL or LOAEL not available or not applicable based on the selection criteria discussed in Section C.2.3

[a] Low effects or no effects were observed for all endpoints listed for both the NOAEL and/or LOAEL presented.

[b] Food contained a mixture of paraffins and aromatic hydrocarbons, including acenaphthylene, acenaphthene, and phenanthrene.[c] A chlordane mixture containing alpha and gamma isomers of chlordane was used.

[d] Technical chlordane (a mixture of chlordane-related compounds, including alpha- and gamma-chlordane) was used.

The LOAEL and NOAEL values for RBC derivation were chosen as follows: 1) the selected LOAEL was the lowest LOAEL from any study using any of the specified endpoints (i.e., growth, reproduction, survival), and 2) the selected NOAEL was the highest NOAEL that was lower than the selected LOAEL, with the same endpoint as the selected LOAEL. Studies were not chosen for RBC derivation if the following concerns warranted the consideration of other studies:

- The exposure duration was not chronic[6] or was not conducted during a sensitive life stage (i.e., reproduction or early growth stages).
- The effect endpoint was egg productivity in a domestic species, such as chickens or Japanese quail. These species are bred to have unnaturally high egg-laying rates, so toxic threshold effects on egg production in these species are not comparable to similar effects in non-domestic avian receptors because of differences in reproductive physiology.
- Exposure was through gavage, oral intubation, or injection rather than through the diet. These routes of exposure are not directly related to environmental exposures of birds.
- Results were not statistically evaluated to identify significant differences from control values.
- Endpoints were not related to growth, reproduction, or survival.

For some chemicals, either a NOAEL or a LOAEL of the same endpoint were available but not both. In addition, for some chemicals, no relevant toxicity data were available. Where reviews of appropriate toxicity studies had been previously conducted by Windward Environmental LLC (Windward) for chemicals that are not considered chemicals of interest, RBCs were derived for those chemicals as well. These chemicals include aldrin, endosulfan, endrin, hexachlorobutadiene, and mirex.

C.2.2.2 RBC derivation

The NOAELs and LOAELs derived from toxicity studies were expressed as daily dietary doses normalized for BW. To convert these doses to a concentration in ingested sediment, Equation 3 was used:

$$C_S = (\text{Dose} \times \text{BW})/\text{DSC} \qquad \textbf{Equation 3}$$

where:

C_S = concentration in sediment (mg/kg dw)
Dose = NOAEL or LOAEL (mg/kg BW/day)
BW = body weight (kg)
DSC = daily sediment consumption rate (kg dw/day)

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[6] Chronic exposure for avian receptors is defined as more than 10 weeks or exposure during a critical lifestage (i.e., reproduction, gestation, or development) (Sample et al. 1996).

If the NOAEL or LOAEL was based on a reproductive endpoint, the C_S was calculated using the female BW and DSC. If the NOAEL or LOAEL was based on growth or mortality, C_S was calculated using the male and female average for BW and DSC. The DSC was calculated as 18% of the daily food consumption (DFC) on a dry weight basis based on the average sediment ingestion by four species of sandpipers that feed on mud-dwelling invertebrates (EPA 1993). The following BW, DFC, and DSC values were used:

- Female spotted sandpiper BW = 0.0471 kg; DFC = 0.0074 kg dw/day; and DSC = 0.00133 kg dw/day
- Average (male and female) spotted sandpiper BW = 0.0425 kg; DFC = 0.0067 kg dw/day; and DSC = 0.00121 kg dw/day

BWs for spotted sandpipers were obtained from studies by Maxson and Oring (1980), as cited in EPA's Wildlife Exposure Factors Handbook (1993). The daily food consumption was calculated as a function of the metabolic rate and the caloric content of the spotted sandpiper's prey based on data from Nagy et al. (1999) and Nagy (1987), as described in Section A.5.1.3 of the Phase 1 ERA (Windward 2003b). RBCs are presented for both NOAELs and LOAELs, where available.

C.2.3 RBC DERIVATION FOR THE PROTECTION OF HUMANS

RBCs for the protection of human health were derived for both direct and indirect (i.e., seafood consumption) exposure pathways. For non-bioaccumulative chemicals, RBCs were calculated for direct exposure pathways, as described in Section C.2.3.1. For bioaccumulative chemicals, RBCs were calculated for the seafood consumption pathway, as described in Section C.2.3.2. Bioaccumulative compounds were identified by EPA (2000).

C.2.3.1 Direct sediment exposure pathway

RBCs for the protection of humans that may directly contact or incidentally ingest sediment are expressed as chemical concentrations in sediment. Human health guidance documents were reviewed for RBCs for human health. EPA Region 10 has not developed RBCs for the protection of human health, but EPA Region 9 has developed RBCs for the protection of human health from exposures to soil (EPA 2002). The Model Toxics Control Act (MTCA, a Washington State statute) also includes RBCs for soil, but they are higher than the EPA RBCs because of different exposure parameters. Consequently, EPA RBCs were used instead of MTCA RBCs because they are more health protective. The EPA soil RBCs are applicable to sediment because the assumed exposure routes for soil used in RBC development (direct contact and incidental ingestion) will be evaluated in the Phase 2 HHRA along with the seafood ingestion exposure route.

EPA (2002) contains soil RBCs for both industrial and residential scenarios. Residential RBCs were used in this appendix because they are more health protective than the industrial RBCs. The exposure assumptions used in the EPA RBCs are more health protective than the exposure assumptions to be used in the Phase 2 HHRA. For example, the exposure frequency used by EPA Region 9 for residential soil exposure was 350 days/year, compared to 44 days/year to be used for the beach play scenario in the Phase 2 HHRA. Region 9 RBCs for chemicals with noncarcinogenic effects were decreased by a factor of 10 to account for the target hazard quotients of 0.1 used in screening by EPA Region 10.[7] RBCs can be calculated for chemicals with either carcinogenic or non-carcinogenic endpoints; some chemicals have both types of endpoints. For chemicals with both endpoints, the lower RBC is shown in Table C-1.

C.2.3.2 Indirect sediment exposure pathway

RBCs for the indirect sediment exposure pathway (i.e., seafood consumption) require that a relationship be developed between chemical concentrations in tissue and sediment. One commonly used method for evaluating such a relationship for nonpolar organic chemicals that may bioaccumulate is the biota sediment accumulation factor (BSAF).

BSAFs can be derived using Equation 4:

$$\text{BSAF} = \frac{C_{WB} \div F_L}{C_{sed} \div F_{oc}} \qquad \textbf{Equation 4}$$

where:

C_{WB} = chemical concentration in whole-body tissue (mg/kg ww)
C_{sed} = chemical concentration in sediment (mg/kg dw)
F_L = fraction lipid in tissue (kg lipid/kg ww)
F_{oc} = fraction organic carbon in sediment (kg OC/kg dw)

A key variable in the BSAF equation is the sediment concentration (C_{sed}). The BSAF equation is based on the assumption that C_{sed} represents the average chemical concentration in sediment to which the organism is exposed. For animals with very small home ranges, such as clams, this assumption may be reasonable if sediment data are collected concurrently with tissue data at the tissue collection locations. For animals with larger home ranges, such as fish, there is greater uncertainty in this assumption because many fish are highly mobile and are not likely to inhabit all areas of their home range with equal frequency. Consequently, fish BSAFs for a given chemical may easily range over at least an order of magnitude (USACE 2003). Given this large uncertainty, this appendix describes ACGs for sediment based on the

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[7] EPA Region 10 recommends a target hazard quotient of 0.1; therefore, the EPA Region 9 RBCs (which are based on a target hazard quotient of 1) have been adjusted by dividing by 10 for the purposes of this appendix.

analytical concentration goals for clams presented in Appendix C of the benthic invertebrate QAPP (Windward 2004).

Equation 4 can be rearranged to solve for C_{sed}, as follows:

$$C_{sed} = \frac{(C_{WB} \div F_L) \times F_{oc}}{BSAF} \qquad \textbf{Equation 5}$$

In the benthic invertebrate QAPP, ACGs for clams were calculated using two assumed consumption rates, a lower rate of 58 g/day based on clam consumption and a higher rate of 98 g/day based on total seafood consumption. The rate based on total seafood consumption (98 g/day) is more relevant for this appendix because the sediment data to be collected according to this QAPP may support food web modeling for fish and crabs, and the total consumption rate includes fish and crabs. For this appendix, the C_{WB} based on 98 g/day was used in Equation 5. The BSAFs used to calculate ACGs for sediment (i.e., C_{sed} in Equation 5) were from four sources:

- US Army Corps of Engineers Environmental Residue-Effects Database (ERED) - http://www.wes.army.mil/el/ered/
- Tracey GA, Hansen DJ. 1996. Use of biota-sediment accumulation factors to assess similarity of nonionic organic chemical exposure to benthically-coupled organisms of differing trophic mode. Arch Environ Contam Toxicol 30:467-475.
- EPA. 1997. The incidence and severity of sediment contamination in surface waters of the United States. Volume 1: National Sediment Quality Survey. EPA 823-R-97-006. US Environmental Protection Agency, Office of Science and Technology, Washington, DC.
- Washington State Department of Health. 1995. Tier I report, development of sediment quality criteria for the protection of human health. Washington State Department of Health, Olympia, Washington.

The BSAFs cited in these four sources will not necessarily be used for any other purpose in the Phase 2 RI other than developing sediment ACGs in this appendix. BSAFs for bivalve mollusks are most appropriate for the ACG calculation, as described above. However, some fish BSAFs were used in this appendix when bivalve BSAFs were not available (i.e., some SVOCs and 2,3,7,8-TCDD).

C.3.0 Comparison of ACGs to RLs

ACGs were determined for sediment by selecting the lowest RBC for each chemical from Table C-1. These ACGs for sediment were compared with RLs, which represent the minimum analyte concentrations that can be reliably quantified, and with MDLs, which are lower than the RL and represent the minimum analyte concentration that can be detected.

As shown in Table C-5, all ACGs are higher than the RLs, with the exception of four PAHs (benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, and indeno(1,2,3-c,d)pyrene), six other semivolatile organic compounds (1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, hexachlorobenzene, N-nitrosodiphenylamine, and N-nitrosodimethylamine), all seven Aroclors, 13 dioxin/furan congeners, three metals (arsenic, cadmium, mercury), TBT, and six pesticides (total DDTs, aldrin, beta-BHC, dieldrin, gamma-BHC, and heptachlor). When the ACGs for these analytes were compared with the MDLs, ACGs for 19 of the analytes listed above (one Aroclor, dioxin/furan congeners, TBT, and four pesticides) were higher than the MDL. The remaining analytes with ACGs lower than both their RL and MDL (four PAHs, six other SVOCs, six Aroclors, three metals, and two pesticides) are discussed below.

The four PAHs listed above, as well as arsenic and mercury were detected in over 90% of the historical sediment samples using standard RLs. Cadmium and total PCBs as Aroclors were detected in over 95% and 75%, respectively, of the historical sediment samples. Based on these historical results, the PAHs, PCBs, and metals listed above are also likely to be detected in most or all the sediment samples described in this QAPP. Consequently, the fact that the ACGs are lower than both the MDL and RL should not compromise the quality of the data to be used in the risk assessments for these chemicals.

All six of the other semivolatile organic compounds listed above will also be analyzed in a subset of samples by at least one other method beside EPA 8270C to achieve lower RLs. The chlorobenzene compounds 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, and 1,4-dichlorobenzene will be analyzed by EPA 8270C-SIM (selected ion monitoring) in 78 samples, as shown in Table 3-3 in the main body of the QAPP. The ACGs for 1,2-dichlorobenzene and 1,4-dichlorobenzene are higher than the SIM RLs. However, the ACG for 1,2,4-trichlorobenzene (0.0041 mg/kg dw) remains slightly lower than the SIM RL (0.0067 mg/kg ww). The MDL is not available because ARI is currently conducting an MDL study for this compound using 8270C-SIM. The ACG for hexachlorobenzene (0.0019 mg/kg dw) is lower than the 8081A RL (0.02 mg/kg dw). The hexachlorobenzene ACG is also slightly lower than the 8270C-SIM RL (0.0067 mg/kg dw), which will be analyzed in 78 samples. The MDL is not available because ARI is currently conducting an MDL study for this compound using 8270C-SIM.

