FINAL
REMEDIAL INVESTIGATION REPORT

U.S. Government Moorings
Portland, Oregon

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Prepared for:

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Prepared by

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US Army Corps of Engineers®

EXECUTIVE SUMMARY

A Remedial Investigation was conducted in the spring and summer of 2008 at the U.S. Government Moorings Site, 8010 NW St. Helens Road, Portland, Oregon. This activity was conducted by KTA/TEC Inc. on behalf of the Portland District of the U.S. Army Corps of Engineers. The Moorings has been named a Potential Responsible Party for the Portland Harbor Superfund Site, as identified by the U.S. Environmental Protection Agency under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The work was performed to meet USACE responsibility under CERCLA for the Moorings site. The USEPA issued a Unilateral Order to USACE under RCRA Section 3013 to address the data needs for the site. This investigation was conducted to determine the nature and extent of contamination at the Moorings, both upland and in the near shore sediments.

Remedial investigation activities were conducted both upland and in-water at the Moorings. Upland investigation activities included shallow and deep soils, groundwater, surface water and upland sediment sampling and analysis. In-water activities included surface and subsurface sediment sampling. Samples collected were analyzed for volatile organic compounds, semivolatile organic compounds including polycyclic aromatic hydrocarbons, chlorinated pesticides, polychlorinated biphenyls, metals, cyanide, organobutyltins, and petroleum hydrocarbons. A screening level risk evaluation was conducted for all contaminants of potential concern.

On the upland portions of the site polycyclic aromatic hydrocarbons (PAHs) and metals, especially arsenic, were widely detected across the site. Cyanide was detected across the southern half of the site in significant concentrations in both soils and groundwater, with concentrations highest along the southern property line of the site. Conversely, volatile organic compounds, particularly chlorinated solvents, pesticides and PCBs were detected only at very low concentrations in limited numbers of samples, with no apparent distribution pattern and without obvious point sources. Despite widespread detections of chemicals of interest there are very few chemicals of potential concern with detected values that exceed any screening criteria.

In-water sediments also showed high concentrations of PAHs, especially high molecular weight PAHs, metals, and cyanide. Trace amounts of pesticides and polychlorinated biphenyls were detected in low levels in some samples. Concentrations of chemicals of interest in sediments are consistently highest near the southern border of the site, decreasing to the north.

The nature and extent of contamination is largely commensurate with the long-term use of the site as a shipyard and light industrial facility. Exceptions include extensive distribution of cyanide for which there is no known historic on-site source and the elevated concentrations of PAHs in groundwater that exist at levels higher than would be anticipated by on-site soil concentrations of the same.

For those media posing a risk to human health or the environment, according to the criteria agreed upon in the conceptual site model, the chemicals of interest were compared against various screening criteria and thresholds as identified in the Portland Harbor Joint Source Control Strategy document to establish a list of chemicals of potential concern for the site.

Results of the human health screening evaluation conclude that there is little risk to human health on the Moorings site, primarily due to controlled, limited access; pavement or hard-packed gravel surfacing and an armored shoreline; and little residual contamination from historic site activities. The maximum anticipated risk to site workers is well below U.S. Environmental Protection Agency guidelines and could be further mitigated by implementation of institutional controls if considered necessary.

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ACRONYMS AND ABBREVIATIONS

AC	acre
APP	Accident Prevention Plan
ARAR	applicable or relevant and appropriate requirements
AST	aboveground storage tank
ASTM	American Society for Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry.
AWQC	ambient water quality criteria
BFB	bromofluorobenzene
bgs	below ground surface
BHC	benzene hexachloride
BTEX	benzene, toluene, ethylbenzene, and xylene
CAD	computer aided design
CATC	Cyanide Amenable to Chlorination
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CF	calibration factor
CLARC	cleanup levels and risk calculation
CLP	U.S. EPA Contract Laboratory Program
CoC	Chain of Custody
COI	chemical of interest
COPC	chemical of potential concern
CRBG	Columbia River Basalt Group
CRD	Columbia River Datum
CSF	cancer slope factor for chronic oral exposure
CSM	conceptual site model
CT	central tendency
DBT	dibutyltin
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DDX	The sum of all isomers DDD, DDE,and DDT
DFTPP	decafluorotriphenylphosphine
DGPS	differential corrected global positioning system
DNAPL	dense non-aqueous phase liquids
DO	dissolved oxygen
DPT	direct push technology
DQAR	data quality assessment report
DQO	data quality objective

EPC	exposure point concentration
FIA	flow injection analysis
FOC	fractional soil organic carbon content
FS	feasibility study
FSP	field sampling plan
GPS	Global Positioning System
HCN	hydrocyanic acid
HDPE	high density polyethylene
HHRA	human health risk assessment
HI	hazard index
HPAH	high-molecular-weight polycyclic aromatic hydrocarbon
HQ	Hazard Quotient
ID	identification
IDW	investigation-derived waste
IRIS	Integrated Risk Information System
ISE	ion selective electrode
IUR	cancer inhalation unit risks for chronic inhalation exposure
J&E	Johnson and Ettinger
JSCS	Joint Source Control Strategy
K_d	soil-water partition coefficient
K_{oc}	soil organic carbon-water partition coefficient
K_{ow}	Octanol-water partition coefficient
KTA	KTA Associates, Inc.
LCS	laboratory control sample
LNAPL	light non-aqueous phase liquids
LPAH	low-molecular-weight polycyclic aromatic hydrocarbon
LWG	Lower Willamette Group
μg/kg	microgram per kilogram
μg/L	microgram per liter
MBT	monobutyltin
MCL	maximum contaminant level
MDL	method detection limit
mg/kg	milligram per kilogram
mg/L	milligram per liter
MGP	Manufactured Gas Plant
MIS	multi-increment sampling
Moorings	U.S. Government Moorings
mph	miles per hour

MRL	method reporting limit
MS	matrix spike
MSD	matrix spike duplicate
msl	mean sea level
MU	Management Unit
NAD83	North American Datum of 1983
NAPL	non-aqueous phase liquid
NFGs	CLP National Functional Guidelines for Data Review (USEPA 2007 – Organics, USEPA 2004 - Inorganics)
ng/kg	nanogram per kilogram
NGVD88	National Geodetic Vertical Datum of 1988
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRWQC	National Recommended Water Quality Criteria
NSI	native soil interface
OAR	Oregon Administrative Rules
ODEQ	Oregon Department of Environmental Quality
ODOT	Oregon Department of Transportation
ORNL	Oak Ridge National Laboratory
ORP	oxygen reduction potential
PAH	polycyclic aromatic hydrocarbon
PbB	blood lead level
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PEC	probable effects cocentration
PID	Photo Ionization Detector
PPE	personal protective equipment
PPRVT	Provisional Peer Reviewed Toxicity Values
ppm	parts per million
PQL	practical quantitation limit
PRG	preliminary remediation goal
PRP	Potential Responsible Party
PSEP	Puget Sound Estuary Program
PVC	poly vinyl chloride
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
RAGS	USEPA Risk Assessment Guidance for Superfund

RAIS	risk assessment information system
RCRA	Resource Conservation and Recovery Act
RBC	risk-based concentration
RfC	reference dose for chronic oral exposure
RfD	reference concentration for chronic inhalation exposure
rgs	regional screening levels
RI	remedial investigation
RM	river mile
RME	reasonable maximum exposure
RPD	relative percent difference
RSL	regional screening levels
SAP	sampling and analysis plan
SDG	sample delivery group
SEDQUAL	Sediment Quality Information System
SF	slope factor
SLV	screening levels values
SPLP	synthetic precipitation leaching procedure
SVOC	semivolatile organic compound
TBT	tributyltin
TCA	trichloroethane
TCDD	tetrachlorodibenzo-*p*-dioxin
TCE	trichloroethene
TCLP	Toxicity Characteristics Leaching Procedure
TEC	TEC Inc.
TOC	total organic carbon
TPAH	total polycyclic aromatic hydrocarbons
TPH	total petroleum hydrocarbon
TSS	total suspended solids
UCL	Upper Confidence Limit
µg/kg	microgram/kilogram
µg/L	microgram/liter
USACE	U.S. Army Corps of Engineers
USCS	Unified Soil Classification System
USEPA	U.S. Environmental Protection Agency
UST	underground storage tank
VOC	volatile organic compound
WAD	weak acid dissociable
WBZ	water bearing zone
WLI	water level indicator

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U.S. Government Moorings Mac Robison	Site Contact	8010 NW St. Helens Road Portland, OR Phone: 503-808-5400 Fax: 503-808-5415
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SEE, LLC Tim Thompson	Sediment Lead	4401 Latona Ave NE Seattle, WA 98105 Phone: 206.619.4401 Fax: 206.418.6187
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1.0 INTRODUCTION

1.1 PURPOSE

On behalf of the Portland District of the U.S. Army Corps of Engineers (USACE), KTA Associates, Inc., (KTA), conducted a Remedial Investigation (RI) at the U.S. Government Moorings (Moorings) site, 8010 NW St. Helens Road, Portland, Oregon. Supporting KTA was team member TEC Inc. (TEC). The Moorings is located on the Willamette River within the industrial harbor of Portland, Oregon (Figure 2-1, page 2-2).

The Moorings has been named a Potential Responsible Party (PRP) for the Portland Harbor Superfund Site, as identified by the U.S. Environmental Protection Agency (USEPA) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The work was performed to meet USACE responsibility under CERCLA for the Moorings site. The USEPA issued a Unilateral Order to USACE under the Resource Conservation and Recovery Act (RCRA) Section 3013 to address the data needs for the site. This report, meets the substantive requirements of the RCRA order and the CERCLA RI.

The primary objectives of this RI were to:

1. Determine if the site is a source of contamination to the Willamette River;
2. Determine if the upland portions of the site present unacceptable risks to human health or the environment;
3. Determine if off-site sources of contamination are impacting the site;
4. Determine if the upland portions of the site are contaminated from historic dredge material placement;
5. Determine the adequacy and completeness of previous remedial activities; and
6. Characterize potential sediment contamination in support of USACE sediment management activities and on-going Lower Willamette Group (LWG) studies.

Primary field activities were conducted under delivery order 14, HTRW Contract No. W912DW-06 D-1007 through Seattle District Corps of Engineers in March and April, 2008, with an additional one-week sampling event in early August 2008. This report provides a description of the RI and the results of the field events.

1.2 SCOPE

To meet the project objectives, the scope of work for this RI consisted of field activities conducted in accordance with the *Management Plan for the Remedial Investigation U.S. Government Moorings, Portland, Oregon* (KTA/TEC 2008)[1], which defined the following scope elements in detail.

Upland Soil and Groundwater Investigation

Conduct the collection and analysis of surface and subsurface soil samples along with groundwater samples from the southern portion of the upland area using discrete sampling techniques. Sample results were used to determine if chemicals of potential concern (COPCs)

[1] This document is available per request by contacting USACE Seattle District.

exist in on-site soils or groundwater, and if present, whether they present a risk to humans or the environment. Sample results were also used to identify potential contaminant sources and identify potential preferential migration pathways.

Conduct the collection and analysis of surface and subsurface soil samples from Management Units (MUs) located in the northern and central portion of the upland area using the multi-increment sampling (MIS) technique. Sample results were used to determine if COPCs exist in on-site soils, and if present, whether they present a risk to on-site workers. Sample results were also used to identify potential contaminant sources, assess previous cleanup efforts, and identify potential preferential migration pathways. If COPCs are detected during MIS sampling, groundwater samples may be collected and analyzed from locations downgradient of the affected MUs.

Upland Surface Water Investigation

Conduct the collection and analysis of stormwater samples from an Oregon Department of Transportation (ODOT) catch basin and storm drains from St. Helens Road/Highway 30, (henceforth referred to as the ODOT outfalls) to determine if COPCs are potentially exiting the site via stormwater discharges. If available, obtain historical information on the existing ODOT outfalls and verify that old stormwater conveyance systems have been properly abandoned.

Upland Sediment Investigation

Conduct the collection and analysis of upland surface sediments to determine if COPCs are potentially exiting the site via stormwater discharges.

In-Water Sediment Investigation

Conduct the collection and analysis of sediment samples in the Willamette River from beneath the docks, dredge areas, the small-boat basin, and near the storm drain outfalls and bulkheads. Sediment sample results will be used to augment existing data to help characterize known COPCs in near-shore sediments and to support USACE sediment management activities.

1.3 REPORT ORGANIZATION

This RI Report has been organized into the following sections.

- Section 1.0 Introduction
- Section 2.0 Site Background
- Section 3.0 Conceptual Site Model
- Section 4.0 Site Investigation
- Section 5.0 Investigation Results
- Section 6.0 Nature and Extent of Contamination
- Section 7.0 Risk Assessment
- Section 8.0 Summary and Conclusions
- Section 9.0 References

2.0 SITE BACKGROUND

2.1 SITE LOCATION AND DESCRIPTION

The Moorings is located on the west bank of the Willamette River at approximately river mile (RM) 6.08 through 6.21, within the industrial harbor of Portland, Oregon (Figure 2-1, page 2-2). The site address is 8010 Northwest St. Helens Road, Portland, Oregon, and is owned and operated by the USACE Portland District. The site is bounded on the northeast by the Willamette River, on the northwest by Advanced American Construction, on the southwest by BNSF Railway and St. Helens Road, and on the southeast by the NW Natural property (formerly GASCO), which also includes Koppers and Siltronic activities.

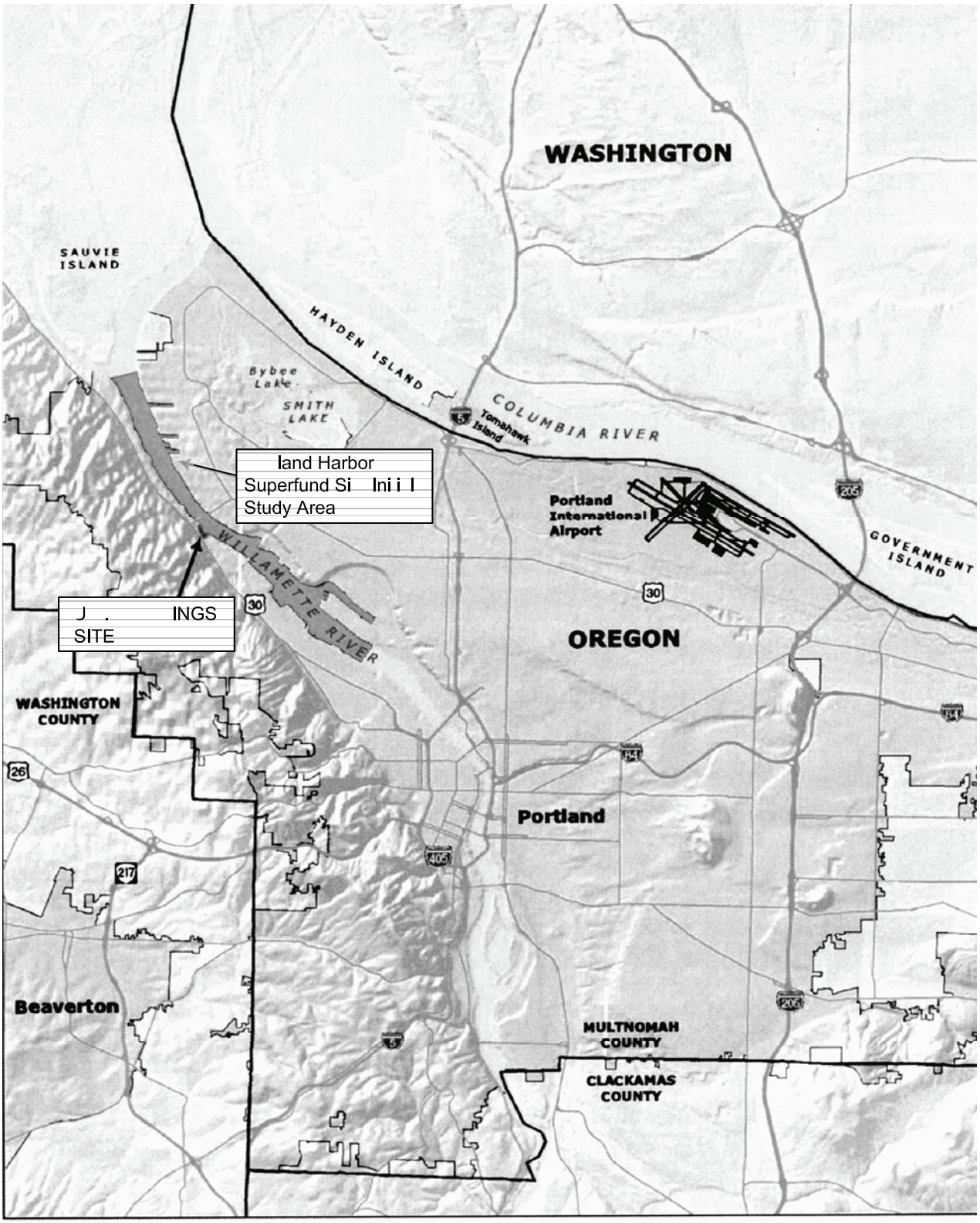
The Moorings consists of 13.14 land acres, that includes approximately 3 acres of submerged land that is partially covered by 26,700 square feet of dock. Approximately one-half of the upland area on the southern end of the property is paved or covered by buildings. The remaining land surface, northwest of Building 17, is either covered by buildings or gravel and pavement. Figure 2-2 (page 2-3) depicts the current physical layout of the site.

The riverbank at the site is a 1 to 1 riprap-covered slope with a timber bulkhead at the toe of the slope, generally following the historic shoreline. Average river stages for the area range from 8.0 feet Columbia River Datum (CRD) in August and September to 12.5 feet CRD in May and June. The in-water vertical datum used at this site is the CRD, which is the one established for the Portland Harbor Superfund site. The upland vertical datum is the National Geodetic Vertical Datum of 1988 (NGVD88), which is equivalent to mean sea level (msl). The CRD is approximately 4 to 5 feet below the NGVD88. The staff gauge at the Moorings reports river stages in CRD, and is located northwest of the small boat dock (Dock B, Figure 2-2, page 2-3). The land surface elevation for most of the site is approximately 30 feet above msl (approximately 26 feet CRD).

2.2 REGULATORY STATUS

The Moorings is located within a reach of the Willamette River identified by the USEPA as a Superfund site under CERCLA. The Portland Harbor Superfund site assessment area extends from approximately RM 0/1 to 12, which includes part of the Multnomah Channel and includes upland portions of properties that have or could impact the river sediments. The Portland Harbor Superfund site was listed on the National Priorities List (NPL) on December 1, 2000 (65 Federal Register 75179-01). This reach of the Willamette River has served as a major industrial waterway since the early 1900s. The river is also habitat to wildlife, numerous fish, shellfish, and other aquatic species, including salmonid species listed under the Endangered Species Act. Additionally, several tribes have treaty-reserved rights and resources in the harbor.

The Moorings has been named a PRP for the Portland Harbor Superfund Site by the USEPA under the CERCLA. This RI report meets the requirements of CERCLA and with the requirements of the Statement of Work set forth in the Statement of Work to the RCRA Section 3013 order issued by the USEPA.



