Lower Duwamish Waterway
Slip 4 Early Action Area

Appendix A
Revised Draft Technical Memorandum on
Proposed Boundary of the Removal Action

LOWER DUWAMISH WATERWAY
SLIP 4 EARLY ACTION AREA

REVISED DRAFT TECHNICAL MEMORANDUM ON PROPOSED BOUNDARY OF THE REMOVAL ACTION

Submitted to

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2LAET	second lowest apparent effects threshold
AET	apparent effects threshold
AOC	Administrative Order on Consent
BEHP	bis(2-ethylhexyl)phthalate
CFR	Code of Federal Regulations
CSL	Cleanup Screening Levels
dw	dry weight
Ecology	Washington Department of Ecology
EE/CA	engineering evaluation and cost analysis
EF	exceedance factor
EPA	U.S. Environmental Protection Agency
FS	feasibility study
LDW	Lower Duwamish Waterway
LDWG	Lower Duwamish Waterway Group
LAET	lowest apparent effects threshold
MLLW	mean lower low water
MTCA	Model Toxics Control Act
NAD	North American Datum
NOAA	National Oceanic and Atmospheric Administration
OC	organic carbon
PCBs	polychlorinated biphenyls
QC	quality control
RI	remedial investigation
SAP	sampling and analysis plan
SMS	Sediment Management Standards
SOW	Statement of Work
SQS	Sediment Quality Standard
TOC	total organic carbon
WAC	Washington Administrative Code

1 INTRODUCTION

This technical memorandum presents the proposed boundary for the Slip 4 Early Action Area removal action[1]. Slip 4 is located approximately 2.8 miles from the mouth of the Duwamish River in Seattle, WA (Figure 1). The City of Seattle and King County are performing the Slip 4 characterization and boundary definition work under Tasks 9 and 10 of the existing Administrative Order on Consent (AOC) Statement of Work (SOW) for the Lower Duwamish Waterway (LDW), and per requirements of the Slip 4 Revised Work Plan (Integral 2004b).

The proposed removal action boundary for the Slip 4 Early Action Area is presented in this memorandum to facilitate discussions on the boundary among all stakeholders prior to preparation of the engineering evaluation and cost analysis (EE/CA). This memorandum relies on data presented in SEA (2004) and Integral (2004a). The EE/CA will contain more detailed information than is presented in this memorandum, and will undergo a formal public review. The final boundary will be selected by the U.S. Environmental Protection Agency (EPA) in a formal decision document (the Action Memorandum).

1.1 PROJECT BACKGROUND

The Lower Duwamish Waterway (LDW) in Seattle, WA, was added to EPA's National Priorities List (aka Superfund) in September 2001 because of chemical contaminants in sediments. The key parties involved in the LDW site are the Lower Duwamish Waterway Group (LDWG) (comprised of the City of Seattle, King County, the Port of Seattle, and The Boeing Company), EPA, and Washington Department of Ecology (Ecology). The LDWG is voluntarily conducting the LDW remedial investigation and feasibility study (RI/FS).

The first phase of the LDW RI used existing data to evaluate the nature and extent of chemical distributions in LDW sediments and presented preliminary risk estimates (Windward 2003b). Information obtained during the LDW Phase 1 RI was used to identify locations in the LDW that could be candidates for early cleanup action (Windward 2003a,b). Slip 4 was identified as a candidate early action site by EPA and Ecology (Windward 2003a) based primarily on elevated concentrations of polychlorinated biphenyls (PCBs). Compared to a remedial action (which typically

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[1] EPA and Ecology (Windward 2003a) use the term "early action" to refer to short-term cleanups that are called "removal actions" under CERCLA, "interim actions" under MTCA, or "partial cleanup actions" under the Washington State Sediment Management Standards (SMS). This document uses the term "removal action."

occurs after the RI/FS, proposed plan, and Record of Decision have been prepared), removal actions are generally defined as short-term, quickly implemented actions designed to eliminate or minimize a known significant risk from Superfund sites.

The process used by EPA and Ecology to identify early action sites followed both the National Contingency Plan, which requires that threats to human or animal populations, sensitive ecosystems or other significant factors affecting the health or welfare of the public or environment be considered when identifying removal actions (40 CFR 300.415), and the Washington State Model Toxics Control Act (MTCA). MTCA defines interim actions as "a remedial action that is technically necessary to reduce a threat to human health or the environment by eliminating or substantially reducing one or more pathways for exposure to a hazardous substance at a facility" (WAC 173-340-430) (Windward 2003a).

Existing information for the Slip 4 Early Action Area was compiled by SEA (2004). That report included descriptions of the physical environment, potential chemical sources, sediment data collected between 1990 and 1998, and existing habitat and human uses of the slip. SEA (2004) also identified data gaps to be filled prior to the identification of the boundary for an early removal action of contaminated sediments. Additional sediment and bank chemistry data were collected in March and July 2004 (Integral 2004c,d,e; Landau 2004) to address these data gaps and were reported by Integral (2004a). These data form the basis for the proposed removal action boundary identified in this report.

This memorandum evaluates available Slip 4 data and identifies the proposed boundary of the Slip 4 Early Action Area removal action. Minor modifications to this boundary may be made in response to engineering constraints that will be identified during the upcoming EE/CA. The removal action boundary may be refined in the EE/CA. The EE/CA process includes a formal public comment period. EPA will then document and approve the removal action boundary in an Action Memorandum, which is EPA's primary decision document for a removal response.

Areas in the LDW outside of the boundary will continue to be evaluated by the LDWG, EPA, and Ecology under the LDW RI/FS. The LDW RI/FS will include an ecological and human health risk assessment to evaluate potential risks to human health and the environment posed by the LDW site. Ecology will continue to evaluate upland sites adjacent to the waterway and within the Slip 4 drainage basin for source control or other action, as appropriate.

1.2 REPORT ORGANIZATION

Section 2 of this report briefly summarizes the historic and recent sediment chemistry data that were considered for use in determining the removal action boundary. Section 3 presents the proposed boundary for the removal action and describes the process used to identify the boundary. Finally, references are listed in Section 4.

2 SUMMARY OF SEDIMENT CHARACTERIZATION RESULTS

As required by the work plan (Integral 2004b), all available data were considered for development of the boundary for the Slip 4 Early Action Area removal action. All sediment chemistry data collected in Slip 4 have been presented in detail in earlier reports[2]. SEA (2004) described data collected from 1990 – 1998, and Integral (2004a) described data collected in 2004. No data were collected between 1998 and 2004. Both the historic and 2004 data are briefly summarized below and are depicted in Figures 2 – 5.

For characterization purposes and to assist in data interpretation, results are compared to Washington State Sediment Management Standards (SMS) numerical criteria for sediment quality standards (SQS) and cleanup screening levels (CSL) (WAC 173-204 (Table 1)[3]. These values provide a basis for identifying the aerial extent of sediments that may pose a risk to some ecological receptors, and are thus useful for identifying sediments that may pose unacceptable risks. Sediments that are not identified as requiring removal using the SMS will continue to be evaluated for risks to both human health and other ecological receptors by the LDW RI/FS human health and ecological baseline risk assessment processes.

Sediments with chemical concentrations less than the SQS are expected to have no adverse effects on biological resources in sediments. An exceedance of the SQS numerical criteria indicates the potential for minor adverse biological effects or toxicity; and biological testing may be used to confirm that minor adverse effects actually occur. The CSL is defined as the maximum allowed chemical concentration and level of biological effects permissible at a cleanup site to be achieved 10 years after cleanup is completed. The CSL is greater than or equal to the SQS and represents a higher level of risk to benthic organisms than SQS levels.

The EE/CA that will be prepared for Slip 4 will contain more detailed information than is presented in this document, including a streamlined risk evaluation for human health and ecological risks.

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[2] Only sediment chemistry data are available for Slip 4. The only biological data were collected in areas that have since been dredged (SEA 2004).

[3] The minimum total organic carbon (TOC) concentration for TOC normalization and comparison to the SMS is 0.2% (Michelsen 1992). Chemical concentrations in the few samples with TOC < 0.2% are compared to dry-weight apparent effects threshold (AET) values instead of TOC-normalized SMS values.

2.1 SURFACE SEDIMENT

2.1.1 1990 – 1998 Data

Surface sediment chemistry data were collected from 41 locations in Slip 4 from 1990 to 1998 by a number of investigations. PCBs data are compared to SMS criteria and summarized in Figure 2. [Note that some of the data generated by the National Oceanic and Atmospheric Administration (NOAA) have been determined to be potentially biased high due to the analytical methodology (not sampling) bias (Araki 2004)[4]. Affected PCB data with potential high bias include all samples beginning with "EIT" or "EST" except for EIT-067, EIT-068, EST-171, EST-172, EST-173, and EST-175.] All chemical concentrations greater than the SQS (i.e., chemicals potentially having adverse impacts on biological communities in sediments) are listed in Table 2.

The historic data confirmed that PCBs are the contaminant of primary concern in Slip 4 surface sediments[5]. PCBs exceeded the SQS at nearly all sampling locations; over half the locations exceeded the PCB CSL. The highest PCB concentrations were at the head of the slip, and concentrations decreased toward the mouth. In addition to PCBs, metals and polycyclic aromatic hydrocarbons (PAHs) exceeded SQS values in samples located in the vicinity of the outfalls at the head of the slip (Table 2). Finally, bis(2-ethylhexyl)phthalate (BEHP) also exceeded the SQS and the CSL at some stations.

2.1.2 2004 Data

PCB Aroclors and mercury were analyzed in surface sediment samples collected at 29 locations (plus 2 field replicates), one intertidal composite location, and 6 bank sample locations in 2004. The other SMS analytes were analyzed in a subset of samples from areas likely to be outside the boundary, as well as at a quality control (QC) station in the upper portion of the slip. [The rationale for selection of samples for SMS analysis is provided in Integral (2004e).] Chemicals with SQS and CSL exceedances in surface and bank samples are listed in Table 3 and shown in Figures 3 and 4.

In comparison to the historical data for surface sediments, PCB concentrations in 2004 were substantially lower than concentrations found in the period 1990 – 1998. PCB concentrations in 2004 exceeded the SQS at six stations (Figure 3). CSL exceedances

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[4] As stated by Araki (2004):

"Results that are less than 100 µg/kg are considered estimates and should be "J" qualified because they may have a large potential negative bias (i.e., PCB concentrations may be underestimated).

Results between 100 and 600 µg/kg are considered usable without qualification. However, there is still a potential positive bias which may be associated with these results and cannot be confirmed.

Results that are greater than 600 µg/kg are considered estimates and should be "J" qualified because they may have a potential positive bias (i.e., PCB concentrations may be overestimated). Depending upon the PCB congener this potential systematic positive bias ranges from 5% to 9%."

[5] Of the 41 historic sampling locations, there were only two locations (SL4-10 and SL4-12; Figure 2) where detected chemicals other than PCBs exceeded the SQS, but PCBs did not exceed the SQS (Table 2).

were confined to three stations at the head of the slip and the intertidal composite sample located along the southern end of First South Properties. Total PCBs at the remaining 20 surface sediment stations were below the SQS.