N-nitrosodiphenylamine and N-nitrosodimethylamine will also be analyzed by 8270C-SIM in 78 samples. The ACG for N-nitrosodiphenylamine is higher than the SIM RL. The ACG for N-nitrosodimethylamine of 0.0095 mg/kg dw, which was derived from the human health RBC, is slightly lower than the SIM RL (0.033 mg/kg dw). N-nitrosodimethylamine has never been detected in LDW sediments (87 surface sediment samples analyzed for this chemical).

The MDL and RL for dieldrin are higher than the ACG. Dieldrin was detected in 5% of the historical sediment samples and was not identified as a chemical of potential concern in sediment. It was never detected in historical tissue samples.

The MDL for total DDTs was equated to the highest MDL of the six DDT isomers (0.0011 mg/kg dw for 2,4′ DDD), which was slightly higher than the ACG (0.00092 mg/kg dw). The highest MDL would only be applied if all DDT isomers were undetected. The uncertainty associated with non-detected results for dieldrin, total DDTs, and other pesticides will be discussed in the HHRA report.

Table C-5. Comparison of sediment RLs and MDLs to sediment ACGs

METHOD AND ANALYTE	RL[a] (mg/kg dw)	MDL[a] (mg/kg dw)	SEDIMENT ACG[b] (mg/kg dw)
EPA Method 8270C			
PAHs			
Acenaphthylene	0.02	0.00909	0.33
Benzo(a)anthracene	**0.02**	**0.00834**	0.0052
Benzo(a)pyrene	**0.02**	**0.00731**	0.00076
Benzo(b)fluoranthene	**0.02**	**0.00734**	0.0047
Benzo(k)fluoranthene	0.02	0.0104	0.047
Total benzofluoranthenes [c]	0.02	0.0104	1.2
Benzo(g,h,i)perylene	0.02	0.00804	0.16
Chrysene	0.02	0.00809	0.48
Dibenzo(a,h)anthracene	0.02	0.00835	0.06
Fluoranthene	0.02	0.00849	0.80
Indeno(1,2,3-cd)pyrene	**0.02**	**0.00854**	0.0029
Phenanthrene	0.02	0.00863	0.50
Pyrene	0.02	0.00872	5.0
Acenaphthene	0.02	0.00936	0.08
Anthracene	0.02	0.00869	1.1
Fluorene	0.02	0.00917	0.12
Naphthalene	0.02	0.00753	0.50
2-Methylnaphthalene	0.02	0.00721	0.19
Dibenzofuran	0.02	0.00795	0.075
Total LPAHs [d]	0.02	0.00936	1.9
Total HPAHs [e]	0.02	0.0104	4.8
Total PAHs [f]	0.02	0.0104	1,410
Other SVOCs			
1,2,4-Trichlorobenzene	**0.02**	**0.00588**	0.0041
1,2-Dichlorobenzene	**0.02**	0.00876	0.012
1,3-Dichlorobenzene	0.02	0.00755	0.17
1,4-Dichlorobenzene	**0.02**	0.00816	0.016
2,4,5-Trichlorophenol	0.10	0.00834	610
2,4,6-Trichlorophenol	0.10	0.010	0.61
2,4-Dichlorophenol	0.10	0.00773	18
2,4-Dimethylphenol	0.02	0.01052	0.029

Method and Analyte	**RL[a] (mg/kg dw)**	**MDL[a] (mg/kg dw)**	**Sediment ACG[b] (mg/kg dw)**
2,4-Dinitrophenol	0.20	0.1042	12
2,4-Dinitrotoluene	0.10	0.00897	12
2,6-Dinitrotoluene	0.10	0.01073	6.1
2-Chloronaphthalene	0.02	0.00832	490
2-Chlorophenol	0.20	0.00948	6.3
2-Methylphenol	0.02	0.0138	0.063
3,3'-Dichlorobenzidine	0.10	0.0617	1.1
4-Chloroaniline	0.10	0.0257	24
4-Methylphenol	0.10	0.0135	0.67
Aniline	0.02	0.00912	85
Benzoic acid	0.20	0.105	0.65
Benzyl alcohol	0.40	0.041	0.057
Bis(2-chloroethyl)ether	0.02	0.00993	0.21
Bis(2-ethylhexyl)phthalate	0.02	0.0108	0.24
Bis-chloroisopropyl ether	0.02	0.00996	2.9
Butyl benzyl phthalate	0.02	0.0103	0.025
Di-ethyl phthalate	0.02	0.135	0.31
Dimethyl phthalate	0.02	0.0120	0.27
Di-n-butyl phthalate	0.02	0.0135	1.1
Di-n-octyl phthalate	0.02	0.0113	0.29
Hexachlorobenzene	**0.02**	**0.00928**	0.0019
Hexachlorobutadiene	0.02	0.00828	0.02
Hexachloroethane	0.02	0.00798	0.12
Isophorone	0.02	0.00738	510
Nitrobenzene	0.02	0.0159	2.0
N-Nitrosodimethylamine	**0.10**	**0.00912**	0.0095
N-Nitrosodi-n-propylamine	**0.10**	0.0102	0.069
N-Nitrosodiphenylamine	0.02	0.0107	0.055
Pentachlorophenol	0.10	0.0371	0.36
Phenol	0.02	0.00947	0.42
EPA Method 8270C-SIM			
1,2,4-Trichlorobenzene	**0.0067**	tbd	0.0041
1,2-Dichlorobenzene	0.0067	tbd	0.012
1,4-Dichlorobenzene	0.0067	tbd	0.016
2,4-Dimethylphenol	0.0067	tbd	0.029
2-Methylphenol	0.0067	tbd	0.063
Benzoic acid	0.067	tbd	0.65
Benzyl alcohol	0.017	tbd	0.057
Butyl benzyl phthalate	0.0067	tbd	0.025

METHOD AND ANALYTE	RL[a] (mg/kg dw)	MDL[a] (mg/kg dw)	SEDIMENT ACG[b] (mg/kg dw)
Di-ethyl phthalate	0.0067	tbd	0.31
Dimethyl phthalate	0.0067	tbd	0.27
Hexachlorobenzene	**0.0067**	tbd	0.0019
Hexachlorobutadiene	0.0067	tbd	0.12
N-Nitrosodimethylamine	**0.033**	tbd	0.0095
N-Nitrosodiphenylamine	0.0067	tbd	0.055
N-Nitrosodi-n-propylamine	0.033	tbd	0.069
Pentachlorophenol	0.033	tbd	0.36
EPA Method 8082			
Aroclor 1016	**0.02**	0.00098	0.0061
Aroclor 1221	**0.02**	**0.00098**	0.00021
Aroclor 1232	**0.02**	**0.00098**	0.00021
Aroclor 1242	**0.02**	**0.00098**	0.00021
Aroclor 1248	**0.02**	**0.00098**	0.00021
Aroclor 1254	**0.02**	**0.00098**	0.00021
Aroclor 1260	**0.02**	**0.00098**	0.00021
Total PCBs [g]	**0.02**	**0.00098**	0.00021
EPA Method 1668			
PCB-77 [h]	2.0E-6	3.9E-7	3.5E-3
PCB-81 [h]	2.0E-6	3.9E-7	3.5E-3
PCB-105 [h]	2.0E-6	4.4E-7	3.5E-3
PCB-114 [h]	2.0E-6	4.6E-7	7.0E-4
PCB-118 [h]	2.0E-6	3.7E-7	3.5E-3
PCB-123 [h]	2.0E-6	9.5E-7	3.5E-3
PCB-126 [h]	2.0E-6	2.1E-7	3.5E-6
PCB-156 [h]	2.0E-6	6.6E-7	7.0E-4
PCB-157 [h]	2.0E-6	6.6E-7	7.0E-4
PCB-167 [h]	2.0E-6	3.5E-7	3.5E-2
PCB-169 [h]	2.0E-6	4.4E-7	3.5E-2
PCB-189 [h]	2.0E-6	3.4E-7	3.5E-3
EPA Method 1613B			
2,3,7,8-TCDD	1.0E-6	5.9E-8	3.5E-07
1,2,3,7,8-PeCDD[h]	5.0E-6	1.53E-7	3.5E-07
1,2,3,4,7,8-HxCDD[h]	5.0E-6	1.72E-7	7.0E-07
1,2,3,6,7,8-HxCDD[h]	5.0E-6	1.18E-7	3.5E-06
1,2,3,7,8,9-HxCDD[h]	5.0E-6	1.72E-7	3.5E-06
1,2,3,4,6,7,8-HpCDD[h]	5.0E-6	1.69E-7	3.5E-06
OCDD[h]	1.0E-5	5.18E-7	3.5E-06
2,3,7,8-TCDF[h]	1.0E-6	7.7E-8	3.5E-06

METHOD AND ANALYTE	**RL[a] (mg/kg dw)**	**MDL[a] (mg/kg dw)**	**SEDIMENT ACG[b] (mg/kg dw)**
1,2,3,7,8-PeCDF[h]	5.0E-6	1.32E-7	3.5E-06
2,3,4,7,8-PeCDF[h]	5.0E-6	1.43E-7	3.5E-06
1,2,3,4,7,8-HxCDF[h]	5.0E-6	1.48E-7	3.5E-06
1,2,3,6,7,8-HxCDF[h]	5.0E-6	1.54E-7	7.0E-06
1,2,3,7,8,9-HxCDF[h]	5.0E-6	1.48E-7	3.5E-05
2,3,4,6,7,8-HxCDF[h]	5.0E-6	9E-8	3.5E-05
1,2,3,4,6,7,8-HpCDF[h]	5.0E-6	1.83E-7	3.5E-05
1,2,3,4,7,8,9-HpCDF[h]	5.0E-6	8.1E-8	0.0035
OCDF[h]	1.0E-5	3.81E-7	0.0035
EPA Method 6010 (except as noted)			
Antimony (EPA 6020)	0.20	0.005	3.1
Arsenic (EPA 6020)	**0.20**	**0.02**	0.006
Cadmium	**0.20**	**0.02**	0.003
Chromium	0.50	0.09	100
Cobalt	0.30	0.03	900
Copper	0.20	0.04	1.3
Lead	2.00	0.12	40
Molybdenum	0.50	0.06	39
Nickel	1.00	0.38	140
Selenium	5.00	0.3	14.9
Silver	0.30	0.03	6.1
Thallium (EPA 6020)	0.20	0.003	0.52
Vanadium	0.30	0.03	55
Zinc	0.60	0.29	16
EPA Method 7471			
Mercury	**0.05**	0.003	0.016
TBT Method - Krone 1989			
Tri-n-butyltin	**0.006**	0.00284	0.00028
EPA Method 8081			
4,4'-DDD	0.002	0.000320	0.0083
4,4'-DDE	0.002	0.000166	0.0026
4,4'-DDT	**0.001**	0.000284	0.00092
2,4'-DDD	0.002	0.0011	0.0083
2,4'-DDE	0.002	0.000894	0.0026
2,4'-DDT	0.002	0.000870	0.00092
Total DDT [j]	**0.002**	**0.0011**	0.00092
Aldrin	**0.001**	0.000054	0.000063
alpha-BHC	**0.001**	0.000214	0.09
beta-BHC	0.001	0.000045	0.00063

METHOD AND ANALYTE	RL[a] (mg/kg dw)	MDL[a] (mg/kg dw)	SEDIMENT ACG[b] (mg/kg dw)
alpha-Chlordane	0.001	0.000144	0.01
Total chlordane[k]	0.001	0.000964	0.0017
Dieldrin	**0.001**	**0.000049**	0.000033
Endosulfan	0.001	0.000129	0.50
Endrin	0.002	0.00024	0.027
gamma-BHC (Lindane)	**0.001**	0.000141	0.00083
Heptachlor	**0.001**	0.000027	0.00025
Heptachlor epoxide	0.001	0.000122	0.053
Hexachlorobenzene	0.001	0.000034	0.0019
Methoxychlor	0.010	0.000402	0.44
Mirex	0.002	0.00122	0.27
Toxaphene	0.100	0.0297	0.44

na – not available; the method detection limit for PCB and dioxin congeners is a sample-specific detection limit, which is calculated from specific sample analyses

tbd – to be determined; ARI is currently conducting an MDL study for these analytes for this method

RLs or MDLs in BOLD are greater than at least one of their respective ACGs. All of the ACGs that are lower than RLs or MDLs are based on human health RBCs, with the exception of the following four chemicals, which are based on benthic invertebrate RBCs: 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, and hexachlorobenzene.