SOURCE: RLIS METRO DATA SET AND USGS DEM

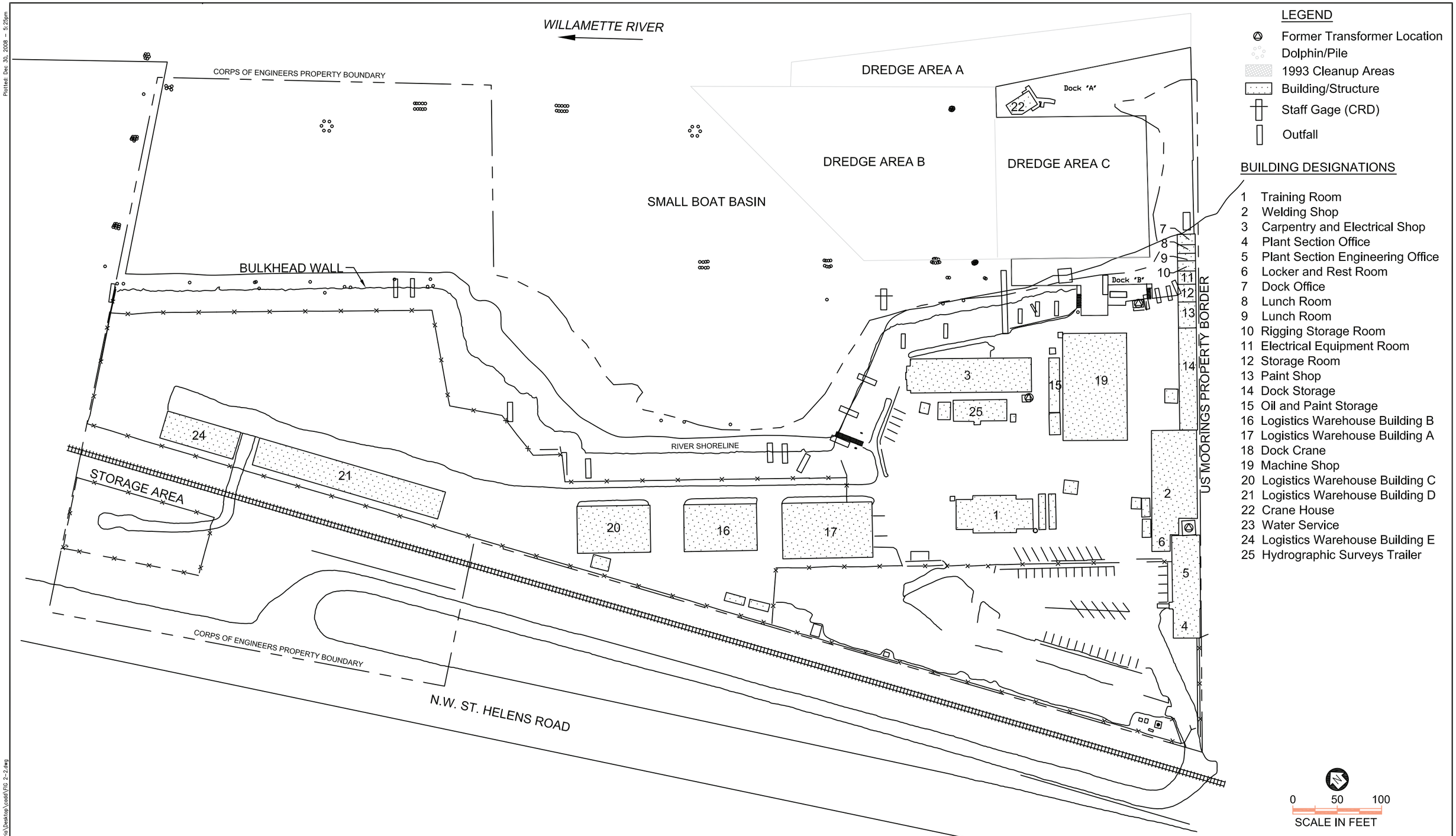
0 0.5 1 2 3 4 5 Miles

TEC Inc.
1450 114th Ave
Bellevue, Wa 98004
425

NMENT MOORINGS
REMEDIAL INVESTIGATION

SITE LOCATION

FIGURE 2-



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TEC Inc.
1450 114th Ave S.E.
Suite 220
Bellevue, Wa 98004
425.453.4040
425.454.7043 fax

US GOVERNMENT MOORINGS

REMEDIAL INVESTIGATION

SITE PLAN

DRAWING NUMBER: FIGURE 2–2
CAD FILE NUMBER:
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REV.

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2.3 CURRENT SITE USE

The Moorings currently provides port, supply, and repair facilities for the USACE Portland District fleet of dredges, hydrosurvey vessels, and other support vessels. The USACE Portland District warehouse is also located at the site, mostly providing storage for the Moorings operations. Shipyard operations are restricted to the southern area of the site south of the fence along Building 17. The remaining area is used for warehouse and storage. The Moorings is a registered small quantity hazardous waste generator.

The site contains a variety of permanent buildings plus docks for two ocean-going hopper dredges and a small boat dock for several survey boats. Site buildings include offices, a welding shop, machine shop, electronics shop, and storage.

The site has supported the USACE Portland fleet of dredges and other vessels since its inception. The Portland District Operating Plan does not include any plans to modify the site in the future.

2.4 SITE HISTORY

Use of the site began in 1903 to provide centralized maintenance and supply facilities for the USACE Portland District. The original boundaries contained what is now the southern portion of the site. In 1905, an additional tract was acquired to bring the area of the site to six acres. In 1940, a third parcel (5.29 acres) was acquired at the northwest end of the property, completing the land acquisition phase at the site. The site was further expanded with the use of fill materials to change the elevations of the site (Section 2.4.3, page 2-8) and by three phases of major construction (Section 2.4.2, page 2-8). Figure 2-3 (page 2-6) shows a historic view of the Moorings, circa 1946. Figure 2-4 (page 2-7) shows a view of the site today.

2.4.1 Historical Site Use

While the industrial practices at the Moorings have been continuously updated and modernized since 1903, the site's primary use has remained as a shipyard facility, providing port, supply, and repair facilities for the USACE Portland District fleet of dredges, hydrosurvey vessels, and other support vessels. The types of vessels served includes, or has included in the past, hopper dredges, pipeline dredges, bypasser dredges, service barges, oil barges, survey boats, tugs, and miscellaneous watercraft. The remaining area is used for warehouses and storage.

The USACE North Pacific Division laboratory also operated at the Moorings in Building 3 (currently the Carpentry Shop) from approximately 1939 until 1948, prior to the establishment of the Troutdale Laboratory. However, only physical testing of soil and geotechinical properties were conducted, rather than chemical testing that later took place at the Troutdale facility.

Vehicle maintenance was conducted on government vehicles in Building 1 until 1986; however, the start date of this activity is unknown. The Vehicle Maintenance Shop conducted routine maintenance activities on site vehicles, which included oil changes, car washes, and general upkeep. Currently, government vehicles are taken off site for maintenance and car washes (USACE 2008).

Normal activities adjacent to and over the river have included fueling of vessels, delivery of and removal of lube oil, painting and paint removal, welding, metal cutting, vessel parts delivery and installation, supply delivery to vessels and solid waste removal from vessels (USACE 2008). Historical records imply that new construction or refurbishing of some smaller vessels occurred in the early years of the site (USACE 1946).

PORTLAND DISTRICT MOORINGS. View showing grounds and buildings with Derrick Barge Cascade and 20" pipe-line dredge Raymond berthed at docks. View taken from St. John's Bridge.

Photo taken October 7, 1946.

Figure 2-3 U.S. Moorings circa 1946

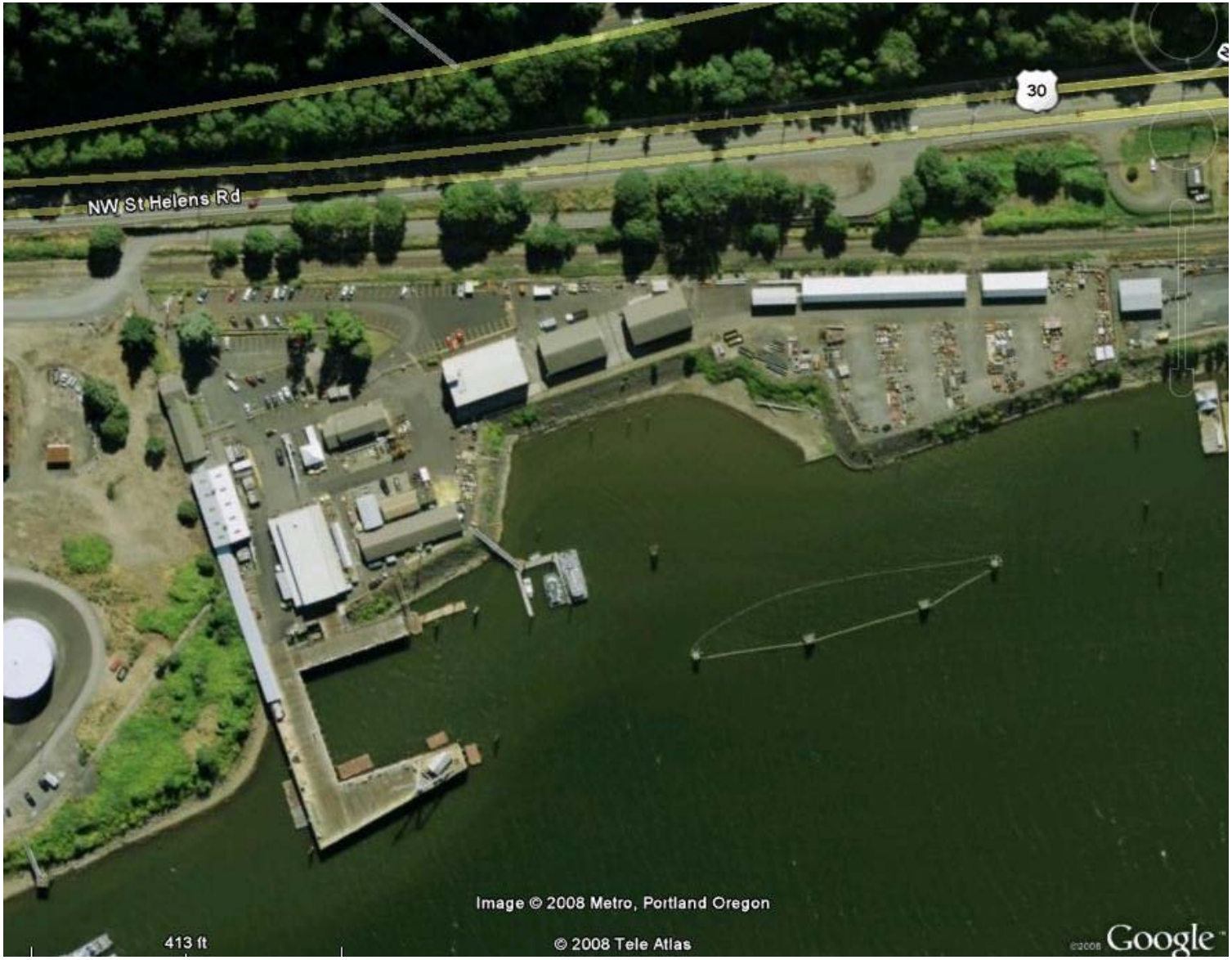


Figure 2-4 U.S. Moorings - 2008

2.4.2 Building Construction

In 1913, new construction at the site included a bulkhead, housing for a watchman, and a water tank. The second phase of site expansion occurred from the late 1930s through the mid 1940s, and included the addition of a warehouse and garage in 1937. The office building, locker, soils laboratory, and pattern buildings were constructed between 1938 and 1939. In addition, three warehouses and the machine shop were constructed between 1940 and 1945. Dock B was also reconstructed during the 1940s. The last major renovation of the site was completed during the 1960s. The lumber and storage warehouse, overseer's quarters, carpentry shop, and sales storage building were demolished.

Additional construction activities included remodeling to convert the vehicle maintenance shop (Building 1) to office and conference space in 1986, and an emergency response vehicle garage was added in 1995.

2.4.3 Dredge and Fill Activities

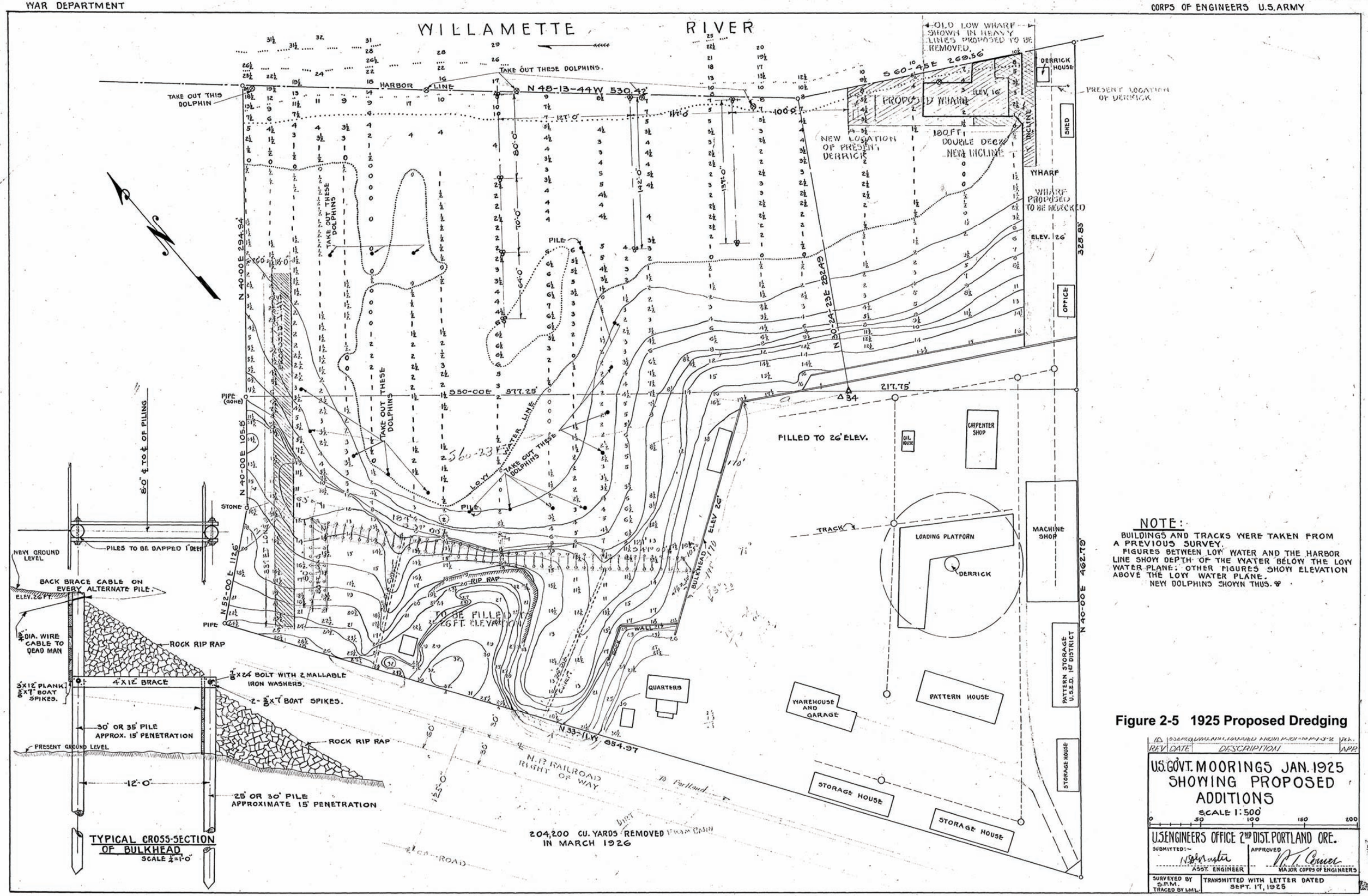
In addition to the purchase of supplementary acres, fill material from dredging activities was used to expand the site footprint. Three dredging periods where river sediment was used for upland fill have been documented. Documentation indicates that the fill material came from the basin directly in front of the site, between the shoreline and harbor line.

- After the bulkhead was completed in 1913, an estimated 30,000 cubic yards of material was dredged from the Willamette River directly in front of the site and placed upland.
- In 1925, a similar site development action created land to the north of the existing industrialized area where the three current warehouse buildings stand (Buildings 16, 17 and 20). Also, a portion of the upland area south of the current Building 17 was likely shaved down to match the current site elevation of about 30 feet msl[1]. The remainder of the central area was filled to an elevation of about 30 feet msl with sediment dredged from the river for navigational or berthing requirements. The central section of the site required approximately 15 feet of fill to reach the final elevation of 30 feet msl. Figure 2-5 (page 2-9) is the 1925 drawing illustrating proposed 1926 dredging operations. Based on these historic contours an estimated 205,000 cubic yards were dredged from the basin.
- The 1945-dredged sediment also came from the basin in front of the site between the shoreline and harbor line and was used as fill material for the northwest end of the property, adding approximately 1.7 acres of land. The northwest section had approximately 10 to 14 feet of material added to the native soil to reach the final elevation of 30 feet msl. Figure 2-6 (page 2-11) is a portion of the drawing illustrating 1945 dredging operations. Figure 2-7 (page 2-12) is a photograph of the site during 1945 fill activities.

Maintenance dredging activities were also documented in 1965 and 1981; however, the disposition of this material is unknown (USACE 2008).

Figure 2-8 (page 2-13) depicts approximate contours from 1913, 1925, and 1936 superimposed over the current site plan. The data for this figure was collected from historic drawings and aerial photographs. Figure 2-9 (page 2-15) depicts several cross-sections of the site, showing the estimated depth of fill material based on the contours shown in Figure 2-8 (page 2-13). Figure 2-10 (page 2-17) provides a calculated estimate of the total volume of fill placed at the site.

[1] NGVD 88



NOTE:
BUILDINGS AND TRACKS WERE TAKEN FROM A PREVIOUS SURVEY.
FIGURES BETWEEN LOW WATER AND THE HARBOR LINE SHOW DEPTH OF THE WATER BELOW THE LOW WATER PLANE; OTHER FIGURES SHOW ELEVATION ABOVE THE LOW WATER PLANE.
NEW DOLPHINS SHOWN THUS.

Figure 2-5 1925 Proposed Dredging

REV	DATE	DESCRIPTION	APP
A		DSEPEQ.DWG. RECHANGED FROM P-1-3-2	

U.S. GOVT. MOORINGS JAN. 1925 SHOWING PROPOSED ADDITIONS

SCALE 1:500

0 50 100 150 200

U.S. ENGINEERS OFFICE 2ND DIST. PORTLAND ORE.

SUBMITTED:- N. Schroeder, ASST. ENGINEER

APPROVED W. T. Conner, MAJOR CORPS OF ENGINEERS

SURVEYED BY S.P.M. TRACED BY L.M.L.