For the subset of 2004 samples that were analyzed for other SMS analytes, eight subtidal samples were analyzed for all SMS organic compounds; four of these eight samples were also analyzed for all SMS metals (Figure 4) (Integral 2004e). Two additional samples (i.e., samples SG06 and SG06FR) were analyzed for all SMS organics and metals because they were the project's field quality control (QC) samples. Intertidal station IC01 was also analyzed for all SMS analytes. Except for the field QC samples, only one of these locations (SG16) had detected chemicals other than PCBs at concentrations greater than the SQS (however, PCBs also exceeded the SQS at this location) (Table 3, Figure 3). At Station SG16, BEHP and phenol, as well as PCBs, were slightly above the SQS. In the field QC samples [SG06 and SG06FR(SG41S)], two organic chemicals, as well as PCBs, were greater than the SQS or CSL (Figure 4). No other metals or organic chemicals exceeded the SQS in Slip 4 surface sediment samples collected in 2004.

2.2 SUBSURFACE SEDIMENT

2.2.1 1990 – 1998 Data

The only historic sediment core data for Slip 4 were collected in 1990 (Landau 1990, SEA 2004). As in surface sediments, PCBs were the contaminant with the most frequent SQS exceedances; these results are presented in Figure 5. Only two detected chemicals other than PCBs (i.e., acenaphthene and fluoranthene at SL4-06A and SL4-09A) exceeded the SQS in subsurface sediments below 2 feet (SQS exceedance factors 1.06 – 2.88) [Figure 5-14 in SEA (2004)]. The maximum depth of PCB SQS exceedances ranged from 4 feet to greater than 9 feet (Figure 5). CSL exceedances below 4 feet were observed in only 2 of the 10 cores (i.e., Stations SL4-6A and SL4-10A). At both locations with CSL exceedances below 4 feet, PCBs were the only detected chemical exceeding the CSL at depths greater than 4 feet, and the maximum depth of PCBs exceeding the CSL was greater than 8 – 9 feet. In general, PCB concentrations tended to decrease with depth (based on composited samples from 1.5 to 2-foot core intervals).

2.2.2 2004 Data

Of the 11 stations where subsurface cores were collected in 2004, samples from nine stations were analyzed by either the City of Seattle/King County or The Boeing Company. Samples from Stations SC08 and SC10 remain archived. PCB concentrations from these nine stations are also shown in Figure 5. Six of the nine cores that were analyzed contained one or more intervals with PCBs greater than the CSL. At these stations, CSL exceedances commonly occurred to a depth of 4 or 6 feet. At most locations, no SQS exceedances occurred below 4 – 6 feet, although CSL exceedances occurred in the 8- to 10-foot interval at Station SC-02 and in the 6- to 8-foot interval at

Station SC-03. The depth of sediments exceeding SQS was bounded in all cores except SC-02. An archived sample from the 10- to 12-foot interval at SC-02 may be analyzed, if needed, for design purposes.

Other detected chemicals that exceeded the SQS or CSL in subsurface sediments were limited to mercury (seven samples with exceedances) and silver (one sample) (Table 4). All metals exceedances were in samples that also had PCBs greater than the SQS or CSL except for the 6- to 8-foot interval at Station SC04. Other than PCBs, there were no detected organic chemicals in subsurface sediment samples that exceeded the SQS or CSL (Integral 2004a).

2.3 BANK SAMPLES

Six bank samples were collected at +10 feet mean lower low water (MLLW)[6] along unarmored sections of the Slip 4 shoreline and analyzed for PCB Aroclors and mercury. PCBs at four sampling locations along the southeast shoreline exceeded the SQS, and one station (BK06) exceeded the CSL (Figure 3). Previous upland investigations have characterized the stratigraphy of soils near the Slip 4 embankments (Landau 1990). These soil borings indicate that fill material overlies native tideflat and river deposits. In the vicinity of the southeast Slip 4 shoreline, where bank samples exceeded SQS at +10 feet MLLW, the fill/native interface generally occurs at elevations ranging from +4 to +11 feet MLLW. Therefore, the bank samples collected in this investigation may represent fill material or some mixture of fill material and sedimentary deposits. Field observations by sampling personnel noted possible fill material in bank samples.

Intertidal sediments below the bank in the vicinity of Station BK06 (Station IC01) also contained PCBs at concentrations exceeding the CSL. Sediments exhibiting elevated PCBs in this localized intertidal area are likely being impacted by eroding fill from the bank.

2.4 COMPARISON OF HISTORIC AND 2004 DATA

When the surface PCB concentrations from 2004 are compared with historical data collected between 1990 and 1998, it is evident that PCB concentrations in surface sediments in many areas of the slip are less in 2004 than they were between 1990 and 1998 (Figures 2 and 3). In addition, the 2004 co-located surface (surface to 10 cm) and subsurface sample results can be compared (Figure 5). In all cases, total PCBs in the

[6]All elevations at Slip 4 are referenced to MLLW, a U.S. survey vertical datum, and are given in feet. Tidal elevations at Slip 4 range from extreme lows of approximately -4 feet MLLW to extreme highs of approximately +13 feet MLLW. The estimated top of bank elevation in Slip 4 is approximately +12 to +16 ft MLLW.

surface sample are less than the concentrations in the top interval (0-2 feet) of the co-located core. These decreasing PCB concentrations over time and throughout the slip may be the result of reduced PCB input due to source control, physical processes consistent with natural recovery (e.g., sedimentation, dispersion, dilution, bioturbation), or other factors occurring within Slip 4.

3 PROPOSED BOUNDARY IDENTIFICATION AND RATIONALE

The proposed boundary for the removal action at the Slip 4 Early Action Area is presented in this section along with the supporting rationale. This proposed boundary is preliminary and may be refined during the EE/CA. In addition, the vertical boundary for the removal action (i.e., the depth to which sediments may require remediation) is not defined as part of this memorandum, but will be determined during the EE/CA based on the removal alternatives, sediment characteristics, and engineering considerations. EPA will document and approve the removal action boundary in an Action Memorandum, which is EPA's primary decision document for a removal response.

In addition to presenting the removal action boundary, the EE/CA will include information on the site such as the nature and extent of existing sediment contamination; relevant physical, geological and biological conditions; and source control considerations. The EE/CA will include a streamlined risk evaluation for human health and ecological risks. It will also present potential cleanup technologies, evaluate cleanup alternatives and identify the preferred cleanup alternative for the removal action.

Areas in the LDW outside of the boundary will continue to be evaluated by the LDWG, EPA, and Ecology under the LDW RI/FS. The LDW RI/FS will include an ecological and human health risk assessment to evaluate potential risks to human health and the environment posed by the LDW site. Ecology will continue to evaluate upland sites adjacent to the waterway and within the Slip 4 drainage basin for source control or other action, as appropriate.

3.1 BOUNDARY DEFINITION CONSIDERATIONS

The boundary was identified after considering the following:

- The City of Seattle and King County are actively involved in source control efforts in the Slip 4 drainage basin. The boundary of the removal action reflects the area of Slip 4 that appears to have been impacted by one or more uncontrolled sources within this drainage basin.

- The proposed boundary is based on 2004 data. Comparison of historic (1990 – 1998) surface sediment data and 2004 data indicate that present-day surface sediments throughout the slip are substantially cleaner than those collected 6 to 14 years ago. This observation of reduced surface PCB concentrations in surface sediments is further supported by subsurface core data and comparisons of co-located surface and subsurface samples (Section 2.4).

- The overall approach for identifying the boundary compared surface sediment chemical concentrations to the Washington State SMS values (CSL and SQS). The approach focused on the areal extent of PCBs because the historical data (Table 2; Table 5-6 of SEA 2004) had shown that PCBs were the primary contaminant of concern. In the historical data set, only PCBs and BEHP exceeded the CSL at more than one station, and the distribution of PCB exceedances was greater than the distribution of BEHP exceedances. Analyses in 2004 focused on PCBs, but full-suite SMS analyses were also performed on a subset of samples to determine if other chemical exceedances exist outside of the PCB exceedance area.

- The proposed boundary includes a section that crosses the slip and a section that follows the shoreline. The proposed boundary across the slip is generally based on exceedances of the PCB SQS value [12 mg/kg organic carbon (OC)] in surface (i.e., 0 – 10 cm) sediments. There were no CSL exceedances and only two slight SQS exceedances at one station outside of the proposed boundary (Figure 4). The proposed boundary across the slip is set outside of the bank areas that have elevated PCB concentrations. This boundary crosses the slip so that it abuts the area near the southwestern portion of the Crowley dock that was dredged in 1996. It includes the intertidal composite sample area with elevated PCBs. The proposed boundary along the shoreline is set at the face of the Crowley dock or the toe of the bank.

- Banks with elevated PCB concentrations exist along the eastern shoreline of Slip 4 (Figure 3). The banks comprise eroding, low-bank bluffs and failing or dilapidated bulkheads. These bank deposits likely include fill material that may be a historic and/or ongoing source to Slip 4 sediment and are therefore considered candidates for source control or removal actions by Ecology. Ecology is moving forward to investigate the nature, extent, and source of this material and will oversee cleanup as needed. Because this fill material is being addressed by Ecology, areas above the toe of the bank or bulkhead are not included within the proposed removal action boundary.

The proposed removal boundary includes the inner half of Slip 4 (Figure 6). This area includes all surface sediments with chemical concentrations greater than the SQS except for one isolated station with minor SQS exceedances. Areas outside the proposed boundary will continue to be evaluated by the LDWG, EPA, and Ecology pursuant to the LDW RI/FS. A detailed Slip 4 map showing the topographic and bathymetric contours with the proposed removal boundary is included in Appendix A.

3.2 BOUNDARY ACROSS THE SLIP

The portion of the proposed boundary across the slip was drawn perpendicular to the shoreline beginning at the edge of the riprap on the northeastern edge of the property owned by The Boeing Company and extending across the slip to the Crowley pier. The edge of the riprap on Boeing property also coincides with a chain-link fence at the top of the bank that demarks the property line between First South Properties and Boeing. All but one 2004 surface sample in the outer half of the slip had PCB concentrations below the SQS. Station SG16 had a PCB concentration of 15.4 mg/kg OC (the PCB SQS is 12 mg/kg OC), and had very minor exceedances of the SQS values for phenol and BEHP (Figures 3 and 4). (The SQS exceedance factors for these two chemicals were 1.14 and 1.09, respectively.) It is also in an area that was dredged in 1996.

Two historical surface sampling stations (i.e., Stations EIT066 and SL4-11) located offshore of Boeing's riprap (Figure 2) exceeded the CSL for PCBs. These stations are not contained within the removal action boundary. Station EIT066 was sampled by NOAA in 1997. EPA has determined that the PCB data at station EIT066 are potentially biased high due to bias in the methodology (see Section 2.1.1) (Araki 2004). Data for Station SL4-11 were reported by Landau (1990). As shown on Figure 5, this area was resampled as part of the Slip 4 Early Action Area characterization in 2004 and found to contain both surface and subsurface sediment PCB concentrations below the SQS. Similarly, historical surface sampling Station DR-181, located offshore of Crowley, exceeded the CSL for PCBs. This area was also resampled in 2004 and surface sediment PCB concentrations were below the SQS.

3.3 SHORELINE BOUNDARY

The proposed removal action boundary around the shoreline of the upper half of Slip 4 was drawn to be either at the face of the Crowley pier or at the toe of the bank or bulkhead (Figure 6). "Toe of the bank" is defined as the elevation at which there is a well-defined increase in slope and a transition from relatively shallow slopes to oversteepened or unstable embankments. "Toe of the bulkhead" is the elevation at which the bulkhead intersects the groundline on the waterward side (i.e., mudline). The proposed boundary has been divided into five areas (see Figure 6). This division of areas reflects physical shoreline features and bank soil chemistry information, and has been made to facilitate defining the elevation at which the boundary occurs. These five areas include the following:

- **Area 1** occurs along the Crowley pier. The area under the pier includes some sediment deposits, but is mostly steeply sloped riprap next to a vertical bulkhead. The proposed removal action boundary is at the pier face. Information concerning the presence of sediments on the riprap beneath the pier, and chemical concentrations within those sediments, may be generated during design.

