



**PORTLAND HARBOR RI/FS  
ROUND 2A SEDIMENT SITE  
CHARACTERIZATION SUMMARY REPORT**

**DRAFT**

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July 15, 2005

**Prepared for**  
Lower Willamette Group

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## LIST OF ACRONYMS

CAS	Columbia Analytical Services
GC/ECD	gas chromatography/electron capture detection
CLP	Contract Laboratory Program
COI	chemicals of interest
CRD	Columbia River datum
CSM	conceptual site model
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DGPS	differential geographical positioning system
EDD	electronic data deliverable
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
ERA	ecological risk assessment
FID/PID	flame ionization detector /photo-ionization detector
FOD	frequency of detection
FSP	field sampling plan
GC	gas chromatograph
GC/MS	gas chromatograph/mass spectrometer
HHRA	human health risk assessment
HPAH	high molecular weight polycyclic aromatic hydrocarbons
ICP-MS	inductively coupled plasma-mass spectrometry
ICP-OES	inductively coupled plasma-optical emission
ISA	initial study area
LCS/LCSD	laboratory control sample/laboratory control sample duplicate
LDC	Laboratory Data Consultants, Inc.
LPAH	low molecular weight polycyclic aromatic hydrocarbons
LWG	Lower Willamette Group
MCPA	(4-chloro-2-methylphenoxy)acetic acid
MCPP	2-(2-methyl-4-chlorophenoxy)propionic acid
MS/MSD	matrix spike/matrix spike duplicate
N&E	nature and extent
NEA	Northeast Analytical
NOAA	National Oceanographic and Atmospheric Administration
PAH	polycyclic aromatic hydrocarbons
PCB	polychlorinated biphenyls
PCDD/FS	polychlorinated dibenzo-p-dioxins and furans
QA	quality assurance
QAPP	quality assurance project plans
QC	quality control
RDL	reported detection limits

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RI/FS	remedial investigation and feasibility study
RM	river mile
SCRA	site characterization and risk assessment
SIM	selective ion monitoring
SOP	standard operating procedure
SVOC	semivolatile organic compound
TCE	trichloroethene
TEF	toxicity equivalence factor
TEQ	toxicity equivalent
TOC	total organic carbon
TPH	total petroleum hydrocarbon
VOC	volatile organic compound

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## 1.0 INTRODUCTION

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This Round 2A Sediment Site Characterization Summary Report presents the results of sediment sampling performed by the Lower Willamette Group (LWG) for the Portland Harbor remedial investigation and feasibility study (RI/FS) during the summer and fall of 2004 (hereafter referred to as Round 2A). The *Round 2 Surface and Beach Sediment Field Sampling Report* and the *Round 2A Subsurface Sediment Field Sampling Report*, detailing the sediment sample collection and handling procedures, were submitted to the U.S. Environmental Protection Agency (EPA) on January 4 and January 10, respectively (Integral 2005; Integral and Anchor 2005).

The required content of this site characterization summary report is specified in the EPA-approved Portland Harbor RI/FS Programmatic Work Plan (Work Plan) (Table 6-1; Integral et al. 2004c), where the purpose of the report is described as

Provides validated sample analysis results in tabular format. Provides chemical concentration maps showing the distribution of sample analysis results for selected [chemicals of interest] COIs. Data validation reports and a summary of data validation results also will be included in each site characterization summary report. [Exposure point concentrations] EPCs for human health will be submitted as interim deliverables with site characterization summary reports.<sup>1</sup>

This Round 2A Sediment Site Characterization Summary Report summarizes the data collection activities and describes the laboratory analyses, data validation, and data management procedures used to generate the Round 2A chemical and physical sediment characterization data. All Round 2A sediment data are summarized in tables, and selected COI results are geographically depicted on maps. This report consists of four sections and four appendices. The remaining sections of this report include the following information:

- **Section 2: Data Collection Activities.** Section 2 summarizes the objectives and methodologies used in the beach, surface, and subsurface sediment sample collection. Detailed sample acquisition information is provided in the field sampling reports (Integral 2005; Integral and Anchor 2005). Section 2 also notes deviations from the approved Round 2 field sampling plans that occurred during Round 2A.
- **Section 3: Sample Analyses and Data Management.** Section 3 provides a detailed account of the sample processing and laboratory analyses, highlighting deviations from the Round 2 Quality Assurance Project Plan (QAPP). The chemical data validation and database management processes are detailed,

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<sup>1</sup> EPCs for human health will be submitted as an interim deliverable 90 days after EPA approval of the Exposure Point Concentration Approach and Summary of Exposure Factors Interim Deliverable.

including the development of the Round 2 site characterization and risk assessment (SCRA) database from the full Round 2 database.

- **Section 4: Round 2A Results.** Section 4 presents the Round 2A sediment chemistry and physical characterization results.
- **Section 5: References.** Citations noted in the text are provided in Section 5.
- **Appendices.** Appendix A contains the complete set of final subsurface core logs from Round 2 cores, both in hardcopy and electronic format. Appendix B presents a summary of the chemical data quality review and validation process. Appendix C contains the full SCRA database (on CD). Appendix D presents cross-tab tables of beach, surface, and subsurface SCRA data for the subset of chemicals that are mapped in this report.

This report does not contain the results of the benthic toxicity testing or the sedimentation core sampling, which are presented under separate cover (Windward 2005; Anchor 2005). The results of other Round 2 sampling events (e.g., surface water, groundwater) will be presented in subsequent site characterization summary reports as those data become available.

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## 2.0 DATA COLLECTION ACTIVITIES

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This section provides summaries of the Round 2A sediment data collection activities and deviations from the approved sampling plans.

### 2.1 SEDIMENT SAMPLE COLLECTION

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The purpose of Round 2A sampling was to collect sediment data for the RI and risk assessments and initiate data collection for the FS. The specific objective of the Round 2 sediment sampling program was to collect the following types of data:

- Beach sediment chemistry to support the human health risk assessment (HHRA)
- Shoreline and riverbed surface sediment chemistry to characterize chemical distributions in surface sediments and potential source effects to the river, and to support the ecological risk assessment (ERA) and HHRA
- Subsurface sediment chemistry and physical data to characterize chemical distributions in subsurface sediments and potential source effects to the river, to support the FS and groundwater impacts assessment tasks, and to confirm the physical conceptual site model (CSM)
- Preliminary sedimentation samples (e.g., radioisotope cores) in areas that may have depositional processes to support the FS.

The following sections briefly describe sampling methods used for the collection of the various sediment types. Detailed descriptions of the data collection methods associated with each type of data were included in the sediment field sampling reports (Integral 2005; Integral and Anchor 2005).

Map 2-1a – i provide an overview of all station locations and sample types associated with the Round 2A sediment sampling fieldwork.

#### 2.1.1 Shorebird Foraging Areas and Human Use Beach Sediment Sampling

Composite shoreline sediment samples were collected from July 26-30, and on November 5, 2004 at 21 shorebird foraging areas from river mile (RM) 2 to 10, and 4 collocated shorebird foraging areas and potential human use beaches between RM 2 and 3. The 25 Round 2A shoreline samples are indicated by a “B” in the station identification code on Map 2-1a – i (e.g., B001). The 4 collocated shorebird and human beach area locations stations are B001, B002, B003, and B005 on Map 2-1a. For presentation purposes, Map 2-1a – i depicts the shoreline samples as a point only. The Surface and Beach Field Sampling Report (Integral 2005) provides a map that more accurately displays the actual shoreline area sampled. As described below, all of the Round 2A shoreline samples were collected close to waterline; these samples are generally referred to as “beach” samples in this data report.

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Shorebird foraging and human use shoreline areas up to 500 m in length were selected for sampling. Each beach was divided into 100-m segments, and, based on the width of the beach, a transect was placed at either the +4 or +5 ft Columbia River Datum (CRD) level. The transect elevation was calculated from the waterline at the beach based on real-time river levels read from the river level gage on the Morrison Bridge in downtown Portland. The transect was located on the beach using a graduated staff and level. Once the location of the transect was determined, it was divided into 100-m sections, and each 100-m section was subdivided into three 33-m subsections. A point on the transect was randomly selected within each of the 33-m subsections. The subsample was collected from one of three locations at each point: 1) on the transect line, 2) 0.5 m downslope (toward the water), or 3) 0.5 m upslope of the transect line. The specific location was randomly selected for each point on the transect. If the total sampling location was less than 100 m long, the full distance of the location was measured and divided into three subsections, and one surface sediment subsample was collected randomly within each subsection. All subsamples were composited into one sediment sample for each beach.

At each beach sampling location, sediments were collected to a depth of 15 cm using a stainless-steel, hand-held coring device. The sediment was placed into a stainless-steel bowl, and the physical characteristics were recorded. The composite sample bowl was covered with aluminum foil between discrete subsample locations. This process was repeated until sediment was collected from the three or more discrete sample locations identified for the composite sample.

A total of 28 composite beach sediment samples (including two field replicate samples and one homogenate split sample) were collected and submitted to the analytical laboratories for chemical testing. Similar to the beach composite samples, the replicate beach samples were composed of subsamples and were collected contemporaneously alongside each primary beach subsample. The replicate subsamples were composited and processed separately from the primary sample. At sampling stations where field quality assurance (QA) samples were collected, the primary field sample was assigned the “-1” sample ID suffix (e.g., B025-1), the field replicate sample was assigned the “-2” sample ID suffix (e.g., B025-2), and field homogenate split was assigned the “-3” sample ID suffix (e.g., B025-3).

### **2.1.2 Surface Riverbed Sediment Sampling**

Surface riverbed sediment grab samples (0-30 cm; generally referred to as “surface” samples in this report) were collected in the lower Willamette River from July 19 through November 5, 2004 at a total of 523 target locations distributed from about RM 2 to RM 25. All but eight of these stations (i.e., 515 stations) were locations identified in the sediment field sampling plan (FSP) and were located in Portland Harbor from about RM 2 to RM 11 (Map 2-1a – i). These Round 2A surface sediment stations are indicated by a “G” in the station identification code (e.g., G001; Map 2-1a – i). Six upstream stations (between RM 16 and 25) and two downstream (between RM 2 and 3) stations were added for chemical and toxicity sampling in October 2004 based on discussions between EPA

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and the LWG. These stations are indicated by a “U” (upstream stations) or a “D” (additional downstream stations) on Map 2-1a – i.

All but five surface sediment samples were collected using the 0.3-m<sup>2</sup> hydraulic power grab sampler deployed from a sampling vessel equipped with a differential geographical positioning system (GPS) navigation system that targeted and recorded the coordinates at each sampling location. Five stations (G124, G126, G161, G411, and G431) could not be accessed directly by boat due to water depth or in-water obstructions (e.g., pilings). These stations were sampled from the shoreline below the high-water mark using a hand-held GPS unit for positioning. These samples were collected by hand with sampling spoons and mixing bowls. The sampled elevations for these stations ranged from +10 to +5 ft NAVD88 (+5 to 0 ft CRD).

Typically, following retrieval of the power grab sampler, overlying water was siphoned off the top of the grab, and the sample was evaluated for acceptability based on the criteria defined in the FSP. Once an acceptable grab was obtained, subsamples for volatile analytes and sulfides (if required) were collected immediately from the bulk sample. After the sediment in the grab was described, sample volumes for the remaining non-volatile analytes were collected and homogenized using stainless-steel spoons and pots.

Including field replicates and homogenate splits, a total of 576 surface sediment grab samples from 523 stations were submitted to analytical laboratories for chemical testing. Surface sediments from 222 of the 523 stations, including the six upstream stations, were submitted to the bioassay laboratory for toxicity testing. The results of the toxicity testing have been presented under separate cover (Windward 2005) and will not be discussed in this report. Field replicate grabs were collected by targeting the primary grab sample coordinates. The distances between the primary and duplicate sample locations ranged from 3 to 29 ft. At sampling stations where field QA samples were collected, the primary field sample was assigned the “-1” sample ID suffix (e.g., G007-1), the field replicate sample was assigned the “-2” sample ID suffix (e.g., G007-2), and field homogenate split was assigned the “-3” sample ID suffix (e.g., G007-3).