TRANSMITTED WITH LETTER DATED SEPT. 1ST, 1925

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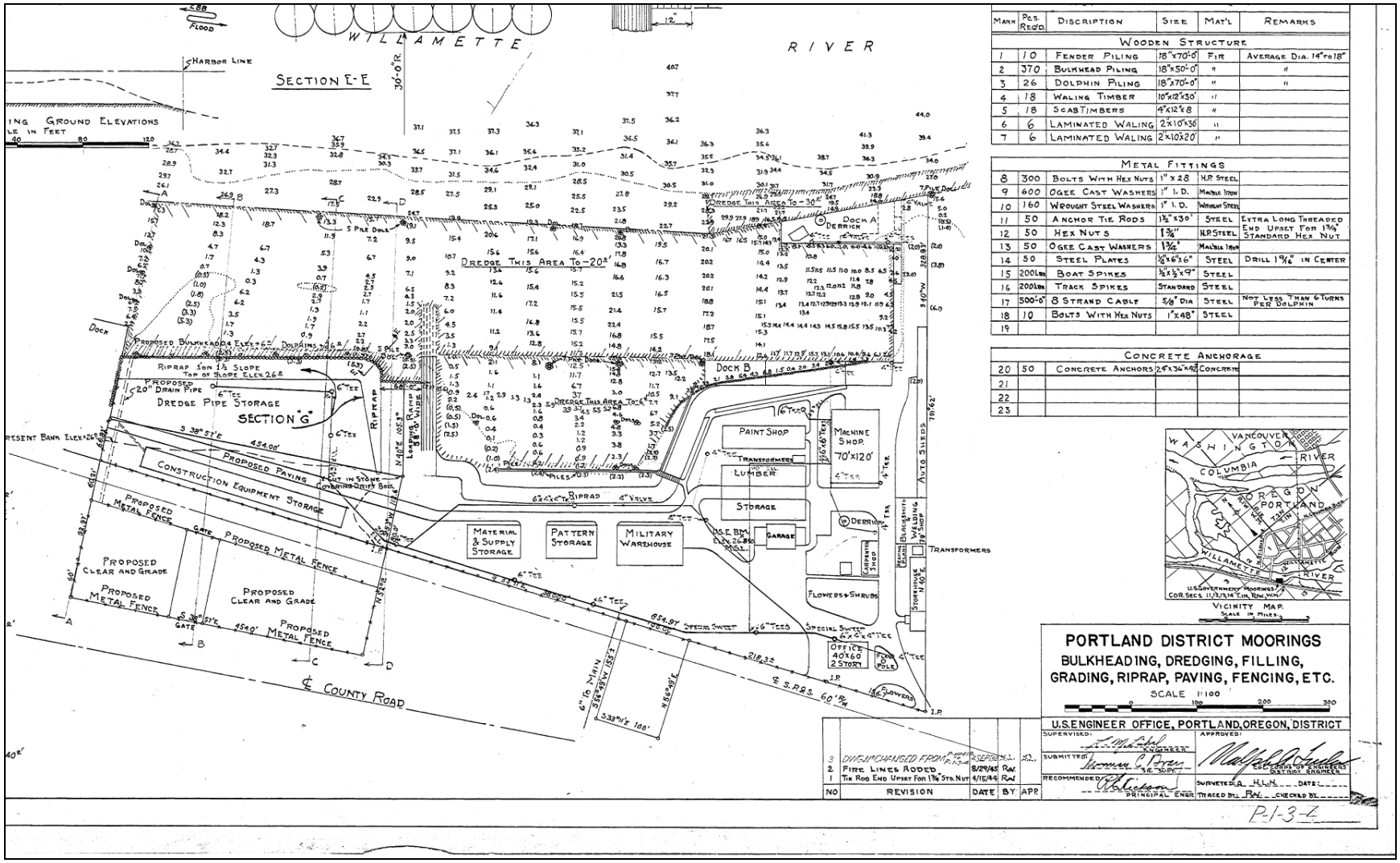


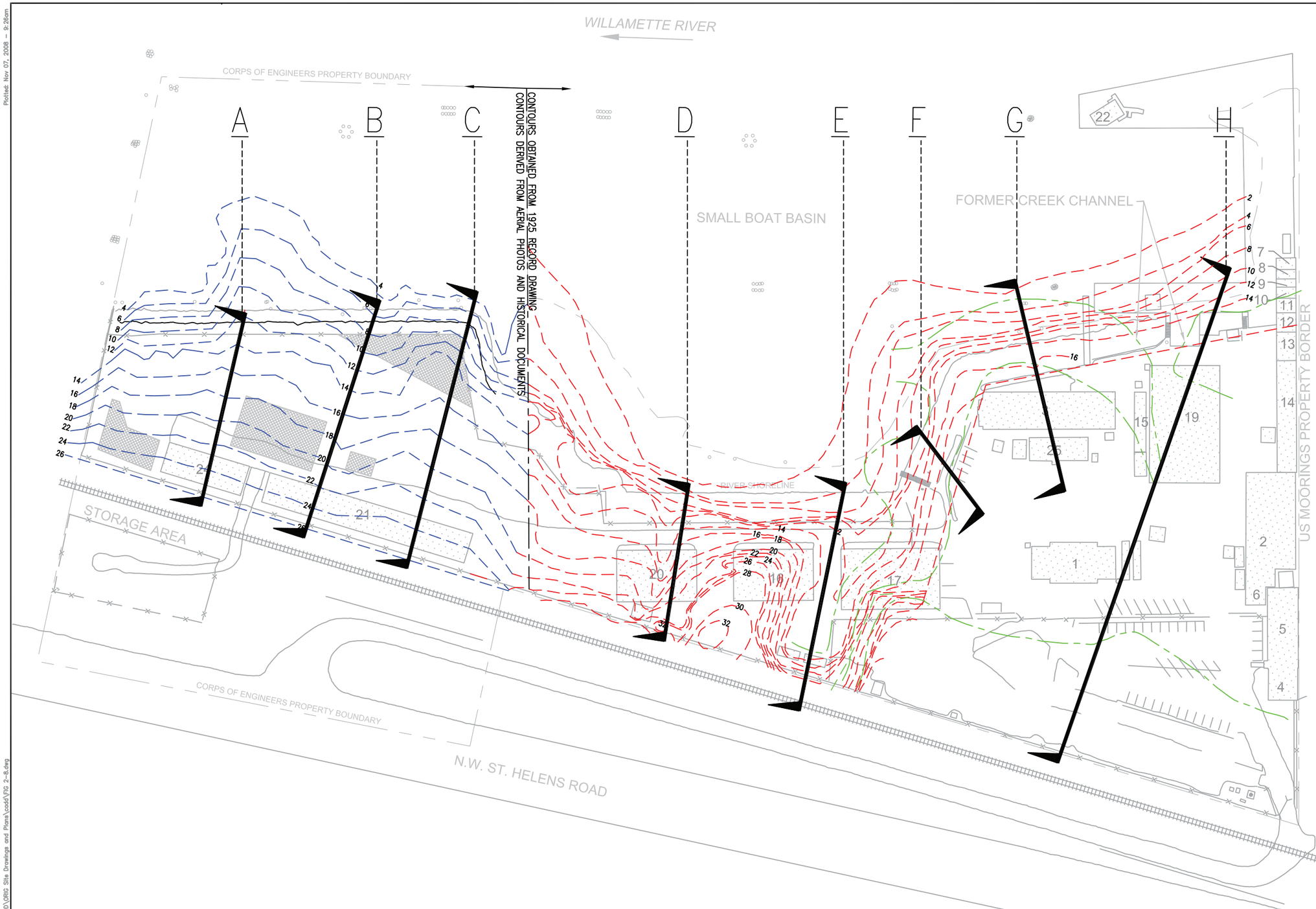
Mark	Pcs. Req'd	Discription	Size	Mat'l	Remarks
		Wooden Structure			
1	10	Fender Piling	18"x70'-0"	Fir	Average Dia. 14" to 18"
2	370	Bulkhead Piling	18"x50'-0"	"	"
3	26	Dolphin Piling	18"x70'-0"	"	"
4	18	Waling Timber	10"x12"x30'	"	
5	18	Scab Timbers	4"x12"x8	"	
6	6	Laminated Waling	2"x10"x30	"	
7	6	Laminated Waling	2"x10"x20'	"	
		Metal Fittings			
8	300	Bolts With Hex Nuts	1" x 28	H.P. Steel	
9	600	Ogee Cast Washers	1" I. D.	Malleable Iron	
10	160	Wrought Steel Washers	1" I. D.	Wrought Steel	
11	50	Anchor Tie Rods	1½" x 30'	Steel	Extra Long Threaded End Upset For 1¾" Standard Hex Nut
12	50	Hex Nuts	1¾"	H.P. Steel	
13	50	Ogee Cast Washers	1½"	Malleable Iron	
14	50	Steel Plates	½"x6"x6"	Steel	Drill 1 9/16" in Center
15	200 lbs	Boat Spikes	½"x½"x9"	Steel	
16	200 lbs	Track Spikes	Standard	Steel	
17	500'-0"	8 Strand Cable	5/8" Dia	Steel	Not Less Than 6 Turns Per Dolphin
18	10	Bolts With Hex Nuts	1"x48"	Steel	
19					
		Concrete Anchorage			
20	50	Concrete Anchors	2.5"x36"x42"	Concrete	
21					
22					
23					

No	Revision	Date	By	App
3	Dike Up Changed From Prior Approval	8/29/45		
2	Fire Lines Added	8/29/45	Rai	
1	Tie Rod End Upset For 1¾" Sta. Nut	4/16/44	Rai	

Figure 2-6 1945 Proposed Dredging

View showing grounds and buildings with floating plant berthed at docks. Photograph taken ca. 1945.

Figure 2-7 1945 Dredging Placement



BUILDING DESIGNATIONS

1 Training Room
2 Welding Shop
3 Carpentry and Electrical Shop
4 Plant Section Office
5 Plant Section Engineering Office
6 Locker and Rest Room
7 Dock Office
8 Lunch Room
9 Lunch Room
10 Rigging Storage Room
11 Electrical Equipment Room
12 Storage Room
13 Paint Shop
14 Dock Storage
15 Oil and Paint Storage
16 Logistics Warehouse Building B
17 Logistics Warehouse Building A
18 Dock Crane
19 Machine Shop
20 Logistics Warehouse Building C
21 Logistics Warehouse Building D
22 Crane House
23 Water Service
24 Logistics Warehouse Building E
25 Hydrographic Surveys Trailer

LEGEND

- - - - NATIVE SOIL OBTAINED BY 1925 RECORD DRAWING

— — — NATIVE SOIL AS OF 1913

- - - - CONTOURS DERIVED FROM 1936 AERIAL PHOTO

SECTION LINE, SEE FIGURE 3-3

No.	DATE	BY	REVISION

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CHECKED BY: | DATE:

WARNING
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US GOVERNMENT MOORINGS

REMEDIAL INVESTIGATION

ESTIMATED UPLAND FILL CONTOUR MAP

DRAWING NUMBER: FIGURE 2–8
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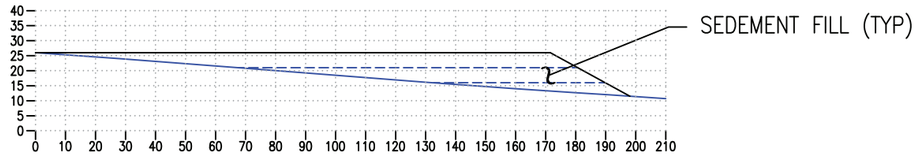

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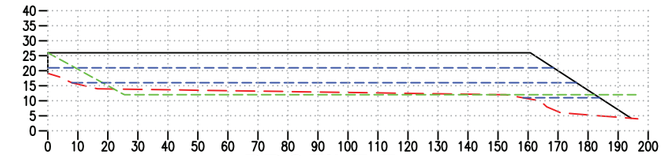

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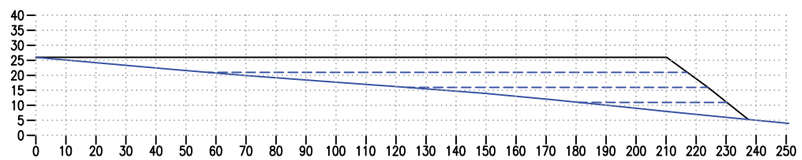

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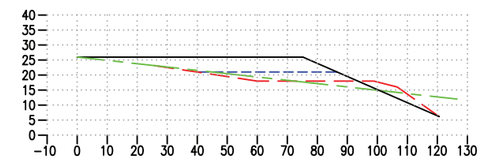
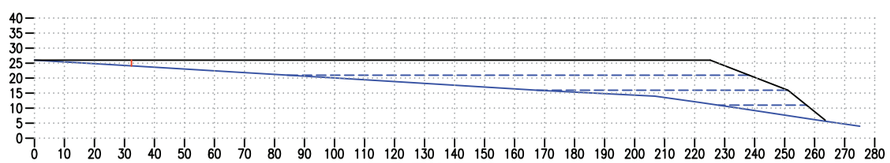


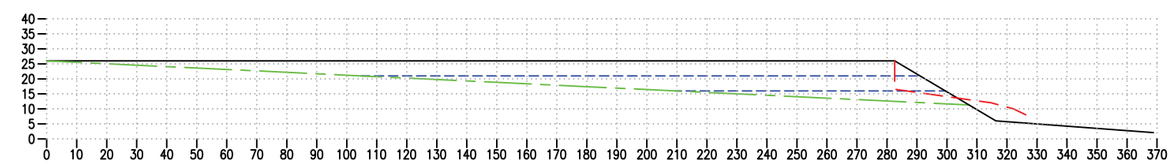
PROFILE F

LEGEND

- FILL LEVEL
- NATIVE SOIL AS OF 1925
- NATIVE SOIL AS OF 1913
- 5FT INTERVALS
- EXTRAPOLATED COTOURS FROM 1936 AERIAL PHOTO



PROFILE C



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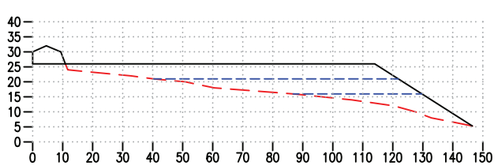

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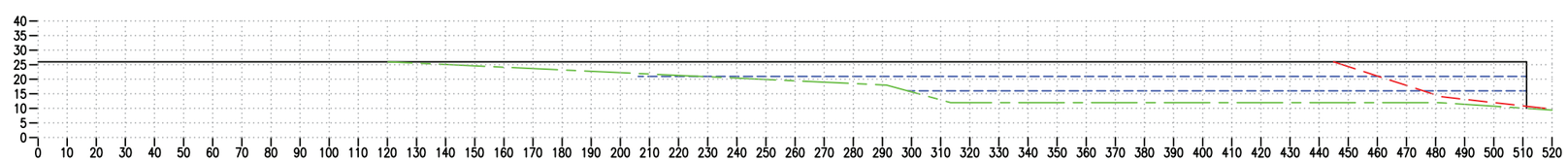

PROFILE H

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425.454.7043 fax

US GOVERNMENT MOORINGS

REMEDIAL INVESTIGATION

ESTIMATED UPLAND FILL PROFILES

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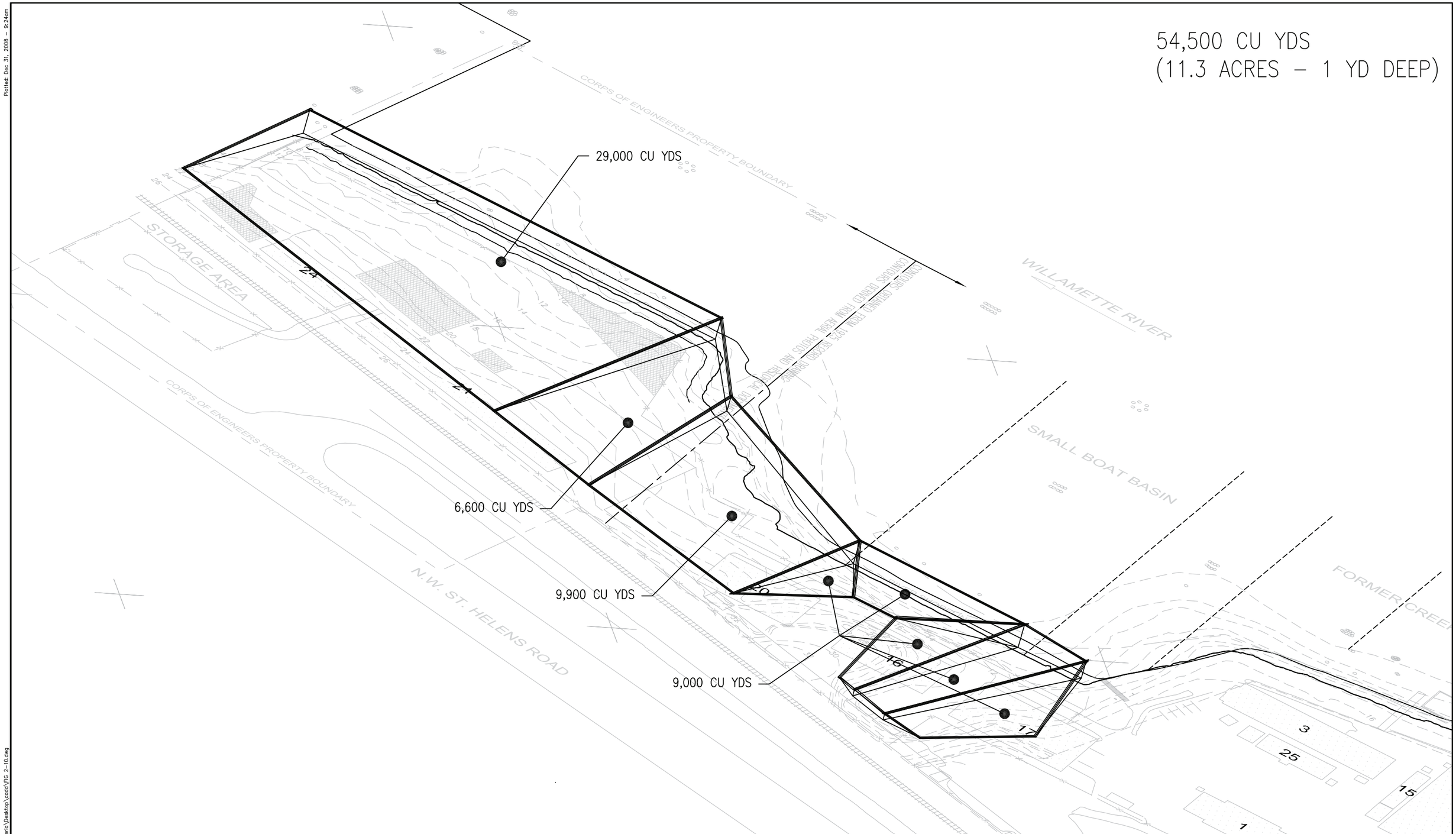

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WARNING
0 1/2 1
IF BAR DOES NOT MEASURE 1" AT FULL SIZE, THEN SCALES ON DRAWING NOT TO SCALE.