- **Area 2** extends from the north edge of the Crowley pier, around the head of the slip to the edge of the easternmost outfall (i.e., the King County East Marginal Way pump station emergency overflow outfall). The proposed removal action boundary is at the toe of the bank in this area and ranges from approximately +5 to +8 feet MLLW. Bank sample BK01 (collected at approximately +10 feet MLLW) was collected northwest of the outfalls in this area and found to contain only 2.4 mg/kg OC PCBs. The bank above the boundary does not require remediation.

- **Area 3** extends from the King County outfall to the edge of the existing bulkhead on First South Properties. The proposed removal action boundary is at the toe of the bank in this region, which ranges from about +6 to +10 ft MLLW. A failed bulkhead is present in a portion of this area. Bank samples BK02 and BK03 (collected at approximately +10 ft MLLW) contained 47 mg/kg OC and 48.6 mg/kg OC PCBs, respectively. (A field replicate sample at BK02 contained 28.9 mg/kg OC PCBs,) The bank above the boundary is likely composed of fill material and will be evaluated for potential source control by Ecology.

- **Area 4** is comprised of the bulkhead on the southern half of First South Properties. The proposed removal action boundary is at the toe of the bulkhead at approximately +5 ft MLLW. Bank samples BK04 (20.2 mg/kg OC PCBs) and BK05 (26.3 mg/kg OC PCBs) represent fill material located behind the bulkhead. The bulkhead and associated fill material above the boundary will be evaluated for potential source control by Ecology.

- **Area 5** is located between the bulkhead and the northeast limits of engineered riprap that is present along the Boeing property shoreline. A chain-link fence at the top of the bank along the property line between First South Properties and Boeing coincides with the limits of the riprap. The proposed removal action boundary is at the toe of the bank in Area 5, which is located at about +5 ft MLLW. The bank in this area appears to be eroding fill material. Bank sample BK06 (collected at approximately +10 ft MLLW in this area) contained 402 mg/kg OC PCBs. The bank above the boundary is being evaluated for potential source control, investigation, and/or remedial action by Ecology.

3.4 DESIGN CONSIDERATIONS

Bank sediments/soils located above the proposed boundary may be affected by the removal action depending on the removal alternative(s) selected and engineering requirements. In the removal design, specific engineering considerations, such as slope and structural stability will be assessed, as well as the status of Ecology's source control investigation and/or remedial actions in each embankment area. Design details will be developed to address these considerations, and the design may include elements (such as slope stabilization measures) that extend slightly outside the proposed removal boundaries.

The potential for recontamination of Slip 4 sediments caused by eroding bank soils will also be assessed in the EE/CA. Proper sequencing of any required bank remediation by Ecology and the early removal actions in the sediments will be essential to avoid recontamination of remediated areas.

3.5 STATUS OF SEDIMENTS OUTSIDE THE PROPOSED BOUNDARY

The identification of early removal actions in the LDW was an early objective of the LDWG, EPA, and Ecology. The identification of early action areas, and the subsequent removal actions within those areas, serves to more quickly reduce risks to both human health and ecological receptors than does the full RI/FS process. Sediments that are not included within a removal action boundary remain a part of the LDW RI/FS and will continue to be evaluated through that more detailed scientific process.

Sediments outside the removal boundary will be included in the residual ecological and human health risks assessments conducted as part of the RI/FS to evaluate potential risks to human health and the environment posed by the LDW site after the early actions. LDWG is also conducting a fate and transport study on the LDW. Sediments outside of the Slip 4 boundary that are found through the RI process to present unacceptable risks will be addressed in the FS.

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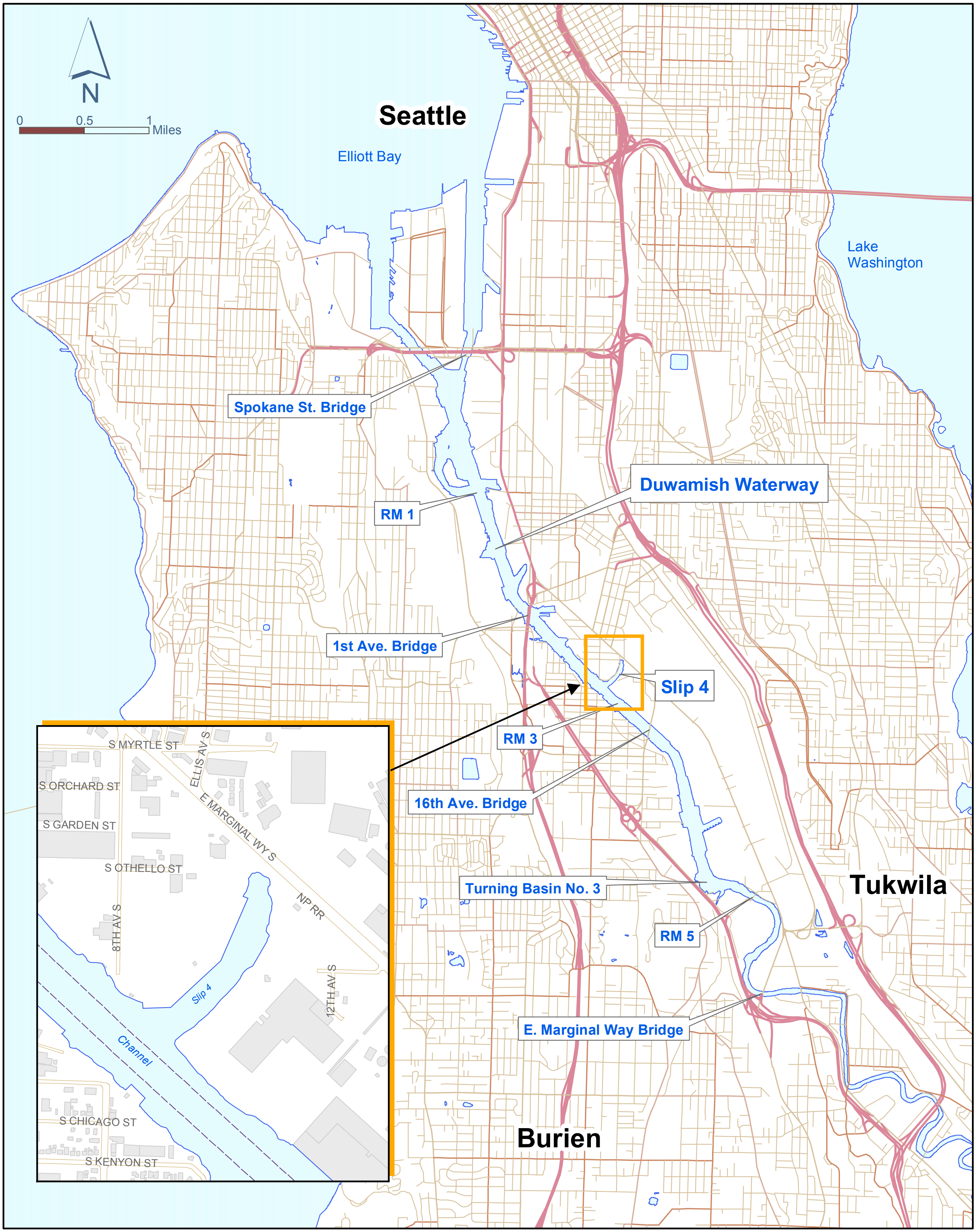
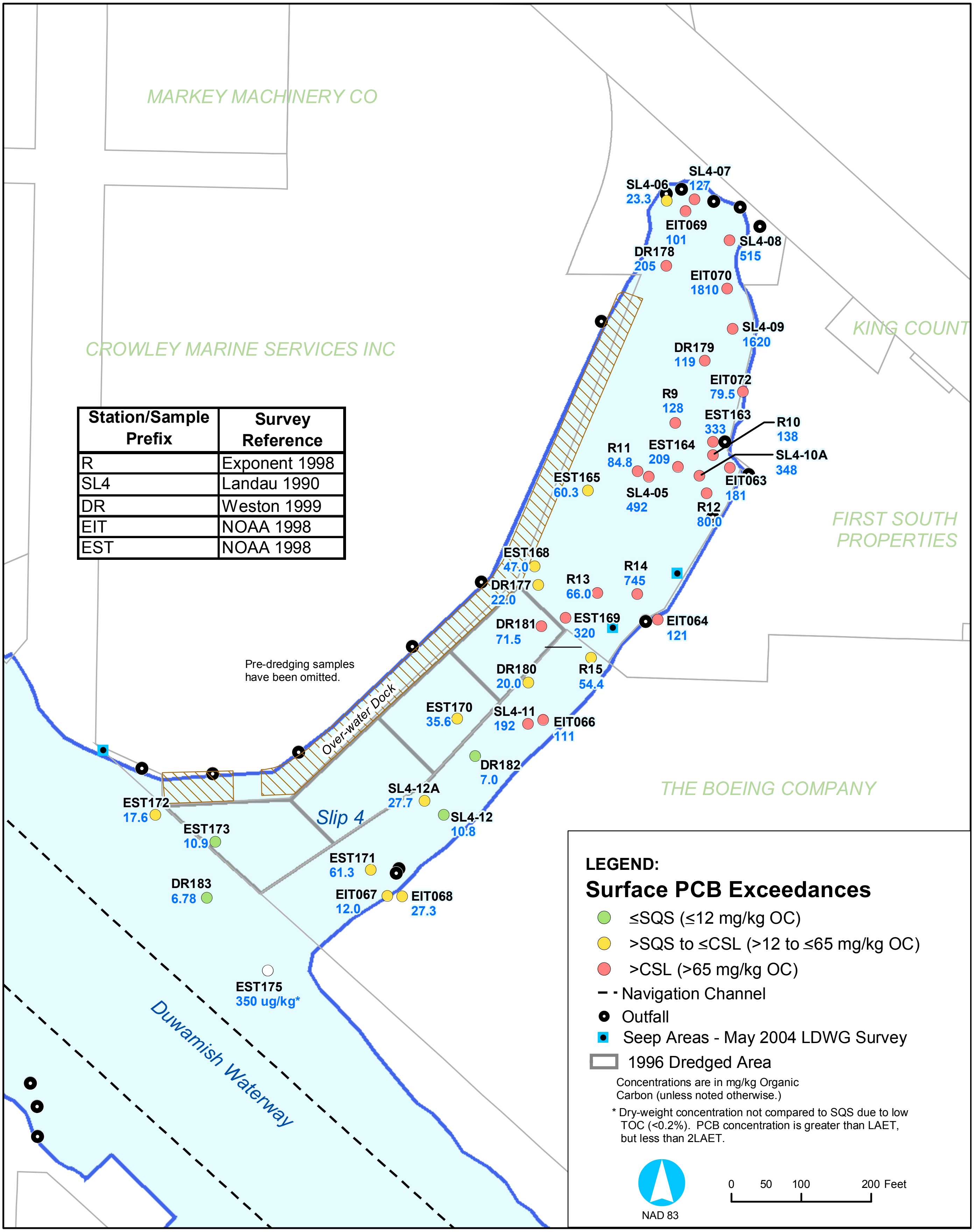


Map Feature Sources: King County GIS,
Seattle Public Utilities, USACE, Ecology, and others.
Plot date: 1/15/2004

Figure 1. Site Location Map



Station/Sample Prefix	Survey Reference
R	Exponent 1998
SL4	Landau 1990
DR	Weston 1999
EIT	NOAA 1998
EST	NOAA 1998