### **2.1.3 Subsurface Riverbed Sediment Sampling**

Subsurface riverbed sediment cores were collected at 200 locations within the lower Willamette River between RM 2 to 10 from September 20 to October 8 and from October 18 to November 11, 2004. Samples from these cores are generally referred to as subsurface samples in this report. Subsurface sediment station locations are indicated by a “C” in the station identification code (e.g., C009) on Map 2-1a – i. Most of these locations were sampled to support chemical distribution in subsurface sediments; however, 49 locations also supported FS purposes, 11 locations were sampled to further support the physical CSM studies and hydrodynamic modeling effort, and 4 locations were sampled to evaluate sedimentation processes.

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Subsurface sediment cores were collected over water using a vessel-deployed vibracore. Onboard the sampling vessel, the cores were cut into segments approximately 4 ft long for handling, storage, and transport to the core processing lab. At the processing lab, the cores were typically opened using a table saw. The two halves of the core were then separated using a decontaminated, stainless-steel spatula or wire. After the sediment in each segment of a core was exposed, the subsurface sample intervals were determined based on the core type designation (e.g., N&E, FS, CSM, or sedimentation), following the strategies presented in the coring field sampling plans (FSPs) (Integral et al. 2004a; Anchor and Texas A&M 2004). Samples for short-holding time analytes and flame ionization detector/photo-ionization detector (FID/PID) field screening data were collected immediately. The sediment was then described, photographed, and sampled for the remaining analytes. Core logs, including the field screening values, are provided in Appendix A. Photographs of all cores are included in the Round 2A Subsurface Sediment Field Sampling Report (Integral and Anchor 2005).

A total of 218 subsurface sediment cores were collected from the 200 stations. A total of 717 sediment samples from the cores were submitted for chemical and/or physical analyses, including 30 replicate core samples and 19 homogenate split samples. Unlike field replicate grab samples, the locations of replicate cores were deliberately shifted from the initial sampling location in order to avoid the area disturbed during the collection of the initial core. The distances between the initial and replicate core locations ranged between 1 to 43 feet. At sampling stations where field QA samples were collected, the primary field sample was assigned the “-1” sample ID suffix (e.g., C011-A1), the field replicate sample was assigned the “-2” sample ID suffix (e.g., C011-A2), and field homogenate split was assigned the “-3” sample ID suffix (e.g., C011-A3). The suffix designation “1” (e.g., C207-B1) was omitted from samples at a few stations where split and/or replicate cores were later collected.

Of the total 717 core samples, 60 samples were collected from sedimentation cores and submitted for <sup>210</sup>Pb and bulk metals analyses. An additional 72 sedimentation core samples were analyzed exclusively for radioisotopes <sup>7</sup>Be and <sup>137</sup>Cs. Twelve samples were submitted for conventionals and organics analyses in ancillary cores taken immediately adjacent to the sedimentation core at each station. The results of the sedimentation core analyses are not included here; they have been presented by Anchor under separate cover (Anchor 2005).

## **2.2 DEVIATIONS FROM APPROVED FIELD SAMPLING PLANS**

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This section summarizes the deviations from the Round 2 FSPs (Integral et al. 2004a,b) that occurred during the Round 2 field sampling due to necessary modifications to sample station locations, sampling difficulties, or the inability to obtain the proposed samples at target locations and the substitution of alternative locations. These are minor deviations, and they do not impact the overall objectives and goals of the sampling program. Also, the changes to the surface and subsurface sampling stations were discussed during weekly teleconferences between LWG field staff and EPA and its team members. This

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weekly call provided a forum for the discussion and resolution of sampling issues that arose while the sampling program was in progress.

Section 3.1 of this report details changes made to the approved QAPP and standard operating procedures (SOPs) during sample processing and chemical analyses of sediment samples.

## **2.2.1 Station Location Deviations**

### **2.2.1.1. Beach Sampling Locations**

Based on the findings of a field reconnaissance conducted on June 29, 2004, modifications were made to the beach sampling approach and the areas proposed for sampling in the Shorebird Area and Beach Sediment Sampling FSP (Integral et al. 2004b). Two of the proposed shoreline locations were dropped because there was no or very little suitable beach habitat present, and the target elevation for all the beach sampling was altered from +7 ft to +5 ft CRD. EPA and LWG agreed to these modifications, which were documented in a July 16, 2004 memorandum from Windward to EPA prior to the sampling event. This memorandum was presented as Appendix A in the *Round 2 Surface and Beach Sediment Field Sampling Report* (Integral 2005).

### **2.2.1.2. Surface Sampling Locations**

Changes were made to 44 surface sediment station locations during Round 2A field activities. Thirty-four surface stations were moved more than approximately 50 feet away from their target location generally due to obstructions or water depth limitations, six stations were dropped from the sampling program primarily because the target location was onshore, and two stations were added due to navigational errors. Table 2-1 lists the changes that were made to the surface sediment sampling locations during Round 2A sampling and the rationale for each modification; additional details are provided in Integral (2005).

### **2.2.1.3. Subsurface Sampling Locations**

During the implementation of the Round 2A sampling program, the actual surface grab sampling locations (i.e., the x, y coordinates recorded during the grab sample acquisition) were used as the target coordinates for the subsequent subsurface sampling at that station (Integral and Anchor 2005). There were three exceptions to this rule: 1) at certain locations, field conditions (e.g., overwater structures) and/or water depth requirements for the safe operation of the coring equipment prevented the coring vessel from occupying the sampled surface location; 2), at two stations (C093 and C420) where schedule constraints regarding on-water dredging operations made it necessary to collect subsurface cores prior to the surface grab sample collection, and 3) at sedimentation core locations, where no surface grab samples were collected. In the latter two cases, the proposed station coordinates listed in the Sediment Sampling and Benthic Toxicity Testing FSP were used as the target core sampling locations (Integral et al. 2004a).

During the sampling effort, changes were made to 40 of the planned subsurface sampling locations. Core samples were collected more than approximately 50 feet from their

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planned target location at 31 stations (Integral and Anchor 2005) to correspond to changes in the surface samples discussed above. Four other subsurface stations were dropped because the target sampling location was onshore, and five core stations were added, including two that were initially proposed to be collected during the Round 2B sampling event (currently scheduled for the late summer/fall 2005; Integral and Anchor 2005). Table 2-2 lists the changes that were made to the subsurface sampling locations during Round 2A sampling and the rationale for each modification.

### 2.2.2 Subsurface Core Length Deviations

In addition to station location changes, at five locations, the targeted sample length of subsurface cores was changed. These changes were discussed with EPA during the field effort, are described in Integral and Anchor (2005), and are summarized in the table below.

<b>Station</b>	<b>Proposed Length</b>	<b>Change</b>
C019	20	Inadvertently sampled initially as 14-ft core on 9/23/04 (C019); a supplemental 20-ft core was collected on 11/01/04 (C019-2).
C025	20	Inadvertently sampled initially as 14-ft core on 9/23/04 (C025); a supplemental 20-ft core was collected on 11/01/04 (C025-2).
C210	14	Originally planned as a 14-ft core, sampled as 20-ft core in exchange for C213.
C213	20	Originally planned as a 20-ft core, inadvertently sampled as 14-ft core.
C477	14	Changed from 14 ft to 20 ft per LWG request.

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## **3.0 SAMPLE ANALYSES AND DATA MANAGEMENT**

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This section describes the sample processing and laboratory methods used to analyze the sediment samples. Any deviations from the analytical methods detailed in the QAPP are described below. The data management subsection details how the data validation process occurred from the laboratory data package receipt to a final validated electronic data deliverable (EDD). Furthermore, it describes how the SCRA database was compiled into a series of compatible Excel tables, which were then distributed to the SCRA data users. The EcoChem (Seattle, WA) data validation reports are provided as an attachment to Appendix B.

### **3.1 SEDIMENT SAMPLE PROCESSING AND ANALYSIS**

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This section provides an overview of the laboratory sample processing and analytical procedures used during Round 2A. Each subsection notes any deviations from the proposed Round 2 SOPs (Integral et al. 2004a,b) and Round 2 QAPP (Integral and Windward 2004).

#### **3.1.1 Sample Processing and Deviations**

A detailed description of sediment sample handling and processing between the field collection and the analytical laboratory, including any deviations from the QAPP and FSPs, is included in the Round 2 sediment field sampling reports (Integral 2005; Integral and Anchor 2005). A brief summary is provided here. These are minor deviations and do not impact the overall objectives and goals of the sampling program.

Following collection, beach composite sample jars were placed inside sealed plastic bags and stored in coolers with ice. At the end of each day, the sample coolers were transported to the field lab where the jars were individually wrapped in bubble wrap, sealed in plastic bags, and either stored in refrigerators at the field lab or shipped to the analytical laboratories. The samples were generally shipped on ice within 48 hours of collection.

Similarly, surface grab sample jars were bagged individually and stored on the grab sampling support vessel in coolers on ice until the end of the sampling day. At the end of each day, all sample coolers were transported to the field lab where the samples were placed in refrigerators. Approximately twice each week, samples were packed in coolers on ice and shipped to the analytical laboratories for analysis.

Subsurface sediment samples were collected from cores at the field lab. Sample jars for analysis were bagged individually and transferred directly to refrigerators to await shipment to the analytical labs. Archival samples from subsurface intervals not selected for analysis were bagged individually and transferred to field lab freezers for storage.

The surface and beach sediment sample processing effort followed the sampling procedures described in the surface sediment and beach FSPs. Minor changes or

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deviations from the subsurface sampling procedures outlined in the FSP occurred in the field and are discussed in the field sampling report (Integral 2005).

### **3.1.2 Chemical Analyses and Deviations**

Beach, surface, and subsurface sediment samples were collected and analyzed for organic, inorganic, and physical/conventional parameters according to the laboratory methods indicated in Table 3-1. The sediment samples were analyzed by the following laboratories:

- Severn Trent Laboratories (STL – Tacoma, Washington) completed analyses for herbicides
- Northeast Analytical (NEA – Schenectady, New York) completed analyses for pesticides and PCB Aroclors
- Alta Analytical (Alta – El Dorado Hills, California) completed analyses for PCB congeners
- Columbia Analytical Services (CAS – Kelso, Washington; Redding, California; and Houston, Texas) completed the remaining analyses.

All samples were analyzed for metals, semivolatile organic compounds (SVOCs), total organic carbon, grain size, and total solids. Selected samples were additionally analyzed for organochlorine pesticides, chlorinated herbicides, PCB Aroclors, polychlorinated dibenzo-p-dioxins and furans (PCDD/Fs), butyltins, volatile organic compounds (VOCs), and total petroleum hydrocarbons (TPH) as identified in the FSPs (Integral et al. 2004a,b). Shorebird foraging human use beach area samples were also analyzed for coplanar dioxin-like polychlorinated biphenyl (PCB) congeners. Additional archived sediment samples for PCB congener analysis are currently being identified by the LWG and EPA. Samples from sedimentation cores were submitted for chemical and radioisotope analyses. The results of these samples will be presented by Anchor under separate cover and are not discussed in this report.