[a] RLs and MDLs from ARI

[b] ACG for sediment is the lowest of the RBCs for benthic invertebrates, spotted sandpipers, and humans.

[c] Total benzofluoranthenes is the sum of benzo(b)fluoranthene and benzo(k)fluoranthene. RL and MDL are the highest of the RLs and MDLs for benzo(b)fluoranthene or benzo(k)fluoranthene.

[d] Total LPAHs is the sum of naphthalene, 2-methyl naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene. RL and MDL are the highest RL and MDL for the LPAHs.

[e] Total HPAHs is the sum of fluoranthene, pyrene, benz(a)anthracene, chrysene, benzo(k)fluoranthene, benzo(b)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, dibenz(a,h)anthracene, and benzo(g,h,i)perylene. RL and MDL are the highest RL and MDL for the HPAHs.

[f] Total PAHs is the sum of the LPAHs and the HPAHs. RL and MDL are the highest RL and MDL for either the LPAHs or HPAHs.

[g] Total PCBs is the sum of the Aroclors. RL and MDL are the highest RL and MDL for the individual Aroclors.

[h] Dioxin-like PCB and dioxin/furan congeners will be evaluated as toxic equivalents (TEQs) in the risk assessments, rather than as individual congeners. However, because TEQs are calculated, rather than measured by the laboratory, RBCs for individual congeners are presented to facilitate comparison with RLs for those congeners. In reality, risks will be assessed based on sums of these congeners (normalized per their relative toxicity to TCDD), and thus comparison to RLs on a congener-specific basis is somewhat uncertain.

[i] Chromium cannot be analyzed by Method 6020 (ICP-MS) because of interferences.

[j] Total DDT is the sum of 4,4’-DDD, 4,4-DDE, 4,4’-DDT, 2,4’-DDD, 2,4-DDE, and 2,4’-DDT. RL and MDL are the highest RL and MDL for the DDT isomers.

[k] Total chlordane is the sum of oxychlordane, alpha- and gamma-chlordane, and cis- and trans-nonachlor. RL and MDL are the highest RL and MDL for the chlordane-related compounds.

C.4.0 References

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APPENDIX D. BACKGROUND APPROACH FOR ARSENIC

D.1 Introduction

This appendix provides the problem definition, sampling design, schedule, sample identification scheme, and a summary of sampling and analysis methods for background sampling of surface sediment for arsenic. Sections D.2 and D.3 in this appendix provide equivalent types of information as Sections 2.2 and 3.1 in the quality assurance project plan (QAPP), respectively. All other project elements discussed in the QAPP (i.e., field and analytical methods, quality assurance/quality control [QA/QC], data management) are applicable to the background sampling.

D.2 Problem Definition and Existing Information

This section presents the problem definition, arsenic data from Central Puget Sound and other regional locations, and discusses the available upstream background sediment data for arsenic.

D.2.1 PROBLEM DEFINITION

Arsenic was identified as one of the primary risk drivers in the Phase 1 human health risk assessment (HHRA) based on assumed[8] inorganic arsenic concentrations in seafood collected from the Lower Duwamish Waterway (LDW). Human health risks associated with arsenic exposure via direct sediment contact were much lower than risks associated with seafood consumption, but were still potentially of concern. Arsenic risks in Phase 2 will be evaluated for direct sediment exposures (e.g., netfishing and beach play) and indirect sediment exposure (i.e., seafood consumption) using an incremental risk approach.

The Phase 1 risk estimates did not consider what percent of the total arsenic risk in the LDW could be attributable to potential arsenic sources within the LDW, to arsenic that occurs naturally in the Puget Sound basin, or to arsenic from anthropogenic sources outside the LDW. During the Phase 2 risk assessments, the relative influence of arsenic sources within and outside the LDW on risks associated with arsenic will be distinguished by conducting an incremental risk analysis for arsenic. The incremental risk approach compares site-specific risks with risks estimated for background areas. If site risk is greater than background risk, the incremental risk will be determined by calculating the difference between the site risk and the background risk. Therefore, the objective of the sampling described in this appendix is to provide data for the incremental risk approach.

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[8] At the request of EPA, tissue concentrations of inorganic arsenic, which is the most toxic fraction of total arsenic and the arsenic species for which a cancer slope factor has been derived, were assumed to be 10% of the total arsenic tissue concentrations. During Phase 2, inorganic arsenic will be measured directly in tissue, making such an assumption unnecessary.

The Duwamish River upstream of the LDW is a suitable area for background sediment collection because it is affected by similar natural (i.e., soils of volcanic origin) and anthropogenic sources outside the LDW (i.e., the airborne plume from the former Asarco smelter in Ruston, Washington, northwest of Tacoma). Therefore, sediment samples will be collected from the Duwamish River upstream of the LDW to supplement the existing upstream sediment dataset. This appendix describes the specific study design and collection methods.

Note that tissue samples of fish (shiner surfperch and English sole) and invertebrates (clams and crabs) were collected from background areas in September and October 2004 for use in the incremental risk approach for arsenic for the seafood consumption pathway. The collection of these tissue samples was discussed in the fish and crab QAPP (Windward 2004b). These tissue samples were collected from outside the LDW watershed because these species are not found in the Duwamish or Green Rivers upstream of the LDW.

D.2.2 ARSENIC IN THE CENTRAL PUGET SOUND REGION

Arsenic, which occurs naturally in sediments and soils of the Puget Sound region, is found in sediments of central and northern Puget Sound as a result of natural geological features, such as volcanoes (Washington Department of Health 2002). These natural arsenic levels in Puget Sound sediments are known to be elevated when compared to other regions of the country (Ecology 2000).

The primary anthropogenic arsenic source outside the LDW is the former Asarco smelter, which operated from the 1890s to 1986. The Washington State Department of Ecology is studying the impact of the airborne smelter plume on the concentration of arsenic in soils downwind of the former smelter location (Ecology 2001). The highest arsenic concentrations in soils closely follow the prevailing wind patterns in the central Puget Sound basin. The wind blows from the southwest to the northeast (toward the LDW) about 60% of the time, and from the northeast to the southwest about 40% of the time (Figure D-1). The prevailing wind direction directed the smelter plume over the Duwamish and Lower Green watershed and resulted in higher arsenic soil concentrations in those drainage basins. These soils erode into the Lower Green/Duwamish River via surface runoff, which provides the majority of the sediment load to the LDW.

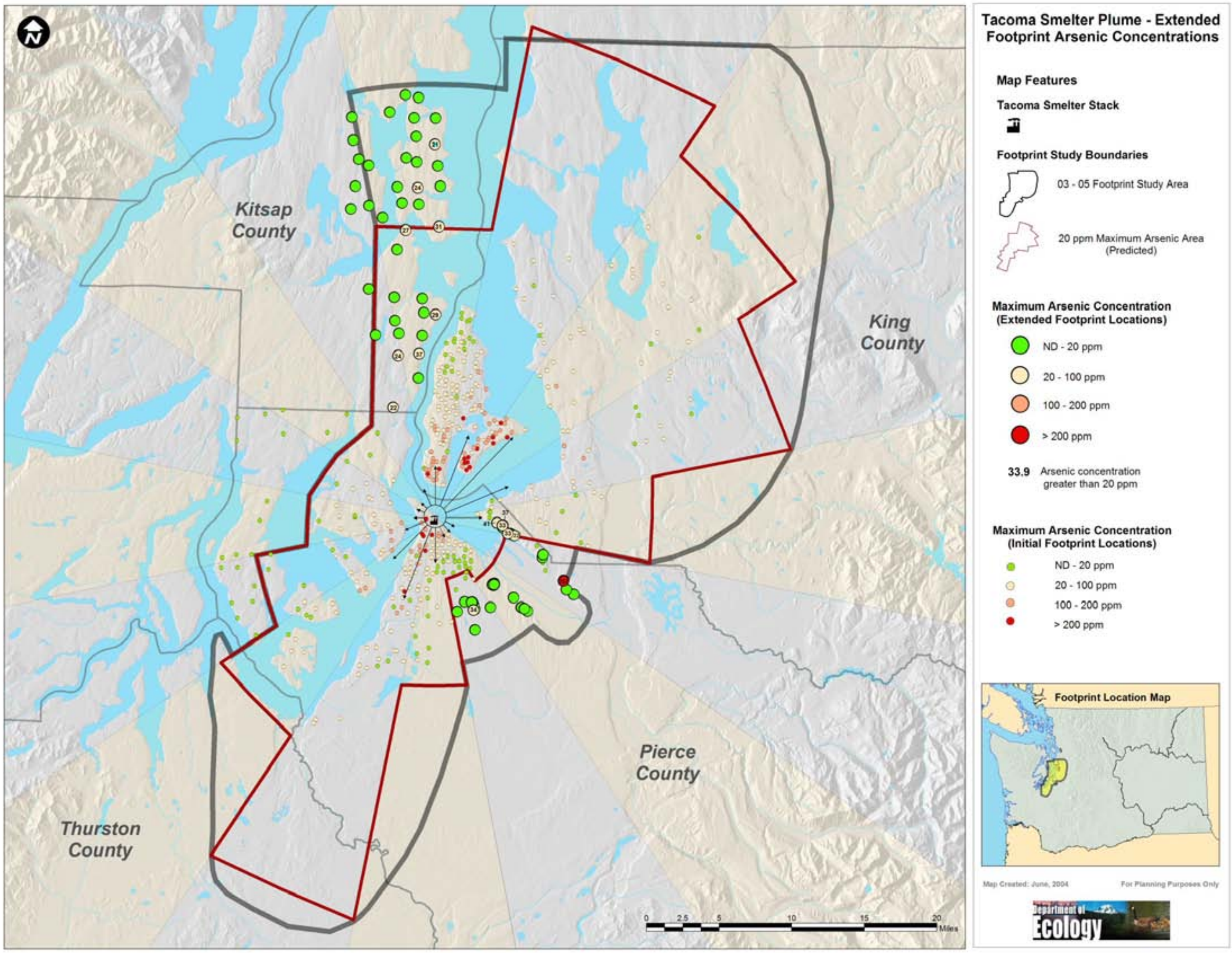

Figure D-1. Tacoma smelter plume – extended footprint soil arsenic concentration

Source: www.ecy.wa.gov/programs/tcp/sites/tacoma_smelter/Extended_Footprint_June_2004/Sample_Grids_11062003_reduced.pdf

D.2.3 EXISTING INFORMATION

As part of previous sediment investigations (Weston 1999; Exponent 1998), surface sediment samples were collected from eight locations in areas upstream of RM 5.2 in the Duwamish River, with arsenic concentrations ranging from 4.0 to 7.2 mg/kg dw (median of 4.5 mg/kg dw) (Table D-1). These eight historical sample locations are shown in Figure D-2.

Analysis of the existing LDW arsenic data suggests that concentrations in very fine sediments (> 80% fines) are higher (mean of 13 mg/kg dw) than concentrations in sandy sediment (<20% fines; 8.6 mg/kg dw). Consequently, the sediment grain size in the background sediments is a consideration in the sampling design (see Section D.3.1.2). Sediments from the locations just upstream of the LDW (RM 5.3 to 5.5) were all sand, whereas sediments from the other three locations at RM 6.1 were either sand or a mixture of sand and finer sediments (Table D-1).