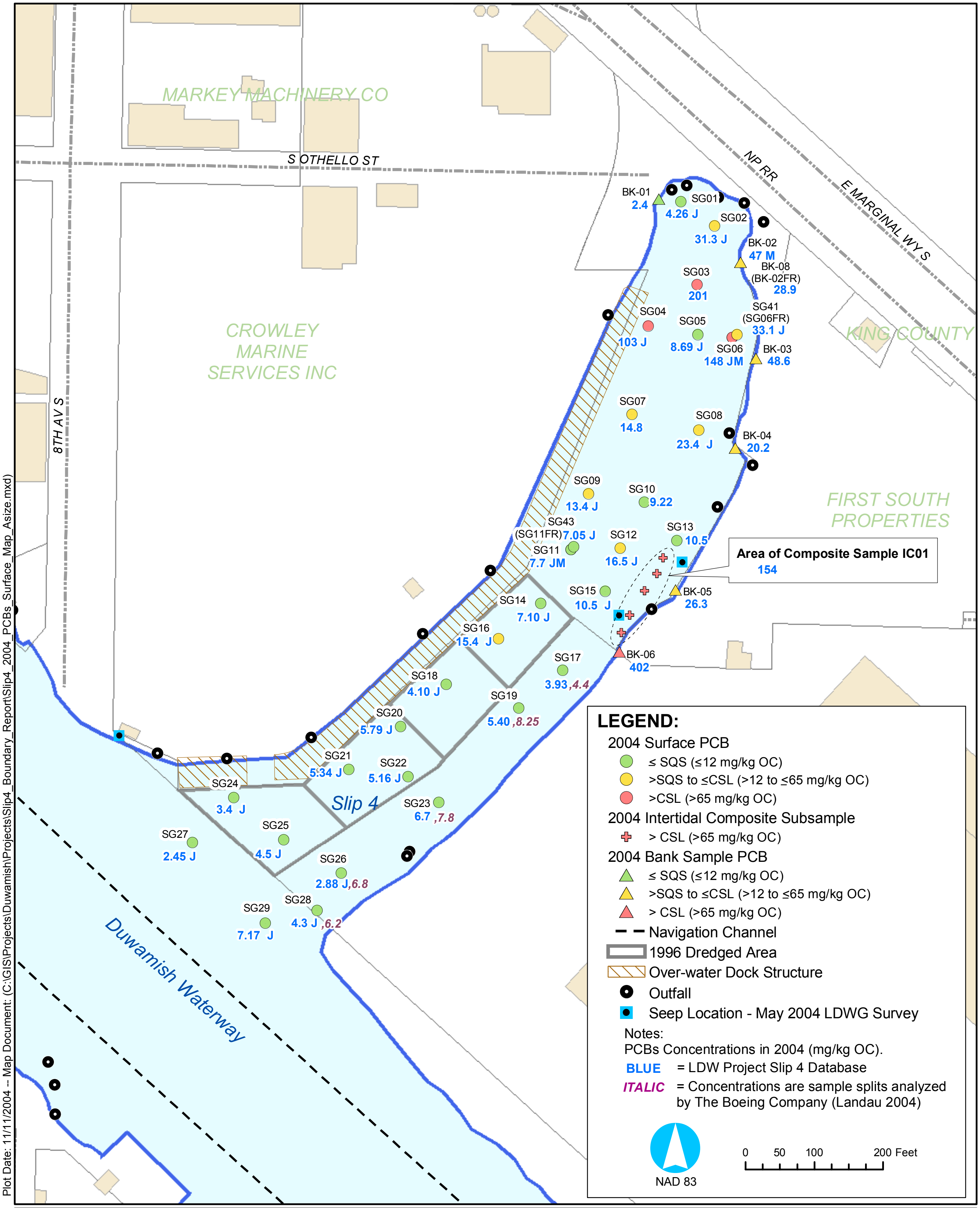
Plot Date: 01/03/2005 -- Map Document: (C:\GIS\Projects\Duwamish\Projects\Slip4_Boundary_Report\Slip4_2004_PCB_Historic_Surface_Map_Asize.mxd)

integral consulting inc.

Map Feature Sources:
King County GIS, Seattle Public Utilities, USACE, Ecology, Windward Environmental, David Evans, Inc., and others.
Sediment Chemistry:
Lower Duwamish Project Database and 2004 Slip 4 Survey PCB analysis results.

Figure 2.
PCB Concentrations in Surface Sediments Collected in 1990-1998.

Plot Date: 11/11/2004 -- Map Document: (C:\GIS\Projects\Duwamish\Projects\Slip4_Boundary_Report\Slip4_2004_PCBs_Surface_Map_Asize.mxd)



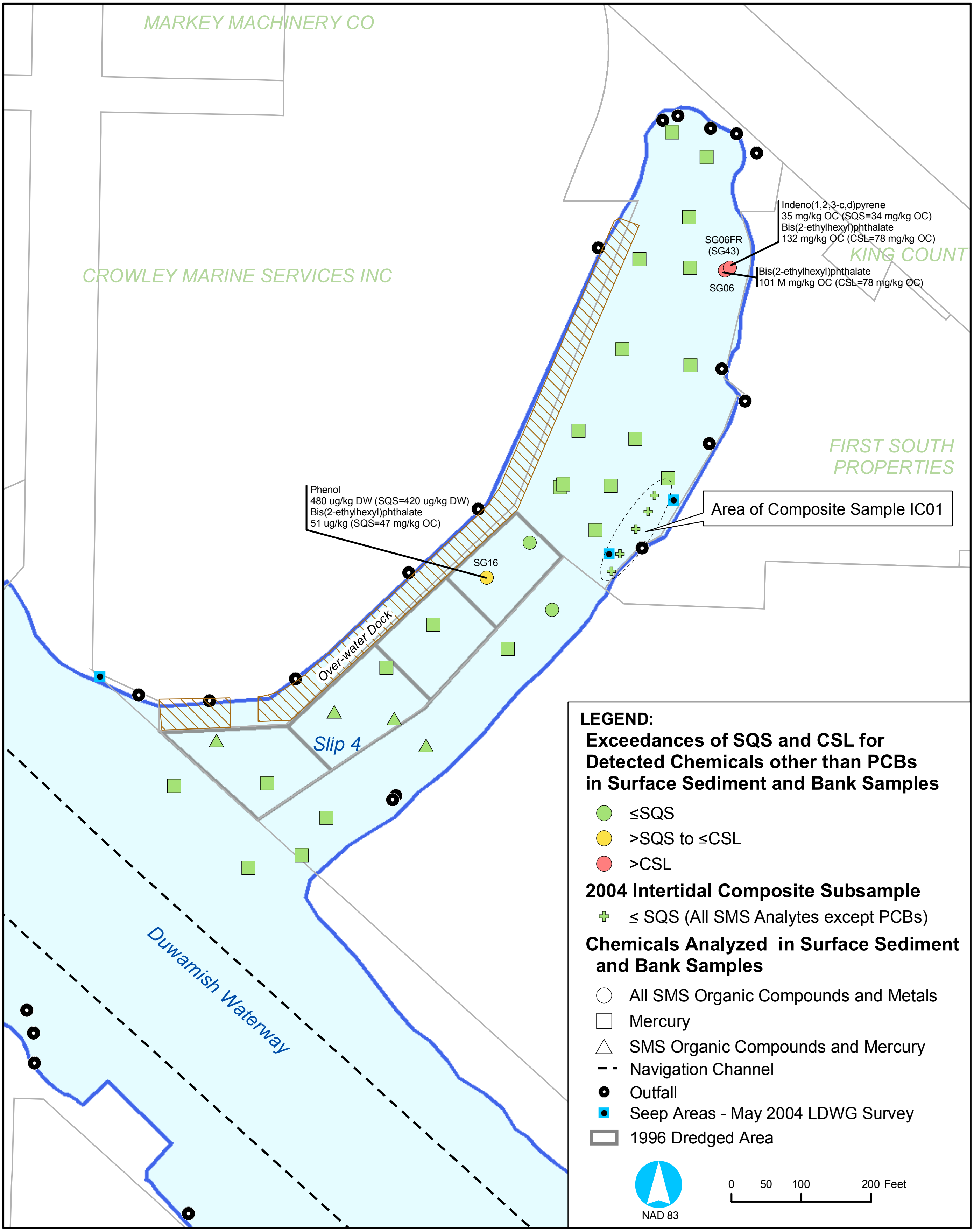
integral consulting inc.

Map Feature Sources:
King County GIS, Seattle Public Utilities, USACE, Ecology, Windward Environmental, David Evans, Inc., and others.
Station locations: Lower Duwamish Project Database and 2004 Slip 4 FSP Navigation Table.

Qualifiers:
J=Estimated
M=Mean of field duplicate (i.e., split)
FR=Field replicate

Figure 3.
PCB Concentrations in Surface Sediment and Bank Samples Collected in 2004

Plot Date: 01/03/2005 -- Map Document: (C:\GIS\Projects\Duwamish\Projects\Slip4_Boundary_Report\Slip4_2004_Non-PCB_Surface_Map_Asize2.mxd)

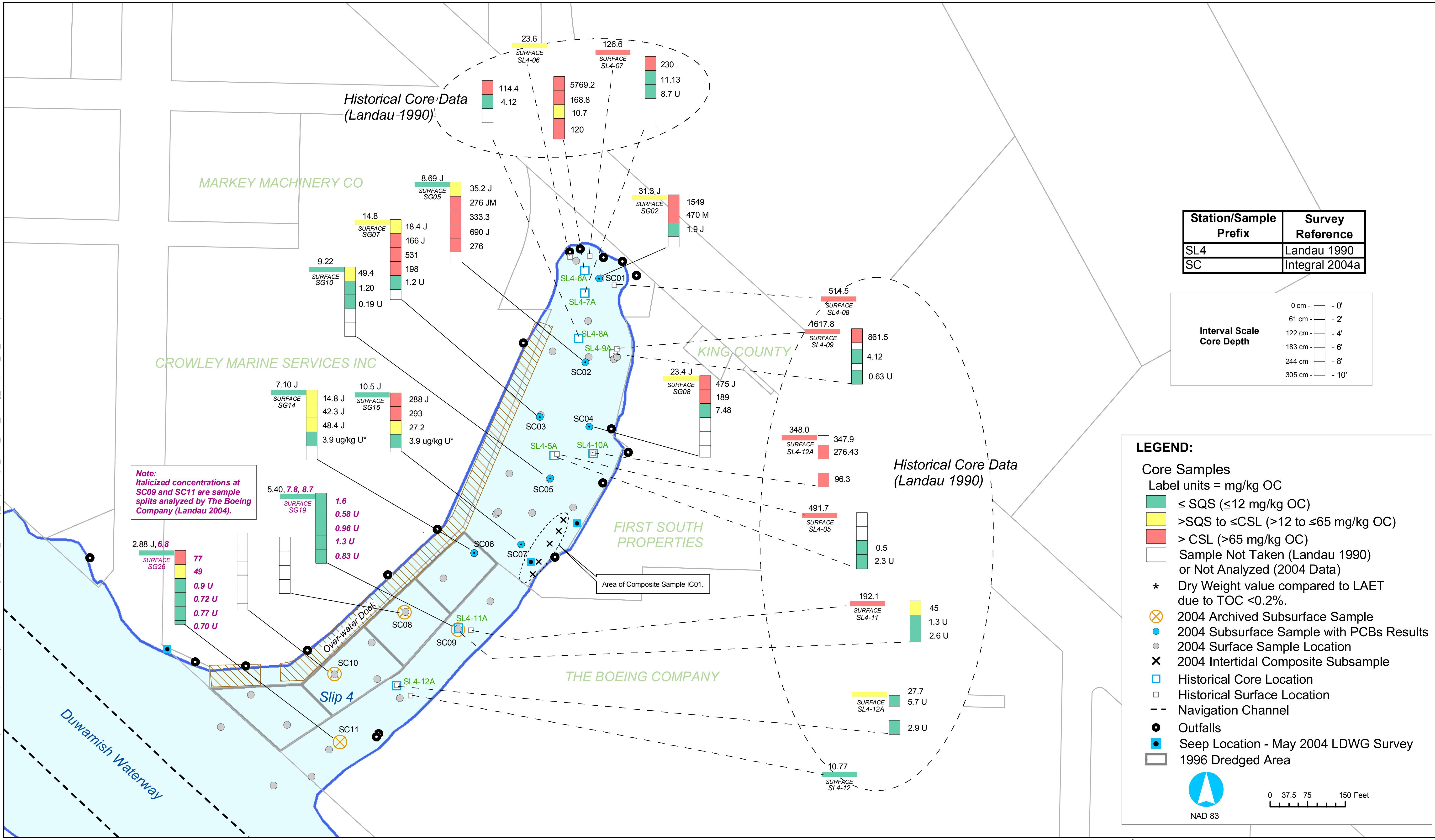


integral consulting inc.