A summary of sampling locations and the chemical analyses conducted for each Round 2A sample is included in Tables 3-2, 3-3, and 3-4. The following deviations or changes from the target analyte lists included in the FSPs are noted in these tables and include:

- Beach sample B050 was not submitted for dioxin/furan analysis.
- Surface sample G060 was not submitted for VOC analysis.
- Surface samples G302 and G474 were not submitted for dioxin/furan analysis.
- Surface sample G197-2 was not analyzed for specific gravity.
- Dioxin/furan analysis was added to surface sample G374.
- Tributyltin (TBT) analysis was added to surface samples G098, 102, and 359.
- PCB Aroclors analysis was added to surface sample G061.

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- Total diesel-range petroleum hydrocarbon (TPH-D) analysis was added to surface sample G066.
- Sulfide analysis was added to surface samples G098, G102, and G112.
- Ammonia analysis was added to surface samples G112, -G196, -G302, -G330, -G354, -G357, -G365, -G369, and -G374
- Subsurface samples C066-D, -C066-E, -C121-C, -C397-C and -C397-D were not submitted for grain-size analysis.
- Subsurface samples C066-D, -C066-E, -C397-C and -C397-D were not submitted for specific gravity analysis.
- Subsurface sample 093-D was not submitted for VOC analysis; total gas-range petroleum hydrocarbon (TPH-G) analysis was added to this sample in the field.
- Core sample C144-E (bottom segment) was not submitted for TPH-G analysis.
- Core sample C270-D (bottom segment) was not submitted for TPH-G or VOC analyses.
- Subsurface samples C417-B and C417-D were not submitted for TBT analysis.
- TPH-G analysis was added to sample 355-B.

Given the very large number of sample analyses conducted in Round 2A, these are relatively minor omissions and do not impact the overall objectives and goals of the sampling program. In addition, the LWG is currently addressing those missed analyses that can be rectified (e.g., using archived sample aliquots to generate the data).

### **3.1.3 QAPP Deviations**

In general, sample analyses were conducted according to the sample preparation and analytical procedures described in the Round 2 QAPP (Integral and Windward 2004), the corrective action plans for SVOC analyses (Integral 2004c,d), and the QAPP addendum for PCB congener analysis (Integral 2004a).

Deviations from the Round 2 QAPP (Integral and Windward 2004) for the analyses of metals, conventional parameters (i.e., grain size), and SVOCs are summarized below. Additional information regarding laboratory procedures used for the sediment samples is provided for VOCs and PCB congeners. There were no deviations from the analytical methods described in the QAPP for these methods or for the analyses of TPH, herbicides, pesticides, PCB Aroclors, butyltins, or dioxins and furans.

#### **3.1.3.1 Metals**

The Round 2 QAPP states that metals analyses would be completed by inductively coupled plasma-mass spectrometry (ICP/MS) (EPA Method 6020) for all metals except mercury and, if undetected by ICP/MS, arsenic and selenium. However, as stated in the laboratory case narratives, aluminum, chromium, copper, nickel, and zinc were analyzed by EPA Method 6010B rather than EPA Method 6020. The elevated aluminum

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concentrations found in the samples were not appropriate for analysis by ICP/MS and were therefore reported by inductively coupled plasma – optical emission spectroscopy (ICP-OES) (EPA Method 6010B). Copper, nickel, and zinc required multiple dilutions for analysis by ICP-MS due to matrix interferences. Since the concentrations of these analytes were sufficiently high, they were reported from the inductively coupled plasma-optical emission (ICP-OES) analysis for all samples.

Two options for analysis of arsenic and selenium were provided in the Round 2 QAPP, depending on their concentrations in the samples. Arsenic was detected and consequently reported by EPA Method 6020 (ICP/MS) for all of the samples. Selenium was analyzed by EPA Method 7742 due to isobaric interference on both the primary selenium isotope ( $^{82}\text{Se}$ ) and the secondary isotope ( $^{77}\text{Se}$ ) when EPA Method 6020 (ICP/MS) was used.

### **3.1.3.2 Conventional Parameters**

The series of grain-size intervals for clay-size fractions indicated in the Round 2 QAPP included phi sizes 8-9, 9-10, and >10 (Table A6-2 of Integral and Windward 2004). This series was consistent with data provided for Round 1. However, the intervals specified in the laboratory contract for the Round 2 analyses and subsequently reported by the laboratory did not include the smallest two intervals; the smallest interval reported was phi >8. The reported intervals are consistent with the specifications provided in the Round 1 QAPP (SEA 2002) and are sufficient for site characterization and risk assessment. No further action has been taken.

There were no other deviations from the analytical methods listed in the QAPP for laboratory analyses conducted for conventional parameters.

### **3.1.3.3 Semivolatile Organic Compounds**

According to the QAPP, SVOC analyses were to be completed by NEA using gas chromatography (GC) and full scan mass spectrometry (MS) with ion trap. However, high levels of interferences were noted in the samples. Therefore, the SVOC analyses were completed by CAS instead of NEA using a series of three analyses that circumvented some of the interferences, thus improving the quality and usability of the results, and allowing the laboratory to complete analyses in a time-efficient manner overall. These procedures are described in detail in Integral (2004a) and included the following components:

- 1) Prescreening the samples to determine the approximate levels of analytes and matrix interferences
- 2) Analysis of SVOCs by full scan GC/MS at an appropriate dilution, as determined by the screening
- 3) Analysis of PAHs by GC/MS with selected ion monitoring (SIM)
- 4) Analysis of tri-, tetra-, and pentachlorophenols by GC/electron capture detector (ECD).

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These procedures were described in the SVOC corrective action plans for sediment cores and surface sediment (Integral 2004c,d). This approach was approved by EPA and successfully implemented by CAS.

#### **3.1.3.4 Volatile Organic Compounds**

There were no deviations from the analytical methods included in the QAPP for the laboratory analysis for VOCs in sediment. Samples containing relatively high concentrations of VOCs were analyzed as medium-level samples rather than low-level samples. Low-level samples are analyzed directly by purge-and-trap, whereas medium-level samples are first extracted with methanol to allow dilution of the samples for analysis of the higher levels of VOCs. The reported detection limits (RDLs) of medium-level samples reflect this procedure and are higher than RDLs for the low-level samples. In addition, an error in the analyte list in the Round 2 QAPP was corrected. The analyte bromoethane should have been 1,2-dibromoethane (ethylene dibromide). The laboratory modified their analyte list accordingly.

#### **3.1.3.5 PCB Congeners**

PCB congener analyses have currently been conducted only for beach sediments. There were no deviations from the analytical methods included in the QAPP addendum (Integral 2004c) for these analyses. Although provisions were made for analysis of up to 50 g of sample to decrease detection limits (EPA 2005, pers. comm.), PCB levels in the beach samples were sufficiently high that the method-specified sample mass of 10 g of sample could be used in all cases.

## **3.2 DATA VALIDATION**

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As required by the Round 2 QAPP (Integral and Windward 2004), approximately 10% of the sediment data were fully validated, and the remaining data were subjected to Level 3 data validation, which includes the evaluation and assessment of the sample results and applicable quality control results reported by the laboratory. The data validation subcontractor for the Round 2 sediment data was EcoChem, Inc., located in Seattle, WA. The first data package for each analytical method was additionally submitted to EPA for data validation by EPA's QA Office.

The inorganic, organic, PCB congener, and PCDD/F data were validated in accordance with guidance specified by the U.S. EPA Contract Laboratory Program (CLP) National Functional Guidelines for Inorganic and Organic Data Review, by EPA Region 10 SOPs for validation of PCB congener data and PCDD/F data (EPA 1994, 1995, 1996, 1999), and by *Guidance on Environmental Data Verification and Validation* (EPA 2002). Modifications were made to the Functional Guidelines to accommodate quality assurance/quality control (QA/QC) requirements of the non-CLP methods that were used for this project. Data qualifiers were assigned during data validation if applicable control limits were not met, in accordance with the EPA data validation guidelines and the quality control requirements included in the referenced methods. The data validation qualifiers and definitions are summarized in Table 3-5.

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The following laboratory deliverables were reviewed during Level 3 and full data validation:

- The case narrative discussing analytical problems (if any) and procedures
- Chain-of-custody documentation and laboratory sample receipt logs
- Instrument calibration results
- Method blank results
- Results for laboratory quality control samples required by the referenced method, including laboratory control sample/laboratory control sample duplicate (LCS/LCSD) analyses, matrix spike/matrix spike duplicate (MS/MSD) analyses, surrogate recoveries, and other method specific quality control samples (e.g., serial dilutions for ICP analyses)
- Results for field quality control samples (i.e., equipment blanks, field duplicates, and field split samples)
- Analytical results for the sediment samples.

In addition, all chromatograms were reviewed for PCBs to verify the identity of the reported Aroclors, and for pesticides to evaluate any effects of interference by PCBs and other sample constituents. Chromatograms were reviewed for Level 3 and full validation.

For data packages subjected to full validation, in addition to review and assessment of the documentation identified above, the validation included verification of reported concentrations for the field and QC samples, verification of intermediate transcriptions, and review of instrument data such as mass spectra to verify analyte identification procedures.

After completing the data validation activities for each sediment sample type, a data quality report and a tabular summary of qualified data were generated by EcoChem. The EcoChem data quality reports are included in Attachment 1 of Appendix B. EcoChem chemists added data validation qualifiers assigned during validation to the laboratory report forms and to the laboratory EDDs. The revised EDDs and the hard-copy data validation reports were submitted as the project deliverable. The revised EDDs were then incorporated into the project database, as described in Section 3.4 below.

### **3.3 DATA QUALITY**

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Selected data not meeting the data quality criteria were qualified as undetected, estimated, tentatively identified, or rejected during validation, in accordance with the QAPP. A summary of the qualified data by parameter group, including the reasons for qualification, is included in Table 3-6. Additional detail is provided in Appendix B. Data qualified as undetected are usable for all intended purposes. Data qualified as estimated or tentatively identified are usable for all intended purposes, with the knowledge that these data may be less precise or less accurate than unqualified data.

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Rejected data are not usable for any purpose. The numbers of rejected data points per analyte group are listed in Table C-2 in Appendix B. Overall, the data quality was good and meets program objectives and goals for the RI/FS.

### **3.4 DATA MANAGEMENT**

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The laboratories exported sample, test, batch, and result information into comma-delimited text files with data columns arranged in an order that was recognized by EQuIS. These Electronic Data Deliverables (EDDs) were emailed to Integral where they were checked for proper EQuIS structure and appended with specific information that was unknown or hidden from the labs, such as sampling location, composite information, and field replicate and split information. If any problems were found in the structure of the EDDs, then the laboratory was notified and asked to correct the problem and resubmit the EDD. Each email EDD transmission, with the original, unaltered EDD attachment, was stored to document and track the laboratories' delivery of electronic data to Integral.

When the EDD structure checked out satisfactorily and the appended information was completed, the EDDs were checked electronically by loading them into the temporary section of Integral's LWG project database. In the process of loading, EQuIS checked the EDDs for correct lookup codes (such as for analytes, test methods, and sample matrices), proper relationships for results, tests, batches, and samples (to ensure all results match with a test, tests with samples, and sample/test pairs with batches), and that all derived samples (such as replicates, splits, and matrix spikes) had corresponding parent samples. In addition to these checks, EQuIS also checked "less important" characteristics such as date and time formats and text field lengths to ensure consistency throughout the database. Any error prevented the EDD from loading until the error was corrected. If errors were found that related to the way the lab was reporting the data or constructing the EDD, then the laboratory was notified and asked to correct the problem and resubmit the EDD. If errors were related to Excel automatically formatting date and time fields, for example, then the error was corrected and steps taken to avoid repeats of the problem (such as changing default settings in the software). Each successfully loaded EDD was saved to document and track the data that were loaded into Integral's LWG project database.

In the temporary section of the project database, the newly loaded data were flagged as unvalidated and merged into the permanent section of the project database where they could be queried and examined. As EcoChem completed their validation, the validated data, which included the validator qualifiers, reason codes, and final qualifiers, were loaded into the temporary section of the project database. An update merge was used to apply the validation to the data in the permanent section of the project database and at the same time change the unvalidated flags to validated flags.