TEC Inc.
1450 114th Ave S.E.
Suite 220
Bellevue, Wa 98004
425.453.4040
425.454.7043 fax

US GOVERNMENT MOORINGS

REMEDIAL INVESTIGATION

ESTIMATED UPLAND FILL CONTOUR MAP

DRAWING NUMBER: FIGURE 2–10
CAD FILE NUMBER:
SHEET: OF
REV.

Plotted: Dec 31, 2008 – 9:24am
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It is estimated that approximately 54,500 cubic yards of fill were used to bring the site to current elevation. The volume required to bring the site to current elevation estimated from the contours is much smaller than the total volume of material dredged from the river as derived from historic documents. The reason for this discrepancy is unknown, although plausible explanations for the difference include compaction of the fill material upon upland placement or the disposal of dredged material elsewhere than on site.

2.4.4 Historic Marine Railway

After the 1945 fill event, a loading ramp was completed to facilitate loading and unloading of dredge pipe and other equipment. The ramp extended from a pile bulkhead, six feet above low water, to a paved roadway at an elevation of 24 feet above low water ending approximately where Building 21 is now located, and was approximately 75 feet wide and 175 feet long. The loading ramp was also used as a slipway for launching and retrieving small boats using a steel carriage running on a track system (USACE 1946). The ramp was removed from this area sometime during the late 1950s to the early 1960s. Figure 2-11 below highlights the boatway.

Figure 2-11 Historic Boatway circa 1946

2.5 GEOLOGICAL SETTING

The geology of the Portland area is generally characterized by a broad structural depression, or basin, bordered by the Cascade Mountains on the east and the Coast Range Mountains on the west. Geologic formations in the basin are also folded and dissected by a number of northwest-trending faults. The Tualatin Mountains form a northwest-trending anticlinal ridge that is faulted along its eastern flank by the Portland Hills Fault. The Willamette River flows along the base of the eastern side of the Tualatin Mountains. The Moorings is located on the west bank of the river. A number of additional faults are located approximately parallel or perpendicular to the

Portland Hills Fault and are mapped along or near the Tualatin Mountains (Map-Beeson et al. 1991).

The Moorings is located within the Portland basin, which is a northwest trending structural feature that contains a thick sequence of alluvial deposits overlying the basalt flows of the Columbia River Basalt Group (CRBG) (Map-Beeson et al. 1991). The basin is bounded on the northwest by the Tualatin Mountains that were formed by uplift along the Portland Hills fault zone (Map-Tolan and Reidel 1989). From youngest to oldest, the alluvial deposits in the basin consist of Quaternary deposits (artificial fill, flood-plain and channel deposits of the Willamette and Columbia Rivers, and deposits from Ice-Age catastrophic floods from glacial Lake Missoula), and older alluvial deposits of Pliocene to Miocene age (Troutdale Formation and Sandy River Mudstone) (Map-Beeson et al. 1991). The Miocene CRBG consists of a series of flood basalt flows of varying extent, thickness, structure, magnetic polarity, and geochemistry.

The area surrounding the Moorings was previously dominated by lakes, including Kittridge and Doane Lakes. The lakes were connected by sloughs developed on the former flood plain of the Willamette River. The flood plain was buried beneath fill during industrial development.

Descriptions of the geologic formations (from oldest to youngest) of regional significance that are most likely to be present at or near the site are presented below.

2.5.1 Columbia River Basalt Group

The Portland basin is underlain by the CRBG, which consists of flood basalt erupted 6 to 17 million years ago. These Miocene-age flood basalts are characterized by a thick sequence of dense basalt flows separated by permeable interflow zones. These interflow zones may be characterized by productive aquifers. This unit has been folded and faulted and forms the Tualatin Mountain uplands southwest of the site. The CRBG dips steeply to the northeast near the site. The top of the CRBG is at the ground surface west of St. Helens Road about 0.2 miles west of the Moorings and is estimated to be at a depth of 65 to greater than 100 feet below the site (Geraghty & Miller Map 1991). On the east bank of the river, basalt depths are estimated to be 300 to 450 feet below ground surface (bgs) (Map-Madin 1990). The Columbia River Basalt flows are overlain by fluvial sediments of the Troutdale Formation. Near the Tualatin Mountains, these deposits may be absent.

2.5.2 Troutdale Formation

The Troutdale Formation is of Miocene to Pliocene age and, in this area, consists of interbedded conglomerates and finer-grained deposits (Map-Beeson et al. 1991). The Troutdale Formation is characterized by pebble to cobble conglomerates consisting primarily of Columbia River Basalt clasts with allocthonous clasts of volcanic, plutonic, and metamorphic rocks, and interbedded with micaceous arkosic and vitric sandstone (Beeson and Tolan 1984; Map-Beeson et al. 1991). Major regional aquifers in the Troutdale Formation underlie east Portland. The thickness of the Troutdale Formation ranges from 900 feet near Troutdale to 200 to 300 feet in the western parts of the basin east of the Willamette River (Map-Beeson et al. 1991). The Troutdale Formation is expected to be thin or locally absent at the Moorings and is not a significant aquifer in the vicinity of the Moorings.

2.5.3 Catastrophic Flood Deposits

During the Pleistocene Era, thick deposits of boulders, gravels, sands, and silts accumulated throughout the Portland basin as a result of the repeated failures of glacial ice dams that impounded the ancient glacial Lake Missoula (Waitt 1985). These catastrophic flood deposits

form the terrace surfaces in the eastern Portland area and are composed of three different facies. Coarse-grained pebble to boulder gravels and sand make up the core of these terraces, with fine-grained sand and silt deposits mantling the coarser-grained facies. A finer-grained, interlayered silt, sand, and gravel facies is found adjacent to the Columbia and Willamette River channels. The coarse-grained facies reach a maximum thickness of 60 to 100 feet, whereas the fine-grained facies reach a maximum thickness of 100 to 130 feet. The channel facies typically range in thickness from 15 to 45 feet (Map-Beeson et al. 1991). Catastrophic flood deposits are not anticipated west of the Willamette River in the vicinity of the site; however, these deposits are regionally significant east of the Willamette River.

2.5.4 Recent Alluvium

Recent alluvium consists of Quaternary deposits of sands, silts, and gravels deposited by the Willamette and Columbia rivers. These deposits include the channel bottoms and floodplains of the rivers, and range in thickness up to 150 feet (Map-Beeson et al. 1991). In addition to geologic formations, anthropogenic surficial fill is common in many of the floodplain terraces adjacent to the Willamette and Columbia Rivers.

2.6 HYDROGEOLOGIC SETTING

Previous work at upgradient properties (GASCO and Siltronic) has shown that groundwater occurs in three hydrologic zones; the unconfined surficial fill water bearing zone (WBZ), the semi-confined alluvial WBZ, and the confined bedrock aquifers of the CRBG. It is assumed that similar conditions occur below the Moorings and, for the purpose of this investigation only, the unconfined surficial fill WBZ and the semi-confined alluvial WBZ are significant. A discussion of each of the zones, based on the previous upgradient site investigations, is presented below. The majority of the data presented in this section is from the prior work conducted at the GASCO and Siltronic sites. Unless the information presented specifically refers to the Moorings or another cited reference, it can be assumed that the information refers to GASCO or Siltronic investigations.

2.6.1 Groundwater Occurrence

At the regional scale, groundwater within the Portland Basin is expected to flow from recharge areas on hills and ridges toward discharge areas along stream valleys. In the vicinity of the Moorings, this means that groundwater is expected to flow to the northeast from the adjacent Tualatin Mountains toward the Willamette River. Similarly, groundwater across the Willamette River from Moorings is expected to flow southwest to the river, from the southwestern portion of the topographic high in the vicinity of St. John's and University Park.

With respect to the overall regional groundwater flow regime in the vicinity of the site, it is anticipated that the Tualatin Mountains form a regional groundwater recharge area to the southwest of the site. The Willamette River forms a regional groundwater discharge boundary with regard to the surficial fill WBZ and at least the upper to intermediate depth intervals within the alluvial WBZ.

Groundwater flow at the Moorings is expected to be consistent with that of the properties directly upgradient, predominantly horizontal and toward the Willamette River, based on the relatively small differences in groundwater elevations as measured. Vertical flow is generally downward across these zones nearest the Tualatin Mountains.

2.6.1.1 Low Permeability Silt Unit

Beneath the surficial fill WBZ and defining the surface of the alluvial unit, is a laterally extensive fine-grained silt unit. The silt unit beneath the upgradient GASCO and Siltronic properties has been found to range in thickness from approximately 40 to 70 feet near the central portion of the properties, thinning toward the river, where thicknesses of 1 to 3 feet are common at the riverbank. Beyond the riverbank, a thickening prism of silt has been identified.

2.6.1.2 Surficial Fill Water Bearing Zone

Immediately above the low permeability silt unit is the surficial fill WBZ. The saturated thickness of the surficial fill WBZ at the GASCO site typically ranges between 1 and 5 feet at locations adjacent to the river, and between 10 and 25 feet at the central and western portions of the GASCO site. At some locations adjacent to the river, the existence of the surficial fill WBZ appears seasonally dependent. Although the saturated thickness of the surficial fill WBZ seasonally becomes quite thin (2 to 3 feet) along the GASCO shoreline, dry conditions within soil borings or monitoring wells completed across this zone have not been identified at any time of the year.

Flow Direction

The overall groundwater flow direction across a majority of the Moorings within the surficial fill WBZ is interpreted as being similar to the GASCO property, flowing to the northeast, toward the Willamette River.

Horizontal and Vertical Gradients

The horizontal hydraulic gradient within the surficial fill WBZ calculated for the GASCO site ranges from 0.015 to 0.020 (Hahn 2006a). Vertically, a downward hydraulic gradient between the surficial fill WBZ and the alluvial WBZ is typical at the GASCO and Siltronic properties with a downward vertical gradient (potential) ranging from a 0.052 to 0.392. As such, groundwater in the surficial fill WBZ may be expected to migrate to the alluvial WBZ in areas where the underlying silt unit thins or does not otherwise impede downward flow.

Hydraulic Conductivity

Slug testing and analysis completed by Hahn in March 1996 at GASCO resulted in estimated hydraulic conductivities for the surficial fill WBZ ranging from 9.7×10^{-5} cm/sec to 9.1×10^{-3} cm/sec with one location exhibiting an anomalously low hydraulic conductivity of 2.4×10^{-6} cm/sec (Hahn 1998). The low hydraulic conductivity is likely a function of the tarry soils present at this well location within the former tar pond area. Slug testing completed by Hahn on surficial fill WBZ wells located at the Siltronic property resulted in hydraulic conductivities ranging from 2.3×10^{-4} to 5.4×10^{-4} cm/sec (Hahn 2005).

2.6.1.3 Alluvial WBZ from the GASCO Site

The alluvial WBZ consists of interbedded sands and silts underlying the silt unit. The thickness of the alluvial WBZ ranges from 2 to 25 feet at the central and western portions of the GASCO/Siltronic area, to up to 175 feet near the eastern corner of the GASCO site/northern corner of Siltronic site adjacent to the river. Although interbedded silts and sandy silts are present across various depth intervals within the alluvial WBZ, boring log data does not suggest the presence of separate hydrostratigraphic zones within the alluvial WBZ. Because monitoring wells were screened in various portions of the alluvial WBZ, for the purpose of groundwater flow evaluation, the alluvial WBZ was arbitrarily subdivided into upper (typically shallower than 85

feet bgs), intermediate (typically 85 to 125 feet bgs,) and lower (typically greater than 125 feet bgs intervals).

Flow Direction and Horizontal Gradient

Typical groundwater flow direction within the upper alluvial WBZ at GASCO (based on wells screened shallower than 85 feet bgs) is north-northeast towards the Willamette River, with a substantial flattening of the gradient within 300 feet of the riverbank where a very flat, tidally influenced, gradient exists. Very low gradients within the zone 300 feet from the river shoreline are common, with an occasional reversal of flow direction within this zone (i.e., away from the river) being noted. Overall groundwater flow direction within the intermediate-depth alluvial WBZ (based on wells screened between 85 to 125 feet bgs) was found to be to the northeast towards the Willamette River, with an average hydraulic gradient of 0.010 in December 2005 (Hahn 2007).

Although the limited number and distribution of lower alluvial WBZ wells at the GASCO site restricts the interpretation of flow direction within this zone, the groundwater potentiometric surface for the lower depth interval, as well as the presence of chemicals of interest (COIs) originating from the Rhone-Poulenc/Aventis project area to the south, indicates that this zone may have more of a northerly component than the shallower alluvial zones (Hahn 2005).

Vertical Gradients

At the GASCO site, vertical hydraulic gradients between upper alluvial WBZ and intermediate-depth alluvial WBZ typically range between –0.002 to -0.02 upward and between 0.002 and 0.07 downward, with the downward gradient occurrence predominating.

A very slight, but consistently upward hydraulic gradient between -0.0005 and -0.009 has been calculated between the lower and intermediate depth portions of the alluvial WBZ at the GASCO site, near the eastern corner of the property.

At the adjacent Siltronic property, a downward gradient ranging from 0.03 to 0.12 has been calculated between the upper-alluvial and intermediate-alluvial depth, while a consistent -0.03 upward gradient has been identified at the WS-13 location (Hahn 2005).

Consistent across both the GASCO and Siltronic sites is an overall upward vertical gradient tending to predominate between the lower and intermediate-depth intervals within the alluvial WBZ, with upward gradients of approximately -0.005 (Siltronic WS-16 location) and -0.04 being relatively consistent through time, and as noted above, upward gradients ranging from -0.0005 to -0.009 at the MW-5 location at GASCO.

Overall, water levels collected from the GASCO and Siltronic properties suggest that the vertical groundwater gradient in the alluvial WBZ is predominantly downward within the upper portions of the alluvial WBZ, and upward across the lower portions of the alluvial WBZ.

Aquifer Parameter Estimates and Linear Velocities

Estimated hydraulic conductivities for the alluvial WBZ beneath the GASCO site exhibit less variability than observed in the surficial fill WBZ. The calculated conductivities at the GASCO site range from a low of 2.9×10^{-5} cm/sec to a high of 5.3×10^{-4} cm/sec based on slug testing results. At the Siltronic site, the estimated hydraulic conductivity (based on slug testing) for the upper Alluvial WBZ were calculated and range from 9.7×10^{-5} to 1.4×10^{-4} cm/sec.

More extensive and likely more representative estimates of aquifer parameters for the alluvial WBZ were obtained from the GASCO site in 2005. The 2005 aquifer parameter evaluation was based on an aquifer pumping test as opposed to single well slug tests; therefore estimates of transmissivity and storativity were possible in addition to hydraulic conductivity. The aquifer testing involved the constant rate pumping of a well while simultaneously collecting drawdown data at numerous nearby observation wells. The methods for conducting the test and the subsequent evaluation were previously documented within an Aquifer Test Report (Hahn 2006b).

2.6.1.4 Columbia River Basalt Group

The Miocene-age CRBG, composed of a series of individual lava flows, generally forms the base (bedrock) of the Portland Basin and outcrops immediately to the southwest of the site in the Tualatin Mountains. Groundwater resources within the CRBG are typically limited to the interflow zones where sedimentation occurred between lava flows or within the rubble tops of the flows themselves, with these zones having the potential for relatively high horizontal permeability, but low vertical permeability due to overlying and underlying low permeability basalt flows (Hampton 1972). The presence of faulting can have the effect of isolating the more permeable inter-flow areas by positioning them against up-thrown or down-thrown basalt flows. Although yields may be high within the interflow areas, the storativities tend to be low due to low amounts of recharge.

2.6.2 Relationship between Groundwater and River Elevations

The results from continuous water level monitoring at GASCO indicate the presence of a direct and rapid response to tidally-influenced changes in Willamette River elevation within the shoreline alluvial WBZ wells. A similar, but subdued and delayed response to Willamette River tidal fluctuations was observed at a greater distance from the river in interior alluvial WBZ wells. Specifically, the crest-to-crest time delay between peak river level and peak groundwater elevation at wells adjacent to the shoreline was approximately 15 to 30 minutes, while the delay at a well 250 feet upland from the shoreline was approximately 4.5 hours. The preceding suggests direct hydraulic communication between the Willamette River and the alluvial WBZ, with river stage playing an important role with regard to groundwater transport and brief periods of flow reversal observed at the peak of most high tide cycles.

Results of continuous water level monitoring within the surficial fill WBZ at GASCO did not identify a pronounced short-term direct relationship between tidal fluctuations of the Willamette River and water levels within the surficial fill WBZ. However, long-term, seasonal fluctuations in river level were generally matched by similar fluctuations of groundwater level within the surficial fill WBZ wells. The preceding suggests that although discharge of groundwater from the surficial fill WBZ to the Willamette River is expected, it appears that a degree of isolation exists between these features as daily fluctuations in river level do not appear to have an impact on groundwater levels or flow within the surficial fill WBZ.

A relatively thick (greater than 10 feet) layer of silt is present in near shore sediments adjacent to the GASCO and Siltronic sites, extending 200 to 300 feet from the shoreline (MFA 2005, Anchor 2004). It is expected that the fine-grained silt materials impede near shore discharge of groundwater to the river from both the surficial fill and the upper portions of the alluvial unit. Although this silt may impede flow, the tidal response data would not suggest it acts as a barrier to flow.

2.7 CLIMATOLOGY

The following data and description of the local climate was obtained from the National Weather Services, Portland Office Local Climate Data from Portland International Airport, as compiled online (Rockey 2007).

Official weather records began in 1871 in downtown Portland by the Signal Corps of the U.S. Army. Weather was observed from various downtown sites from 1871 through 1928. In 1928, the Portland Airport opened near what is presently the Swan Island Shipyards. Weather recording instruments were moved to this new location approximately 3 miles northwest of downtown Portland (note, the Swan Island Shipyards are just under 4 miles southeast from the Moorings). In 1940, the weather stations were relocated to the then new Portland International Airport, located 9 miles northeast of downtown Portland on the south banks of the Columbia River. The Moorings is approximately 8 miles to the west and south of the Portland Airport.

The City of Portland is located at roughly 20 feet above msl and approximately 65 miles inland from the Pacific near the convergence of the Willamette and Columbia Rivers. It lies midway between the Coast Range (west) and Cascade Range (east) at the northern end of the Willamette River Valley.

The Coast Range provides limited shielding from Pacific Ocean storms whereas the Cascade Range provides a barrier to cold air masses that migrate from Canada. The high Cascades also provide an obstacle to moisture laden westerly winds, resulting in moderate rainfall for the region. On average, Portland has 155 days of measurable precipitation with 90% of the rainfall occurring within the months of October through May. Summers are relatively dry with an average 3% rainfall in July and August. Precipitation varies across the Portland metropolitan area. The West Hills (which includes the area of the Moorings) receives 60 inches of rain per year, but the airport to the east only receives about 36 inches. An occasional arctic air mass does enter the region via the Columbia River Gorge resulting in freezing rain and snow in elevations above 500 feet. This occurs an average of four days per year.