Map Feature Sources:
King County GIS, Seattle Public Utilities, USACE, Ecology, Windward Environmental, David Evans, Inc., and others.
Sediment Chemistry:
Lower Duwamish Project Database and 2004 Slip 4 Survey PCB analysis results.

M=Mean of Field Duplicate (i.e., split)
FR=Field Replicate

Figure 4.
Exceedances of SQS and CSL for Detected Chemicals other than PCBs in Surface Sediment and Bank Samples Collected in 2004



Plot Date: 12/29/2004 -- Map Document: (C:\GIS\Projects\Duwamish\Projects\Slip4_Boundary_Report\Slip4_2004_PCB_Coring_Graphics_v3_rfn.mxd)

integral consulting inc.

Map Feature Sources:
King County GIS, Seattle Public Utilities, USACE, Ecology, Windward Environmental, David Evans, Inc., and others.
Sediment Chemistry:
Lower Duwamish Project Database and 2004 Slip 4 Survey PCB analysis results, The Boeing Company.

U=Undetected
J=Estimated
M=Mean of field duplicates (i.e., split)

Figure 5.
Historical and 2004 PCB Concentrations in Subsurface Sediments in Slip 4.

integral consulting inc.

Map Feature Sources:
King County GIS, Seattle Public Utilities, USACE, Ecology, Windward Environmental, David Evans, Inc., and others.
Sediment Chemistry:
Lower Duwamish Project Database and 2004 Slip 4 Survey PCB analysis results.

Figure 6.
Slip 4 Proposed
Removal Action Boundary

Table 1. Numerical Criteria for Puget Sound Marine Sediments.

	Sediment Management Standards (WAC 173-204)	
	SQS	**CSL**
Metals	***(mg/kg, dry weight)***	
Arsenic	57	93
Cadmium	5.1	6.7
Chromium	260	270
Copper	390	390
Lead	450	530
Mercury	0.41	0.59
Silver	6.1	6.1
Zinc	410	960
Organics	***(mg/kg organic carbon)***	
LPAHs	370	780
Naphthalene	99	170
Acenaphthylene	66	66
Acenaphthene	16	57
Fluorene	23	79
Phenanthrene	100	480
Anthracene	220	1,200
2-Methylnaphthalene	38	64
HPAHs	960	5,300
Fluoranthene	160	1,200
Pyrene	1,000	1,400
Benzo(a)anthracene	110	270
Chrysene	110	460
Benzofluoranthenes	230	450
Benzo(a)pyrene	99	210
Indeno(1,2,3-c,d)pyrene	34	88
Dibenzo(a,h)anthracene	12	33
Benzo(g,h,i)perylene	31	78
Chlorinated Hydrocarbons		
1,4-Dichlorobenzene	3.1	9
1,2-Dichlorobenzene	2.3	2.3
1,2,4-Trichlorobenzene	0.81	1.8
Hexachlorobenzene	0.38	2.3
Phthalates		
Dimethylphthalate	53	53
Diethylphthalate	61	110
Di-n-buylphthalate	220	1,700
Butylbenzylphthalate	4.9	64
Bis(2-ethylhexyl)phthalate	47	78
Di-n-octylphthalate	58	4,500

Table 1. Numerical Criteria for Puget Sound Marine Sediments.

	Sediment Management Standards (WAC 173-204)	
	SQS	**CSL**
Miscellaneous		
Dibenzofuran	15	58
Hexachlorobutadiene	3.9	6.2
N-nitrosodiphenylamine	11	11
Total PCBs	12	65
Ionizable Organic Compounds	***(µg/kg, dry weight)***	
Phenol	420	1,200
2-Methylphenol	63	63
4-Methylphenol	670	670
2,4-Dimethylphenol	29	29
Pentachlorophenol	360	690
Benzyl Alcohol	57	73
Benzoic Acid	650	650

Table 2. SQS and CSL Exceedances in Surface Sediments Collected in 1990 - 1998.
(Undetected chemicals are italicized.)

Location	Depth (cm)	TOC (%)	Chemical	Concentration		SQS EF[a]	CSL EF
DR177	0-10	2.87	PCBs	22.0	mg/kg OC	1.84	---[b]
			Hexachlorobenzene	*0.7 U*	*mg/kg OC*	*1.83*	---
DR178	0-10	3.44	PCBs	205	mg/kg OC	17.06	3.15
			Bis(2-ethylhexyl)phthalate	148	mg/kg OC	3.15	1.90
			Benzo(g,h,i)perylene	61.0 J	mg/kg OC	1.97	---
			Indeno(1,2,3-cd)pyrene	66.9 J	mg/kg OC	1.97	---
			Dibenzo(a,h)anthracene	19.8 J	mg/kg OC	1.65	---
			Butyl benzyl phthalate	7.8	mg/kg OC	1.60	---
			Mercury	0.5	mg/kg dw	1.12	---
			Benzo(a)pyrene	102 J	mg/kg OC	1.03	---
			Total HPAH	982	mg/kg OC	1.02	---
			Chrysene	102	mg/kg OC	1.02	---
			Benzofluoranthenes	233	mg/kg OC	1.01	---
			Hexachlorobenzene	*0.6 U*	*mg/kg OC*	*1.53*	---
DR179	0-10	2.83	PCBs	119	mg/kg OC	9.89	1.83
			Mercury	1.1	mg/kg dw	2.73	1.90
			Bis(2-ethylhexyl)phthalate	98.9	mg/kg OC	2.11	1.27
			Indeno(1,2,3-cd)pyrene	38.9	mg/kg OC	1.14	---
			Hexachlorobenzene	*0.7 U*	*mg/kg OC*	*1.86*	---
DR180	0-10	2.63	PCBs	20.0	mg/kg OC	1.67	---
			Hexachlorobenzene	*0.8 U*	*mg/kg OC*	*2.00*	---
DR181	0-10	2.34	PCBs	71.5	mg/kg OC	5.95	1.10
			Hexachlorobenzene	*0.9 U*	*mg/kg OC*	*2.25*	---
			1,2,4-Trichlorobenzene	*0.9 U*	*mg/kg OC*	*1.06*	---
DR182	*0-10*	*4.54*	*Hexachlorobenzene*	*0.4 U*	*mg/kg OC*	*1.16*	---
DR183	*0-10*	*1.80*	*Hexachlorobenzene*	*1.1 U*	*mg/kg OC*	*2.92*	---
			1,2,4-Trichlorobenzene	*1.1 U*	*mg/kg OC*	*1.37*	---
EIT063	0-10	1.27	PCBs	181	mg/kg OC	15.09	2.79
EIT064	0-10	1.49	PCBs	121	mg/kg OC	10.07	1.86
EIT066	0-10	0.54	PCBs	111	mg/kg OC	9.26	1.71
EIT067	0-10	1.08	PCBs	12.0	mg/kg OC	1.0003	---
EIT068	0-10	0.30	PCBs	27.3	mg/kg OC	2.28	---
EIT069	0-10	3.27	PCBs	101	mg/kg OC	8.41	1.55

Table 2. SQS and CSL Exceedances in Surface Sediments Collected in 1990 - 1998.
(Undetected chemicals are italicized.)

Location	Depth (cm)	TOC (%)	Chemical	Concentration		SQS EF[a]	CSL EF
EIT070	0-10	1.39	PCBs	1810	mg/kg OC	150.42	27.77
EIT072	0-10	1.51	PCBs	79.5	mg/kg OC	6.62	1.22
EST163	0-10	2.10	PCBs	333	mg/kg OC	27.78	5.13
EST164	0-10	1.96	PCBs	209	mg/kg OC	17.43	3.22
EST165	0-10	2.32	PCBs	60.3	mg/kg OC	5.03	---
EST168	0-10	2.34	PCBs	47.0	mg/kg OC	3.92	---
EST169	0-10	2.06	PCBs	320	mg/kg OC	26.70	4.93
EST170	0-10	2.08	PCBs	35.6	mg/kg OC	2.96	---
EST171	0-10	0.31	PCBs	61.3	mg/kg OC	5.11	---
EST172	0-10	1.70	PCBs	17.6	mg/kg OC	1.47	---
EST175	0-10	0.13	PCBs	350	mg/kg dw	2.69[c]	---
R9	0-10	2.30	PCBs	128	mg/kg OC	10.69	1.97
			Bis(2-ethylhexyl)phthalate	65.2	mg/kg OC	1.39	---
			1,2,4-Trichlorobenzene	*0.8 U*	*mg/kg OC*	*1.02*	---
R10	0-10	2.30	PCBs	138	mg/kg OC	11.52	2.13
			Bis(2-ethylhexyl)phthalate	100	mg/kg OC	2.13	1.28
			Indeno(1,2,3-cd)pyrene	38.3	mg/kg OC	1.13	---
			Dibenzo(a,h)anthracene	12.2 J	mg/kg OC	1.01	---
			1,2,4-Trichlorobenzene	*0.8 U*	*mg/kg OC*	*1.02*	---
R11	0-10	2.10	PCBs	84.8	mg/kg OC	7.06	1.30
			Bis(2-ethylhexyl)phthalate	66.7	mg/kg OC	1.42	---
			1,2,4-Trichlorobenzene	*0.9 U*	*mg/kg OC*	*1.12*	---
R12	0-10	2.00	PCBs	80.0	mg/kg OC	6.67	1.23
			1,2,4-Trichlorobenzene	*1.0 U*	*mg/kg OC*	*1.17*	---
R13	0-10	2.00	PCBs	66.0	mg/kg OC	5.50	1.02
			1,2,4-Trichlorobenzene	*1.0 UJ*	*mg/kg OC*	*1.17*	---
R14	0-10	2.20	PCBs	745	mg/kg OC	62.12	11.47
			Hexachlorobenzene	*4.4 UJ*	*mg/kg OC*	*11.60*	*1.92*
			1,2,4-Trichlorobenzene	*0.9 U*	*mg/kg OC*	*1.07*	---
R15	0-10	2.50	PCBs	54.4	mg/kg OC	4.53	---

Table 2. SQS and CSL Exceedances in Surface Sediments Collected in 1990 - 1998.
(Undetected chemicals are italicized.)