Several queries were set up in the permanent database to translate the data structure to a form compatible with National Oceanographic and Atmospheric Administration's (NOAA) Query Manager. The data translation included creating station and sample

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identifiers, converting the sample type code, and changing the date format. The translated data were imported into an Access file that was provided by NOAA and contained template tables for the Query Manager structure. These tables included one for stations, sediment samples, and sediment chemistry. Tables with definitions of qualifiers and analytical method abbreviations were also imported.

Integral's LWG project database contains all of the data reported by the analytical laboratories. This includes field and lab replicates, lab dilutions, results for the same analyte from multiple analytical methods (SW8270 and SW8270-SIM, for example), and laboratory QA samples such as matrix spikes, surrogates, and method blanks. The data handling rules described in *Guidelines for Data Averaging and Treatment of Non-detected Values for the Round 1 Database* (Integral 2004b, Appendix A) were used to create a data set for the SCRA data users that was simpler: the data set contained only one result per analyte per sample and excluded all of the laboratory QA results. This involved creating a SCRA database that excluded lab QA results, contained only the most appropriate dilution result and analytical method for each analyte, and contained the average of replicates. Excluding the lab QA results was a simple database querying step. Selection of the most appropriate dilution was either done by the reporting laboratory or by the data validator. Selection of the most appropriate analytical method was described in the guidelines document and was accomplished by flagging the appropriate method in the project database. The guidelines document described the rules used for averaging data and carrying qualifiers. Because it was the most data manipulation intensive procedure, the data were divided into subgroups and approximately 40% of each subgroup was verified. If any problems were found with the averaging, then the 100% of the subgroup was verified and problems were corrected. The preliminary SCRA database was compiled into a series of database-compatible Excel tables and distributed to the SCRA data users over the period between April 7 and May 17, 2005.

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## 4.0 ROUND 2A RESULTS

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Round 2A results for the sediment chemistry and physical analyses are presented in this section. As noted in Section 1, this data report is a straightforward presentation of the sediment data collected during Round 2A. Review and evaluation of these data in conjunction with other data types (e.g., surface water), evaluation of spatial trends in the distribution of contaminants in sediments, source evaluation, and preliminary risk analyses will be presented in the Comprehensive Round 2 Site Characterization Summary and Data Gaps Analysis Report.

The complete Round 2A sediment data set containing all results is provided as an Excel cross-tab table in Appendix C. Summary statistics for all analytical results in the Round 2A beach, riverbed surface, and subsurface sediment samples are compiled in Tables 4-1, 4-2, and 4-3, respectively. The summary statistics tabulated include the frequency of detection (FOD), and the minimum, maximum, mean, median, and 95<sup>th</sup> percentile values for both detected only and both detected and undetected values combined, on analyte-by-analyte basis. The results of the 13 core samples analyzed from the 0-30 cm interval (the “A” core interval which was typically archived) have been grouped with the surface sediment grab sample analytical results in Table 4-2.

Map 4-1a – i shows the distribution of percent fines (combined silts and clays) in the beach, surface, and subsurface sediment samples as determined through laboratory grain-size analysis, and Table 4-4 lists the grain-size data (coarse silts through clays) used to calculate the percent fines for each sample. Map 4-2a – i shows the total organic carbon (TOC) content in each sample. Maps 4-3a – i through 4-29a – i show the mapped distribution, on a chemical-by-chemical basis, of selected Round 2A sediment chemical data. A map key at the front of the map folio explains the mapped data format. Note that due to display size constraints, the chemical concentration data and sampled depth data are not displayed at the exact station location; however, the actual station locations are indicated on the maps for cross-referencing. Beach, surface, and subsurface data and core segments that were archived (e.g., most “A” segments are indicated) on the maps. The core segment divisions displayed on the maps are scaled to the thickness of each core segment analyzed. To illustrate the overall range of measured concentrations, graphs showing the frequency distributions of the sediment data for each mapped analyte are presented in Figures 4-1 through 4-29 for both beach and surface data combined and the subsurface data.

The mapped compounds were selected to represent the major chemicals or chemical groups detected in the Round 2A data. Most are chemicals detected at among the highest frequencies for their analyte groups and/or they exhibited among the highest maximum or mean concentrations. Many overlap with the indicator chemicals determined from historical samples (i.e., those mapped in the Work Plan), as well as the Round 1 data (those mapped in the Round 1 Site Summary Report). All chemicals selected for mapping had a FOD of at least 10% in samples analyzed. The chemicals selected for map presentation in this report due to relatively high FOD in their analyte groups in

surface and subsurface samples (Tables 4-2 and 4-3) that were not mapped in the Work Plan or Round 1 Site Summary report include the individual PCB Aroclors 1248, 1254, and 1260; total chlordanes; hexachlorobenzene; benzene; TPH; and chromium. The complete data set used to generate the maps is provided as Excel cross-tab tables in Appendix D.

The color-coded concentration ranges included on Maps 4-1a – i through 4-39a – i were derived as follows. The fines percentages on Map 4-1a – i are presented in into quartiles. The percent TOC data (Map 4-2a – i) are shown in three intervals: 0.5 to 1%, 1 to 5%, and greater than 5%. The concentration categories (e.g., breaks) used in chemical data on Maps 4-3a – i through 4-29a – i are the same or similar to the ones used in the Work Plan and Round 1 report, which were based on the frequency distributions in the historical data set for these compounds and modified/approved by EPA. Concentration categories for chemicals that were not mapped in previous reports are grouped based on natural breaks observed in the data.

The primary objective of this Round 2A data summary report is to document the horizontal and vertical distribution of chemicals in sediment in the study area. When calculating summed analyte concentration values, such as total PCB Aroclors, TPH, total low molecular weight polycyclic aromatic hydrocarbons (LPAHs), total high molecular weight polycyclic aromatic hydrocarbons (HPAHs), chlordanes, and total p,p'-DDD, -DDE, -DDT, a value of zero was used for non-detects on an individual sample basis. The summed LPAHs include naphthalene, 2-methylnaphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene. Summed HPAHs include fluoranthene, pyrene, benz(a)anthracene, chrysene, benzo(k and b) flouranthenes, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, dibenz(a,h)anthracene, and benzo(g,h,i)perylene. 2,3,7,8-Tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) toxicity equivalent (TEQ) values were calculated with World Health Organization 1997 TEFs for mammals, as was done for the Round 1 data (see Appendix C, Integral 2004b). Sample statistics presented in tables and text were calculated using reported detection limit values for non-detects. Tables 4-4 through 4-12 present the constituent concentrations used in each summed analyte group shown on the maps.

#### **4.1 SHOREBIRD FORAGING AREA AND HUMAN USE BEACH SEDIMENT RESULTS**

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This section describes the physical characteristics and chemical concentrations measured in the 27 beach sediment sample results reported in the SCRA database. The major analyte groups measured in beach or shoreline sediment samples included conventionals (grain size, total solids, TOC), metals, PCBs as Aroclors, PCBs as congeners, organochlorine pesticides, SVOCs, and dioxins and furans. The summary statistics for all analytes measured in the beach sediment samples are shown in Table 4-1. The data for both the shorebird foraging areas and the combined shorebird forage area/human use beach areas are combined in Table 4-1. The summary statistics include the FOD, and the minimum, maximum, mean, median, and 95<sup>th</sup> percentile values for both detected only

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and both detected and undetected values combined. A general overview of the summary statistics for detected constituents compiled in Table 4-1 is given below. The histograms provided in Figures 4-1 through 4-29 show the data distribution for the mapped indicator chemicals.

The fines content (combined silts and clays) in beach samples ranged from 0.32 to 49.5% (Map 4-1a – i), with a mean value of 12.1% and a median value of 8.1%. TOC content ranged from an estimated (J) 0.04 to 1.97% (both maxima occurred at B026; Map 4-2a – i), with a mean value of 0.48% and a median value of 0.27%.

The 12 metals analyzed in the beach samples were detected in all samples, except for antimony (detected in 15 samples), mercury (detected in 26 samples), and selenium (detected in 7 samples). For the mapped metals, detected concentrations ranged from a minimum of 1.67 to a maximum of 8 milligrams per kilogram (mg/kg) (max at B024) for arsenic (Map 4-3a – i), with a mean value of 3.09 mg/kg and a median value of 2.72 mg/kg. Detected concentrations of cadmium ranged from 0.076 to 4.21 mg/kg (max at B021; Map 4-4a – i), with a mean value of 0.385 mg/kg and a median value of 0.14 mg/kg. Detected concentrations of total chromium ranged from 11 to 83.6 mg/kg (max at B004; Map 4-5a – i), with a mean value of 23.2 mg/kg and a median value of 18.6 mg/kg. Detected concentrations of copper ranged from 8.8 J to 108 mg/kg (max at B018; Map 4-6a – i), with a mean value of 26 mg/kg and a median value of 18.9 J mg/kg. Detected lead concentrations ranged from 4.79 to 242 mg/kg (max at B021; Map 4-7a – i), with a mean value of 29.8 mg/kg and a median value of 15.9 mg/kg. Detected concentrations of mercury ranged from 0.008 J to 0.412 mg/kg (max at B015; Map 4-8a – i), with a mean value of 0.0515 mg/kg and a median value of 0.024 J mg/kg. Detected concentrations of zinc ranged from 52.7 to 1,230 mg/kg (max at B021; Map 4-9a – i), with a mean value of 156 mg/kg and a median value of 78.1 mg/kg.

Three PCB Aroclors (1248, 1254, and 1260) were detected in the beach samples (Maps 4-12a – i, 4-13a – i, and 4-14a – i, respectively). Detected concentrations of total PCBs based on Aroclors (Total PCBs, Map 4-11a – i) ranged from 4.4 to 1,400 micrograms/kilogram ( $\mu\text{g}/\text{kg}$ ) (max at B004), with an overall mean value of 166  $\mu\text{g}/\text{kg}$  and a median value of 73  $\mu\text{g}/\text{kg}$ . Aroclor 1260, detected in 13 samples, was the most frequently detected Aroclors. Detected concentrations of Aroclor 1260 (Map 4-14a – i) ranged from 4.4 to 240  $\mu\text{g}/\text{kg}$  (max at B026), with a mean value of 57.6  $\mu\text{g}/\text{kg}$  and a median value of 32  $\mu\text{g}/\text{kg}$ . Aroclor 1248 was detected in seven samples, but was present at the highest concentration among the three Aroclors. Detected concentrations of Aroclor 1248 (Map 4-12a – i) ranged from 8.7 to 1,400  $\mu\text{g}/\text{kg}$  (max at B004), with a mean value of 243  $\mu\text{g}/\text{kg}$  and a median value of 37  $\mu\text{g}/\text{kg}$ . Aroclor 1254 (Map 4-13a – i) was detected in only three samples, at concentrations ranging from 54 J to 78  $\mu\text{g}/\text{kg}$  (max at B025-1). Thirteen of the 27 beach samples were analyzed for 13 coplanar PCB congeners, and all but two congeners were detected in each of the samples analyzed. PCB congener results were converted to their 2,3,7,8-TCDD TEQ values, which are discussed below.