Temperatures are generally mild. Typical winter temperatures reach the 40s and lower 50s, with night lows in the 30s. As mentioned above, an occasional cold air blast does reach the area; however, temperatures below zero degrees are rare, occurring only six times since 1871[2]. Spring weather remains wet and cool with temperatures rising to the 60s and 70s at the start of the dry summer months. Afternoon highs in the 80s and low 90s are a regular occurrence during the summer months. Late summer remains warm and dry in general with fall temperatures returning back to the 60s in October. On average, the last occurrence of 32 degrees is late March with the first of fall occurring in early-mid November.

Severe storms are rare in the area. Surface winds seldom exceed gale force (50 miles per hour [mph]). Average wind speeds at the Portland International Airport monitoring station range from a low of 6.5 mph in September to a high of 10 mph in January. Thunderstorms can occur throughout the year, but are uncommon. Summer thunderstorms can produce strong winds, large hail, and prolific lightening. Winter and spring thunderstorms are generally weak with brief gusty winds and light hail.

In February 1996 a flood covered the site with several feet of water and caused the slope in the laydown area to weaken and fail. (The repaired area is the Slump Management Unit, discussed

[2] To date, 2007

in Section 4.1.2.3.5 (page 4-20). After the flood, the failure was repaired, a French drain was installed, and the entire laydown area was overlain with gravel.

Table 2-1 (page 2-27) includes a condensed climatic table from the National Weather Service for the Portland area.

2.8 TERRESTRIAL HABITAT

2.8.1 Upland

The Moorings consists of approximately 10 land acres. The southern half of the property consists of asphalt paving where not covered with buildings. The remaining land surface to the north is a mix of concrete pavement and hard packed gravel, 6 to 9 inches deep.

Occasional opportunistic vegetation is present. In addition, small areas of landscaped grass are present (approximately 1,000 square feet throughout the property). A visual survey of neighboring properties shows predominantly grass/low shrub habitats interspersed with areas of tall trees.

While a variety of species are common to the Portland Metropolitan area (Audubon 2008a, Audubon 2008b), due to the limitation of vegetation, the Moorings should not be considered a habitat area; however, the Moorings may be used as intermediate areas of protective cover for species located on adjacent properties.

2.8.2 Riverbank

The Moorings is bordered by the Willamette River. The river border is approximately 1,460 linear feet of armor rock riprap with a small section covered with Oregon Blackberry shrubs. While the blackberry shrubs may provide protective cover for native birds or waterfowl, it is unlikely to be used as a permanent habitat due to the lack of any other nearby vegetation.

In addition to the land acres, the Moorings also includes approximately three acres of submerged lands partially covered by 26,700 square feet of dock. In the middle section of the site there is a riverbank in the basin where a natural sandy beach becomes apparent at low tide and marks the original water line. Only a concrete riprap slope directly above the sandy beach is visible at high tide.

Table 2-1 Portland's Condensed Climatic Normals and Extremes

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
TEMPERATURE (Deg. F)													
Normals													
-Daily Maximum	45.4	51.0	56.0	60.6	67.1	74.0	79.9	80.3	74.6	64.0	52.6	45.6	62.6
-Daily Minimum	33.7	36.1	38.6	41.3	47.0	52.9	56.5	56.9	52.0	44.9	39.5	34.8	44.5
-Monthly	39.6	43.6	47.3	51.0	57.1	63.5	68.2	68.6	63.3	54.5	46.1	40.2	53.6
Extremes													
-Record Highest	63	71	80	87	100	100	107	107	105	92	73	65	107
-Record Lowest	-2	-3	19	29	29	39	43	44	34	26	13	6	-3
MEAN NUMBER OF DAYS:													
Precipitation: .01 inches or more	18.0	15.6	16.9	14.4	11.8	9.2	3.9	4.9	7.5	12.3	18.0	18.7	150.9
Snow, Ice Pellets, Hail 1.0 inches or more	1.0	0.3	0.1	0.0	0.*	0.0	0.0	0.0	0.0	0.0	0.1	0.5	2.1
Thunderstorms	0.*	0.1	0.5	0.9	1.5	0.9	0.8	1.0	0.7	0.4	0.3	0.1	7.1
Temperature Deg. F													
-Maximum													
90 Deg. F and above	0.0	0.0	0.0	0.0	0.3	1.2	3.6	3.7	1.8	0.1	0.0	0.0	10.8
32 Deg. F and below	2.1	0.3	0.*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.8	3.5
-Minimum	13.0	8.1	4.6	0.9	0.1	0.0	0.0	0.0	0.0	0.6	5.1	9.6	42.1
32 Deg. F and below	0.*	0.*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*
0 Deg. F and below													
PRECIPITATION (in.)													
Water Equivalent													
-Normal	5.35	3.85	3.56	2.39	2.06	1.48	0.63	1.09	1.75	2.7	5.34	6.13	36.30
WIND													
Mean Speed (mph)	10.0	9.2	8.3	7.4	7.1	7.2	7.6	7.1	6.5	6.5	8.6	9.6	7.9
Prevailing Direction through 1964	ESE	ESE	ESE	NW	NW	NW	NW	NW	NW	ESE	ESE	ESE	ESE

SOURCE: National Weather Service Portland, Oregon. 9 September 2009 </www.wrh.noaa.gov/pqr/pdxclimate/PG105.html>
Notes
0.* or * - The value is between 0.0 and 0.05.
Normals - Based on the 1961 - 1990 record period.
Extremes - Dates are the most recent occurrence.

LATITUDE: 45 Deg. 36 Min. N LONGITUDE: 122 Deg. 36 Min. W ELEVATION: FT. GRND 21 BARO 27 TIME ZONE: PACIFIC WBAN: 24229

2.9 PREVIOUS INVESTIGATIONS AND REMOVAL ACTIVITIES

Key reports from previous investigations were reviewed to assess the usability of the data and to identify possible gaps in the current understanding of site conditions. Several recent field investigations and removal actions have been conducted at the Moorings and are summarized below. Figure 2-12 (page 2-35) illustrates the previous sampling locations in the uplands and in-water portion of the Moorings. A summary of previous investigations and removal actions is described in the following sections. After review of the past activities on site, it was determined that no comprehensive upland investigations have been conducted and that most of the existing data was too old or of unknown quality and will not be used in any site evaluations.

2.9.1 Upland Investigations

2.9.1.1 1984 Underground Storage Tank Removal

A 1,000-gallon gasoline underground storage tank (UST) was reportedly removed from the southwest corner of Building 17 in approximately 1984 (USACE 2008). Anecdotal evidence states that the UST began leaking in the late 1970s (USACE 2008). There are no records of the tank removal. The USACE hired a contractor in 1999 to attempt to locate the tank. The contractor was unable to find the tank using visual, magnetometer, and soil probing methods.

2.9.1.2 1990 U.S. Moorings Feasibility Study

In 1990, a feasibility study (FS) was conducted in advance of proposed construction in the southern area of the site of a building for office, warehouse, and storage space (USACE 1990a). The study consisted of a cultural resources report, a building history, a site utilities report, a Level 1 preliminary site assessment, and preliminary geotechnical evaluation. The study concluded that the construction would not adversely affect any significant cultural resources. The Level 1 assessment concluded that the possibility exists for historical releases surrounding the UST and fuel island and the open storage area near the westerly warehouses. The assessment also concluded that the off-site sources to the north, Advanced American Construction (formerly General Construction Company) and to the south, NW Natural (formerly GASCO) were potential contaminant sources that could impact groundwater beneath the site. It is not clear if any samples were collected during this study. A geotechnical cross section was included with this study based on 1981 borings conducted by the USACE. The study was not finalized and only a partial copy of a draft document is available (USACE 2008).

2.9.1.3 1993 Preconstruction Geotechnical and Hazardous Waste Study

A subsurface geotechnical investigation was conducted by Squier Associates in 1992–1993 in advance of proposed modifications to the warehouses at the northwest end of the site (USACE 1993a). The investigation included surface and subsurface soil sampling for contamination. Surface samples in the gravel equipment laydown area on the north side of the site showed evidence of small spills of oil from equipment and metals contamination from open sandblasting. Contamination of lead (up to 1,300 milligram per kilogram [mg/kg]), copper (up to 11,000 mg/kg), zinc (up to 3,800 mg/kg), nickel (up to 4,800 mg/kg), chromium (up to 1,600 mg/kg), arsenic (up to 190 mg/kg), and total petroleum hydrocarbons (TPHs) (up to 36,000 mg/kg) was found in surface soils (see Figure 2-12, page 2-35, for sampling locations). A detection of petroleum-contaminated soil in a sample collected immediately beneath the paved parking lot at the west end of the facility was also noted (sample location CBR-6 reported 2,400 mg/kg TPH diesel/bunker oil). The contamination was limited to a narrow vertical horizon. No significant contamination was found at depth across the site. The depth to groundwater was

measured during drilling; however, no groundwater samples were collected. The proposed warehouse was not constructed.

2.9.1.3.1 1993 Sandblast Area Clean-up

As a result of the geotechnical study finding discussed above, the USACE directed a cleanup of surface soil in four areas at the northwestern portion of the site where historic sandblast activities occurred (USACE 1993b). At two of the cleanup areas (Area 1, the northwestern most corner of the site, and Area 2 along the western bulkhead wall), visible sandblast grit was removed. Soils that were visually impacted with petroleum hydrocarbons were removed from the other two areas (Areas 3 [gravel storage yard] and 4, east of and adjacent to warehouse storage Buildings 21 and 24). A total of 239 tons of soil were removed from the four areas and disposed of off site. The four areas are shown on Figure 2-12 (page 2-35).

In Area 1, visible grit was removed to a depth of 2 to 8 inches bgs over an approximately 2,000 square foot area. In Area 2, an 8 to 12 inch bgs layer over an approximately 4,500 square foot area was removed. A composite of the spent grit in each area was analyzed for polychlorinated biphenyls (PCBs), TPH, solvents, and Toxicity Characteristics Leaching Procedures (TCLP) metals. TCLP barium was detected above detection limits at 0.07 milligrams per liter (mg/L) in Area 1 and in Area 2, while barium, chromium, and lead were detected; they were at levels below hazardous waste limits (USACE 2008).

Composite samples were collected from a 100 square foot section at Area 3. Composite samples from the 2 to 6 inch horizon were analyzed and tested for TPH and PCBs. Aroclor© 1254 was detected at 0.5 parts per million (ppm) and TPH was detected at 102,000 ppm (USACE 2008). Approximately 18 inches of soil was removed and confirmation sampling showed a TPH detect at 40 mg/kg and PCBs were not detected.

Area 4 was sampled before excavation of approximately 10 square feet of soil over asphalt from a petroleum spill; TPH was detected at 89,000 mg/kg and PCBs were not detected. Removed soils were profiled for disposal.

2.9.1.4 1994 Underground Storage Tank Removal

A 5,000 gallon gasoline UST located immediately north of Building 1 was removed in October 1994 in accordance with Oregon Department of Environmental Quality (ODEQ) rules (USACE 2008). In 1993, the UST was successfully tightness tested and still appeared sound upon its removal. The removal effort required excavation of asphalt and concrete, which were moved off site. Two soil samples were collected at either end of the tank and showed non-detect by Oregon Hydrocarbon Identification analysis (USACE 2008). The excavation area was backfilled with excavated material as well as acquired granular backfill and then repaved.

2.9.1.5 1994 Preliminary Assessment

A preliminary assessment was conducted in 1994 for USEPA consideration of the site for inclusion on the NPL (USACE 1994a). No sampling was completed during the preliminary assessment. USEPA reviewed the preliminary assessment in 1995 and referred the evaluation of upland operations and potential cleanup to the State of Oregon (USEPA 1995).

2.9.1.6 1994 Sandblast Area Investigation (upland portion)

Following a review of the preliminary assessment by USEPA in 1994 (Section 2.9.1.5, page 2-29) an additional investigation surrounding the areas used for sandblast activities was conducted in December 1994 to evaluate the effectiveness of previous cleanup effort (Section 2.9.1.3.1, page 2-29) (USEPA 1995). Nine upland samples, discussed below, and nine sediment samples, discussed in Section 2.9.2.2 (page 2-31), were collected.

One in-water and two upland samples were collected at background locations. The samples were analyzed for the 13 priority pollutant metals (arsenic, antimony, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc). The background samples had detectable concentrations of arsenic, chromium, copper, lead, nickel, and zinc. Upland surface soils contained concentrations of arsenic (up to 9 mg/kg), chromium (up to 51 mg/kg), copper (up to 66 mg/kg), lead (up to 110 mg/kg), nickel (up to 28 mg/kg), and zinc (up to 209 mg/kg).

2.9.1.7 1996 Storage Shed Removal Action

The storage shed was historically used for the storage of small quantities of fuel and various hydraulic and lubricating oils associated with lawn maintenance equipment. The shed was located north of the machine shop (Building 19) and southwest of the oil and paint storage (Building 15). Stained soils were discovered at the shed during an environmental audit conducted by the USACE in October 1995 (USACE 1999). To evaluate whether the stained soils were above generic industrial cleanup standards, two surface soil samples were collected by a USACE District Environmental Response Team. The two samples were a composite of unknown aliquots; one was collected at the surface and the other collected at 6 to 12 inches bgs. The samples were analyzed for a full priority pollutant scan (USACE 2008).

The results of three subsequent verification samples reported concentrations of semivolatile organic compounds (SVOCs) and arsenic slightly above the ODEQ industrial soil cleanup standards. Petroleum hydrocarbons were also reported at 1,300 mg/kg in the shallowest sample. Based on the exceedances, a decision was made to remove a 12- by 24-foot section of soil to a depth of 18 inches across the area. The soil was removed by the District Environmental Response Team on July 19, 1996, and disposed of off site. The results of three subsequent verification samples reported concentrations of the SVOCs and arsenic above the cleanup standards. Petroleum hydrocarbons were reported at 23 mg/kg in one sample. The shed was removed from the site and the area was backfilled with clean gravel. This area is no longer used to store hazardous substances.

2.9.2 In-Water Investigations

Since 1989, several in-water investigations have been conducted to allow for maintenance dredging, delineation of the in-water impact associated with upland activities at the former sandblast activity area, assessment for a new dock, and assessment of sediment quality as part of the Portland Harbor RI/FS. Figure 2-12 (page 2-35) illustrates the previous sampling locations discussed in this section.

2.9.2.1 1989 Dock A Sediment Sampling

In 1989, sediment samples were collected from three cores on the river side of Dock A prior to maintenance dredging (USACE 1990b). DDD was detected at 0.47 mg/kg, DDT at 0.2 mg/kg, lead at 335 mg/kg, low-molecular-weight polycyclic aromatic hydrocarbons (LPAHs) at 70.2 mg/kg, and high-molecular-weight PAHs (HPAHs) at 80.3 mg/kg. A composite sediment

sample analyzed for dioxins showed a tetrachlorodibenzo-p-dioxin (TCDD) equivalence of 7.76 nanogram per kilogram (ng/kg). This investigation was accomplished in advance of maintenance dredging. Because contaminants were detected, dredging plans were suspended.

2.9.2.2 1994 Sandblast Area Investigation (In-Water Portion)

Following a review of the preliminary assessment by USEPA in 1994 (Section 2.9.1.5, page 2-29), an additional investigation surrounding the areas used for sandblast activities was conducted in December 1994 to evaluate the effectiveness of the previous cleanup effort (Section 2.9.1.3.1, page 2-29) (USEPA 1995). Nine sediment samples were collected just off shore and analyzed for priority pollutant metals (USEPA 1995).

Concentrations of arsenic (up to 60 mg/kg), chromium (up to 130 mg/kg), copper (up to 140 mg/kg), lead (up to 100 mg/kg), nickel (up to 50 mg/kg), and zinc (up to 638 mg/kg) were found in the sediment samples collected just offshore of the sandblasting area. Nine upland samples were also collected and were discussed previously in Section 2.9.1.6 (page 2-30).

2.9.2.3 1994 Dock and Basin Sediment Sampling

Additional surface sediment samples were collected in June 1994 in preparation for construction of a dock in the small boat basin (USACE 1994b). Samples were analyzed for metals, PAHs, tributyltin (TBT), PCBs, pesticides, SVOCs, and dioxins. Numerous PAHs were detected, with total PAHs exceeding 60 mg/kg in some cases. TBT up to 0.41 mg/kg bulk and DDT up to 0.2 mg/kg were found. Metals results showed maximum concentrations of arsenic at 6.7 mg/kg, chromium at 56.4 mg/kg, copper at 97.8 mg/kg, nickel at 33 mg/kg, zinc at 175 mg/kg, and lead at 86.9 mg/kg. Dioxins were detected in several samples.

2.9.2.4 1995 Sediment Quality Evaluation

Sediment core samples were collected again from cores near docks A and B in preparation for maintenance dredging in 1995 (USACE 2002b). Core sampling was conducted within the dredging prism, with additional samples collected beneath the prism. Sediment samples were collected from cores near docks A and B in 1995 in preparation for dredging (USACE 2002b). Core sampling was conducted within the dredging prism, with additional samples collected beneath the prism.

- Concentrations of lead, the only metal analyzed, were found up to 618 mg/kg from a sample collected beneath the dredge prism.
- TBT was not detected at a reporting limit of 3 micrograms per kilogram (μg/kg).
- The following pesticides were detected above reporting limits: alpha-benzene hexachloride (BHC), aldrin, DDD, DDE, DDT, heptachlor epoxide, gamma-BHC (lindane), dieldrin, and endrin aldehyde. The highest levels of pesticides reported were 2.5 mg/kg of DDT, 2.0 mg/kg of DDD, 0.1 mg/kg of DDE, and 0.54 mg/kg of gamma-BHC.
- All samples had detectable concentrations of PAHs. Concentrations of HPAHs ranged from 8.41 mg/kg to 549.5 mg/kg. LPAHs had total concentrations ranging from 2.24 mg/kg to 456.6 mg/kg.

2.9.2.5 1997 Portland Harbor Sediment Study

In March 1997, ODEQ and USEPA began a joint study of river sediments in the Portland Harbor area. Near-shore sediment samples were collected in September and October 1997 (when the Willamette was at its lowest seasonal levels) and analyzed for a variety of contaminants. The study, completed in May 1998, found sediments throughout the harbor area to be contaminated with metals, polynuclear aromatic compounds, PCBs, chlorinated pesticides, and dioxins. Levels of these compounds appeared to be highest adjacent to on-shore sites already known to be contaminated.

A total of 227 sediment samples were collected by the USEPA in 1997 as part of a site inspection of Portland Harbor between Willamette RM 3.5 and 9.5 (USACE 1998). Thirteen core and surface sediment samples were collected during the investigation on the south side of the river between RM 6.0 and 7.0 (the Moorings is on the south side of the river at RM 6.08-6.21). The following indicator chemicals were reviewed for the samples collected between RM 6.0 and 7.0:

- PCBs - ranging between 0.051 mg/kg and 0.057 mg/kg,
- Benzo(a)pyrene - ranging between 0.024 mg/kg and 57 mg/kg,
- Chromium - ranging between 18.6 mg/kg and 42.5 mg/kg,
- Lead - ranging between 9 mg/kg and 89 mg/kg,
- Dioxins, as measured in TCDD toxicity equivalents - found in one sample at 2.76 ng/kg, and
- DDT - ranging between 0.0039 mg/kg and 0.32 mg/kg.