Table D-1. Existing surface sediment arsenic data from the Duwamish River upstream of the LDW

LOCATION ID	RIVER MILE	SAMPLE DATE	ARSENIC CONCENTRATION (MG/KG DW)	PERCENT FINES
DR297	5.28	9/16/1998	4.0	< 0.01
DR298	5.34	9/16/1998	5.1	< 0.01
DR299	5.38	9/16/1998	4.2	< 0.01
DR300	5.45	9/16/1998	4.1	< 0.01
DR301	5.49	9/16/1998	4.4	< 0.01
REF-1	6.12	10/18/1997	4.8	42
REF-2	6.13	10/18/1997	7.2	53
REF-3	6.13	10/18/1997	4.5	1.0

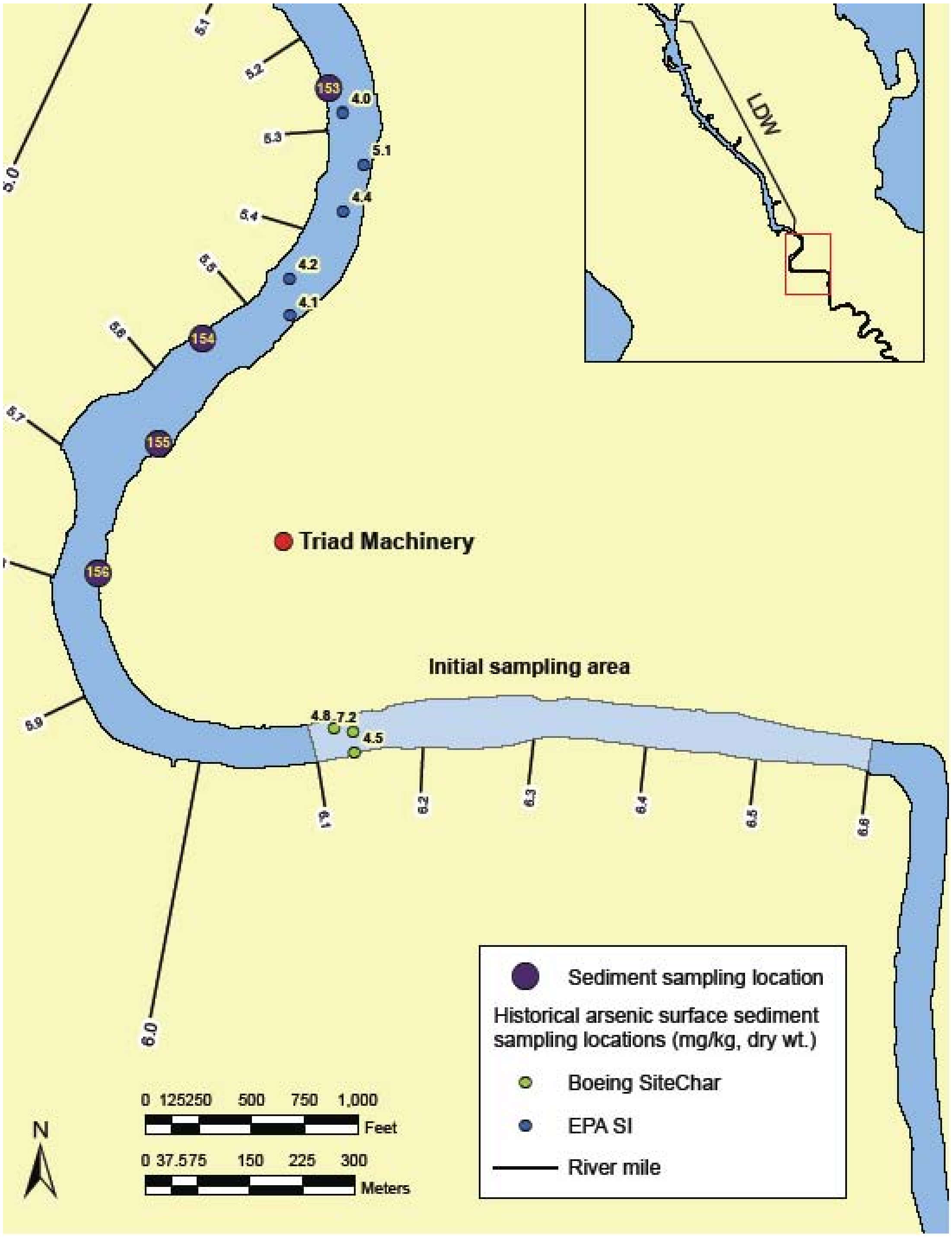

Figure D-2. Historical and current surface sediment sampling area

D.3 Sampling Design

This section discusses the number of background samples that will be collected, their locations, sampling schedule, sample identification, and a summary of sample collection and analysis methods.

D.3.1 SELECTION OF BACKGROUND LOCATIONS AND NUMBER OF SAMPLES

D.3.1.1 Criteria for selecting sampling locations

The locations for background sediment samples for arsenic were selected to meet the following criteria:

- be similar to the LDW in terms of physical and geological characteristics
- have no known regulated or unregulated point sources of arsenic
- have similar aerial deposition of arsenic in the past from the Asarco copper smelter based on its proximity to the LDW study area

To identify known regulated or unregulated point sources of arsenic, Ecology's Confirmed and Suspected Contaminated Sites database was reviewed. One site (Triad Machinery) with confirmed arsenic issues in groundwater is located at 11120 Pacific Highway South in Tukwila, approximately 750 ft east of RM 5.8 (Figure D-2). The degree to which this site may influence arsenic concentrations in sediment in the vicinity of this site is not known. Therefore, background sampling locations were placed upstream of this site, as discussed in Section D.3.1.2.

D.3.1.2 Number and location of samples

Eight new samples will be collected and analyzed for arsenic to represent upstream conditions. The study design for determining the number and location of these samples is based primarily on the adequacy of spatial coverage within the area of interest (i.e., Duwamish River upstream of the LDW), as discussed below.

Figure D-2 shows the locations of the eight historical sample locations. This figure also shows four sampling locations that will be sampled for all target chemicals to further delineate the upstream boundary of the site, as described in Section 3.1.1 of the QAPP. Arsenic data from these locations may be useful for characterizing background, assuming the other chemical data from these locations indicate "background" conditions (i.e., no chemical concentrations above the SQS). Because the arsenic concentrations at LDWG-154, 155, and 156 could potentially be influenced by the Triad Machinery site, the arsenic data from these locations will only be included in the arsenic background dataset if the concentrations are less than the mean arsenic concentration from the other background sampling locations, including locations sampled during previous events (Table D-1).

The eight new surface sediment samples will be located upstream of Triad Machinery.[9] Analysis of these eight samples plus the four stations upstream of the LDW (discussed above) will bring the total number of historical and Phase 2 samples in this upstream area to 20.

As indicated in Table D-1 and Figure D-3, many areas in the LDW have finer sediments than the eight historical sediment samples collected from the background sampling area. Consequently, the field crew will attempt to locate areas with at least 60% fine sediment in the field. The 60% cutoff was selected based on the prevalence of 60-90% fines in the histogram shown in Figure D-3. Assuming eight locations with more than 60% fines can be located in the field, the grain size distribution for the 16 background samples (not counting the 4 full-suite samples) would be as follows:

- 0 to 30% fines – 6 historical samples
- 30-60% fines – 2 historical samples
- >60% fines – 8 new samples

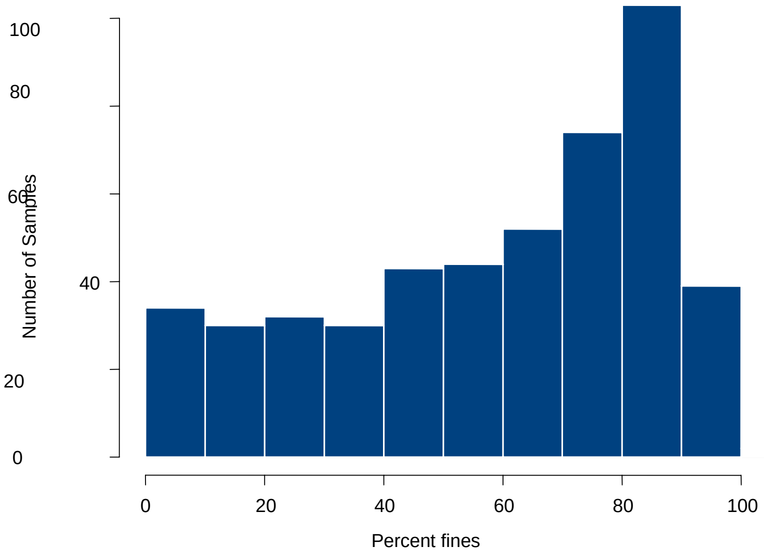

Figure D-3. Histogram of LDW percent fines in historical LDW surface sediment samples

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[9] EPA and Ecology reserve the right to request additional research on potential arsenic sources in the area of background sampling and/or reject samples for use as background samples if unusually high arsenic concentrations are found in background areas.

This distribution roughly corresponds to the grain size frequencies in the historical LDW dataset (Figure D-3). The eight additional sample locations are not shown on Figure D-2 because the field crew will decide in the field where to place these samples based on field screening methods for grain size determination (see Section D.3.4). The field crew will initially focus their sampling efforts on intertidal mud flats between RM 6.1 and 6.6, where finer sediments are more likely to be found. If a sufficient number of fine sediment samples are not found in this region, sampling will continue upstream of RM 6.6.

D.3.2 SCHEDULE

The sediment sampling for background arsenic will be conducted immediately following the first round of LDW surface sediment sampling, which is currently scheduled for January 2005. Assuming that surface sediment sampling in the LDW is completed by January 26, as described in the QAPP, background sediment sampling will be begin on January 31.

D.3.3 LOCATION AND SAMPLE IDENTIFICATION

Each background sampling location will be assigned a unique alphanumeric location ID number. The first three characters of the location ID are "DR" to identify the Duwamish River. The next characters are SS to indicate the type of samples to be collected (surface sediment), followed by a consecutive number identifying the specific location within the Duwamish River. Sample IDs will resemble location IDs, but will include a suffix of '010' to indicate that sediment from the 0-10 cm depth range is included in the sample. For example, the sediment sample collected at location DR-SS1 will be identified as DR-SS1-010. One field duplicate sample will be collected. The duplicate sample ID will be designated DR-SS9-010.

D.3.4 SAMPLING METHODS

The background sediment samples will be collected either from a small boat using a 0.02-m^2 Ekman grab sampler or by hand in intertidal areas using a stainless steel spoon. Other sampling method elements and sampling handling procedures are identical to those described in Sections 3.2 and 3.3 of the QAPP.

The field crew will spend up to two full days in the field collecting the background samples and will attempt to optimize the two primary sampling design considerations of grain size and spatial coverage during that time. Up to 20 sediment samples with greater than 60% fines will be collected in the targeted area (RM 6.1 to 6.6). The coordinates and the percent fines (as determined in the field; see below) of all these samples will be submitted to EPA and Ecology along with recommendations regarding the eight samples that best provide spatial coverage and meet grain size criteria. EPA, Ecology, and LDWG will then discuss and ultimately reach consensus on which samples to submit to the analytical laboratory.

The field crew will qualitatively assess the grain size at a potential sampling area by observing the sediment characteristics of the adjacent river bank. If there is a reason to believe the sampling area contains fine sediment, a sample will be collected for field screening of grain size. Prior to screening, the sample will be homogenized and split so grain size can be assessed in the field in one portion of the sample and the remainder can be submitted for laboratory analyses, if the sample passes the grain size screen. Percent fines will be determined by screening 100 mL of sediment through a 63-µm sieve in the field and collecting the remainder (i.e., the sand and gravel fraction) in a graduated cylinder. The difference between the original volume (100 mL) and the volume of the sand and gravel fraction is equivalent to percent fines. Field screening of grain size will be completed at each prospective sampling location before moving to the next sampling location.

At each sampled location with percent fines greater than 60%, as determined by field screening, 500 g of sediment will be collected and stored in two glass jars in a cooler with ice, according to the sample handling and shipping procedures outlined in Section 3.3 in the QAPP. Sediment samples will be delivered on ice to ARI following chain of custody procedures for analysis of total arsenic (MDL = 0.2 mg/kg dw), grain size, and moisture content.