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Twenty-two of the 28 organochlorine pesticide compounds analyzed were detected in the 27 beach samples. The most frequently detected compounds were 4,4'-DDT (26 samples; Map 4-18a – i) and its metabolites, 4,4'-DDD (23 samples; Map 4-16a – i) and 4,4'-DDE (20 samples; Map 4-17a – i), one or more of which were detected in each of the beach samples. Detected concentrations of the summed total of these compounds (Map 4-15a – i) ranged from 0.311 J to 334 J  $\mu\text{g}/\text{kg}$  (max at B018), with an overall mean value of 22.4  $\mu\text{g}/\text{kg}$  and a median value of 2 J  $\mu\text{g}/\text{kg}$ . Total chlordane constituents were detected in 12 samples. The summed detected concentrations of total chlordane constituents (total chlordanes, Map 4-19a – i) in the beach samples ranged from 0.036 J to 6.33 J  $\mu\text{g}/\text{kg}$  (max at B024), with a mean value of 1.4  $\mu\text{g}/\text{kg}$  and a median value of 0.215 J  $\mu\text{g}/\text{kg}$ .

Of the SVOCs analyzed, several PAH group compounds were detected in each of the beach samples, and these were present at the highest maximum and mean detected concentrations among all the SVOCs. Total PAH concentrations in samples ranged from 4.92 J to 94,200  $\mu\text{g}/\text{kg}$  (max at B016), with a mean value of 4,720  $\mu\text{g}/\text{kg}$  and a median value of 183 J  $\mu\text{g}/\text{kg}$ . Total LPAH (Map 4-26a – i) detected concentrations ranged from 1.62 J to 8,640  $\mu\text{g}/\text{kg}$  (max at B016) with mean and median values of 439  $\mu\text{g}/\text{kg}$  and 19.6 J  $\mu\text{g}/\text{kg}$ , respectively. Total HPAH (Map 4-27a – i) detected concentrations ranged from 3.3 J to 85,600  $\mu\text{g}/\text{kg}$  (max at B016) with mean and median values of 4,290  $\mu\text{g}/\text{kg}$  and 150 J  $\mu\text{g}/\text{kg}$ , respectively. After PAHs, dibenzofuran (Map 4-22a – i), detected at concentrations ranging from 0.28 J to 76 J  $\mu\text{g}/\text{kg}$  (max at B016) was the most frequently detected SVOC, with mean and median values of 6.44  $\mu\text{g}/\text{kg}$  and 0.82 J  $\mu\text{g}/\text{kg}$ , respectively. The chemical hexachlorobenzene (Map 4-23a – i) was detected in six beach samples, at concentrations ranging from 0.099 to 2.09 J  $\mu\text{g}/\text{kg}$  (max at B018), with a mean value of 0.894  $\mu\text{g}/\text{kg}$  and a median value of 0.176 J  $\mu\text{g}/\text{kg}$ . Bis(2-ethylhexyl)phthalate (Map 4-25a – i) was detected in five beach samples, at concentrations ranging from 39 to 2,600  $\mu\text{g}/\text{kg}$  (max at B022-1), with a mean value of 652  $\mu\text{g}/\text{kg}$  and a median value of 190  $\mu\text{g}/\text{kg}$ . Concentrations of 4-methylphenol (Map 4-24a – i) were detected in two beach samples, at concentrations of 4.6 J  $\mu\text{g}/\text{kg}$  at B010 and 9.5 J  $\mu\text{g}/\text{kg}$  at B003. Herbicides were not analyzed in beach samples (Table 3-2).

Several dioxin and furan compounds were detected in each of the 26 beach samples for which they were analyzed. Detected total 2,3,7,8-TCDD TEQ values Map 4-29a – i) ranged from 0.0272 J at B001 to 76.8 J picograms per gram (pg/g) at B018 (including coplanar PCB congener TEQs), with a mean value of 7.5 pg/g and a median value of 1.08 J pg/g. The maximum 2,3,7,8-TCDD TEQ value that did not include PCB congener results was 15.5 J pg/g at B009. Table 4-12 lists the individual compound concentrations used to calculate the TEQ value for each beach sample.

## 4.2 SURFACE RIVERBED SEDIMENT RESULTS

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This section describes the physical characteristics and chemical concentrations measured in the 562 riverbed surface sediment grab samples and 13 surface (“A” interval) core samples. The summary statistics for all analytes measured in surface sediment samples

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are compiled on an analyte-by-analyte basis in Table 4-2. An overview of the surface data for detected constituents is given below. Frequency distributions, showing both detected and undetected values, of surface and beach data combined for each mapped analyte are provided in Figures 4-1 through 4-29

The fines content (combined silts and clays) in surface interval samples ranged from 0.62 to 100% (max at G384-1; Map 4-1a – i), with a mean value of 51.4% and a median value of 57.7%. TOC content ranged from 0.08 to 27% (max at G006; Map 4-2a – i), with a mean value of 1.98% and a median value of 1.94%.

Aluminum, arsenic, copper, lead, silver, and zinc were detected in each of the 562 samples analyzed for metals. Detected arsenic concentrations ranged from 0.97 to 34 mg/kg (max at G445; Map 4-3a – i), with a mean value of 4.16 mg/kg, and a median value of 3.67 mg/kg. Detected cadmium concentrations ranged from 0.043 to 5.41 mg/kg (max at G453; Map 4-4a – i), with a mean value of 0.304 mg/kg and a median value of 0.246 mg/kg. Detected concentrations of total chromium ranged from 8.7 to 224 mg/kg (max at G025; Map 4-5a – i), with a mean value of 31.7 mg/kg and a median value of 31.1 mg/kg. Detected concentrations of copper ranged from 9.7 to 1,080 mg/kg (max at G390; Map 4-6a – i), with a mean value of 53.8 mg/kg and a median value of 39.1 mg/kg. Detected concentrations of lead ranged from 2.5 to 1,290 mg/kg (max at G355; Map 4-7a – i), with a mean value of 28.9 mg/kg and a median value of 14.8 mg/kg. Detected concentrations of mercury ranged from 0.006 to 2.01 mg/kg (max at G453; Map 4-8a – i), with a mean value of 0.0907 mg/kg and a median value of 0.065 mg/kg. Detected concentrations of zinc ranged from 40.9 to 1,940 mg/kg (max at G111; Map 4-9a – i), with a mean value of 139 mg/kg and a median value of 109 mg/kg.

Butyltins were analyzed in 116 samples, and detected in 52 samples. The dibutyltin ion (116 samples) and tributyltin ion (115 samples) were the most frequently detected forms, and also displayed the highest concentrations. Detected concentrations ranged from 0.14 to 2,700 µg/kg (max at G421) for dibutyltin, with mean and median values of 69.9 µg/kg and 9 µg/kg, respectively, and from 0.45 to 46,000 µg/kg (max at G421) for tributyltin (Map 4-10a – i), with mean and median values of 608 µg/kg and 28 µg/kg, respectively.

Six different PCB Aroclors (1221, 1242, 1248, 1254, 1260, and 1268) were detected in the surface samples. Aroclor 1260 (Map 4-14a – i) was the most frequently detected (389 samples), while Aroclor 1248 (Map 4-12a – i) was present at the highest detected concentration. Aroclor 1260 detected concentrations ranged from 1.3 to 5,070 µg/kg (max at G453) with a mean value of 67.9 µg/kg and a median value of 12 µg/kg. Aroclor 1248 concentrations ranged from 2.59 to 22,300 µg/kg (also at G453), with a mean value of 189 µg/kg, and a median value of 15 µg/kg. Total detected PCB Aroclor concentrations (Map 4-11a – i) in surface samples ranged from 0.851 to 27,400 µg/kg (max at G453), with an overall mean value of 216 µg/kg and a median value of 29 µg/kg.

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Organochlorine pesticide compounds were measured in 508 surface interval samples. With the exception of toxaphene, all 28 measured pesticide compounds were detected in one or more samples. The pesticides 4,4'-DDD (491 samples; Map 4-16a – i) and 4,4'-DDE (483 samples; Map 4-17a – i) were the most frequently detected, occurring in 96.7% and 95.1% of the samples analyzed, respectively, although 4,4'-DDT, tentatively identified, was present at the highest maximum (estimated at 12,000 µg/kg; G360; Map 4-18a – i) and mean concentrations (86.6 µg/kg). The highest median concentration among these three compounds was 2.21 J µg/kg for 4,4'-DDE. Total 4,4'-DDT (sum of 4,4'-DDT, -DDD and -DDE) concentrations were derived for 495 samples (97.4% of samples analyzed; Map 4-15a – i) and ranged from 0.051 J to 15,300 µg/kg (max at G360), with an overall mean value of 123 µg/kg and a median value of 5.4 J µg/kg. Total chlordane constituents were detected in 417 samples. Derived total chlordane detected concentrations (Map 4-19a – i) ranged from 0.042 J to 669 J µg/kg (max at G355), with a mean value of 6.14 µg/kg and a median value of 0.991 J µg/kg.

Herbicides were analyzed in 66 samples. Only four herbicide compounds were detected: MCPP (in one sample); 2,4-DB (in one sample), MCPA (in two samples); and 2,4-D (in seven samples). Concentrations of 2,4-D were the highest detected, ranging from 10.8 to 3,250 J µg/kg (max at G334), with a mean value of 497 µg/kg and a median value of 30.2 µg/kg.

VOCs were analyzed in 147 surface samples. Nineteen of the 49 compounds analyzed for were detected. Methyl ethyl ketone was the most frequently detected (in 39 samples), occurring at concentrations ranging from 2.1 J to 15 J µg/kg (max at G288), and with a mean value of 4.25 µg/kg and a median value of 3.8 J µg/kg. The VOC detected at the highest concentration was ethylbenzene, concentrations of which ranged from 0.11 J µg/kg to 5,700 µg/kg (max at G298), with a mean value of 353 µg/kg and a median value of 0.35 J µg/kg. Concentrations of total xylenes (the sum of o- and m,p-xylenes), a mapped analyte detected in 38 samples (Map 4-21a – i), ranged from an 0.14 J to 270 µg/kg (max at G298), with a mean value of 12.2 µg/kg and a median value of 0.68 J µg/kg. Benzene concentrations (Map 4-20a – i), detected in 23 samples, ranged from 0.074 J to 1,100 µg/kg (max at G298), with a mean value of 83.6 µg/kg and a median value of 0.41 J µg/kg.

SVOCs were analyzed in 562 surface interval samples. PAH compounds were detected in 99.1% (557 samples) of total samples analyzed, and were present at the highest maximum and mean detected concentrations. Total PAH concentrations in samples ranged from 0.91 J to 7,950,000 µg/kg (max at G298), with a mean value of 60,000 µg/kg and a median value of 1,010 µg/kg. Detected concentrations of LPAH compounds (552 samples; Map 4-26a – i) ranged from 0.91 J to 5,130,000 (max at G298) µg/kg, with an overall mean value of 25,800 µg/kg and a median value of 149 J µg/kg. Detected concentrations of HPAH compounds (556 samples; Map 4-27a – i) ranged from 1.7 J to 4,350,000 µg/kg (max at G225), with an overall mean value of 34,500 µg/kg and a median value of 832 µg/kg. Following several PAH compounds, bis(2-ethylhexyl)phthalate, a mapped chemical detected in 314 samples (Map 4-25a – i), was

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present at some of the highest concentrations. Detected concentrations of bis(2-ethylhexyl)phthalate ranged from 4.2 J to 440,000 J  $\mu\text{g}/\text{kg}$  (max at G367), with an overall mean value of 1,920  $\mu\text{g}/\text{kg}$  and a median value of 100  $\mu\text{g}/\text{kg}$ . Dibenzofuran, hexachlorobenzene, and 4-methylphenol were detected in 95.6% (537 samples), 48.6% (273 samples), and 50.3% (282 samples) of samples analyzed, respectively. Detected concentrations of dibenzofuran (Map 4-22a – i) ranged from 0.25 J to 46,000  $\mu\text{g}/\text{kg}$  (max at G298), with a mean value of 283  $\mu\text{g}/\text{kg}$  and a median value of 4.4  $\mu\text{g}/\text{kg}$ . Detected concentrations of hexachlorobenzene (Map 4-23a – i) ranged from 0.025 J to 338 J  $\mu\text{g}/\text{kg}$  (max at G355), with a mean value of 2.91  $\mu\text{g}/\text{kg}$  and a median value of 0.784 J  $\mu\text{g}/\text{kg}$ . Detected concentrations of 4-methylphenol (Map 4-24a – i) ranged from 4 J to 2,500  $\mu\text{g}/\text{kg}$  (max at G418), with a mean value of 77.9  $\mu\text{g}/\text{kg}$  and a median value of 16 J  $\mu\text{g}/\text{kg}$ .