2.9.2.6 2002 Limited Sediment Investigation

In September 2002, a limited investigation of sediments in the Willamette River near the docks was conducted (USACE 2002b) to evaluate the impact on berthing and docking procedures with respect to sediment resuspension. This study indicated that chemical concentrations in sediments within the approach channel and berthing area were higher than similar chemical concentrations in sediments at the locations sampled downriver. As a result, the USACE implemented operational changes to berthing procedures to minimize or eliminate the resuspension of sediments during vessel docking.

Concentrations of chemicals detected in composite sediment samples collected from the berthing area and approach channels at the Moorings follow.

- Total HPAH concentrations ranged from 3 mg/kg to 152 mg/kg. Total LPAH concentrations ranged from 0.7 mg/kg to 98 mg/kg. Maximum concentrations of individual SVOCs included phenanthrene at 60 mg/kg, fluoranthene at 6.5 mg/kg, and pyrene at 1 mg/kg.
- Maximum concentrations of pesticides included 4,4′-DDE at 0.002 mg/kg and 4,4′-DDD at 0.074 mg/kg.
- No PCB compounds were detected.

- Maximum detected metals concentrations included antimony at 0.7 mg/kg, cadmium at 0.7 mg/kg, total chromium at 48 mg/kg, copper at 63 mg/kg, lead at 36 mg/kg, mercury at 0.43 mg/kg, and zinc at 203 mg/kg.
- Detected concentrations of TBT ranged from 0.009 mg/kg to 0.014 mg/kg.
- Maximum concentration of cyanide was reported at 2.0 mg/kg.
- TPH-Diesel ranged from 52 mg/kg to 3,500 mg/kg.
- TPH-Motor Oil ranged from 110 mg/kg to 2,300 mg/kg.

2.9.2.7 Lower Willamette Group RI/FS Round 2

The LWG conducted multiple sediment sampling efforts between the fall/winter of 2004 and the spring/summer/fall of 2005 as part of the Portland Harbor RI/FS. The purpose of this sediment sampling effort (referred to as Round 2) was to collect the major sediment data set for the RI and risk assessment, and to initiate data collection for the FS.

The Round-2 sediment sampling involved:

- Collection of sediment samples along the shoreline in potential shorebird and human beaches;
- Collection of surface sediment samples in the riverbed;
- Collection of subsurface sediment samples and physical data; and
- Collection of radioisotope cores in the Study Area as part of the FS monitored natural recovery assessment.

The LWG collected a third round (referred to as Round 3) of sediment samples the results of which were not reviewed prior to this investigation.

2.9.3 Adjacent Sites - Previous Investigations

2.9.3.1 Remedial Investigation Report, NW Natural - GASCO

The property to the south of Moorings, currently owned by NW Natural, was previously the GASCO facility, a producer of Manufactured Gas Products (MGP) [3]. NW Natural conducted a RI and the final report summarizes the upland conditions at the GASCO facility (Hahn 2007). Process residuals confirmed at the site include purifier box wastes resulting from use of lime and metal oxides to remove sulfur and cyanide from product gas. Spent oxide wastes were piled at the northeast portion of the GASCO site, immediately adjacent to the Moorings (Figures 3-1 through 3-4, pages 3-11 through 3-14).

Contaminants identified in the GASCO RI associated with spent oxide wastes include non-aqueous phase liquids (NAPL), trace metals, cyanide (predominately as ferrocyanates), PAHs, and benzene, toluene, ethylbenzene, and xylenes (BTEX). MGP related tars and NAPL were present in surfical fill and upper silt layer throughought the formor production areas of the gas plant. Dense non-aqueous phase liquid (DNAPL) was found to have migrated vertically into the

[3] NW Natual – GASCO is discussed in more detail under Section 3.1 (page 3-1), Potential Sources of Contamination

alluvial unit. PAH concentrations were found to be the highest in the former tar pond area for both surface and subsurface areas.

The GASCO RI reports that the most common forms of cyanide at MGP sites are complexed with iron – most prominently Prussian Blue or ferric-ferrocyanide. Samples collected at stations with the greatest total cyanide concentrations exhibited the characteristic iridescent blue associated with “Prussian Blue”.

2.9.3.2 Offshore Investigation Report, NW Natural - GASCO

NW Natural conducted off-shore sediment, groundwater, and surface water sampling in the Willamette River off of the GASCO site from July 2006 through October 2007 (Anchor 2008). The investigation reported that benzene, naphthalene, and cyanide concentrations in shallow shoreline sediments are generally higher than the groundwater concentrations from similar intervals collected upland. The report suggests that this is indicative of materials that have accumulated in the shallow sediment and indicates that the concentrations derive from spent oxide wastes that historically were deposited or discharged to the shallow sediments along the shoreline. The report further suggests that total cyanide concentrations in groundwater the deeper alluvium are higher than the sediment concentrations as a result of adsorption from the upland groundwater plume.

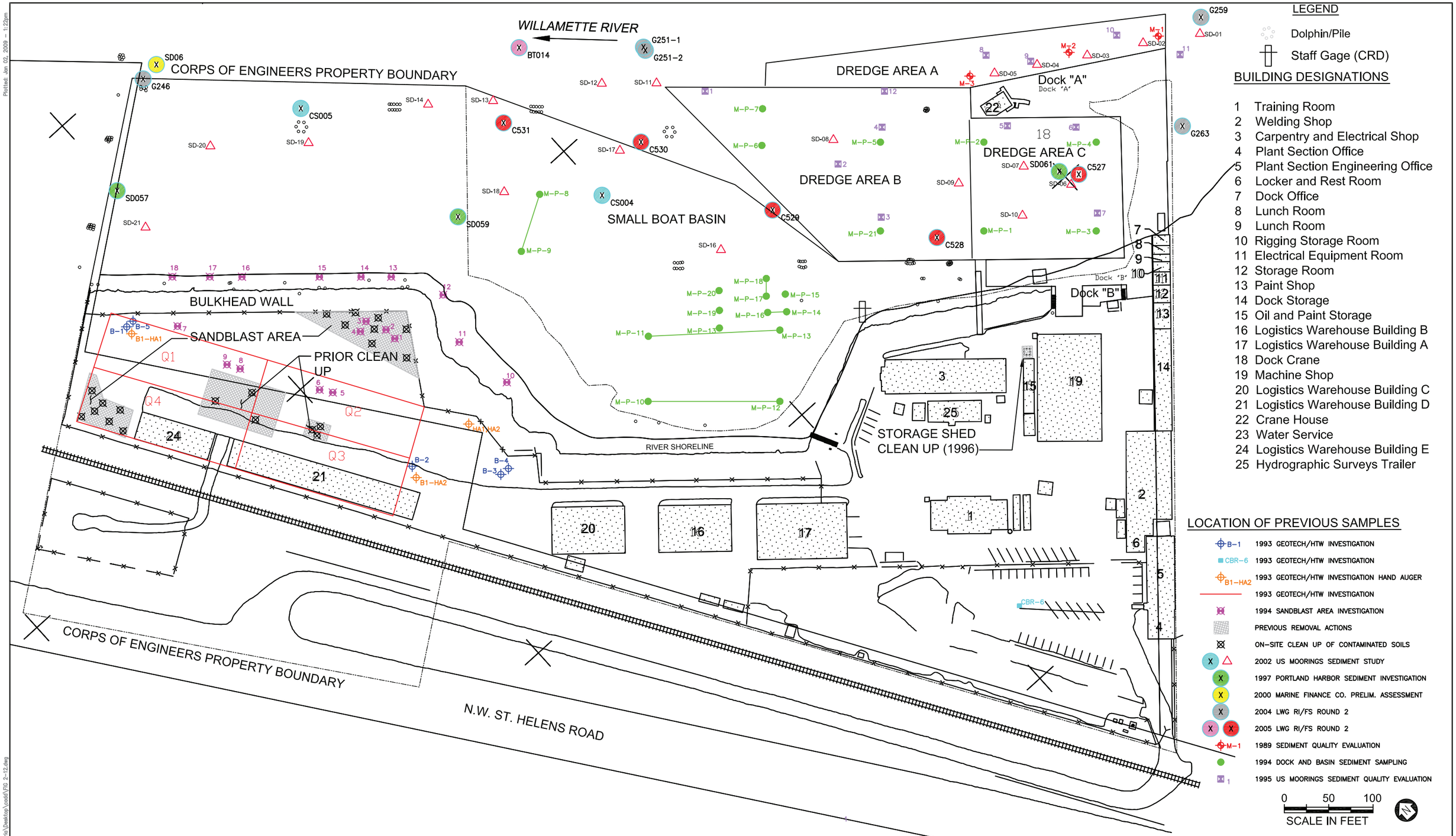
2.9.3.3 2000 Marine Finance Company Expanded Preliminary Assessment

In August 2000, an expanded Preliminary Assessment was conducted by Jacobs Engineering on behalf of ODEQ. The subject property is currently owned by Advanced American Construction which borders the Moorings to the north. The expanded assessment was conducted to assess the nature and extent of contamination of soil on site and sediment located adjacent to the site. Jacobs Engineering completed the removal of abandoned waste containers, batteries, and drums at the facility in May 2001. The assessment included collecting six groundwater samples, five Willamette River sediment samples (Figure 2-12, page 2-35), and 13 soil samples. In general, the expanded Preliminary Assessment indicated that there was not widespread contamination at the site, but a full evaluation of potential impacts to the Willamette River had not been completed (ODEQ 2004). Analytical results of this assessment are not available.

2.9.4 Stormwater Discharges

Stormwater runoff monitoring data has been collected and submitted to the ODEQ since June 1995 (USACE 2002b). The data is collected to meet the biannual sampling requirements associated with the Moorings’ National Pollutant Discharge Elimination System (NPDES) General Permit - Industrial Stormwater Discharges (Permit # 14396, GEN12Z Industrial Stormwater, Class: minor). The current permit was issued in April 1998, renewed in September 2007 without modification, and expires on June 30, 2012.

The two outfalls from oil/water separators (numbered 5 and 10 in Figure 2-13, page 2-37) are monitored for total metals (copper, lead, and zinc), pH, total suspended solids (TSS), oil and grease, and visual indicators (floating solids or sheen). Isolated exceedances over the past 5 years of some permit limits have been detected in recent sampling rounds (e.g., copper and TSS). Location 5 has had the most exceedances (i.e., metals) and is located where most of the industrial operations occur. Figure 2-13 (page 2-37) provides a general layout of the outfall locations and associated catch basins.



No.	DATE	BY	REVISION

JOB No. | DESIGNED: | PROJ. ENGINEER:
SCALE: | DRAWN BY: | APPROVED BY:
CHECKED BY: | DATE:

WARNING
0 1/2 1
IF BAR DOES NOT MEASURE 1" AT FULL SIZE, THEN SCALES ON DRAWING NOT TO SCALE.

TEC Inc.
1450 114th Ave S.E.
Suite 220
Bellevue, Wa 98004
425.453.4040
425.454.7043 fax

US GOVERNMENT MOORINGS

REMEDIAL INVESTIGATION

PREVIOUS UP-LAND AND IN-WATER INVESTIGATIONS AND REMOVAL ACTIONS (INCLUDES LWG SAMPLES)

DRAWING NUMBER: FIGURE 2-12
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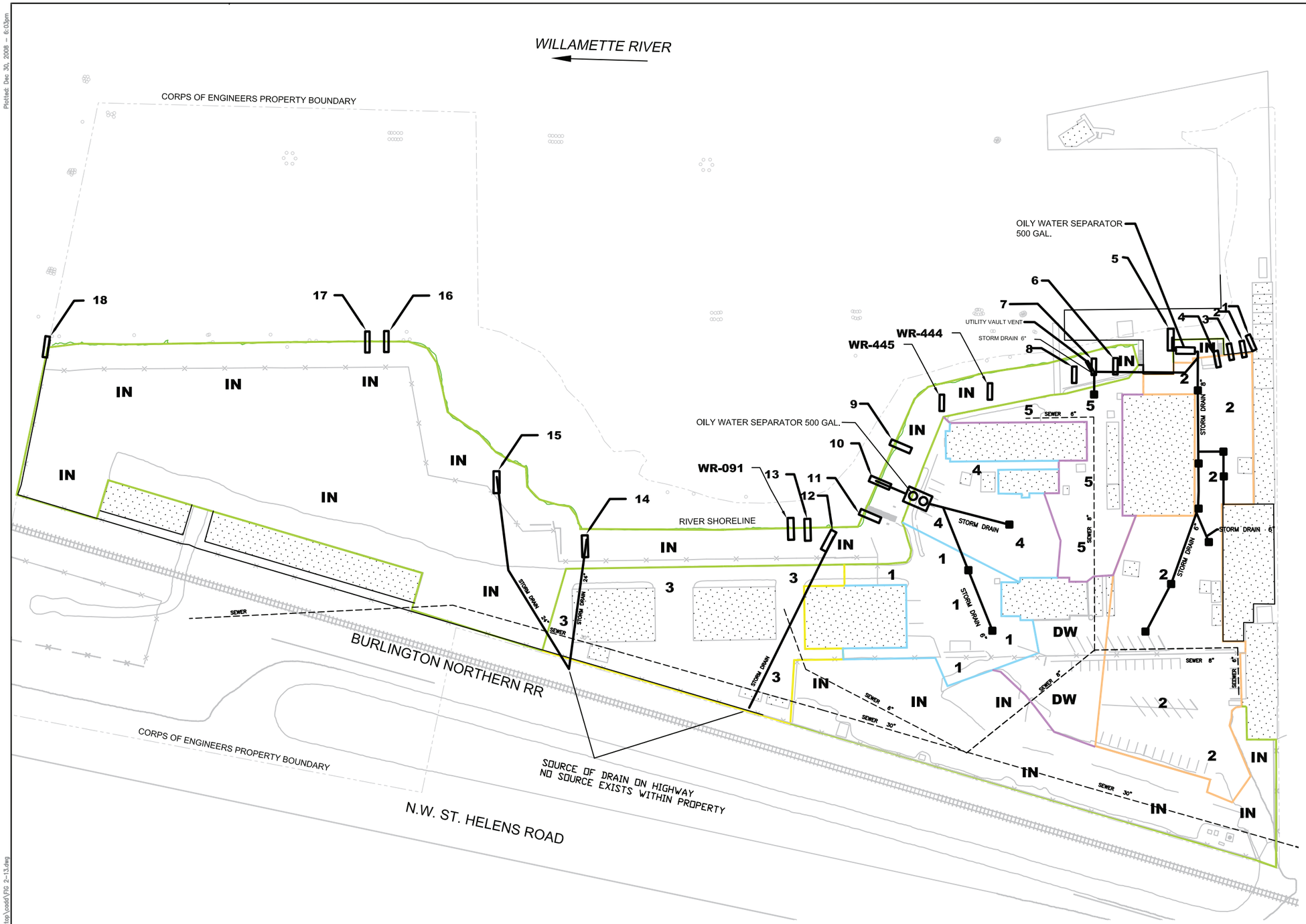

DRAINAGE AREAS

- IN — Infiltration, or Drainage to Infiltration Zone
- DW — Dry Well, no Off-Site Drain
- 1 — Drainage Area 1
- 2 — Drainage Area 2
- 3 — Drainage Area 3
- 4 — Drainage Area 4
- 5 — Drainage Area 5

OUTFALLS

1 6" PVC drainage from yard shop roof
2 6" PVC drainage from yard shop roof
3 12" steel roof drain (abandoned)
4 4" steel unknown drain (abandoned and capped)
5 6" PVC oily water separator outfall B
6 Steel machine shop sink drain (abandoned)
7 Utility vault vent
8 12" steel drain from battery room
9 4" steel storm water outfall (abandoned)
10 6" PVC oily water separator outfall A
11 4" steel storm water outfall (abandoned)
12 Concrete outfall from DOT
13 6" PVC warehouse roof drain
14 Storm drain from DOT
15 Storm drain from DOT
16 6" PVC french drains
17 6" PVC french drains
18 24" steel (Storm drain in from DOT)

Provided by LWG:

WR-444 Active outfall (4") Corrugated plastic, Drains (1) downspout to bldg. 3, located behind smoker shack.

WR-445 Active outfall (4") Corrugated plastic, Drains (1) downspout to bldg. 3, located NE corner.

WR-091 Unknown (8") Concrete, Attempted to dye and smoke test this location to verify its orgin. Pipe appears to be capped or plugged ~2' up gradinet but could not be verified.

Legend

- Sewer pipeline
- Storm drain pipeline
- Storm drain inlet
- Outfall location

0 50 100
SCALE IN FEET

BASEMAP SOURCE: USACE-PORTLAND DISTRICT(MOORINGS_DRAINAGE MAP FIG 3.DWG)

No.	DATE	BY	REVISION

JOB No. | DESIGNED: | PROJ. ENGINEER:
SCALE: | DRAWN BY: | APPROVED BY:
CHECKED BY: | DATE:

WARNING
0 1/2 1
IF BAR DOES NOT MEASURE 1" AT FULL SIZE, THEN SCALES ON DRAWING NOT TO SCALE.

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US GOVERNMENT MOORINGS

REMEDIAL INVESTIGATION

STORM DRAIN MAP

DRAWING NUMBER: FIGURE 2–13
CAD FILE NUMBER:
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REV.

Plotted: Dec 30, 2008 – 6:03pm
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3.0 CONCEPTUAL SITE MODEL

A Conceptual Site Model (CSM) was developed for the Moorings as a part of the RI planning process (see *Management Plan for Remedial Investigation – Work Plan for U.S. Moorings, Portland, Oregon [KTA/TEC 2008]).* The CSM used historical records and readily available information to:

- Describe the Moorings, its environmental setting, and the nature of activities that have taken place on-site and at nearby sites;
- Identify potential sources and types of environmental contamination at the site;
- Identify potential contaminant transport pathways and possible human and ecological receptors;
- Describe potential human health and ecological exposure scenarios;
- Identify gaps in the current understanding of the site that potentially require investigation during the RI; and
- Provide guidance for the development of the RI objectives, tasks, methods, and decision criteria/rationale.

This section highlights key components of the CSM as presented in the RI Management Plan (KTA/TEC 2008). It is intended to serve as a link between the site background information presented in Section 2, the RI investigation strategy presented in Section 4, and the RI results summarized in Section 5. Moreover, it provides with the foundation needed to critically review and understand the nature and extent of contamination at the site (Section 6) and potential human health and ecological risks that may be present (Section 7).

The Moorings CSM description includes a brief review of human health and ecological risk considerations for the site (Section 3.1, page 3-1); a summary of site features and activities (Section 3.2, page 3-3); potential contaminant sources and COIs (Section 3.3, page 3-3); characteristics of the site setting (Section 3.4, page 3-15); descriptions of potential exposure pathways (Section 3.5, page 3-16); and a summary of the final RI objectives that were derived from the CSM as well as documentation of key decisions made as part of the RI planning and data quality objective (DQO) process (Section 3.6, page 3-24).