D.4 References

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APPENDIX E. BACKGROUND APPROACH FOR DIOXINS AND FURANS

E.1.0 Introduction

This appendix provides the problem definition, sampling design, schedule, sample identification scheme, and summary of sample collection and analysis methods for background sampling of surface sediment for dioxins and furans. Sections E.2 and E.3 in this appendix provide equivalent types of information as Sections 2.2 and 3.1 in the quality assurance project plan (QAPP), respectively. All other project elements discussed in the QAPP (i.e., field and analytical methods, quality assurance/quality control [QA/QC], data management) are applicable to the background sampling.

E.2.0 Problem Definition and Existing Information

This section presents the problem definition and summarizes relevant existing information regarding dioxin/furan sources and their concentrations in sediments on a local scale (in the Lower Duwamish Waterway [LDW]), a regional scale (in Puget Sound), and nationally.

E.2.1 PROBLEM DEFINITION

Dioxins and furans were identified as chemicals of potential concern in the Phase 1 human health risk assessment (HHRA) through direct exposure to sediment based on the existing dataset of 29 surface sediment samples from the LDW. Dioxins/furans are believed to be toxic to human and ecological receptors at very low concentrations, but are also ubiquitous in both rural and urban areas as a result of both nonpoint runoff and aerial distribution pathways (EPA 2000). To determine if local point sources are responsible for the concentrations of dioxins/furans in LDW sediment, additional investigation is being conducted as part of the Phase 2 remedial investigation (RI).

To further investigate dioxins/furans in the LDW area, an additional 20 surface sediment samples will be collected in the LDW. These samples will be collected from: 1) locations associated with higher concentrations based on existing sediment data, 2) locations adjacent to potential point sources in the LDW, or 3) locations with elevated PCB concentrations. In addition, as discussed in this appendix, 13 surface sediment samples will be collected from the greater Seattle metropolitan area to assess the range of dioxin/furan concentrations associated with outfalls draining urban watersheds, which will be considered in determining appropriate background levels for comparison to dioxin/furan concentrations in LDW sediment.

Dioxins and furans enter the aquatic environment through nonpoint source runoff via storm drains, through direct atmospheric deposition to surface water, or through point source discharges associated with certain industrial practices (e.g., pulp mills or pentachlorophenol [PCP] production). Urban sources of dioxins and furans include combustion (e.g., burning of fuels, particularly diesel fuel), backyard burning, and wood stoves. Incineration of waste materials containing chlorine, such as medical waste and municipal solid waste, and certain types of chemical manufacturing can also result in air releases of dioxins/furans. Because air emission is one of the most common mechanisms for release of dioxins and furans into the environment, these chemicals are commonly dispersed in urban areas; thus, storm runoff from surfaces such as parking lots, streets, and roof tops can have low, but significant on a cumulative basis, concentrations of dioxins and furans.

To assess the influence of general urban runoff on dioxins and furans in background sediments, the sediment samples discussed in this appendix will be collected at the appropriate distance from storm drains serving drainage basins similar in size and land use to those in the LDW (see Section E 3.0, Sampling Design). To select the most appropriate areas to sample, existing sediment data and potential source information for dioxins/furans and other chemicals were reviewed to select sampling locations unlikely to be influenced by known point sources of dioxins/furans. Thus, these samples should represent the general influence of Seattle area urban runoff on concentrations of dioxins and furans in sediment.

EPA has guidance for conducting and interpreting background data. The most relevant guidance regarding consideration of background concentrations in risk assessment and risk management at Superfund sites is *Role of Background in the CERCLA Cleanup Program* (EPA 2002). As stated in the guidance:

> *Background information is important to risk managers because the CERCLA program, generally, does not clean up to concentrations below natural or anthropogenic background levels. The reasons for this approach include cost-effectiveness, technical practicability, and the potential for recontamination of remediated areas by surrounding areas with elevated background concentrations.*

Thus, the key objective for the dioxin/furan sediment background assessment is to determine whether concentrations of dioxins/furans in LDW sediments are attributable to local point sources or whether they represent general urban background concentrations. This sampling approach will allow comparison of the Lower Duwamish to similarly utilized urban/industrial areas around Seattle. This assessment will be based on an evaluation of the following information:

- Concentrations and distributions of dioxins/furans in sediments of the LDW using existing surface sediment data (29 sediment samples) and additional data to be collected in the LDW as described in the QAPP (20 surface sediment samples; see Section 3.1.2 in the QAPP)
- Concentrations and distributions of dioxins/furans in sediments in the area of outfalls draining greater Seattle area watersheds that may be considered representative of areas influenced by urban outfalls in the LDW
- Concentrations and distributions of dioxins/furans in sediments of waterways from other urban areas in the Puget Sound and nationally that are not

influenced by point sources and are thereby consistent with the urban background concept

- Potential dioxin/furan source information in the LDW, greater Seattle metropolitan area, and other urban areas in Puget Sound with existing sediment data

This information will be used to determine the most appropriate course of action for evaluating dioxins/furans in LDW sediment in the Phase 2 RI, which will be made in consultation with the US Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology).

E.2.2 DIOXIN/FURAN SOURCES

This section discusses general categories of dioxin and furan releases identified on a national level by EPA (1998), as well as those identified on a state level by Ecology (1998). In addition, potential local dioxin/furan sources to the LDW are discussed.

E.2.2.1 Dioxin/furan sources identified by EPA

Major categories of general dioxin and furan sources on a national level, both point and non-point, were initially identified by EPA (1998) as:

- combustion sources (e.g., waste incineration, fuel burning, cement kilns, uncontrolled burns)
- primary and secondary metals operations (e.g., smelting, refining, processing, as well as iron ore sintering, steel production, and scrap metal recovery)
- chemical manufacturing and processing (e.g., chlorine-bleached wood pulp, PCP, PCBs)
- biological and photochemical processes (e.g., composting or photolysis of chlorinated phenols)

More recently, EPA (2000) also identified the following sources as increasing major contributors of dioxins/furans, particularly as the above industrial releases are decreasing: 1) backyard barrel burning,[10] 2) residential wood burning, 3) utility/industrial coal and oil combustion, 4) on-road fuel combustion of diesel, unleaded gas, and leaded gas, and 5) crematoria. Residential wood burning and vehicle emissions are ubiquitous sources in the urban environment. Current total emissions from combustion sources are estimated to be more than an order of magnitude greater than emissions from all other categories combined (EPA 1998).

Dioxins and furans from the common urban sources listed above are released to the air in urban environments, deposited on urban soil and impervious surfaces, and conveyed to aquatic waterways through secondary transport via storm drains.

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[10] Backyard burning is banned in the Seattle area, but may still occur.

Concentrations of dioxins and furans in urban soils and air resulting from these non-point sources are considered by EPA to represent urban background (EPA 2000). In San Francisco Bay, the San Francisco Bay Water Quality Control Board has estimated that on a mass contribution per year basis (g/yr), storm water runoff transports 80% of dioxins/furans to the Bay followed by 18% from direct deposition to water, 2% from sewage treatment plants, and 0.06% from petroleum refineries (SFBRWQCB 1997). In the Bay area, motor vehicle sources were estimated to account for approximately 70% of dioxin air emissions, with the majority from diesel engines (BAAQMD 1996). Sufficient data were not available to characterize the relative input of dioxins/furans in urban runoff among various land uses (Wenning et al. 1999).

E.2.2.2 Dioxin/furan sources identified by Ecology

In the *Washington State Dioxin Source Assessment*, Ecology (1998) identified major confirmed categories of dioxin/furan releases to air, lands, or waterways in Washington State as municipal and medical waste incinerators, hog-fuel boilers, bleached pulp and paper mills, cement kilns, municipal wastewater treatment,[11] and activated carbon regeneration. The "confirmed" dioxin source categories are those for which there were adequate data to calculate a dioxin load from at least one individual source in that group. Other source categories for which dioxin loads could not be reliably calculated included wood-treating facilities and oil refineries. Several additional categories were noted as "potential" rather than "confirmed" sources of dioxins because dioxin data were not available to calculate a dioxin load. These sources include structure fires, illegal burning of prohibited materials, metal smelting and refining, and other small miscellaneous sources.

E.2.2.3 Potential dioxin/furan sources to the LDW

The sources of dioxins/furans to the LDW have not been fully identified, but are likely a mix of localized historical point source releases to the waterway and releases to air followed by deposition and transport to the waterway via secondary non-point sources.

Specific facilities identified by Ecology (1998) with current air emissions that are located on the LDW are Holnam Cement, Inc. (RM 1.0 to 1.2 west) and Ash Grove Cement (RM 0.0 to 0.2 east).[12] Identified potential point sources in the vicinity of the LDW include waste incinerators at the Northwest Hospital and the US Veterans

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[11] Wastewater treatment does not generate dioxins, although treated water discharged from these facilities, as well as associated biosolids (sludges), can contain dioxins from sources, (i.e., sewage, industrial pretreatment permitted discharges, or stormwater) that discharge to the plant (Ecology 1998).

[12] Stack emissions tests were conducted six times at Holnam and once at Ash Grove Cement. Dioxins/furans were detected at Holnam but not at Ash Grove. Ecology (1998) suggested the test at Ash Grove was not adequate because it was the only air emissions test for a facility assessed in their review that failed to detect even one of the 17 toxic dioxin and furan congeners.

Administration Medical Center (Figure E-1).[13] Additional potential historical sources of airborne dioxins/furans, for which limited information is available, include the burning of waste at municipal landfills in the vicinity of the LDW as well as a historic lead smelter on Harbor Island.

No specific facilities with current discharges (via water) to the LDW were identified by Ecology (1998) as potential sources of dioxins and furans. However, Ecology (1998) indicated that municipal wastewater could be a potential pathway for dioxins/furans to reach the LDW. Stormwater drainage to the LDW serves areas with approximately 65% residential, 30% industrial, and 5% commercial land use (Figure E-3). It is not known how much of the dioxins/furans in LDW sediments may come from each of these land uses. Nationally, data show that urban areas contribute higher dioxin/furan but there is no breakdown by land use type. It is plausible that industrial areas discharge higher concentrations of dioxins/furans from nonpoint sources such as higher rates of use of diesel engines and other combustion activities such as welding and generators.

Pentachlorophenol (PCP) manufacturers, in general, were identified by Ecology (1998) as potential sources of dioxins/furans. The former Reichold Chemical Company, which manufactured PCP, as well as synthetic resins, formaldehyde, and hydrochloric acid, was located on the west side of the LDW at approximately RM 1.4 (Blomberg 2003), adjacent to the locations with the highest toxic equivalents (TEQs; see Section E.2.3 for a discussion of TEQ calculations) reported to date in the LDW sediments (224 ng/kg dw in sample 902 at RM 1.45). According to reports in Sweet Edwards (1985), "highly toxic wastewater" was discharged from this site directly into the LDW until 1955, when temporary settling basins were used for wastewater disposal. The plant was closed in 1958.

Producers of steel foundry dust were also identified by Ecology (1998) as potential sources of dioxin/furans, although chemical data associated with these industries in Washington State were not found. Dioxin/furans have been detected in previous testing of fertilizers and soil amendments by Ecology, particularly in fertilizers made from electric arc furnace dust from steel mills (K061 wastes). Two industries along the LDW, Birmingham Steel (RM 0.2 to 0.4 east) and Jorgensen Forge (RM 3.6 to 3.7 east) are both generators of K061 waste (Ecology 1998). K061 wastes from these plants are sent to offsite landfills. It is not known if there are other locations of stockpiling or handling steel mill furnace dust along the LDW. The Boeing property located at RM 3.7 to 3.8 (east) was occupied by a steel foundry that was acquired and enlarged by Isaacson Steel in the early 1950s through the 1960s and may have been a historical source of steel foundry dust.

In addition to Holnam Cement, Inc, and Ash Grove Cement, two other cement plants along the LDW were identified from source information provided by EPA and

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[13] Swedish Hospital was also identified as a closed waste incinerator.