Location	Depth (cm)	TOC (%)	Chemical	Concentration			SQS EF[a]	CSL EF
SL4-05	0-10	2.40	PCBs	492		mg/kg OC	40.97	7.56
			Bis(2-ethylhexyl)phthalate	150		mg/kg OC	3.19	1.92
			Hexachlorobenzene	*1.4*	*U*	*mg/kg OC*	*3.73*	---
			Benzyl alcohol	*170*	*U*	*ug/kg dw*	*2.98*	*2.33*
			2,4-Dimethylphenol	*68.0*	*U*	*ug/kg dw*	*2.34*	*2.34*
			1,2,4-Trichlorobenzene	*1.4*	*U*	*mg/kg OC*	*1.75*	---
SL4-06	0-10	4.30	Bis(2-ethylhexyl)phthalate	256	K	mg/kg OC	5.44	3.28
			Butyl benzyl phthalate	11.6		mg/kg OC	2.37	---
			PCBs	23.3		mg/kg OC	1.94	---
			Phenanthrene	186		mg/kg OC	1.86	---
			N-Nitrosodiphenylamine	18.1		mg/kg OC	1.65	1.65
			Zinc	536		mg/kg dw	1.31	---
			Dibenzo(a,h)anthracene	15.6		mg/kg OC	1.30	---
			Lead	507		mg/kg dw	1.13	---
			Di-n-octyl phthalate	62.8		mg/kg OC	1.08	---
			Benzyl alcohol	*160*	*U*	*ug/kg dw*	*2.81*	*2.19*
			2,4-Dimethylphenol	*66.0*	*U*	*ug/kg dw*	*2.28*	*2.28*
			Hexachlorobenzene	*0.8*	*U*	*mg/kg OC*	*2.02*	---
SL4-07	0-10	3.50	PCBs	127		mg/kg OC	10.55	1.95
			Bis(2-ethylhexyl)phthalate	246		mg/kg OC	5.23	3.15
			Acenaphthene	37.1		mg/kg OC	2.32	---
			Fluoranthene	371		mg/kg OC	2.32	---
			Lead	721		mg/kg dw	1.60	1.36
			Zinc	491		mg/kg dw	1.20	---
			Mercury	0.5		mg/kg dw	1.15	---
			Dibenzo(a,h)anthracene	13.4		mg/kg OC	1.12	---
			Indeno(1,2,3-cd)pyrene	37.1		mg/kg OC	1.09	---
			Chrysene	109		mg/kg OC	1.09	---
			Total HPAH	976		mg/kg OC	1.02	---
			Benzo(a)anthracene	111		mg/kg OC	1.01	---
			Benzyl alcohol	*430*	*U*	*ug/kg dw*	*7.54*	*5.89*
			Hexachlorobenzene	*2.5*	*U*	*mg/kg OC*	*6.54*	*1.08*
			2,4-Dimethylphenol	*170*	*U*	*ug/kg dw*	*5.86*	*5.86*
			1,2,4-Trichlorobenzene	*2.5*	*U*	*mg/kg OC*	*3.07*	*1.38*
			2-Methylphenol	*87.0*	*U*	*ug/kg dw*	*1.38*	*1.38*
			Benzoic acid	*870*	*U*	*ug/kg dw*	*1.34*	*1.34*
			Hexachlorobutadiene	*4.9*	*U*	*mg/kg OC*	*1.25*	---
			Pentachlorophenol	*430*	*U*	*ug/kg dw*	*1.19*	---
			1,2-Dichlorobenzene	*2.5*	*U*	*mg/kg OC*	*1.08*	*1.08*

Table 2. SQS and CSL Exceedances in Surface Sediments Collected in 1990 - 1998.
(Undetected chemicals are italicized.)

Location	Depth (cm)	TOC (%)	Chemical	Concentration			SQS EF[a]	CSL EF
SL4-08	0-10	2.00	PCBs	515		mg/kg OC	42.88	7.92
			Bis(2-ethylhexyl)phthalate	185		mg/kg OC	3.94	2.37
			Fluoranthene	365		mg/kg OC	2.28	---
			Dibenzo(a,h)anthracene	21.5		mg/kg OC	1.79	---
			Indeno(1,2,3-cd)pyrene	60.0		mg/kg OC	1.76	---
			Chrysene	150		mg/kg OC	1.50	---
			Phenanthrene	150		mg/kg OC	1.50	---
			Cadmium	7.5		mg/kg dw	1.47	1.12
			Benzo(a)anthracene	125		mg/kg OC	1.14	---
			Mercury	0.5		mg/kg dw	1.12	---
			Total HPAH	1066		mg/kg OC	1.11	---
			Benzofluoranthenes	255		mg/kg OC	1.11	---
			Zinc	411		mg/kg dw	1.002	---
			Hexachlorobenzene	*3.6*	*U*	*mg/kg OC*	*9.34*	*1.54*
			Benzyl alcohol	*350*	*U*	*ug/kg dw*	*6.14*	*4.79*
			2,4-Dimethylphenol	*140*	*U*	*ug/kg dw*	*4.83*	*4.83*
			1,2,4-Trichlorobenzene	*3.6*	*U*	*mg/kg OC*	*4.38*	*1.97*
			Hexachlorobutadiene	*7.0*	*U*	*mg/kg OC*	*1.79*	*1.13*
			1,2-Dichlorobenzene	*3.6*	*U*	*mg/kg OC*	*1.54*	*1.54*
			1,4-Dichlorobenzene	*3.6*	*U*	*mg/kg OC*	*1.15*	---
			2-Methylphenol	*71.0*	*U*	*ug/kg dw*	*1.13*	*1.13*
			Benzoic acid	*710*	*U*	*ug/kg dw*	*1.09*	*1.09*
SL4-09	0-10	2.10	PCBs	1619		mg/kg OC	134.92	24.91
			Bis(2-ethylhexyl)phthalate	52.4		mg/kg OC	1.11	---
			Hexachlorobenzene	*2.9*	*U*	*mg/kg OC*	*7.52*	*1.24*
			Benzyl alcohol	*300*	*U*	*ug/kg dw*	*5.26*	*4.11*
			2,4-Dimethylphenol	*120*	*U*	*ug/kg dw*	*4.14*	*4.14*
			1,2,4-Trichlorobenzene	*2.9*	*U*	*mg/kg OC*	*3.53*	*1.59*
			Hexachlorobutadiene	*5.7*	*U*	*mg/kg OC*	*1.47*	---
			1,2-Dichlorobenzene	*2.9*	*U*	*mg/kg OC*	*1.24*	*1.24*
SL4-10	0-10	0.68	Bis(2-ethylhexyl)phthalate	324		mg/kg OC	6.88	4.15
			Butyl benzyl phthalate	6.9	J	mg/kg OC	1.41	---
			Di-n-octyl phthalate	76.5		mg/kg OC	1.32	---
			Indeno(1,2,3-cd)pyrene	44.1		mg/kg OC	1.30	---
			Fluoranthene	206		mg/kg OC	1.29	---
			Dibenzo(a,h)anthracene	14.7		mg/kg OC	1.23	---
			Chrysene	110		mg/kg OC	1.10	---
			Hexachlorobenzene	*9.6*	*U*	*mg/kg OC*	*25.15*	*4.16*
			1,2,4-Trichlorobenzene	*9.6*	*U*	*mg/kg OC*	*11.80*	*5.31*
			Benzyl alcohol	*330*	*U*	*ug/kg dw*	*5.79*	*4.52*
			Hexachlorobutadiene	*19.1*	*U*	*mg/kg OC*	*4.90*	*3.08*
			2,4-Dimethylphenol	*130*	*U*	*ug/kg dw*	*4.48*	*4.48*
			1,2-Dichlorobenzene	*9.6*	*U*	*mg/kg OC*	*4.16*	*4.16*
			1,4-Dichlorobenzene	*9.6*	*U*	*mg/kg OC*	*3.08*	*1.06*
			2-Methylphenol	*65.0*	*U*	*ug/kg dw*	*1.03*	*1.03*

Table 2. SQS and CSL Exceedances in Surface Sediments Collected in 1990 - 1998.
(Undetected chemicals are italicized.)

Location	Depth (cm)	TOC (%)	Chemical	Concentration			SQS EF[a]	CSL EF
SL4-10A	0-15	1.67	PCBs	348		mg/kg OC	29.00	5.35
			Bis(2-ethylhexyl)phthalate	198		mg/kg OC	4.21	2.54
			Hexachlorobenzene	*3.9*	*U*	*mg/kg OC*	*10.26*	*1.70*
			Benzyl alcohol	*320*	*U*	*ug/kg dw*	*5.61*	*4.38*
			1,2,4-Trichlorobenzene	*3.9*	*U*	*mg/kg OC*	*4.81*	*2.17*
			2,4-Dimethylphenol	*130*	*U*	*ug/kg dw*	*4.48*	*4.48*
			Hexachlorobutadiene	*7.8*	*U*	*mg/kg OC*	*2.00*	*1.26*
			1,2-Dichlorobenzene	*3.9*	*U*	*mg/kg OC*	*1.70*	*1.70*
			1,4-Dichlorobenzene	*3.9*	*U*	*mg/kg OC*	*1.26*	---
			2-Methylphenol	*65.0*	*U*	*ug/kg dw*	*1.03*	*1.03*
SL4-11	0-10	0.38	PCBs	192		mg/kg OC	16.01	2.96
			Bis(2-ethylhexyl)phthalate	65.8		mg/kg OC	1.40	---
			Hexachlorobenzene	*14.5*	*U*	*mg/kg OC*	*38.09*	*6.29*
			1,2,4-Trichlorobenzene	*14.5*	*U*	*mg/kg OC*	*17.87*	*8.04*
			Hexachlorobutadiene	*28.9*	*U*	*mg/kg OC*	*7.42*	*4.67*
			1,2-Dichlorobenzene	*14.5*	*U*	*mg/kg OC*	*6.29*	*6.29*
			Benzyl alcohol	*280*	*U*	*ug/kg dw*	*4.91*	*3.84*
			1,4-Dichlorobenzene	*14.5*	*U*	*mg/kg OC*	*4.67*	*1.61*
			2,4-Dimethylphenol	*110*	*U*	*ug/kg dw*	*3.79*	*3.79*
			Butyl benzyl phthalate	*14.5*	*U*	*mg/kg OC*	*2.95*	---
			N-Nitrosodiphenylamine	*14.5*	*U*	*mg/kg OC*	*1.32*	*1.32*
			Dibenzo(a,h)anthracene	*14.5*	*U*	*mg/kg OC*	*1.21*	---
SL4-12	0-10	0.52	Bis(2-ethylhexyl)phthalate	190		mg/kg OC	4.05	2.44
			Fluoranthene	231		mg/kg OC	1.44	---
			Chrysene	110		mg/kg OC	1.10	---
			Hexachlorobenzene	*11.7*	*U*	*mg/kg OC*	*30.87*	*5.10*
			1,2,4-Trichlorobenzene	*11.7*	*U*	*mg/kg OC*	*14.48*	*6.52*
			Hexachlorobutadiene	*23.1*	*U*	*mg/kg OC*	*5.92*	*3.72*
			Benzyl alcohol	*310*	*U*	*ug/kg dw*	*5.44*	*4.25*
			1,2-Dichlorobenzene	*11.7*	*U*	*mg/kg OC*	*5.10*	*5.10*
			2,4-Dimethylphenol	*120*	*U*	*ug/kg dw*	*4.14*	*4.14*
			1,4-Dichlorobenzene	*11.7*	*U*	*mg/kg OC*	*3.78*	*1.30*
			Butyl benzyl phthalate	*11.7*	*U*	*mg/kg OC*	*2.39*	---
			N-Nitrosodiphenylamine	*11.7*	*U*	*mg/kg OC*	*1.07*	*1.07*
SL4-12A	0-15	0.78	PCBs	27.7		mg/kg OC	2.31	---

Notes:
U = Undetected.
J = Estimated.
K = Reported concentration is less than the detection limit.