3.1 HUMAN HEALTH AND ECOLOGICAL RISK CONSIDERATIONS

The CSM provides a valuable tool for approximating the likelihood of human or ecological receptors being exposed to potential COIs at the Moorings. The CSM is the starting point of all human health risk assessment activities as it describes potential receptor populations, exposure medium, and exposure routes that define potential exposure pathways at the Moorings.

3.1.1 Principle Risk Evaluation Goals

A goal of this RI was to acquire sufficient data to allow identification of areas and conditions on the upland portion of the Moorings that contain contaminants and may therefore present unacceptable risks to human health. The study was also intended to assess whether the upland portions of the Moorings itself is a source of contaminants in near shore sediments. In addition, in-water sediment data was collected as part of this study to support the broader Portland

Harbor Remedial Investigations and Baseline Risk Assessment and has been made available to USEPA and the LWG.

Historically within the Willamette River Basin, numerous sources have released or are currently releasing contaminants to the air, water, and soil. Several such operations within the Portland Harbor Superfund site have been confirmed as sources of contaminants in near-shore sediments at the Moorings. Available data indicate that elevated concentrations of some metals, PAHs, pesticides, PCBs, organobutyltins, and other contaminants attributed to these sources are present in sediment at concentrations that may pose unacceptable risk to humans and to ecological resources (endpoints) in and around the Moorings. The risks associated with exposure to sediments or surface water in the Willamette River within the Portland Harbor Superfund Site will be estimated as part of the ongoing RI/FS process for the site in general.

The CSM establishes the extent to which complete, potentially complete and incomplete exposure pathways can be identified from potential sources to potential receptors at the Moorings. The human health risk assessment for exposure scenarios related to complete and potentially complete upland pathways is presented in Section 7 and is based solely on data generated during this RI as no previous upland studies have been performed. Data generated from this evaluation will also be provided to the LWG so that they can be combined with information from other sites to develop a cumulative effects risk assessment of all sites within the Portland Harbor Superfund site.

3.1.2 Human Health Risk Assessment Methodology

The data gaps report (USACE 2002b) provided the basis for the collection of analytical data (Section 4) to support a human health risk assessment (HHRA) (Section 7) for the site. In addition to collecting and analyzing environmental media samples, the risk assessment requires that the types and length of exposure scenarios be estimated. The specific exposure scenarios evaluated as part of this study are described in Section 7. The Moorings HHRA is consistent with Superfund Human Health Risk Assessment Guidance (USEPA 2001) and estimates the cancer risks and non-cancer hazards associated with exposure to contaminant concentrations likely to occur in groundwater, surface soil (loose soil, 0 to 6 inches in depth), and shallow soils (0 to 5 feet in depth).

3.1.3 Ecological Risk Evaluation Methodology

The Moorings investigation developed data in support of the LWGs ongoing efforts to characterize ecological risks in the Portland Harbor. Because the Moorings site is either paved or covered in thick gravel, no ecological exposures exist for the upland portion of the Moorings; therefore, ecological risks are not assessed. However, a brief discussion of ecological exposure pathways is presented in Section 3.5.2 (page 3-23) and a screening evaluation of groundwater, soil, and upland sediment against the Portland Harbor Joint Source Control Strategy (JSCS) screening level values to qualify potential contribution of contaminants to the Willamette River from the Moorings is presented in Appendix A.

As of the date of this report, all of the in-water data have been provided to the LWG for inclusion into the Portland Harbor RI/FS.

3.2 SUMMARY OF SITE FEATURES AND ACTIVITIES

Section 2 provides a detailed description of the Moorings and its history. In summary, the site has been owned and operated by the USACE Portland District since the early 1900s. It has always been used as a centralized maintenance and supply site in support of the District's fleet of dredges and other vessels, and the District plans to continue using the site is this manner in the foreseeable future.

The site's current configuration is a result of land acquisitions in about 1905 and 1940, and three documented dredge and fill activities in 1913, 1926, and 1945. Potentially important on-site features and/or activities with respect to the RI include the following:

- Vehicle and marine vessel maintenance, including on shore and in-water support facilities and shops;
- Equipment storage and laydown related to the above maintenance activities;
- Vessel fueling (USACE 2008);
- Delivery of and removal of lube oil for vessels (USACE 2008);
- Vessel painting and paint removal (USACE 2008);
- Welding and metal cutting (USACE 2008);
- Solid waste removal from vessels (USACE 2008);
- Sandblasting of vessels (USACE 2008); and
- New construction or refurbishing of some smaller vessels, primarily during the early years of operation (USACE 1946).

In 2000, the USEPA designated a portion of the Willamette River as the Portland Harbor Superfund Site and added it to the NPL. By definition, the Portland Harbor Superfund site includes part of the Multnomah Channel, and several upland properties that have or could potentially impact river sediments. The Moorings lies within the boundaries of the Portland Harbor Superfund site.

3.3 POTENTIAL CONTAMINANT SOURCES AND CHEMICALS OF INTEREST

The Moorings has been continuously used by USACE Portland District since 1904 for support of its dredging fleet. Dredge and fill operations in 1914, 1926, and 1945 increased the elevation of the upland area as well as helped to extend the site footprint to the existing boundaries of 13.14 acres. A variety of industrial operations, such as metal fabrication, woodworking, painting, and sandblasting activities occurred at the site. Routine maintenance of the dredges and survey vessels is still conducted on-site; however, more extensive maintenance such as hull blasting and hull painting is conducted off-site at commercial ship repair facilities.

Currently, small quantities of hazardous materials, including paints, solvents, and petroleum lubricants, are stored on site. Used oil is stored in an on-site above ground storage tank (AST).

Due to its long history of light industrial activities, and its inclusion within the Portland Harbor Superfund site boundary, the Moorings CSM includes both on- and off-site sources of potential contamination.

3.3.1 Potential On-Site Sources

The upland portion of Moorings was divided into two sections for the purposes of this RI based on differences in site uses and fill history: the Industrial Area and the MIS Area (Section 4.1, page 4-2). Figure 4.1 (page 4-11) depicts both areas.

The Industrial Area comprises the southern portion of the site (south of Building 17, Figure 4-1, page 4-11) where the majority of light industrial activities occurred over the years. Part of the Industrial Area was filled during the early history of the site (i.e., 1914 fill event). Currently, this area is almost entirely paved. The MIS Area comprises the northern portion of the site (Figure 4-1, page 4-11). The MIS Area was historically used as a storage and warehouse area for dredge parts. In contrast to the Industrial Area, the MIS Area is primarily fill material. Currently, the surface in this portion of the site consists of compacted gravel with minimal landscaping.

Potential sources of environmental contamination related to on-site activities or features in the Industrial and MIS Areas include the following:

- Former Underground Storage Tanks (2) (Figure 4-2, page 4-13);
- Electrical Transformers (Figure 4-2, page 4-13);
- Drywells (2) and stormwater outfalls (see Figure 2-13, page 2-37);
- Routine vehicle/vessel maintenance activities (including storage and use of small quantities of hazardous materials, sand blasting operations in the storage yard and on the docks, and floor and sink drains in shops that historically discharged to the ground or the river);
- Potentially contaminated fill; and
- Other sources (e.g., bulkhead seep).

Table 3-1 (page 3-7) provides a synopsis of information related to the potential on-site sources and COI in the Industrial Area, and Table 3-2 (page 3-9) provides a synopsis of information related to the potential on-site sources and COI in the MIS Area. Details pertaining to the investigative strategies for each source are provided in Sections 4.1 (page 4-2) through 4.3 (page 4-41) for soil, groundwater, and upland surface water, respectively. Section 6.2 (page 6-2) discusses the results of the investigation with respect to these sources.

3.3.2 Potential Off-Site Sources

As noted above, the Moorings lies within the Portland Harbor Superfund site. As such, it is surrounded by properties that are either known or suspected of contributing to environmental contamination of the Willamette River and sediments. Some of those properties may also be a source of contamination of the Moorings itself. Specifically, the Moorings is bounded on the northeast by the Willamette River, on the northwest by Advanced American Construction, on the southwest by BNSF railroad line and St. Helens Road, and on the southeast by the NW Natural property (formerly GASCO), which also includes land formerly used by Koppers and Siltronic Corporation.

Potential sources of environmental contamination related to off-site activities or features include the following.

- Olympic Pipeline owns two 14-inch diameter underground petroleum fuel lines that run along the west property boundary, with a 50-year easement dating from 1965 for the lines to cross the Moorings property. According to permit drawings, one line is used for "gasoline" transmission and one is used for "fuel" transmission. The permit drawing depicts the lines as buried 36 inches bgs.
- The former GASCO site to the south, which is now owned by NW Natural (including the portion previously leased by Koppers).
- The Siltronic Corporation property south of NW Natural that was the site of several contaminant releases, including trichlorethene (TCE) (Hahn 2007).
- The McCormick and Baxter site across and upstream of Moorings that performed wood treatment operations.
- Other sites upstream (and downstream) of the Moorings that have been identified as sources of contamination of river sediments adjacent to the site (LWG 2005).
- A former creek channel that historic records indicate crossed the GASCO property and continued through the Moorings between Buildings 2 and 4 (Figure 2-8, page 2-13).

Table 3-3 (page 3-10) provides a synopsis of information related to the potential off-site sources and COI at the site. Details pertaining to the investigative strategies for each source are provided in Sections 4.1 through 4.4 (pages 4-2, 4-35, 4-41, 4-55). Section 6.3 (page 6-9) discusses the results of the investigation with respect to off-site sources.

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Table 3-1 Potential On-Site Sources of Environmental Contamination and Chemicals of Interest – Industrial Area

Potential Contaminant Source	Chemicals of Interest and Source Medium
Former Underground Storage Tanks Two USTs used for vehicle fuel storage only have been documented on site at Moorings (Figure 2-2, page 2-3). If leakage occurred in the past, contaminants most likely would have migrated from the tank to soil and groundwater, possibly entering the river from groundwater discharges.	COIs associated with the former USTs are BTEX and TPH related compounds.
Electrical Transformers Three above ground electrical transformers were used on site (Figure 4-2, page 4-13); two were located in the same area as two current transformers. Although it is believed that the former units may have contained PCB based dielectric fluids, there is no evidence of a release of PCB-containing transformer fluids. If leakage did occur, PCB-contaminated soil may have resulted. Groundwater may have been impacted through infiltration of contaminated stormwater/surface water, which may have in turn migrated to the river.	COIs associated with the former electrical transformers are PCBs.
Drywells and Stormwater Outfalls Contaminants from paved surfaces (i.e., related to vehicular traffic and parking), could migrate into stormwater catch basins/dry wells via overland flow where they could then also potentially impact subsurface soils and groundwater through stormwater discharges.	COIs associated with the drywells and stormwater outfalls located on site are SVOCs, PCBs, pesticides, metals, and TPHs.
Routine Vehicle/Vessel Maintenance Activities Small quantities of hazardous materials, including paints, solvents, and petroleum lubricants are stored on site for use at the Moorings or on vessels. Used oil is stored in an on-site AST. Moorings employees have waste management records on file starting in 1990, prior to this date, disposal of waste products are unclear. Routine maintenance of the dredges and survey vessels is also conducted on site; however, more extensive maintenance, such as hull blasting and hull painting, is conducted off site at commercial ship repair facilities. COIs could have potentially impacted the soil and groundwater through historical industrial practices.	COIs associated with routine vehicle/vessel maintenance activities include volatile organic compounds (VOCs), SVOCs, PCBs, pesticides, cyanide, metals organobutyltins, and TPH-Diesel.

Table 3-1 Potential On-Site Sources of Environmental Contamination and Chemicals of Interest – Industrial Area

Potential Contaminant Source	Chemicals of Interest and Source Medium
Other Marine Vessel Activities Three past activities/events associated with Marine Vessel maintenance may have potentially contaminated the Willamette River off-shore of the Industrial Area: • Floor drains in shops and wastewater from a sink in the dock area that historically discharged to the river. • Bilge water discharged to the river before 1972 during normal maintenance activities. • Discharge of about 50 gallons of diesel and 4 gallons of crankcase oil to the river associated with the sinking of the anchor barge *Raggy* in 1990.	COIs associated with past marine vessel activities include VOCs, SVOCs, PCBs, pesticides, cyanide, metals, organobutyltins, and TPH-Diesel.
Bulkhead Seep One seep location was identified at the Moorings along the bulkhead wall. The seep is only visible during low tide and appeared to have continuous discharge. As a natural groundwater discharge point, this seep may provide evidence of contaminant migration via groundwater to the Willamette River.	COIs associated with the Seep are SVOCs, PCBs, pesticides, metals, and TPHs.

Table 3-2 Potential On-Site Contaminant Sources and Chemicals of Interest – MIS Area

Potential Contaminant Source	Chemicals of Interest and Source Medium
Routine Current and Historic Vehicle/Vessel Maintenance Activities The MIS area has been historically used for support of the dredging fleet and has included a variety of industrial operations ranging from metal fabrication to woodworking, painting, and sandblasting activities. Major ship overhaul and outfitting activities are currently conducted at full service shipyards off site. Historic on-site shipyard activities would have been more extensive than the activities that currently occur on site. Contaminants associated with these activities may have migrated to the river through surface water runoff. Soil and groundwater may also have been impacted by industrial practices through infiltration of surface water/stormwater.	COIs from past and current industrial activities include VOCs, SVOCs, PCBs, TPH-Diesel, pesticides, organobutyltins, cyanide, and metals.
Fill Materials Potentially contaminated fill materials from river dredging operations were used to modify the Moorings footprint through the years (Section 2.4.3, page 2-8). Documentation indicates that fill material came from the basin directly in front of the site between the shoreline and harbor line. The fill was then placed on site to modify the site footprint. In addition, a spent oxide waste pile was located on the GASCO/Mooring property boundary, upstream of the Moorings docks. Contaminants from this waste pile, as well as from other upstream sources, could have potentially migrated to the areas dredged and subsequently used for fill; thereby contaminating the site. In addition, the construction and subsequent removal of the marine railway (Section 2.4.4, page 2-19) could have displaced the fill material. Contaminants related to the dredged materials may have contaminated the soils and groundwater in this area.	COIs from the potentially contaminated fill include. VOCs, SVOCs, PCBs, TPH-Diesel, pesticides, cyanide, and metals.

Table 3-3 Potential Off-Site Contaminant Sources and Chemicals of Interest

Potential Contaminant Source Activity	
Fuel Lines Two 14-inch diameter underground petroleum fuel lines run along the west property boundary. Although there are no known on-site leaks or discharges associated with these lines, if leaks occurred contaminants could have potentially migrated from the off-site pipeline to the soils and groundwater at Moorings.	COIs associated with any leakage from the fuel lines include TPHs and fuel related PAH compounds.
GASCO Previous investigations conducted of the GASCO site (Section 2.9.3.1, page 2-33) show significant subsurface contamination, including DNAPL, in some areas (Hahn 2007). COIs could have been transported via groundwater to the Moorings. A stockpile of spent oxide/gas purification materials (waste pile) was located on the GASCO property immediately adjacent to the Moorings property line (Hahn 2007) (Figures 3-1 through 3-4, pages 3-11 through 3-14). Due to the location of the waste pile on the Moorings border, COIs could have potentially contaminated the Moorings soil via airborne transport, physical transport in water, or after leaching into groundwater.	COIs associated with GASCO include heavy petroleum products as identified in the sediments at the Moorings during past investigations. COIs from the spent oxide pile include TPH, cyanide, and metals.
ODOT Outfalls (Catch Basin) Stormwater and surface water from St. Helens Road and the hillside adjacent to the road are discharged to the river via ODOT outfalls. COIs from St. Helens Road are funneled through a catch basin off-site. The discharge runs underneath the site and exits directly in front of the Moorings property, possibly contributing contamination to the river or river sediments..	COIs are SVOCs, PCBs, TPH-Diesel, pesticides and metals.
McCormick and Baxter The McCormick and Baxter site located on the east bank of the Willamette River approximately 0.8 mile upstream of the Moorings is undergoing remediation for contamination from wood treatment products. COIs could have potentially migrated and settled in the sediments off shore of Moorings	COIs include creosote, PAHs, pentachloro-phenol/diesel oil mixtures, and metals from wood treatment products.
Siltronic Corporation Operations at the Siltronic Corporation site south of GASCO have been documented to have had a petroleum buried line breech and a leaking underground storage tank that held TCE (Hahn, 2007). Contaminants may have discharged to the Willamette River and could be conveyed through sediment or groundwater migration.	COIs include TCE, TPH, PAH, and SVOCs.
St. Helen's Road and Railroad Airborne contaminants from St. Helens Road (Highway 30) and particulates from the railroad.	COIs include TPH, PAHs, metals, pesticides, and PCBs.

Figure 3-1 Neighboring Waste Pile circa 1936

586 PORTLAND DISTRICT MOORINGS. Dock office, store room, and open storage shed, looking south.

Photo taken October 7, 1946.

Figure 3-2 Neighboring Waste Pile circa 1946

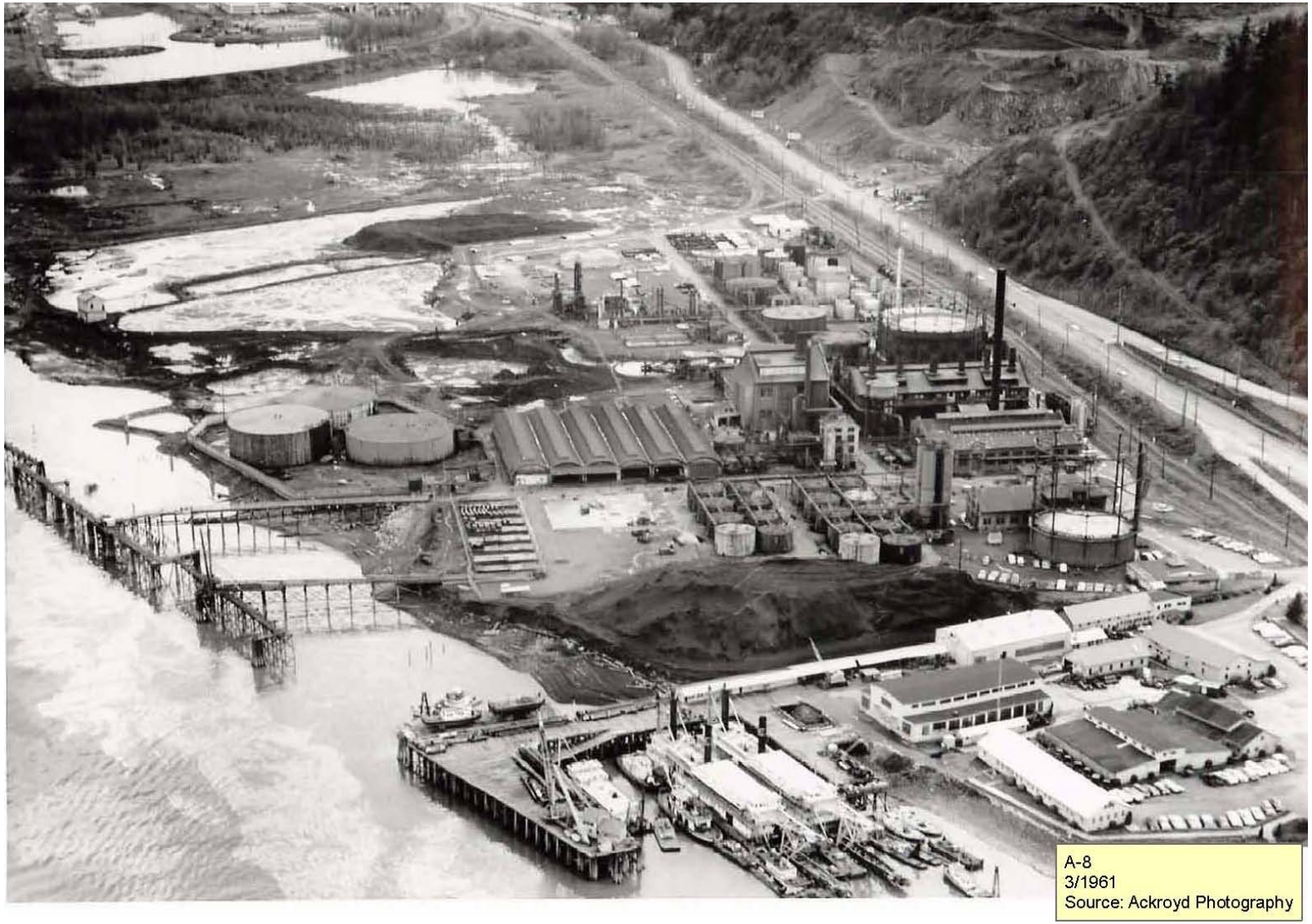

Figure 3-3 Neighboring Waste Pile circa 1961

Figure 3-4 Neighboring Waste Pile circa 1971

3.4 CHARACTERISTICS OF SITE SETTING

The Moorings consists of approximately 13.47 acres. It is subject to government controlled access and offers no recreational opportunities. Moreover, there are no plans to develop the property for residential or recreational uses.