Ecology based on a preliminary file search (Flint 2003). These plants are located at the Glacier NW properties north of Slip 2 on the east side of the LDW at approximately RM 1.7 and on the west side of the LDW at approximately RM 1.5, the location of the highest TEQ reported to date in LDW sediments. Additional information, such as whether cement kilns are operating at these plants, or if stockpiling or handling of cement kiln dust occurred at these sites, was not available. Source information from EPA and Ecology (Flint 2003) also included the presence of a concrete waste disposal facility at the Glacier NW Seattle Ready-Mix plant (RM 2.15 west); the former presence of a wood-treating facility from about 1947 to 1961 at the Glacier NW property north of Slip 2 (RM 1.7 east); and the potential historical presence of a wood preserving company on the Boeing Isaacson property (RM 3.7-3.8 east). Information from Sweet Edwards (1985) noted the reported historical disposal of kiln and truck washdown in a soaking pit/settling pond at the current location of Holnam Cement (formerly Ideal Cement).

Outside of the LDW, but in the greater Seattle area, two former wood treating facilities were identified by Ecology (1998) as potential sources of dioxin/furan discharge to the aquatic environment: the JH Baxter/Quendall Terminals site located at the southeast end of Lake Washington and the Pacific Sound Resources site on Elliott Bay (Figure E-1).

E.2.3 EXISTING DIOXIN/FURAN DATA IN THE LDW

As part of the 1998 EPA site inspection of the LDW (Weston 1999), 29 surface sediment samples were analyzed for dioxins and furans throughout the waterway. These data are summarized in Table E-1 as TEQs and shown by location in Figure E-2. Throughout this memo, dioxins and furan concentration data are presented as TEQs.[14] TEQs were calculated for this memo using mammalian[15] toxic equivalency factors (TEFs) from Van den Berg et al. (1998). The data are presented two ways: 1) assuming half detection limit (DL) for undetected congeners, or 2) assuming undetected congeners have a concentration of zero. No contribution from dioxin-like PCB congeners is included in any of the calculations in this appendix. The basis for TEQ calculations at other sites discussed in Section E.2.4.1 is noted in Table E-2, where information was available.

TEQs ranged from 1.17 to 224 ng/kg dw, with a mean of 19.5 ng/kg dw, using the half DL assumption, and ranged from 0 to 224 ng/kg dw, with a mean of 17.5 ng/kg dw using the zero DL assumption. The difference between zero and half DL values is due

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[14] Dioxin and furan concentrations are presented as TEQs to represent equivalent concentrations in terms of the toxicity of 2,3,7,8 TCDD, the most toxic congener.

[15] Mammalian TEFs were used to provide a common frame of reference; mammalian toxicity data are the basis for the EPA (1989) values used by two other studies described in this memo. Mammalian TEFs from Van den Berg et al. (1998) are equal to or greater than fish or avian TEFs except for 1,2,3,4,7,8-hexaCDD, 2,3,7,8-TCDF, and 2,3,4,7,8-pentaCDF.

primarily to samples with undetected penta-chlorinated dibenzofurans (CDFs) and penta-chlorinated dibenzo-p-dioxins (CDDs), which had high TEFs of 0.5 and 1, respectively, and DLs of up to 5 ng/kg dw.

With the exclusion of two sediment samples from the existing LDW data, with TEQs of 171 and 224 ng/kg dw (using either DL assumption), the remaining TEQs ranged from 1.17 to 16.1 ng/kg dw, with a mean of 6.26 ng/kg dw using the half DL assumption, and from 0 to 11.6 ng/kg dw, with a mean of 4.15 ng/kg dw using the zero DL assumption. The 171 ng/kg sample is located within the Diagonal/Duwamish dredging prism (which has now been dredged), and the 224 ng/kg sample is located within the inlet at RM 1.5 (Figure E-2). These areas are being further characterized for dioxins/furans as part of the Phase 2 surface sediment sampling (see Section 3.1.2 in the QAPP).

Table E-1. Existing surface sediment dioxin/furan data for the LDW presented as TEQs in ng/kg dw

DATUM	TEQ USING HALF DL	TEQ USING ZERO DL
Range of entire LDW dataset	1.17 - 224	0.00 - 224
Mean of entire LDW dataset	19.5	17.5
Range without two high samples[a]	1.17 – 16.1	0 – 11.6
Mean without two high samples[a]	6.26	4.15

Note: Mammalian TEFs from Van den Berg et al. (1998) were used to calculate TEQs.

[a] The two high concentrations excluded are 171 and 224 ng/kg TEQ

E.2.4 EXISTING REGIONAL AND NATIONAL BACKGROUND SEDIMENT DATA

This section presents existing dioxin/furan data for sediment from other sites in the general Puget Sound region. This information provides a regional perspective to the existing dioxin/furan data in the LDW sediment. The risk assessment approaches and cleanup levels for dioxins/furans chosen at those sites are also discussed. National data on sediment dioxins/furans are presented to place both the regional and LDW sediment data in perspective with national background concentrations.

E.2.4.1 Regional background data

Existing data on background dioxins/furans in sediment from waterways in Puget Sound were compiled by searching Ecology's Sediment Quality Information System (SEDQUAL) database, the EPA records of decision (RODs) database, and agency websites. Background sediment data for dioxins/furans were developed for comparison with site conditions as part of the investigations of the following four sites with known dioxin/furan contamination: Olympic View Resource Area (Commencement Bay, Tacoma), Pacific Sound Resources (Elliott Bay, Seattle), Cascade Pole (Budd Inlet, Olympia), and Manchester Annex (Clam Bay, Kitsap Peninsula). A summary of the data identified by EPA and/or Ecology as background for these sites is presented in Table E-2. Data from Elliott Bay in Seattle were collected as part of the remedial investigation for the Pacific Sound Resources site. The Elliott Bay shoreline data [16] are selected for use in the Phase 2 background analysis because of their locations in the general urban environment in which the LDW study area is located. Background data for the other three sites are not selected for used in developing background levels for the LDW because of their location outside the general Seattle urban area. In addition, Olympic View Resource Area and Cascade Pole background samples were collected in the vicinity of point sources.

Table E-2. Existing Puget Sound regional background dioxin/furan sediment data

	Surface sediment TEQ (ng/kg dw)				
	Olympic View Resource Area, Tacoma[a]		Pacific Sound Resources, Seattle[b]	Cascade Pole, Olympia[c]	Manchester Annex, Kitsap Peninsula[d]
Background sample location	**Site perimeter[e]**	**Commencement Bay**	**Elliott Bay**	**Budd Inlet**	**Yukon Harbor**
Number of samples	9	6	4	9	1
Mean	5.5	11.3	1.05	5.91	na
Minimum	2.7	1.7	0.18	0.51	0.72
Maximum	10.4	31.9	4.03	22.4	0.72

na - not applicable

[a] Source: Pentec (2001). TEQs were calculated assuming half detection limit for non-detects. TEFs were from Van den Berg et al. (1998), but it is not known if mammalian, avian, or fish TEFs were used.

[b] Source: Weston (1998) and EPA (1999). TEQs were calculated by Windward using raw congener data, assuming half detection limit for non-detects. Mammalian-based TEFs from Van den Berg et al. (1998) were used.

[c] Source: Kourehdar (2003); Landau (1993), and Landau (2003). TEQs were calculated assuming half detection limit for non-detects. Mammalian-based TEFs from EPA (1989) were used.

[d] Source: EPA (1997) and Kievit (2003). Information on TEQ calculation and TEFs was not available.

[e] The upper 95th percent confidence limit of these samples was 7.4 ng/kg dw

Cleanup levels for dioxins/furans that were established at two sediment sites within Puget Sound may be relevant to the LDW. Remedies at the two sites with the highest dioxin contamination, Cascade Pole and Olympic View (maximum TEQs of 1,290 to 3,416 ng/kg, respectively), included specific sediment TEQ cleanup levels. A sediment TEQ cleanup level of 20 ng/kg dw was set at Olympic View, to result in a spatially weighted average TEQ below the site-specific background TEQ (upper 95th percent confidence limit) of 7.4 ng/kg dw. This background concentration was derived by EPA using nine sediment samples along the site perimeter, where concentrations

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[16] The Elliott Bay station located offshore of Magnolia (Figure E-1) is considered representative of non-urban background Puget Sound conditions rather than urban conditions because of its distance from the shoreline as well as from non-point urban influences. Therefore, this station is not proposed for use in the Phase 2 background analysis.

declined significantly with distance from hotspot areas. At Cascade Pole, the sediment TEQ cleanup level was set at 80 ng/kg, based in part on an ecological risk evaluation performed by Ecology in 1995 and updated in 2000 (Landau 2000). TEQ-based cleanup levels were not established as part of the remedies at the Pacific Sound Resources or Manchester Annex sites.

E.2.4.2 National background data

In their draft human health reassessment of dioxin, EPA (2000) summarized national background concentrations of dioxins/furans for various media, including urban and rural soils, urban and rural air, and sediment cores (only the uppermost, or most recently dated section) using data collected from 11 lakes and reservoirs throughout the US that were considered non-source-impacted sites (Table E-3). No distinction was made between urban and rural sediment sites. Dioxin/furan concentrations in urban soils and air nationally are substantially higher than rural soils and air, likely due to the widespread occurrence of nonpoint urban sources discussed in Section E.2.2. These data were used by EPA to distinguish site media impacted by industrial point sources from those areas considered to be urban background and rural background for dioxins/furans.

Table E-3. Summary of national data in urban and rural soil, air, and sediment (EPA 2000)

MEDIA	ARITHMETIC MEAN OF TEQ [A]	TEQ RANGE	NUMBER OF SAMPLES
Urban soils[b]	9.4 ng/kg	2-21 ng/kg	171
Rural soils[b]	2.5 ng/kg	0.1-6 ng/kg	292
Urban air[c]	0.12 pg/m^3	0.03 -0.2 pg/m^3	106
Rural air[c]	0.017 pg/m^3	0.01-0.02 pg/m^3	7
Sediment[c,d]	5.3 ng/kg	< 1 – 16.3 ng/kg	11

[a] TEQs were calculated using mammalian TEFs from Van den Berg et al. (1998)

[b] Undetected congener concentrations set equal to zero

[c] Undetected congener concentrations set equal to half detection limits

[d] Urban and rural sediment sites not distinguished, but all data are from lakes and reservoirs with no known dioxin/furan sources

E.3.0 Sampling Design

This section discusses the location and number of background samples that will be collected, the sampling schedule, sample identification, and summarizes the sampling and analysis methods.

E.3.1 SELECTION OF BACKGROUND LOCATIONS

As discussed in Section E.2.1, the objective of the Phase 2 dioxin/furan sediment sampling is to determine if the concentrations of dioxins/furans in LDW sediment are within the range of the average Seattle area. To address this objective, it is necessary to determine the concentration range of dioxins/furans in sediment from urban aquatic environments that are influenced by general non-point sources of dioxins/furans. As indicated above, the non-point sources to the LDW include a mix of residential, commercial, and industrial-related releases to air resulting in direct deposition onto the waterway, or deposition onto the LDW basin and subsequent transport to the LDW via runoff. Nearby urban waterways with drainage from land use mixes similar to the LDW will be sampled to assess this concentration range, as discussed below. Background locations within the greater Seattle area were placed to meet the following criteria:

- Drainage of areas with land use similar to that draining to the LDW
- No known industrial point sources of dioxins/furans
- Similar receiving environments(i.e., representing a range of quisence/disturbance conditions)
- Similar discharge flow characteristics (i.e., a range of discharge frequencies, velocities, and types)

To meet these criteria, 13 urban background sampling stations were selected in nine locations. These locations drain basins with mixed land use, similar to the Green/Duwamish sub-watershed (Figure E-3; Tables E-4 and E-5).