TPH, the sum of gasoline-, diesel-, and residual (oil)-range hydrocarbons, was detected in 213 samples (98.6%) of the 216 samples for which these compounds were analyzed (Map 4-28a – i). Detected TPH concentrations in samples ranged from 10 J to 58,600 J  $\text{mg}/\text{kg}$  (at G298), with a mean value of 1,780  $\text{mg}/\text{kg}$  and a median value of 580 J  $\text{mg}/\text{kg}$ . Of the individual components, diesel-range hydrocarbons were the most frequently detected (210 samples), and displayed the highest maximum concentration. Detected diesel concentrations ranged from 10 J to 39,000 J  $\text{mg}/\text{kg}$ , with mean value of 763  $\text{mg}/\text{kg}$  and a median value of 120 J  $\text{mg}/\text{kg}$ . Detected concentrations of residual-range hydrocarbons (203 samples), ranged from 14.5 J to 18,000 J  $\text{mg}/\text{kg}$ , with a mean value of 1,060  $\text{mg}/\text{kg}$  and a median value of 470 J  $\text{mg}/\text{kg}$ . Detected concentrations of gasoline-range hydrocarbons (in 27 samples) ranged from 1.9 to 1,600 J  $\text{mg}/\text{kg}$ , with a mean value of 100  $\text{mg}/\text{kg}$  and a median value of 12 J  $\text{mg}/\text{kg}$ . The maximum concentrations of diesel-, gasoline-, and residual-range hydrocarbons all occurred in sample G298.

Seventy-six surface interval samples were analyzed for dioxin and furan compounds. FODs for these compounds ranged from 17.1% (13 samples) for 2,3,7,8-TCDD to 100% for heptachlorodibenzo-p-dioxin homologs. Calculated total 2,3,7,8-TCDD TEQ values (Map 4-29a – i) of the analyzed dioxins/furans and dioxin/furan homologs ranged from 0.00684 J to 322 J  $\text{pg}/\text{g}$  (max at G351-2), with a mean value of 12.6  $\text{pg}/\text{g}$  and a median value of 0.831 J  $\text{pg}/\text{g}$ .

### 4.3 SUBSURFACE RIVERBED SEDIMENT RESULTS

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This section describes the physical characteristics and chemical concentrations measured in the 609 subsurface sediment samples submitted to the laboratories for analysis. It includes an overview of the detected results from all subsurface samples and a general discussion of chemical trends in the subsurface intervals. The summary statistics for all analytes measured in subsurface sediment samples are shown in Table 4-3. Figures 4-1 through 4-29 include frequency distributions of both detected and undetected values of all subsurface data for each mapped analyte.

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#### 4.3.1 Subsurface Results Summary

The fines content (Map 4-1a – i) in the subsurface samples ranged between 0.29 and 100% (max at C380-B), with a mean value of 50.2% and a median value of 56.8%. TOC content (Map 4-2a – i) ranged from 0.03 to 35.5% (max at C302-C), with a mean value of 2.02% and a median value of 1.88%.

Aluminum, arsenic, chromium, copper, lead, nickel, and zinc were detected in each of the subsurface samples analyzed for metals. Detected arsenic concentrations ranged from 0.8 to 44.5 J mg/kg (max at C384-B; Map 4-3a – i), with a mean value of 4.36 mg/kg and a median value of 3.79 mg/kg. Detected concentrations of cadmium ranged from 0.034 J to 7.03 mg/kg (max at C324-E; Map 4-4a – i), with a mean value of 0.339 mg/kg and a median value of 0.28 J mg/kg. Total chromium detected concentrations ranged from 9.29 to 249 mg/kg (max at 207-B; Map 4-5a – i), with a mean value of 31.5 mg/kg and a median value of 30.2 mg/kg. Detected copper concentrations ranged from 10.4 to 3,290 mg/kg (max at C384-B; Map 4-6a – i), with a mean value of 52.7 mg/kg and a median value of 36.9 mg/kg. Detected lead concentrations ranged from 2.06 to 3,330 J mg/kg (max at C326-C; Map 4-7a – i), with a mean value of 38.5 mg/kg and a median value of 21.5 mg/kg. Detected concentrations of mercury ranged from 0.007 J to 4.14 mg/kg (max at C295-C; Map 4-8a – i), with a mean value of 0.191 mg/kg and a median value of 0.101 mg/kg. Detected concentrations of zinc ranged from 34.2 to 1,930 mg/kg (max at C384-B; Map 4-9a – i), with a mean value of 144 mg/kg and a median value of 117 mg/kg.

Butyltins were analyzed in 171 samples, and detected in at least 42 samples. Dibutyltin (127 samples) and monobutyltin (112 samples) were the most frequently detected, though tributyltin displayed the highest maximum, mean and median concentrations. Detected dibutyltin concentrations ranged from 0.087 J to 6,000 J µg/kg (max at C392-B) with a mean value of 83 µg/kg and a median value of 1.9 µg/kg; monobutyltin detections ranged from 0.12 J to 540 J µg/kg (max in C392-B), with a mean value of 10.3 µg/kg and a median value of 0.71 J µg/kg; and tributyltin (Map 4-10a – i) detections ranged from 0.32 J to 36,000 J µg/kg (max at C384-B), with a mean value of 752 µg/kg and a median value of 12.2 µg/kg.

Five PCB Aroclors (1242, 1248, 1254, 1260, and 1268) were detected in subsurface samples. Aroclors 1260 and 1254 were the most frequently detected (275 samples and 257 samples, respectively), but Aroclor 1242 was detected at the highest maximum concentration. Detected concentrations of Aroclor 1242 ranged from 13.7 J µg/kg to 16,400 µg/kg (max at C455-B) with a mean value of 2,430 µg/kg and a median value of 210 J µg/kg. Detected concentrations of Aroclor 1260 (Map 4-14a – i) ranged from 1.78 J to 3,200 J µg/kg (max at C025-C1), with a mean value of 107 µg/kg and a median value of 37.6 µg/kg. Detected concentrations of Aroclor 1254 (Map 4-13a – i) ranged from 0.906 to 5,520 J µg/kg (max at C455-B), with a mean value of 157 µg/kg and a median value of 59.5 J µg/kg. Detected concentrations of Aroclor 1248 (Map 4-12a – i) ranged from 1.73 J to 1,850 J µg/kg (max in C455-B), with a mean value of 97.9 µg/kg and a median value of 34 µg/kg. Total detected PCB Aroclor concentrations (Map 4-11a – i) in

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subsurface samples ranged from 0.906 to 21,900 J  $\mu\text{g}/\text{kg}$  (max at C455-B), with an overall mean value of 390  $\mu\text{g}/\text{kg}$  and a median value of 116 J  $\mu\text{g}/\text{kg}$ .

Organochlorine pesticide compounds were analyzed in 444 subsurface interval samples. All 28 compounds except toxaphene were detected in one or more samples. The pesticides 4,4'-DDD (357 samples; Map 4-16a – i), 4,4'-DDE (329 samples; Map 4-17a – i), and 4,4'-DDT (324 samples; Map 4-18a – i) were the most frequently detected (74.1% to 80.4% FOD), although some 4,4'-DDD detections were tentatively identified. Total 4,4'-DDT (sum of 4,4'-DDT, -DDD and -DDE; Map 4-15a – i) concentrations were detected in 379 subsurface samples ranging in concentration from 0.08 J to 72,700 J  $\mu\text{g}/\text{kg}$  (max at C348-C), with an overall mean value of 519  $\mu\text{g}/\text{kg}$  and a median value of 12.2 J  $\mu\text{g}/\text{kg}$ . Total chlordane compounds were detected in 279 samples. Derived detected concentrations of total chlordanes (Map 4-19a – i) ranged from 0.038 J to 2,330 J  $\mu\text{g}/\text{kg}$  (max at C455-B), with a mean value of 24.3  $\mu\text{g}/\text{kg}$  and a median value of 2.22 J  $\mu\text{g}/\text{kg}$ .

Herbicides were analyzed in 140 subsurface samples. Only five of the ten herbicide compounds analyzed were detected: Silvex (in one sample), 2,4-DB (in one sample), MCPP (in two samples), MCPA (in three samples), and 2,4-D (in five samples). Detected concentrations of 2,4-D ranged from 7.14 to 473  $\mu\text{g}/\text{kg}$  (max at C335-B), with a mean value of 128  $\mu\text{g}/\text{kg}$  and a median value of 45.5 J  $\mu\text{g}/\text{kg}$ . The one occurrence of 2,4-DB was the highest concentration of detected herbicides, at 797  $\mu\text{g}/\text{kg}$  (max at C335-B).

VOCs were analyzed in 270 subsurface interval samples. Twenty-nine of the 49 compounds analyzed were detected. Methyl ethyl ketone was detected most frequently (in 163 samples), at concentrations ranging from 1.5 J to 31 J  $\mu\text{g}/\text{kg}$  (max at C359-D), with a mean value of 4.87  $\mu\text{g}/\text{kg}$ , and a median value of 3.8 J  $\mu\text{g}/\text{kg}$ . The VOC detected at the highest concentration was trichloroethene (TCE). TCE concentrations, detected in 103 samples, ranged from 0.11 J to 1,900,000  $\mu\text{g}/\text{kg}$  (max at C299-B), with a mean value of 21,400  $\mu\text{g}/\text{kg}$  and a median value of 0.51 J  $\mu\text{g}/\text{kg}$ . Concentrations of total xylenes (the sum of o- and m,p-xylenes), a mapped chemical detected in 80 samples (Map 4-21a – i), ranged from 0.11 J to 280,000  $\mu\text{g}/\text{kg}$  (max at C301-E) with a mean value of 9,960  $\mu\text{g}/\text{kg}$  and a median value of 3.53 J  $\mu\text{g}/\text{kg}$ . Benzene (Map 4-20 a – i) was detected in 23 samples, at concentrations ranging from 0.045 J to 270,000  $\mu\text{g}/\text{kg}$  (max at C301-E), with a mean value of 6,580  $\mu\text{g}/\text{kg}$  and a median value of 0.25 J  $\mu\text{g}/\text{kg}$ .

SVOCs were analyzed in 511 subsurface samples. PAH compounds, detected in 70.5% to 98.6% (from 391 to 504 samples) of samples analyzed, were present at the highest maximum and mean detected concentrations. Total PAH concentrations in samples ranged from 0.54 J to 53,300,000  $\mu\text{g}/\text{kg}$  (max at C302-C), with a mean value of 422,000  $\mu\text{g}/\text{kg}$  and a median value of 1,780  $\mu\text{g}/\text{kg}$ . Detected concentrations of LPAH compounds (detected in 504 samples; Map 4-26a – i) ranged from 0.45 J to 39,900,000  $\mu\text{g}/\text{kg}$  (max at C302-C), with an overall mean value of 291,000  $\mu\text{g}/\text{kg}$  and a median value of 407  $\mu\text{g}/\text{kg}$ . Detected concentrations of HPAH compounds (detected in 498 samples; Map 4-27a – i) ranged from 0.48 J to 13,400,000  $\mu\text{g}/\text{kg}$  (max at C302-C), with an overall mean value of 133,000  $\mu\text{g}/\text{kg}$  and a median value of 1,290  $\mu\text{g}/\text{kg}$ . Concentrations of mapped chemicals

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dibenzofuran, hexachlorobenzene, bis(2-ethylhexyl)phthalate, and 4-methylphenol were detected in 26.6% (hexachlorobenzene) to 90.4% (dibenzofuran) of samples analyzed. Detected concentrations of dibenzofuran (Map 4-22a – i) ranged from 0.22 J to 230,000 µg/kg (max at C302-C), with a mean value of 2,210 µg/kg and a median value of 12 µg/kg. Detected concentrations of hexachlorobenzene (Map 4-23a – i) ranged from 0.066 J to 134 J µg/kg (max at C366-C1), with a mean value of 5.65 µg/kg and a median value of 1.29 J µg/kg. Bis(2-ethylhexyl)phthalate detected concentrations (Map 4-25a – i) ranged from 4.9 J to 10,000 µg/kg (max at C240-B), with an overall mean value of 493 µg/kg and a median value of 93 µg/kg. Detected concentrations of 4-methylphenol (Map 4-24a – i) ranged from 3.6 J to 800 µg/kg (max at C263-B), with a mean value of 65.4 µg/kg and a median value of 34 J µg/kg.