[a] SQS EF(exceedance factor) = concentration in sample/SQS. CSL EF = concentration in sample/CSL.
[b]Concentration does not exceed CSL or 2LAET.
[c]Compared to LAET (130 ug/kg dw) and 2LAET (1,000 ug/kg dw) because TOC is <0.2%.

Table 3. SQS and CSL Exceedances in Surface Sediment and Bank Samples Collected in 2004.
(Undetected chemicals are italicized.) Note: These data are also shown in Figure 8 of the *Cruise and Data Report* (Integral 2004a).

Location	Depth (cm)	TOC (%)	Chemical	Concentration			SQS EF[a]	CSL EF
Surface Sediment								
SG02	0-10	5.18	PCBs	31.3	J	mg/kg OC	2.61	---[b]
SG03	0-10	2.54	PCBs	201		mg/kg OC	16.73	3.09
SG04	0-10	4.78	PCBs	103	J	mg/kg OC	8.61	1.59
SG06	0-10	3.18	PCBs	148	JM	mg/kg OC	12.40	2.29
			Bis(2-ethylhexyl)phtalate	101	M	ug/kg dw	2.17	1.31
			Hexachlorobenzene	*3.77*	*UM*	*mg/kg OC*	*9.93*	*1.64*
			1,2,4-Trichlorobenzene	*3.77*	*UM*	*mg/kg OC*	*4.66*	*2.10*
			2,4-Dimethylphenol	*120*	*UM*	*ug/kg dw*	*4.14*	*4.14*
			Benzyl alcohol	*120*	*UM*	*ug/kg dw*	*2.11*	*1.64*
			2-Methylphenol	*120*	*UM*	*ug/kg dw*	*1.90*	*1.90*
			Benzoic acid	*1200*	*UM*	*ug/kg dw*	*1.85*	*1.85*
			1,2-Dichlorobenzene	*3.77*	*UM*	*mg/kg OC*	*1.64*	*1.64*
			Pentachlorophenol	*580*	*UM*	*ug/kg dw*	*1.61*	---
			1,4-Dichlorobenzene	*3.77*	*UM*	*mg/kg OC*	*1.22*	---
SG06FR	0-10	3.41	Bis(2-ethylhexyl)phtalate	132		ug/kg dw	2.81	1.69
			PCBs	33.1	J	mg/kg OC	2.76	---
			Indeno(1,2,3-cd)pyrene	35.2		mg/kg OC	1.04	---
			Hexachlorobenzene	*3.52*	*U*	*mg/kg OC*	*9.26*	*1.53*
			1,2,4-Trichlorobenzene	*3.52*	*U*	*mg/kg OC*	*4.34*	*1.96*
			2,4-Dimethylphenol	*120*	*U*	*ug/kg dw*	*4.14*	*4.14*
			Benzyl alcohol	*120*	*U*	*ug/kg dw*	*2.11*	*1.64*
			2-Methylphenol	*120*	*U*	*ug/kg dw*	*1.90*	*1.90*
			Benzoic acid	*1200*	*U*	*ug/kg dw*	*1.85*	*1.85*
			Pentachlorophenol	*590*	*U*	*ug/kg dw*	*1.64*	---
			1,2-Dichlorobenzene	*3.52*	*U*	*mg/kg OC*	*1.53*	*1.53*
			1,4-Dichlorobenzene	*3.52*	*U*	*mg/kg OC*	*1.14*	---
SG07	0-10	3.18	PCBs	14.8		mg/kg OC	1.23	---
SG08	0-10	3.04	PCBs	23.4	J	mg/kg OC	1.95	---
SG09	0-10	3.61	PCBs	13.4	J	mg/kg OC	1.11	---
SG12	0-10	3.2	PCBs	16.5	J	mg/kg OC	1.38	---
SG14	0-10	2.79	*Hexachlorobenzene*	*0.72*	*U*	*mg/kg OC*	*1.89*	---
SG16	0-10	0.817	PCBs	15.4	J	mg/kg OC	1.29	---
			Phenol	480		ug/kg dw	1.14	---
			Bis(2-ethylhexyl)phthalate	51		mg/kg OC	1.09	---
			Hexachlorobenzene	*2.33*	*U*	*mg/kg OC*	*6.12*	*1.01*
			1,2,4-Trichlorobenzene	*2.33*	*U*	*mg/kg OC*	*2.87*	*1.29*

Table 3. SQS and CSL Exceedances in Surface Sediment and Bank Samples Collected in 2004. (Undetected chemicals are italicized.) Note: These data are also shown in Figure 8 of the *Cruise and Data Report* (Integral 2004a).

Location	Depth (cm)	TOC (%)	Chemical	Concentration			SQS EF[a]	CSL EF
			1,2-Dichlorobenzene	*2.33*	*U*	*mg/kg OC*	*1.01*	*1.01*
SG17	0-10	2.94	*Hexachlorobenzene*	*0.68*	*U*	*mg/kg OC*	*1.79*	---
SG21	0-10	2.96	*Hexachlorobenzene*	*0.68*	*U*	*mg/kg OC*	*1.78*	---
SG22	0-10	2.81	*Hexachlorobenzene*	*0.71*	*U*	*mg/kg OC*	*1.87*	---
SG23	0-10	0.716	*Hexachlorobenzene*	*2.65*	*U*	*mg/kg OC*	*6.98*	*1.15*
			1,2,4-Trichlorobenzene	*2.65*	*U*	*mg/kg OC*	*3.28*	*1.47*
			1,2-Dichlorobenzene	*2.65*	*U*	*mg/kg OC*	*1.15*	*1.15*
SG24	0-10	2.88	*Hexachlorobenzene*	*0.69*	*U*	*mg/kg OC*	*1.83*	---
IC01	0-10	1.07	PCBs	154		mg/kg OC	12.83	2.37
			Hexachlorobenzene	*11.2*	*U*	*mg/kg OC*	*29.51*	*4.88*
			1,2,4-Trichlorobenzene	*11.2*	*U*	*mg/kg OC*	*13.85*	*6.23*
			1,2-Dichlorobenzene	*11.2*	*U*	*mg/kg OC*	*4.88*	*4.88*
			2,4-Dimethylphenol	*120*	*U*	*ug/kg dw*	*4.14*	*4.14*
			1,4-Dichlorobenzene	*11.2*	*U*	*mg/kg OC*	*3.62*	*1.25*
			Hexachlorobutadiene	*11.2*	*U*	*mg/kg OC*	*2.88*	*1.81*
			Butylbenzyl phthalate	*11.2*	*U*	*mg/kg OC*	*2.29*	---
			Benzyl alcohol	*120*	*U*	*ug/kg dw*	*2.11*	*1.64*
			2-Methylphenol	*120*	*U*	*ug/kg dw*	*1.90*	*1.90*
			Benzoic acid	*1200*	*U*	*ug/kg dw*	*1.85*	*1.85*
			Pentachlorophenol	*580*	*U*	*ug/kg dw*	*1.61*	---
			N-Nitrosodiphenylamine	*11.2*	*U*	*mg/kg OC*	*1.02*	*1.02*
Bank								
BK02	0-10	8.23	PCBs	47	M	mg/kg OC	3.91	---
BK02FR	0-10	9.39	PCBs	28.9		mg/kg OC	2.40	---
BK03	0-10	1.75	PCBs	48.6		mg/kg OC	4.05	---
BK04	0-10	3.92	PCBs	20.2		mg/kg OC	1.68	---
BK05	0-10	4.95	PCBs	26.3		mg/kg OC	2.19	---
BK06	0-10	1.94	PCBs	402		mg/kg OC	33.51	6.18

Notes:
U = Undetected.
J = Estimated.
M = Mean of field duplicate results.

[a] SQS EF(exceedance factor) = concentration in sample/SQS. CSL EF = concentration in sample/CSL.
[b]Concentration does not exceed CSL.

Table 4. SQS and CSL Exceedances in Subsurface Sediment Samples Collected in 2004.
(Undetected chemicals are italicized.) Note: These data are also shown in Figure 9 of the *Cruise and Data Report* (Integral 2004a).

Location	Depth (ft)	TOC (%)	Chemical	Concentration			SQS EF[a]	CSL EF
SC01	0-2	2.26	PCBs	1549		mg/kg OC	129	23.8
			Mercury	10.3		mg/kg dw	25.1	17.5
			Mercury - reanalysis	0.99		mg/kg dw	2.41	1.68
	2-4	0.30	PCBs	470	M	mg/kg OC	39.1	7.22
			Hexachlorobenzene	*6*	*U*	*mg/kg OC*	*16*	*2.64*
			1,2,4-Trichlorobenzene	*6*	*U*	*mg/kg OC*	*7.51*	*3.38*
			1,2-Dichlorobenzene	*6*	*U*	*mg/kg OC*	*2.64*	*2.64*
			1,4-Dichlorobenzene	*6*	*U*	*mg/kg OC*	*1.96*	---[b]
			Hexachlorobutadiene	*6*	*U*	*mg/kg OC*	*1.56*	---
			Butylbenzyl phthalate	*6*	*U*	*mg/kg OC*	*1.24*	---
	4-6	0.20	*Hexachlorobenzene*	*9*	*U*	*mg/kg OC*	*24.8*	*4.09*
			1,2,4-Trichlorobenzene	*9*	*U*	*mg/kg OC*	*11.6*	*5.23*
			1,2-Dichlorobenzene	*9*	*U*	*mg/kg OC*	*4.09*	*4.09*
			1,4-Dichlorobenzene	*9*	*U*	*mg/kg OC*	*3.03*	*1.05*
			Hexachlorobutadiene	*9*	*U*	*mg/kg OC*	*2.41*	*1.52*
			Butylbenzyl phthalate	*9*	*U*	*mg/kg OC*	*1.92*	---
SC02	0-2	3.41	PCBs	35.2	J	mg/kg OC	2.93	---
	2-4	3.01	PCBs	276	MJ	mg/kg OC	23	4.24
	4-6	3.27	PCBs	333		mg/kg OC	27.8	5.13
			Mercury	0.51		mg/kg dw	1.24	---
	6-8	2.52	PCBs	690	J	mg/kg OC	57.5	10.62
			Mercury	0.82		mg/kg dw	2	1.39
			Silver	6.4		mg/kg dw	1.05	1.05
			Hexachlorobenzene	*1*	*U*	*mg/kg OC*	*3.34*	---
			1,2,4-Trichlorobenzene	*1*	*U*	*mg/kg OC*	*1.57*	---
			2,4-Dimethylphenol	*32*	*U*	*mg/kg OC*	*1.1*	*1.1*
	8-10	1.96	PCBs	276		mg/kg OC	23	4.24
			Hexachlorobenzene	*1*	*U*	*mg/kg OC*	*3.89*	---
			1,2,4-Trichlorobenzene	*1*	*U*	*mg/kg OC*	*1.83*	---
			2,4-Dimethylphenol	*29*	*U*	*mg/kg OC*	*1*	*1*
SC03	0-2	3.04	PCBs	18.4	J	mg/kg OC	1.53	---
	2-4	2.90	PCBs	166	J	mg/kg OC	13.9	2.56
	4-6	2.77	PCBs	531		mg/kg OC	44.2	8.16
			Mercury	0.48		mg/kg OC	1.17	---
	6-8	1.18	PCBs	198		mg/kg OC	16.5	3.05
			Hexachlorobenzene	*2*	*U*	*mg/kg OC*	*4.68*	---
			1,2,4-Trichlorobenzene	*2*	*U*	*mg/kg OC*	*2.2*	---
	8-10	0.33	*Hexachlorobenzene*	*6*	*U*	*mg/kg OC*	*15.4*	*2.54*
			1,2,4-Trichlorobenzene	*6*	*U*	*mg/kg OC*	*7.22*	*3.25*
			1,2-Dichlorobenzene	*6*	*U*	*mg/kg OC*	*2.54*	*2.54*
			1,4-Dichlorobenzene	*6*	*U*	*mg/kg OC*	*1.89*	---
			Hexachlorobutadiene	*6*	*U*	*mg/kg OC*	*1.5*	---
			Butylbenzyl phthalate	*6*	*U*	*mg/kg OC*	*1.19*	---

Table 4. SQS and CSL Exceedances in Subsurface Sediment Samples Collected in 2004.
(Undetected chemicals are italicized.) Note: These data are also shown in Figure 9 of the *Cruise and Data Report* (Integral 2004a).