Table E-4. Designated land use for Green/Duwamish sub-watershed

COMP PLAN DESCRIPTION	AREA (mi^2)	AREA (ac)	% OF SUB-WATERSHED
Designated agriculture	0.00	0.00	0.00%
Commercial	0.24	153	1.08%
Designated commercial forestry	0.00	0.00	0.00%
Industrial	9.63	6,163	43.31%
Mixed Use (incl. residential)	0.52	336	2.35%
Parks and open space	0.93	597	4.20%
Residential	8.68	5,558	39.06%
Utility and transportation	1.63	1,040	7.31%
Right of way	0.00	0.00	0.00%
Mineral resource lands	0.00	0.00	0.00%
Tribal, governmental, military	0.20	129	0.90%
Unknown designation	0.06	36	0.25%
Water	0.34	218	1.54%
Sub-watershed total	**22.23**	**14,230**	**100%**

Source: King County (2000)

A search was conducted of Ecology's confirmed and suspected contaminated sites (CSC) list for sites contaminated with dioxins/furans, phenols,[17] or PCBs. Existing source information from the CSC list for each of the selected background sampling stations is summarized in Table E-6. Based on this analysis, sampling locations were not placed in areas with known dioxin/furan point discharges,[18] such as former wood treating plants or PCP producers. Although, basins with identified sources of dioxins/furans were excluded, some basins with confirmed or suspected PCB or phenol[19] sources were included. Complete and detailed information on point sources and source control practices is not available for each basin that will be sampled. However, the City of Seattle and King County each require the implementation of best management practices for stormwater control through local ordinances (City of Seattle Title 22.800; King County Code 9.12).

Surface sediment chemistry data collected since 1990 within a 1-mile radius of each background sampling location were retrieved from the SEDQUAL database. Based on the SEDQUAL data review, no obvious patterns of PCB[20] contamination were noted in historical sediment samples near selected background stations. Nevertheless, to assess the potential co-occurrence of PCBs on dioxin/furan concentration, PCBs (as Aroclors) will also be analyzed in each background sample. Additional sediment will be collected and archived from each sample location for potential analysis for other chemicals if needed to interpret sample results.

SEDQUAL data for chemicals other than PCBs, including PCP, were also reviewed. Detected concentrations of multiple chemicals above the CSL were noted throughout Salmon Bay (1a/1b), although no samples have been collected within 100 ft of the selected sampling locations. PCP concentrations in Salmon Bay ranged from 0.019 to 1.24 mg/kg at 19 locations. Chemical concentrations near the 1a/1b sample location are similar to the surrounding area. A potential source of PCP in Salmon Bay may include wood treatment preservatives used in the marine industry. Because dioxins may be a co-contaminant associated with PCP, the samples collected at 1a/1b will also be analyzed for PCP. Several locations in the vicinity of Terminal 91 (2a/2b) also had concentrations greater than the CSL. None of these historical sampling locations were

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[17] The Ecology CSC database does not distinguish pentachlorophenol from the phenol group of compounds.

[18] EPA and Ecology reserve the right to request additional research on potential dioxin/furan sources in the areas of background sampling and/or reject samples for use as background samples if unusually high dioxin/furan concentrations (i.e., greater than the national background range) are found in background areas.

[19] Specific phenols were not listed, so it was not possible to determine if these sources involved pentachlorophenol.

[20] An additional source of dioxins and furans could be associated with PCBs production, because furans, and to a lesser extent dioxins, may be formed during the commercial production of PCBs (EPA 1998).

closer than 1,500 ft to 2a/2b. Historical sample locations in the northeast end of Lake Union (9a/9b) had some CSL exceedances as well, including one location sampled in 2002 adjacent to the Densmore storm drain outfall that had sediment concentrations above the CSL for bis(2-ethylhexyl)phthalate. None of the other historical sampling locations were within 250 ft of 9a/9b. SEDQUAL data in the vicinity of the other background sampling locations were less abundant and generally indicated a low degree of sediment contamination compared to Salmon Bay.

Sediment samples at all nine locations will be collected at approximately 30 to 50 feet from targeted storm drains or CSOs; this distance is intended to capture general runoff that is mixed with other local sedimentary material within the area affected by the discharge, to ensure that samples are representative of urban runoff. The distance of 30 to 50 feet is based on King County and City of Seattle information which indicates that, depending on flow dynamics, the first 30 feet in front of these outfalls tends to be scoured, and that discharged solids begin to mix at about this point. Thus, no samples will be taken closer than 30 feet from the discharge.

EPA and Ecology will work with LDWG to refine specific field sampling protocol that will allow the collection and analysis of composite samples in a zone between 30 to 50 feet from each discharge. Each composite sample will consist of approximately six grabs at each location. The composite samples collected from the 30 to 50 feet zone represent the "a" locations shown on Map E-1. For locations 1, 2, 5, and 9, composite samples will also be collected at the "b" locations. These composite samples will also consist of six grabs, are intended to investigate the concentration as a function of distance, and will be taken from a zone between 100 and 120 feet from the discharge. Prior to sampling LDWG will work with EPA and Ecology to define specific field criteria for determining appropriate placement of samples.

One of the field criteria will be percent gravel. The field crew will qualitatively assess the grain size in background samples to ensure that the sample is being collected outside of the scour zone. Prior to screening, the sample will be homogenized and split so grain size can be assessed in the field in one portion of the sample and the remainder can be submitted for laboratory analyses as part of the composite sample, if the sample passes the grain size screen. Percent gravel will be determined by screening 100 mL of sediment through a 2 mm sieve in the field and collecting the remainder (i.e., the gravel fraction) in a graduated cylinder and estimating its volume. The crew will also bring a 63-µm sieve if a finer distinction of the grain size is needed.

Table E-5. Sediment background dioxin/furan locations, rationale for sampling, and approximate land use

BACKGROUND LOCATION (SEE FIGURE E-1)	DESCRIPTION	RATIONALE	AREA (ACRES)	APPROXIMATE LAND USE (PERCENT)				
				COMMERCIAL	INDUSTRIAL	RESIDENTIAL	ROADS	OPEN /PARKS/ SCHOOLS
1a and 1b[a]	Ship canal, north side offshore of 11th Ave NW	King County CSO serving residential, commercial, and industrial areas in Ballard	1,826	7	3	56	27	7
2a and 2b[a]	Elliott Bay, Pier 91, top northeast corner	Seattle storm drain serving residential, industrial, and commercial areas (Queen Anne)	398	6	16	25	29	18
3	Lake Washington, NE corner	Drainage from residential, commercial, and industrial areas	170	47	23	29	na	na
4	Lake Washington, offshore of Mercer Slough (Bellevue)	Large Bellevue drainage from residential, commercial, and industrial areas	10,700	na	na	na	na	na
5a and 5b[a]	Lake Washington, SW end offshore drain near Renton Municipal Airport	Renton West Hill storm drain serving residential, commercial, and industrial areas	1,236	na	17	54	na	na
6	Springbrook Creek upstream of pump station	Residential, industrial and commercial land uses	16,600	b	9	65	5	21
7	Duwamish River, upstream of LDW site	Boundary condition[c]	>255,000	na	na	na	na	na
8	Laurelhurst, Union Bay	City CSO 018	912	8	<0.1	59	27	6
9a and 9b[a]	Densmore drain, Lake Union under I-5 bridge	Densmore drain serving primarily residential and commercial areas	2187	17	<0.1	35	23	24

[a] The two composite samples at these locations will be located at approximately 30 to 50 feet and 100 to 120 feet from the outfalls. All other composite samples associated with outfalls will be located at approximately 30 to 50 feet from the outfall.

[b] Included with industrial

[c] Includes entire Duwamish/Green River watershed upstream of LDW study area

na - not available

Table E-6. Source information for drainage basins selected for sediment background dioxin/furan sampling

BACKGROUND LOCATION (SEE FIGURE E-1)	LOCATION DESCRIPTION	SITE(S) WITHIN BASIN ON ECOLOGY'S CSC LIST	REASON FOR INCLUSION ON ECOLOGY'S CSC LIST
1a and 1b	Ship canal, north side offshore of 11th Ave NW	2346 – Ballard Auto Wrecking Former 42972957 – Nix Auto Wrecking	suspected PCBs in soil suspected PCBs in soil
2a and 2b	Elliott Bay, Pier 91, top northeast corner	24768 – Seattle Port Terminal 91	confirmed PCBs in soil
3	Lake Washington, NE corner	None	
4	Lake Washington, offshore of Mercer Slough (Bellevue)	None	
5a and 5b	Lake Washington, SW end offshore drain near Renton Municipal Airport	20554 – Renton Municipal Airport 2097 – Boeing Renton 2065 – Paccar, Inc.	confirmed PCBs in soil confirmed PCBs and phenols in soil[a] confirmed PCBs and phenols in soil[a]
6	Springbrook Creek upstream of pump station	47918484 – PSE Grady Way Renton Complex	remediated PCBs in soil
7	Duwamish River, upstream of LDW site	2063 – Duwamish Fill Site	suspected PCBs in soil
8	Union Bay	None	
9	Lake Union, under I-5 bridge	None	

[a] The Ecology CSC list does not specify which phenol compounds are of concern.

The background dataset as a whole will be used to investigate the range of dioxin/furan concentrations in sediments from the greater Seattle urban area. Because an exhaustive source review is not feasible in all drainage basins associated with the background locations listed in Table E-5, potential outliers in the dataset will be discussed with EPA and Ecology to assess their interpretation. Specifically, if concentrations of dioxins/furans at a given location are greater than national norms for background concentrations of dioxins/furans (see Section E.2.4.2), these stations may not be considered to represent appropriate urban background for the LDW. LDWG will consult with EPA and Ecology who will make the final decision regarding whether additional research is needed on potential sources in any of the basins before these stations are used as background locations and whether any locations should be omitted.

E.3.2 SCHEDULE

The background sediment sampling for dioxins/furans will be conducted immediately following the first round of LDW surface sediment sampling, which is currently scheduled for January 2005. Assuming that surface sediment sampling in the LDW is completed by January 26, as described in the QAPP, background sediment sampling will be begin on January 31.

E.3.3 LOCATION AND SAMPLE IDENTIFICATION

Each background sampling location will be assigned a unique alphanumeric location ID number. The first two characters of the location ID identify the sampling area: "DR" for Duwamish River; "EB" for Elliott Bay; "LU" for Lake Union; "LW" for Lake Washington; "PB" for Portage Bay; "SB" for Springbrook Creek; and "SC" for Ship Canal. The next characters are SS to indicate the type of samples to be collected (surface sediment), followed by a consecutive number identifying the specific background location (1 through 8). If more than one sample will be collected in a single area, then each location will be designated with a letter suffix (e.g., SC-SS1a and SC-SS1b). Sample IDs will resemble location IDs, but will include a suffix of '010' to indicate that sediment from the 0-10 cm depth range is included in the sample. For example, the sediment sample collected at location SC-SS1a will be identified as SC-SS1a-010. One field duplicate sample will be collected and designated by using the next available number in the series. For example, if the duplicate sample was collected from Lake Washington, it would be designated LW-SS6-010.

E.3.4 SAMPLE COLLECTION AND ANALYSIS SUMMARY

Surface sediment samples will be collected from a small boat using a 0.02-m^2 Ekman grab sampler. At shallow locations accessed by land, a stainless steel spoon will be used (see Section 3.2.3 in the QAPP for details). Sediment sampling locations are specified in Table E-7. At each location, sediment will be collected, homogenized, and split. Samples from each location will be stored in one 8-oz glass jar and two 1-L glass jars in a cooler with ice, according to the sample handling and shipping procedures outlined in Section 3.3 in the QAPP. One field duplicate sample will also be collected. The 8-oz sample will be shipped on ice to Axys and analyzed for low-level dioxins and furans (MDL = 0.06 ng/kg), total organic carbon, and moisture content. The two 1-L samples from each location will be delivered on ice to ARI for PCB Aroclor analysis. Remaining sediment not used for PCB Aroclor analysis will be archived frozen.