Gasoline-range hydrocarbons, due to the short-holding time for this analysis, were analyzed in 429 subsurface interval samples, while diesel- and residual-range hydrocarbons were analyzed in 348 samples. Overall, detected TPH concentrations (Map 4-28a – i) in samples ranged from 9.25 J to 321,000 J mg/kg (max at C301-C), with a mean value of 5,050 mg/kg and a median value of 1,090 J mg/kg. Of the individual components, diesel-range hydrocarbons were the most frequently detected (302 samples), and displayed the highest maximum detected concentration. Detected diesel concentrations ranged from 9.9 J to 190,000 J mg/kg, with a mean value of 2,850 mg/kg and a median value of 360 J mg/kg. Detected concentrations of residual-range hydrocarbons (detected at 301 samples), ranged from 9.25 J to 110,000 J mg/kg, with a mean value of 2,170 mg/kg and a median value of 750 J mg/kg. Gasoline-range hydrocarbons were detected in 139 samples analyzed, at concentrations ranging from 1.5 to 21,000 J mg/kg, with a mean value of 582 mg/kg and a median value of 32 J mg/kg. The maximum concentrations of all TPH results occurred in sample C301-C.

One hundred nineteen subsurface samples were analyzed for dioxin and furan compounds. Detected total 2,3,7,8-TCDD TEQ values (Map 4-29a – i) of the analyzed dioxins/furans and dioxin/furan homologs ranged from 0.00053 J to 200 pg/g (max at C334-B), with a mean value of 8.46 pg/g and a median value of 1.11 J pg/g.

#### **4.3.2 Subsurface Results by Depth**

This section presents the analytical results of the subsurface sediment samples by depth, including a summary of sample intervals and a discussion of the results for the mapped indicator chemicals.

##### **4.3.2.1 Subsurface Sample Intervals**

The range of starting depths, thicknesses, and maximum end depths for the subsurface intervals are summarized in the following table.

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Interval ID	Maximum Number of Analyzed Samples	Minimum Starting Depth (cm bml)	Maximum Starting Depth (cm bml)	Minimum Thickness (cm)	Maximum Thickness (cm)	Maximum End Depth (cm bml)
B	206	23	32	30	160	198
C	198	60	198	24	155	306
D	122	98	298	24	155	425
E	55	188	440	7	140	533
F	20	223	518	23	137	573
G	7	332	490	35	144	574
H	1	360			88	448

For this discussion, the subsurface samples were grouped according to their end depths into one of three categories:

- 23-199 cm (0-6.5 ft) below mudline (bml)
- 200-399 cm (6.6-13 ft) bml
- 400-574 cm (13.1-18.8 ft) bml.

Listings of the individual core segments included in each of these categories are presented in Table 4-13.

#### 4.3.2.2 Summary of Indicator Chemical Results by Depth Group

Summary statistics for the analytical results based on these three depth categories defined above are presented in Table 4-14. These results are summarized in the following sections. For simplicity, the depth groupings are referred to as the upper (23-199 cm), middle (200-399 cm), and lower (400-574 cm) subsurface samples. The frequency distributions of the detected concentrations by depth group for the mapped indicator chemicals are presented in Figures 4-30 through 4-56.

##### *Metals*

The highest maximum concentrations of arsenic, chromium, copper, lead, and zinc decrease with depth from the upper subsurface to the lower subsurface. Mean and median values for the indicator metals showed ranges within 30 and 34 mg/kg or less, respectively, between the three depth groups. The results for each of the indicator metals are presented below.

Arsenic was detected in all subsurface samples analyzed. The maximum detected concentrations per depth interval decreased with depth, ranging from 8.37 mg/kg in the lower subsurface samples to 44.5 J mg/kg within the upper subsurface samples. Mean detected values ranged within 1 mg/kg, from 3.9 mg/kg in the middle subsurface samples to 4.8 in the upper subsurface samples. Median detected values showed a range of less than 1 mg/kg, from 3.48 mg/kg in the middle subsurface samples to 4.22 J mg/kg in the lower subsurface samples. The histogram of arsenic data is presented in Figure 4-30.

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The FOD for cadmium ranged from 98% in the upper subsurface samples to 100% in the lower subsurface samples. The maximum detected concentrations per depth interval ranged from 0.779 mg/kg in the lower subsurface samples to 7.03 mg/kg in the middle subsurface samples. Mean detected values ranged within approximately 0.1 mg/kg, from 0.3 mg/kg in the middle depth to 0.4 mg/kg in the lower 2 m. Median detected values showed a range of less than 0.2 mg/kg, from 0.218 mg/kg in the middle subsurface samples to 0.394 J mg/kg in the lower subsurface samples. The histogram of cadmium data is presented in Figure 4-31.

Total chromium was detected in all subsurface samples analyzed. The maximum detected concentrations per depth interval decreased with depth, ranging from 43.2 mg/kg in the lower subsurface samples to 249 mg/kg in the upper subsurface samples. The mean detected total chromium concentrations decreased with depth, ranging from 33 mg/kg in the upper depth to 29 mg/kg in the lower subsurface samples. Median detected values ranged from 28.2 mg/kg in the middle subsurface samples to 32.2 mg/kg in the upper subsurface samples. The histogram of total chromium data is presented in Figure 4-32.

Copper was detected in all subsurface samples analyzed. The maximum and mean detected copper concentrations per depth interval decreased with depth. Maximum concentrations ranged from 107 mg/kg in the lower subsurface samples to 3,290 mg/kg in the upper subsurface samples. Mean detected values ranged from 39 mg/kg in the lower subsurface samples to 64 mg/kg in the upper subsurface samples. Median detected values ranged from 30.5 mg/kg in the middle subsurface to 40.2 mg/kg in the upper subsurface samples. The histogram of copper data is presented in Figure 4-33.

Lead was detected in all subsurface samples analyzed. The maximum and mean detected lead concentrations per depth interval decreased with depth. Maximum concentrations ranged from 85.2 J mg/kg in the lower subsurface samples to 3,330 J mg/kg in the upper subsurface samples. Mean detected values ranged from 28 mg/kg in the lower subsurface samples to 48 mg/kg in the upper subsurface samples. Median detected values ranged from 17.9 mg/kg in the middle subsurface samples to 24.9 mg/kg in the upper subsurface samples. The histogram of lead data is presented in Figure 4-34.

The FOD for mercury ranged from 89.5% in the lower subsurface samples to 99.2% in the upper subsurface samples. Maximum detected concentrations ranged from 0.626 J mg/kg in the lower subsurface samples to 4.14 mg/kg in the middle subsurface samples. Mean detected values showed a range of only 0.8 mg/kg among the three depth groups, from 0.18 mg/kg in the upper subsurface samples to 0.26 mg/kg in the lower subsurface samples. Median detected concentrations showed a range of approximately 0.12 mg/kg between the three groups, from 0.092 mg/kg in the middle subsurface samples to 0.212 mg/kg in the lower subsurface samples. The histogram of mercury data is presented in Figure 4-35.

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Zinc was detected in all subsurface samples analyzed. The maximum detected concentrations decreased with depth, ranging from 263 mg/kg in the lower subsurface samples to 1,930 mg/kg in the upper subsurface samples. Mean detected concentrations in both the middle and lower subsurface samples were 130 mg/kg, a decrease from 160 mg/kg in the upper subsurface samples. Median detected concentrations showed a range of 35.2 mg/kg between the three groups, from 95.8 mg/kg in the middle subsurface samples to 131 mg/kg in the upper subsurface samples. The histogram of zinc data is presented in Figure 4-36.

#### *TBT*

TBT was detected in 76.1% of the upper subsurface samples and 46.2% of the middle subsurface samples, but was not detected in any of the lower subsurface samples analyzed. Maximum, mean, and median detected concentrations were all highest in the upper subsurface samples. Maximum detected concentrations were 36,000 J  $\mu\text{g}/\text{kg}$  in the upper subsurface samples and 910  $\mu\text{g}/\text{kg}$  in the middle subsurface samples. Mean detected concentrations showed a range of 1,038  $\mu\text{g}/\text{kg}$  among the two depth groups, from 1,100  $\mu\text{g}/\text{kg}$  in the upper subsurface samples to 62  $\mu\text{g}/\text{kg}$  in the middle subsurface samples. Median detected concentrations showed a range of 13.7  $\mu\text{g}/\text{kg}$ , from 16  $\mu\text{g}/\text{kg}$  in the upper subsurface samples to 2.3  $\mu\text{g}/\text{kg}$  in the middle subsurface samples. The histogram of TBT data is presented in Figure 4-37.

#### *PCBs*

The FOD of summed detected concentrations of total PCBs as Aroclors ranged from 51.4% in the middle subsurface samples to 73.5% in the upper subsurface samples. Maximum concentrations decreased with depth from 832 J  $\mu\text{g}/\text{kg}$  in the lower subsurface samples to 21,900 J  $\mu\text{g}/\text{kg}$  in the upper subsurface samples. Mean detected concentrations showed a range of 360  $\mu\text{g}/\text{kg}$  among the three depth groups, from 180  $\mu\text{g}/\text{kg}$  in the middle subsurface samples to 540  $\mu\text{g}/\text{kg}$  in the upper subsurface samples. Median detected concentrations showed a range of 12  $\mu\text{g}/\text{kg}$ , from 109 J  $\mu\text{g}/\text{kg}$  in the middle subsurface samples to 121 J  $\mu\text{g}/\text{kg}$  in the upper subsurface samples. The histogram of total PCB data is presented in Figure 4-38.

Similarly, the maximum concentrations of the individual indicator PCB Aroclors 1248, 1254, and 1260 all occurred within the upper subsurface samples and decreased with depth in the subsequent depth groups. The histograms of Aroclor 1248, 1254, and 1260 data are presented in Figures 4-39, 4-40, and 4-41, respectively.

#### *Pesticides*

The FOD of total DDT constituents ranged from 73.7% in the lower subsurface samples to 92.2% in the upper subsurface samples. The highest maximum total DDT detected and mean concentrations among the three depth groups occurred in the middle subsurface samples. Maximum detected concentrations ranged from 182 J  $\mu\text{g}/\text{kg}$  in the lower subsurface samples to 72,700 J  $\mu\text{g}/\text{kg}$  in the middle subsurface samples. Mean detected concentrations showed a range of 956  $\mu\text{g}/\text{kg}$ , from 44  $\mu\text{g}/\text{kg}$  in the lower subsurface samples to 1,000  $\mu\text{g}/\text{kg}$  in the middle subsurface samples. Median detected concentrations showed a range of 21.4  $\mu\text{g}/\text{kg}$ , from 11.7 J  $\mu\text{g}/\text{kg}$  in the upper subsurface

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samples to 33.1 J  $\mu\text{g}/\text{kg}$  in the lower subsurface samples. The histogram of total DDT data is presented in Figure 4-42.