Location	Depth (ft)	TOC (%)	Chemical	Concentration			SQS EF[a]	CSL EF
SC04	0-2	3.01	PCBs	475	J	mg/kg OC	39.6	7.31
	2-4	5.13	PCBs	189		mg/kg OC	15.8	2.91
	4-6	4.01	Mercury	0.71		mg/kg dw	1.73	---
			Hexachlorobenzene	*1*	*U*	*mg/kg OC*	*3.48*	---
			2,4-Dimethylphenol	*53*	*U*	*mg/kg OC*	*1.83*	*1.83*
			1,2,4-Trichlorobenzene	*1*	*U*	*mg/kg OC*	*1.63*	---
	6-8	not analyzed	Mercury	0.49		mg/kg dw	1.2	---
SC05	0-2	2.65	PCBs	49.4		mg/kg OC	4.12	---
	2-4	2.22	*Hexachlorobenzene*	*1*	*U*	*mg/kg OC*	*2.13*	---
			1,2,4-Trichlorobenzene	*1*	*U*	*mg/kg OC*	*1*	---
SC06	0-2	2.39	PCBs	14.8	J	mg/kg OC	1.23	---
	2-4	2.34	PCBs	42.3	J	mg/kg OC	3.53	---
	4-6	1.59	PCBs	48.4	J	mg/kg OC	4.04	---
SC07	0-2	2.39	PCBs	288	J	mg/kg OC	24.1	4.44
	2-4	2.49	PCBs	293		mg/kg OC	24.4	4.51
			Mercury	0.47		mg/kg dw	1.15	---
	4-6	1.37	PCBs	27.2		mg/kg OC	2.26	---
			Hexachlorobenzene	*3*	*U*	*mg/kg OC*	*7.68*	*1.27*
			1,2,4-Trichlorobenzene	*3*	*U*	*mg/kg OC*	*3.6*	*1.62*
			2,4-Dimethylphenol	*40*	*U*	*mg/kg OC*	*1.38*	*1.38*
			1,2-Dichlorobenzene	*3*	*U*	*mg/kg OC*	*1.27*	*1.27*
	6-8	0.16	*Hexachlorobutadiene*	*14*	*U*	*ug/kg dw*	*1.27*[c]	---
SC11[d]	0-2	2.30	PCBs	77		mg/kg OC	6.41	1.18
	2-4	1.22	PCBs	49		mg/kg OC	4.1	---

Notes:
U = Undetected.
J = Estimated.

[a] SQS EF(exceedance factor) = concentration in sample/SQS. CSL EF = concentration in sample/CSL.
[b]Concentration does not exceed CSL or 2LAET.
[c]Compared to LAET (11 ug/kg dw) because TOC is <0.2%.
[d]Sample analyzed for PCBs by The Boeing Company.

LOWER DUWAMISH WATERWAY
SLIP 4 EARLY ACTION AREA

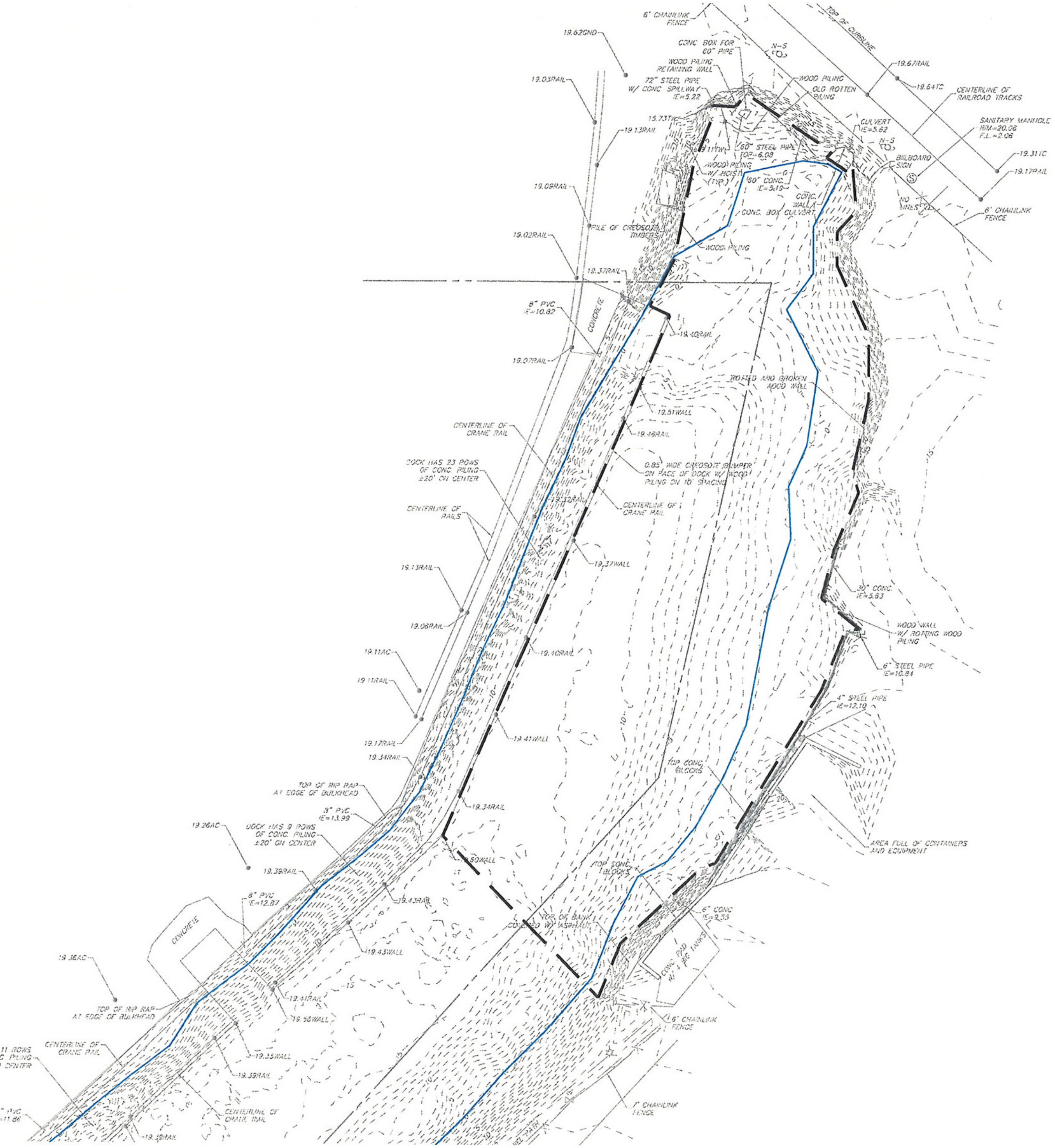
REVISED DRAFT TECHNICAL MEMORANDUM ON PROPOSED BOUNDARY OF THE REMOVAL ACTION

APPENDIX A

Slip 4 Topographic and Hydrographic Contour Map with Proposed Removal Boundary

January 14, 2005

Map Document: (FG-Site Plans.dwg) - Layout: Proposed Removal Boundary
1/10/2005 - 3:45:17 PM



LEGEND

- INDICATES POWER POLE
- INDICATES SANITARY MANHOLE
- INDICATES LUMINARE
- INDICATES IRRIGATION CONTROL VALVE
- INDICATES GUY WIRE
- 19.41WALL INDICATES SPOT ELEVATION
- INDICATES 5 FOOT CONTOUR INTERVAL
- INDICATES 1 FOOT CONTOUR INTERVAL
- PROPOSED REMOVAL BOUNDARY
- APPROXIMATE PROPERTY LINE
- INDICATES EDGE OF WATER AT 7:43AM – 8:54AM ON 09-22-04 (1.5 – 3.5 FT MLLW)

NOTES:

1. HORIZONTAL DATUM: WASHINGTON STATE PLANE COORDINATE SYSTEM, NORTH ZONE (NAD-83/91), U.S. FEET.
2. CONTOURS ARE SHOWN IN FEET AT AN INTERVAL OF 1 FOOT AND INDICATE ELEVATIONS IN REFERENCE TO MEAN LOWER LOW WATER (MLLW). THE BENCH MARK USED IS "DEA 2005" MLLW ELEVATION 16.17'.
3. HORIZONTAL POSITIONS FOR NAVIGATION AND DATA COLLECTION WERE DETERMINED BY USING A TRIMBLE 4700 G.P.S. SYSTEM OPERATING IN DIFFERENTIAL MODE, USING THE G.P.S. CONTINUOUSLY OPERATING REFERENCE STATION (CORS).
4. BATHYMETRIC DATA WAS COLLECTED USING KNUDSEN 320M ECHOSOUNDER WITH A 6 DEGREE SINGLE BEAM TRANSDUCER, OPERATING AT 200 KHZ.
5. SURVEY DATA WAS COLLECTED PARALLEL WITH THE DOCK USING A TEN FOOT LINE SPACING. THE SURVEY DATA COLLECTED ALONG EACH SURVEY LINE WAS THINNED USING A "SHOAL BIAS" METHOD TO AN APPROXIMATE HORIZONTAL SPACING OF 2 FEET.
6. THERE MAY BE BOTTOM FEATURES THAT ARE NOT SHOWN ON THIS MAP DUE TO THE LINE SPACING INTERVAL. THIS SURVEY DOES NOT INCLUDE BATHYMETRIC DATA BETWEEN THE ADJACENT SURVEY LINES.
7. THIS BATHYMETRIC SURVEY IS REPRESENTATIVE OF THE CONDITION OF THE BOTTOM AT THE TIME OF THE SURVEY, BASED ON THE LINE SPACING INTERVAL AND THINNING METHOD USED. THE CONDITION OF THE BOTTOM MAY CHANGE AT ANY TIME AFTER THE DATE OF THIS SURVEY.
8. BATHYMETRIC DATA WAS COLLECTED IN ACCORDANCE WITH THE U.S. ARMY CORPS OF ENGINEERS HYDROGRAPHIC MANUAL EM-1112-02-1003 (JANUARY 2002).
9. DATA COLLECTED: OCTOBER 5, 2004
10. TOPOGRAPHIC & HYDROGRAPHIC BASE INFORMATION PROVIDED BY MINISTER-GLAESER SURVEYING INC, 2200 E. EVERGREEN BLVD., VANCOUVER, WA 98661; MGS JOB#: 04-368; MGS DRAWING NAME: 04368T1.DWG.

N

NAD 83/91 WSPC NZ

0 50 100 Feet

integral consulting inc.

Proposed Removal Boundary