Table E-7. Sediment background dioxin/furan locations

LOCATION	X COORDINATE[a]	Y COORDINATE[a]	LATITUDE[b]	LONGITUDE[b]
1a and 1b[c]	1261557	244294	47 39.5609	122 22.2480
2a and 2b[c]	1259306	234596	47 37.9586	122 22.7485
3[d]	1290101	279037	47 45.3650	122 15.4562
4[d]	1306060	213899	47 34.6996	122 11.2842
5a and 5b[c]	1298259	185678	47 30.0357	122 13.0567
6[d]	1291078	175429	47 28.3285	122 14.7539
7[d]	1278783	187320	47 30.2462	122 17.7908
8[d]	1282021	242360	47 39.3081	122 17.2575
9a and 9b[c]	1273381	241899	47 39.2053	122 19.3585

[a] Coordinates are in Washington State Plane N, NAD83, US ft

[b] Coordinates are in degrees and decimal minutes, NAD83

[c] Composite samples will be taken at approximately 30 to 50 feet and 100 to 120 feet from the targeted CSO or storm drain

[d] Composite samples will be taken at approximately 30 to 50 feet from the targeted CSO or storm drain

E.4.0 References

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APPENDIX F. LABORATORY METHOD DETECTION LIMITS AND REPORTING LIMITS

Table F-1. Surface sediment chemistry analytes and respective method detection limits and reporting limits

Method and Analyte	Method Detection Limit	Reporting Limit
EPA 8082 – PCB Aroclors (µg/kg dw)		
Aroclor 1260	0.98	20
Aroclor 1016	0.98	20
Aroclor 1254	0.98	20
Aroclor 1221	0.98	20
Aroclor 1232	0.98	20
Aroclor 1248	0.98	20
Aroclor 1242	0.98	20
EPA 1668 – PCB Congeners (ng/kg dw)[a]		
PCB-66	0.39	2.0
PCB-77	0.39	2.0
PCB-81	0.44	2.0
PCB-113/90/101	0.46	2.0
PCB-105	0.37	2.0
PCB-110/115	0.95	2.0
PCB-114	0.21	2.0
PCB-118	0.66	2.0
PCB-123	0.66	2.0
PCB-126	0.35	2.0
PCB-138/163/129/160	0.44	2.0
PCB-153/168	0.34	2.0
PCB-156/157	0.39	2.0
PCB-167	0.39	2.0
PCB-169	0.44	2.0
PCB-180/193	0.46	2.0
PCB-189	0.37	2.0
EPA 1613B – Dioxins/furans (ng/kg dw)[a]		
2,3,7,8-TCDD	0.059	1.0
1,2,3,7,8-PeCDD	0.153	5.0
1,2,3,4,7,8-HxCDD	0.172	5.0
1,2,3,6,7,8-HxCDD	0.118	5.0
1,2,3,7,8,9-HxCDD	0.172	5.0
1,2,3,4,6,7,8-HpCDD	0.169	5.0
OCDD	0.518	10
2,3,7,8-TCDF	0.077	1.0
1,2,3,7,8-PeCDF	0.132	5.0
2,3,4,7,8-PeCDF	0.143	5.0
1,2,3,4,7,8-HxCDF	0.148	5.0
1,2,3,6,7,8-HxCDF	0.154	5.0
1,2,3,7,8,9-HxCDF	0.148	5.0
2,3,4,6,7,8-HxCDF	0.09	5.0
1,2,3,4,6,7,8-HpCDF	0.183	5.0
1,2,3,4,7,8,9-HpCDF	0.081	5.0
OCDF	0.381	10
EPA 8081A – Organochlorine pesticides (µg/kg dw)		
2,4'-DDD	1.1	2.0
2,4'-DDE	0.894	2.0
2,4'-DDT	0.870	2.0
4,4'-DDD	0.320	2.0
4,4'-DDE	0.166	2.0
4,4'-DDT	0.284	1.0
Aldrin	0.054	1.0

METHOD AND ANALYTE	METHOD DETECTION LIMIT	REPORTING LIMIT
alpha-BHC	0.214	1.0
alpha-Chlordane	0.144	1.0
beta-BHC	0.045	1.0
delta-BHC	0.051	1.0
Dieldrin	0.049	1.0
Endosulfan I	0.129	1.0
Endosulfan II	0.097	1.0
Endosulfan sulfate	0.088	2.0
Endrin	0.24	2.0
Endrin aldehyde	0.107	2.0
gamma-BHC (Lindane)	0.141	1.0
gamma-Chlordane	0.054	1.0
Heptachlor	0.027	1.0
Heptachlor epoxide	0.122	1.0
Hexachlorobenzene	0.034	1.0
Hexachlorobutadiene	0.369	1.0
Methoxychlor	0.402	10.0
Mirex	1.22	2.0
Oxy-chlordane	0.464	2.0
trans-Nonachlor	0.964	2.0
cis-Nonachlor	0.334	2.0
Toxaphene	2.97	100
EPA 8270C– SVOCs (mg/kg dw)[b]		
1,2,4-Trichlorobenzene	0.00588	0.02
1,2-Dichlorobenzene	0.00876	0.02
1,3-Dichlorobenzene	0.00755	0.02
1,4-Dichlorobenzene	0.00816	0.02
2,4,5-Trichlorophenol	0.00834	0.10
2,4,6-Trichlorophenol	0.010	0.10
2,4-Dichlorophenol	0.00773	0.10
2,4-Dimethylphenol	0.01052	0.02
2,4-Dinitrophenol	0.1042	0.20
2,4-Dinitrotoluene	0.00897	0.10
2,6-Dinitrotoluene	0.01073	0.10
2-Chloronaphthalene	0.00832	0.02
2-Chlorophenol	0.00948	0.20
2-Methyl-4,6-dinitrophenol	0.1061	0.20
2-Methylnaphthalene	0.00721	0.02
2-Methylphenol	0.0138	0.02
2-Nitroaniline	0.02466	0.10
2-Nitrophenol	0.0113	0.10
3,3'-Dichlorobenzidine	0.0617	0.10
3-Nitroaniline	0.0261	0.10
4-Bromophenyl phenyl ether	0.0117	0.02
4-Chloro-3-methylphenol	0.0111	0.10
4-Chloroaniline	0.0257	0.10
4-Chlorophenyl phenyl ether	0.0321	0.10
4-Methylphenol	0.0135	0.10
4-Nitroaniline	0.0321	0.10
4-Nitrophenol	0.0628	0.10
Acenaphthene	0.00936	0.02
Acenaphthylene	0.00909	0.02
Aniline	0.00912	0.02
Anthracene	0.00869	0.02
Benz(a)anthracene	0.00834	0.02
Benzo(a)pyrene	0.00731	0.02

METHOD AND ANALYTE	METHOD DETECTION LIMIT	REPORTING LIMIT
Benzo(b)fluoranthene	0.00734	0.02
Benzo(g,h,i)perylene	0.00804	0.02
Benzo(k)fluoranthene	0.0104	0.02
Benzoic Acid	0.105	0.20
Benzyl Alcohol	0.041	0.40
Bis(2-chloroethoxy)methane	0.0112	0.02
Bis(2-chloroethyl) ether	0.00993	0.02
Bis(2-chloroisopropyl) ether	0.00996	0.02
Bis(2-ethylhexyl) phthalate	0.0108	0.02
Butyl Benzyl phthalate	0.0103	0.02
Chrysene	0.00809	0.02
Dibenz(a,h)anthracene	0.00835	0.02
Dibenzofuran	0.00795	0.02
Diethyl phthalate	0.135	0.02
Dimethyl phthalate	0.0120	0.02
Di-n-butyl phthalate	0.0135	0.02
Di-n-octyl phthalate	0.0113	0.02
Fluoranthene	0.00849	0.02
Fluorene	0.00917	0.02
Hexachlorobenzene	0.00928	0.02
Hexachlorobutadiene	0.00828	0.02
Hexachlorocyclopentadiene	0.0221	0.10
Hexachloroethane	0.00798	0.02
Indeno(1,2,3-cd)pyrene	0.00854	0.02
Isophorone	0.00738	0.02
Naphthalene	0.00753	0.02
Nitrobenzene	0.0159	0.02
N-Nitrosodimethylamine	0.00912	0.10
N-Nitrosodi-n-propylamine	0.0102	0.10
N-Nitrosodiphenylamine	0.0107	0.02
Pentachlorophenol	0.0371	0.10
Phenanthrene	0.00863	0.02
Phenol	0.00947	0.02
Pyrene	0.00872	0.02
EPA 8270C-SIM – SVOCs (mg/kg dw)		
1,2,4-Trichlorobenzene	tbd	0.0067
1,2-Dichlorobenzene	tbd	0.0067
1,4-Dichlorobenzene	tbd	0.0067
2,4-Dimethylphenol	tbd	0.0067
2-Methylphenol	tbd	0.0067
Benzoic acid	tbd	0.067
Benzyl alcohol	tbd	0.017
Butyl benzyl phthalate	tbd	0.0067
Diethyl phthalate	tbd	0.0067
Dimethyl phthalate	tbd	0.0067
Hexachlorobenzene	tbd	0.0067
Hexachlorobutadiene	tbd	0.0067
n-Nitrosodiphenylamine	tbd	0.0067
N-Nitrosodimethylamine	tbd	0.033
N-Nitrosodi-n-propylamine	tbd	0.033
Pentachlorophenol	tbd	0.033
Krone et al (1989) – Butyltins (µg/kg dw)		
Di-n-butyltin	1.76	6.0
n-Butyltin	4.51	6.0
Tetra-n-butyltin		
Tri-n-butyltin	2.84	6.0

METHOD AND ANALYTE	METHOD DETECTION LIMIT	REPORTING LIMIT
EPA 6010 – Metals (mg/kg dw)		
Antimony (EPA 6020)	0.005	0.2
Arsenic (EPA 6020)	0.02	0.2
Cadmium	0.02	0.2
Chromium	0.09	0.5
Cobalt	0.03	0.3
Copper	0.04	0.2
Lead	0.12	2.0
Molybdenum	0.06	0.5
Nickel	0.38	1.0
Selenium	0.3	5.0
Silver	0.03	0.3
Thallium (EPA 6020)	0.003	0.2
Vanadium	0.03	0.3
Zinc	0.29	0.6
EPA 7471A – Mercury (mg/kg dw)		
Mercury	0.003	0.05

tbd – to be determined; ARI is currently conducting an MDL study for these analytes for this method

[a] Reporting limits for PCB and dioxin congeners analyzed by Axys are equivalent to lower calibration limits (Section 3.4.1.2)

[b] The SVOC method will be calibrated to quantify DDT isomers in addition to standard SVOC analytes. These data will be used to confirm higher concentrations reported by Method 8081 because of the possible interference in the DDT quantifications due to the presence of PCB congeners. For DDT isomer MDLs and RLs, please refer to those presented for Method 8081.

APPENDIX G. HISTORICAL SURFACE SEDIMENT LOCATIONS AND SQS OR CSL EXCEEDANCES

This appendix contains maps of historical surface sediment sampling locations in the LDW (Figures G-1 to G-5). This appendix also contains Table G-1, which is a list of all historical surface sediment locations and chemicals with detected and non-detected SQS or CSL exceedances. The information in Table G-1 was used to determine the symbols for SQS or CSL exceedances at locations on Figures 2-2a to 2-2b in the QAPP. If several symbols applied to one location, the following prioritization scheme was used to select the symbol: 1) detected CSL/ML exceedance, 2) detected SQS/SL exceedance, 3) non-detected CSL/ML exceedance, 4) non-detected SQS/SL exceedance, and 5) detected concentration less than SQS/SL.

Table G-1.	*Location-specific exceedances of SQS or CSL in Phase 2 LDW historical surface sediment chemistry database (Excel file)*
Figure G-1.	*Historical surface sediment sampling locations for the Lower Duwamish Waterway (RM 0.0-1.2)*
Figure G-2.	*Historical surface sediment sampling locations for the Lower Duwamish Waterway (RM 1.2-2.7)*
Figure G-3.	*Historical surface sediment sampling locations for the Lower Duwamish Waterway (RM 2.7-3.7)*
Figure G-4.	*Historical surface sediment sampling locations for the Lower Duwamish Waterway (RM 3.8-4.8)*
Figure G-5.	*Historical surface sediment sampling locations for the Lower Duwamish Waterway (RM 4.8-5.6)*