The FOD of 4,4'-DDD ranged from 72.1% in the middle subsurface samples to 88.9% in the upper subsurface samples. Both the maximum and mean detected concentrations were highest in the middle subsurface samples. Maximum concentrations ranged from 51,800 J  $\mu\text{g}/\text{kg}$  (tentatively identified) in the middle subsurface samples to 165  $\mu\text{g}/\text{kg}$  (tentatively identified) in the lower subsurface samples. Mean concentrations showed a range of 652  $\mu\text{g}/\text{kg}$  among the three depth groups, ranging from 28  $\mu\text{g}/\text{kg}$  in the lower subsurface samples to 680  $\mu\text{g}/\text{kg}$  in the middle subsurface samples. Median detected concentrations showed a range of 5.16  $\mu\text{g}/\text{kg}$ , increasing with depth from 6.74 J  $\mu\text{g}/\text{kg}$  (tentatively identified) in the upper subsurface samples to 11.9 J  $\mu\text{g}/\text{kg}$  in the lower subsurface samples. The histogram of 4,4'-DDD data is presented in Figure 4-43.

The FOD of 4,4'-DDE ranged from 57.9% in the lower subsurface samples to 84.8% in the upper subsurface samples. The maximum detected concentrations decreased with depth, ranging from 22 J  $\mu\text{g}/\text{kg}$  (tentatively identified) in the lower subsurface samples to 2,690 J  $\mu\text{g}/\text{kg}$  in the upper subsurface samples. Mean concentrations showed a range of 19.4  $\mu\text{g}/\text{kg}$  among the three depth groups, from 9.6  $\mu\text{g}/\text{kg}$  in the lower subsurface samples to 29  $\mu\text{g}/\text{kg}$  in the middle subsurface samples. Median detected concentrations showed a range of 5.84  $\mu\text{g}/\text{kg}$ , increasing with depth from 4.05 J  $\mu\text{g}/\text{kg}$  (tentatively identified) in the upper subsurface samples to 9.89 J  $\mu\text{g}/\text{kg}$  in the lower subsurface samples. The histogram of 4,4'-DDE data is presented in Figure 4-44.

The FOD of 4,4'-DDT ranged from 64.7% in the lower subsurface samples to 83.3% in the upper subsurface samples. The maximum detected concentrations ranged from 61.5 J  $\mu\text{g}/\text{kg}$  in the lower subsurface samples to 22,000 J  $\mu\text{g}/\text{kg}$  in the middle subsurface samples. Mean concentrations showed a range of 429  $\mu\text{g}/\text{kg}$  among the three depth groups, from 11  $\mu\text{g}/\text{kg}$  in the lower subsurface samples to 440  $\mu\text{g}/\text{kg}$  in the middle subsurface samples. Median detected concentrations showed a range of 1.34  $\mu\text{g}/\text{kg}$ , increasing with depth from 1.56 J  $\mu\text{g}/\text{kg}$  (tentatively identified) in the upper subsurface samples to 2.9 J  $\mu\text{g}/\text{kg}$  in the lower subsurface samples. The histogram of 4,4'-DDT data is presented in Figure 4-45.

The FOD of the total chlordane constituents ranged from 47.4% in the lower subsurface samples to 70.5% in the upper subsurface samples. The maximum total chlordanes detected concentrations decreased with depth, ranging from 12.7 J  $\mu\text{g}/\text{kg}$  in the lower subsurface samples to 2,330 J  $\mu\text{g}/\text{kg}$  in the upper subsurface samples. Mean concentrations showed a range of 21.8  $\mu\text{g}/\text{kg}$  among the three depth groups, from 4.2  $\mu\text{g}/\text{kg}$  in the lower subsurface samples to 26  $\mu\text{g}/\text{kg}$  in the middle subsurface samples. Median detected concentrations showed a range of 1.37  $\mu\text{g}/\text{kg}$ , increasing with depth from 2.15 J  $\mu\text{g}/\text{kg}$  in the upper subsurface samples to 3.52 J  $\mu\text{g}/\text{kg}$  in the lower subsurface samples. The histogram of total chlordane data is presented in Figure 4-46.

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### VOCs

The FOD of benzene ranged from 38.9% in the upper subsurface samples to 60% in the lower subsurface samples. The maximum detected concentrations ranged from 28,000 µg/kg in the lower subsurface samples to 270,000 µg/kg in the middle subsurface samples. Mean detected values showed a range of 7,100 µg/kg among the three depth groups, from 2,300 µg/kg in the lower subsurface samples to 9,400 µg/kg in the middle subsurface samples. Median detected concentrations showed a range of 0.12 µg/kg among the three subsurface groups, from 0.19 J µg/kg in the middle subsurface samples to 0.31 J µg/kg in the upper subsurface samples. The histogram of benzene data is presented in Figure 4-47.

The FOD of total xylenes ranged from 15% in the lower subsurface samples to 32.4% in the upper subsurface samples. The maximum detected concentrations ranged from 27,400 µg/kg in the lower subsurface samples to 280,000 µg/kg in the middle subsurface samples. Mean detected values showed a range of 12,700 µg/kg among the three depth groups, from 3,300 µg/kg in the upper subsurface samples to 16,000 µg/kg in the middle subsurface samples. Median detected concentrations showed a range of 16.92 µg/kg among the three subsurface groups, from 1.88 J µg/kg in the middle subsurface samples to 18.8 µg/kg in the upper subsurface samples. The histogram of total xylenes data is presented in Figure 4-48.

### SVOCs

The FOD of total LPAHs ranged from 97.9% in the middle subsurface samples to 100% in the lower subsurface samples. The maximum detected concentrations ranged from 1,750,000 µg/kg in the lower subsurface samples to 39,900,000 µg/kg in the middle subsurface samples. Mean detected values showed a range of 380,000 µg/kg among the three depth groups, from 100,000 µg/kg in the lower subsurface samples to 480,000 µg/kg in the middle subsurface samples. Median detected concentrations showed a range of 1,230 µg/kg among the three depth groups, from 360 µg/kg in the upper subsurface samples to 1,590 µg/kg in the lower subsurface samples. The histogram of LPAH data is presented in Figure 4-49.

The FOD of total HPAHs ranged from 94.7% in the lower subsurface samples to 99.2% in the upper subsurface samples. The maximum detected concentrations ranged from 932,000 J µg/kg in the lower subsurface samples to 13,400,000 µg/kg in the middle subsurface samples. Mean detected values showed a range of 114,000 µg/kg among the three depth groups, from 76,000 µg/kg in the lower subsurface samples to 190,000 µg/kg in the middle subsurface samples. Median detected concentrations showed a range of 2,590 µg/kg among the three depth groups, from 1,180 µg/kg in the upper subsurface samples to 3,770 µg/kg in the lower subsurface samples. The histogram of HPAH data is presented in Figure 4-50.

The FOD of dibenzofuran ranged from 84.2% in the lower subsurface samples to 95.7% in the upper subsurface samples. The maximum detected concentrations ranged from 6,300 J µg/kg in the lower subsurface samples to 230,000 µg/kg in the middle subsurface samples. Mean detected values showed a range of 2,950 µg/kg among the three depth

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groups, from 550 µg/kg in the lower subsurface samples to 3,500 µg/kg in the middle subsurface samples. Median detected concentrations showed a range of 9.2 µg/kg among the three depth groups, from 9.8 J µg/kg in the upper subsurface samples to 19 µg/kg in the lower subsurface samples. The histogram of dibenzofuran data is presented in Figure 4-51.

The FOD of hexachlorobenzene ranged from 10.5% in the lower subsurface samples to 28.2% in the upper subsurface samples. The maximum detected concentrations ranged from 0.423 J µg/kg in the lower subsurface samples to 134 J µg/kg in the middle subsurface samples. Mean detected values showed a range of 7.16 µg/kg among the three depth groups, from 0.24 µg/kg in the lower subsurface samples to 7.4 µg/kg in the middle subsurface samples. Median detected concentrations showed a range of 1.26 µg/kg among the three depth groups, from 0.066 J µg/kg in the lower subsurface samples to 1.33 J µg/kg in the middle subsurface samples. The histogram of hexachlorobenzene data is presented in Figure 4-52.

The FOD of 4-methylphenol ranged from 47.3% in the middle subsurface samples to 59.6% in the upper subsurface samples. Maximum detected concentrations decreased with depth, ranging from 300 µg/kg in the lower subsurface samples to 800 µg/kg in the upper subsurface samples. Mean and median detected concentrations of 4-methylphenol increased with depth. Mean concentrations of 4-methylphenol showed a range of 68 µg/kg, from 52 µg/kg in the upper subsurface samples to 120 µg/kg in the lower subsurface samples. Median detected concentrations showed a range of 81 µg/kg, from 29 µg/kg in the upper subsurface samples to 110 µg/kg in the lower subsurface samples. The histogram of 4-methylphenol data is presented in Figure 4-53.

The FOD of bis(2-ethylhexyl)phthalate decreased with depth, ranging from 5.3% (1 sample) in the lower subsurface samples to 36.5% in the upper subsurface samples. Maximum and mean detected concentrations also decreased with depth. Maximum detected concentrations ranged from 94 µg/kg in the one lower subsurface sample to 10,000 µg/kg in the upper subsurface samples. Mean detected concentrations showed a range of 576 µg/kg among the three depth groups, from 94 µg/kg in the one lower subsurface sample to 670 µg/kg in the upper subsurface samples. Median detected concentrations showed a range of 20 µg/kg, from 80 µg/kg in the middle subsurface samples to 100 µg/kg in the upper subsurface samples. The histogram of bis(2-ethylhexyl)phthalate data is presented in Figure 4-54.

#### *TPH*

The FOD for TPH compounds ranged from 87.5% in the lower subsurface samples to 93.6% in the upper subsurface samples. Maximum and mean detected concentrations occurred in the middle subsurface samples. Maximum detected concentrations ranged from 7,720 J µg/kg in the lower subsurface samples to 321,000 J µg/kg in the middle subsurface samples. Mean detected concentrations showed a range of 4,700 µg/kg among the three depth groups, from 2,500 µg/kg in the lower subsurface samples to 7,200 µg/kg in the middle subsurface samples. Median detected concentrations showed a

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range of 550  $\mu\text{g}/\text{kg}$ , from 990 J  $\mu\text{g}/\text{kg}$  in the upper subsurface samples to 1,540 J  $\mu\text{g}/\text{kg}$  in the lower subsurface samples. The histogram of TPH data is presented in Figure 4-55.

#### *2,3,7,8-TCDD TEQ Values*

The FOD for 2,3,7,8-TCDD TEQs ranged from 83.6% in the middle subsurface samples to 100% (based on only 3 samples analyzed) in the lower subsurface samples. Maximum detected concentrations decreased with depth, ranging from 13.7 J  $\text{pg}/\text{g}$  in the lower subsurface samples to 200  $\text{pg}/\text{g}$  in the upper subsurface samples. Mean detected concentrations showed a range of 4.4  $\text{pg}/\text{g}$  among the three depth groups, from 6.6  $\text{pg}/\text{g}$  in the lower subsurface samples to 11  $\text{pg}/\text{g}$  in the middle subsurface samples. Median detected concentrations showed a range of 4.87  $\text{pg}/\text{g}$ , from 0.284 J  $\text{pg}/\text{g}$  in the middle subsurface samples to 5.15 J  $\text{pg}/\text{g}$  in the lower subsurface samples. The histogram of 2,3,7,8-TCDD TEQ data is presented in Figure 4-56.

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This document is currently under review by US EPA and its federal, state, and tribal partners and is subject to change in whole or in part.