3.4.1 Climate

In general, the weather at the Moorings is mild. The site receives an average of 60 inches of precipitation per year, with October through May being the rainiest months. Summers are generally dry and warm. Additional climatologic characteristics of the Moorings are provided in Section 2.7 (page 2-25).

3.4.2 Vegetation and Upland Soils

The Moorings is almost entirely paved in the Industrial Area and covered with a combination of compacted gravel, concrete, and buildings in the MIS Area. There is minimal landscaping on-site, with minimal trees and no major shrubbery. There are approximately 1,000 square feet of small patches of grass in the parking lot. Vegetation preservation is not a concern at the Moorings.

Upland soils are a combination of existing Columbia River Basalt and alluvium surficial fill deposits from dredging activities. Further details on the upland soils are presented in Section 2.5 (page 2-19). For the purposes of the risk evaluation, on-site soils were considered to be predominately sandy clay. Native soils are generally found under pavement, compacted gravel, buildings, or concrete and are not prone to air or water borne transport to the river.

3.4.3 Sediment Transport from Off-Site Sources

The Port of Portland evaluated contaminant sources and sediment transport within the harbor (Port of Portland 1998). The evaluation determined that sediments are transported into the harbor by point or nonpoint discharges from upland sources and as suspended particulates in the river. The amount of suspended sediment transport varies over time, based on the flow velocities of the Willamette River and, to a lesser degree, tidal effects, which can cause a temporary reversal of flow during low-stage river conditions. River velocities are relatively low within the reach of the harbor, due to the widening of the river beyond RM 10.

The U.S. Geological Survey has estimated that sediment transport from the river is seasonally variable, ranging from 1,000 to 50,000 tons/day. The sediment is nearly all muddy sand, but there is some coarser sediment (sand) near the center of the river (GeoSea 2001). The area is in dynamic equilibrium, which indicates that the relative probability of grains being transported is a similar distribution to the actual riverbed deposits. This suggests that the probability of finding a particular grain in the deposit is equal to the probability of its transport and redeposition (i.e., there is a grain by grain replacement along the transport path). The bed is neither accreting nor eroding (GeoSea 2001).

3.4.4 Hydrogeology

No site-specific hydrogeologic characterizations have been completed at Moorings. There are no monitoring or water supply wells at the site. An RI/FS conducted at the adjacent GASCO site included a hydrogeologic characterization (Hahn 1998). The GASCO RI/FS characterization is likely representative of conditions at the Moorings.

It is anticipated that groundwater beneath the site occurs in three hydrogeologic zones: a surficial fill unit, an undifferentiated alluvial deposit unit, and the Columbia River Basalt unit.

The surficial fill layer is anticipated to be variable in thickness and believed to consist primarily of hydraulically-placed dredged sands. The thickness of the alluvium is not definitively known, but it likely increases near the river (Section 2.4.3, page 2-8; Figures 2-8 and 2-9, pages 2-13 and 2-15). According to information developed as part of the GASCO RI/FS, the base of the alluvium (e.g., the contact with the basalt) may range from about 40 to 100 feet bgs along the Moorings property boundary (Hahn 1998). Recent data suggest contact with basalt may exceed 130 feet bgs (Hahn 2007). The alluvium is anticipated to consist of unconsolidated sand, silt, and clay units. At the GASCO site, the top of the alluvial unit was interpreted to be a laterally extensive silt unit (which is overlain by the dredge fill material). Groundwater in the fill and alluvial units likely discharges directly to the Willamette River. At the GASCO site, groundwater is generally present at about 15 to 20 feet bgs.

Based on the site and area topography, groundwater is assumed to migrate across the Moorings into the Willamette River.

3.5 POTENTIAL EXPOSURE PATHWAYS

3.5.1 Human Health

The Moorings CSM for human health exposure (Figure 3-5, page 3-21) depicts all pathways for this site. It identifies four primary sources of site contaminants and three groups of potential receptors who could be exposed to the contaminants via various exposure pathways.

For a complete exposure pathway to exist, the following four elements must be present:

- A source and mechanism of chemical release;
- A retention or transport medium (e.g., soil);
- A point of potential human contact with the affected medium; and
- A means of entry into the body (e.g., ingestion) at the contact point.

Only complete pathways that contain all four elements can result in potential exposures. However, in some circumstances, an exposure pathway may be considered complete (i.e., meet all four elements outlined above), but insignificant. Based on site knowledge and professional judgment, the relative significance of each pathway was determined by considering whether or not one or more of the following conditions was met (USEPA 1989).

- The potential exposure resulting from the pathway was much less than that from another pathway involving the same medium.
- The potential magnitude of exposure from the pathway was low or of limited toxicological importance.
- The probability of the exposure occurring was low and the risks associated with the occurrence are not high.

Only complete and significant exposure pathways typically require quantitative risk evaluation. Complete but insignificant exposure pathways generally do not require quantitative evaluation, but can be discussed qualitatively.

3.5.1.1 Source and Mechanism of Release - Exposure Medium

Primary contaminant sources at the site may include (see also Section 3.3, page 3-3):

- Fill material;
- On-site operations and disposal of chemicals;
- Stormwater and wastewater discharges; and
- Upgradient river and groundwater sources.

Release mechanisms can include current releases, such as wastewater discharges to the Willamette River, historical releases such as spills, or a combination of both.

The exposure media of concern that can retain or transport contaminants with respect to human health risks are:

- Air;
- Surface soil (taken as the 0 to 1 foot depth range for the CSM);
- Shallow soil (taken as the 1 to 5 foot depth range for the CSM);
- Groundwater;
- Surface water; and
- In-water Sediment.

3.5.1.2 Exposure Routes

The exposure routes, or means for the contaminant entering the body, include:

- Inhalation of volatiles or particulate matter;
- Incidental ingestion;
- Dermal contact; and
- Drinking water ingestion.

Multiple ingestion routes can occur at one time. Inhalation can occur for soil, water vapor, or air. Incidental ingestion encompasses ingestion of small quantities of soil or water while performing work activities, but not from actively eating or drinking soil or water. Dermal contact occurs when soil or water gets on the skin and the contaminant is absorbed into the body across the skin. Drinking water ingestion is evaluated for potential future use at the Moorings, however there are no foreseeable plans to utilize groundwater from the site for human consumption.

3.5.1.3 Potential Receptors of Contaminated Media and Estimated Exposure Routes

Based on the joint USEPA/USACE evaluation of site uses, there are three major categories of human exposure and their potential to contact contaminate media. Additional exposure parameters are discussed in Section 7.1.5 (page 7-31).

- On-site office worker
    - full time on-site worker, 8 hours per day, 5 days per week and working primarily inside in an office setting. Buildings 1, 5, and 17 contain office spaces.
    - potential exposure to air contaminants.
    - site pavement precludes contact with surface and subsurface soils.
- On-site maintenance worker
    - full time on-site worker, 8 hours per day, 5 days per week, working either inside or outside, on all areas of the site, and engaged in general grounds/facilities maintenance that does not include intentional disturbance of the surface or subsurface soils.
    - site pavement precludes contact with surface and subsurface soils.
- On-site upland excavation worker
    - contractor working on site with no anticipated repeat work done on site, engaged in specialized work, typically associated with buried utilities (e.g., water, electric, sewer, etc.).
    - potential for direct contact with shallow soils from 0 to 5 feet.
    - potential for incidental ingestion of shallow soils.
    - exposure is expected to occur for approximately one nine-day period only once in a workers lifetime.

The pavement over the entire southern portion of the site (where most site office and maintenance workers work) precludes the majority of surface soil exposure. There is no public access to the Moorings. From land, the site is fenced and gated and from the water, the bank is armored, preventing shore side access and therefore precluding certain exposure pathways. Any recreational exposure scenarios in the Willamette River will be evaluated in the Harbor Wide Baseline Risk Assessment being conducted by the LWG under the supervision of the USEPA.

3.5.1.4 Pathways Identified for Human Health Risk Evaluation

The potentially complete exposure pathways (i.e., exposure scenarios that may be evaluated during the risk assessment depending on site contaminant levels) are as follows. Both a current scenario and a future scenario are identified in Figure 3.5 (page 3-21) because on-site groundwater is not a current source for drinking water at the Moorings, but has potential for future use.

- Current Scenarios:
    - Office worker: inhalation of vapors from volatile chemicals present in soil and groundwater through vapor intrusion;
    - Maintenance worker: inhalation of vapors from volatile chemicals present in soil and groundwater through vapor intrusion; inhalation of particulates present in surface soil;
    - Upland excavation worker: inhalation of vapors from volatile chemicals present in soil and groundwater; inhalation of particulates present in surface and subsurface soil; incidental ingestion of and dermal contact with surface and subsurface soil; dermal exposures to chemicals in groundwater if subsurface soil disturbance reaches saturated soils, interaction with surface water if it rains while working on site, consumption of drinking water.
- Future Scenarios:
    - Office worker: All current exposures plus exposures from groundwater used as drinking water including ingestion, inhalation of vapors, and dermal contact.
    - Maintenance worker: All current exposures plus exposures from groundwater used as drinking water including ingestion, inhalation of vapors, and dermal contact.

As indicated in Figure 3-5 (page 3-21), all surface water/sediment pathways are either incomplete or potentially complete due to their final interaction with the Willamette River. Additionally, the risks associated with exposures to surface water or off-shore sediments are being evaluated in the Harbor Wide Baseline Risk Assessment.

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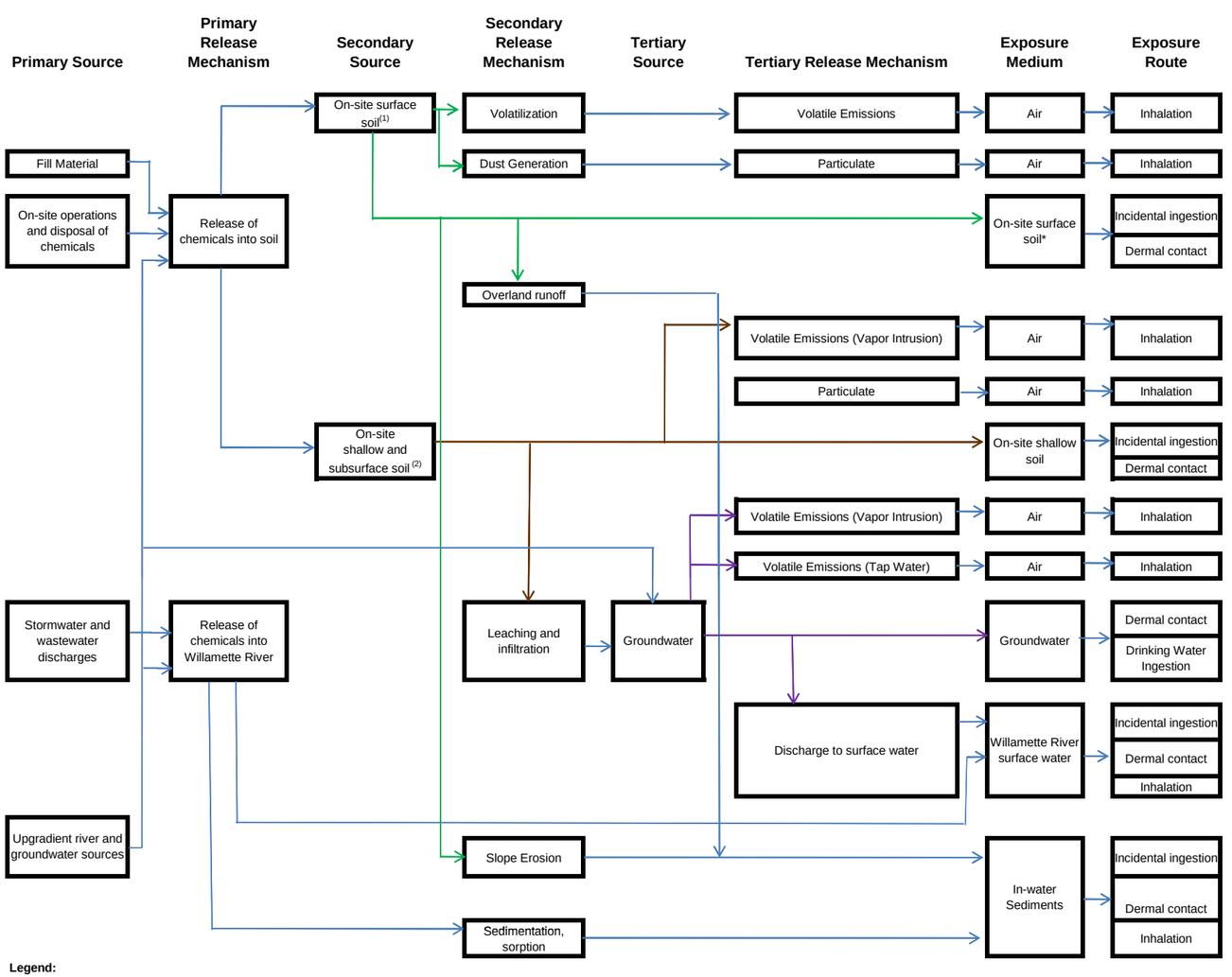

Exposure Route	Current Scenario – Potential Receptors – On-site: Office worker	Current Scenario: Maintenance worker	Current Scenario: Upland excavation worker	Future Scenario – Potential Receptors – On-site: Office worker	Future Scenario: Maintenance worker	Future Scenario: Upland excavation worker
Inhalation (Volatile Emissions)	IC	○	IC	IC	○	IC
Inhalation (Particulate)	IC	○	IC	IC	○	IC
Incidental ingestion (On-site surface soil*)	IC	○	IC	IC	○	IC
Dermal contact (On-site surface soil*)	IC	○	IC	IC	○	IC
Inhalation (Volatile Emissions (Vapor Intrusion))	○	○	IC	○	○	IC
Inhalation (Particulate)	IC	IC	●	IC	IC	●
Incidental ingestion (On-site shallow soil)	IC	IC	●	IC	IC	●
Dermal contact (On-site shallow soil)	IC	IC	●	IC	IC	●
Inhalation (Volatile Emissions (Vapor Intrusion))	○	○	IC	○	○	IC
Inhalation (Volatile Emissions (Tap Water))	IC	IC	IC	●	●	IC
Dermal contact (Groundwater)	IC	IC	IC	●	●	IC
Drinking Water Ingestion (Groundwater)	IC	IC	IC	●	●	IC
Incidental ingestion (Willamette River surface water)	IC	IC	IC	IC	IC	IC
Dermal contact (Willamette River surface water)	IC	IC	IC	IC	IC	IC
Inhalation (Willamette River surface water)	IC	IC	IC	IC	IC	IC
Incidental ingestion (In-water Sediments)	IC	IC	IC	IC	IC	IC
Dermal contact (In-water Sediments)	IC	IC	IC	IC	IC	IC
Inhalation (In-water Sediments)	IC	IC	IC	IC	IC	IC

Legend:
On-site defined as upland portion of U.S. Moorings site
Off-site defined as offshore portion of U.S. Moorings site
● = complete pathway
○ = potentially complete pathway
IC = incomplete pathway, indicates that exposure to the exposure point and medium is unlikely.

Office worker scenario includes temporary stayovers.
Maintenance worker scenario includes outdoor workers without soil disturbance.
Upland excavation worker scenario includes site maintenance with soil disturbance, such as utility trench workers.
(1) Surface soil are samples taken at the 0 to 6 inch depth range in loose soil. No surface soils samples are available under pavement or gravel.
(2) Shallow soil for the purpose of the HHRA is 1 to 4 feet in the Industrial Area and 0 to 5 feet in the MIS Area. Subsurface is anything below
(3) Groundwater exposure applies to a future scenario only. Groundwater is NOT currently used as a tap water source.

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REMEDIAL INVESTIGATION

Figure 3-5

Human Health Conceptual Site Model

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3.5.2 Ecological Exposure Pathways

3.5.2.1 Source and Mechanism of Release - Exposure Medium

The Moorings CSM for ecological exposure (Figure 3-6, page 3-25) identifies the same four potential contaminant sources and exposure media as those identified for human health. However, since the upland portion of the site is essentially completely covered with buildings, pavement, or gravel with minimal landscaping, the USACE and USEPA concur that no ecologically important terrestrial habitat exists on the upland portion of the site. For purposes of this document, it is assumed that ecologically important terrestrial habitats are not present and therefore the on-site air, soil, and subsurface soil pathways are considered incomplete and an ecological risk evaluation is unnecessary.

Primary contaminant sources at the site with respect to ecological risks may include:

- Fill material;
- On-site operations and disposal of chemicals;
- Stormwater and wastewater discharges; and
- Upgradient river and groundwater sources.

Descriptions of potential contamination sources are provided in Section 3.3 (page 3-3). Release mechanisms can represent current releases, such as wastewater discharges to the Willamette River, historical releases such as spills, or a combination of both.

With the exception of groundwater, exposure media of concern for ecological receptors are the same as those identified for human health, namely:

- Air;
- Surface soil;
- Subsurface soil;
- Surface water; and
- Sediment.

3.5.2.2 Exposure Routes and Exposure Pathways

The upland portion of the site is essentially completely covered with buildings, pavement, or gravel, with minimal landscaping. During the RI it was determined that no ecologically important terrestrial habitat is present at the site. Accordingly, the on-site air, soil, and subsurface soil pathways are considered incomplete (Figure 3-6, page 3-25).

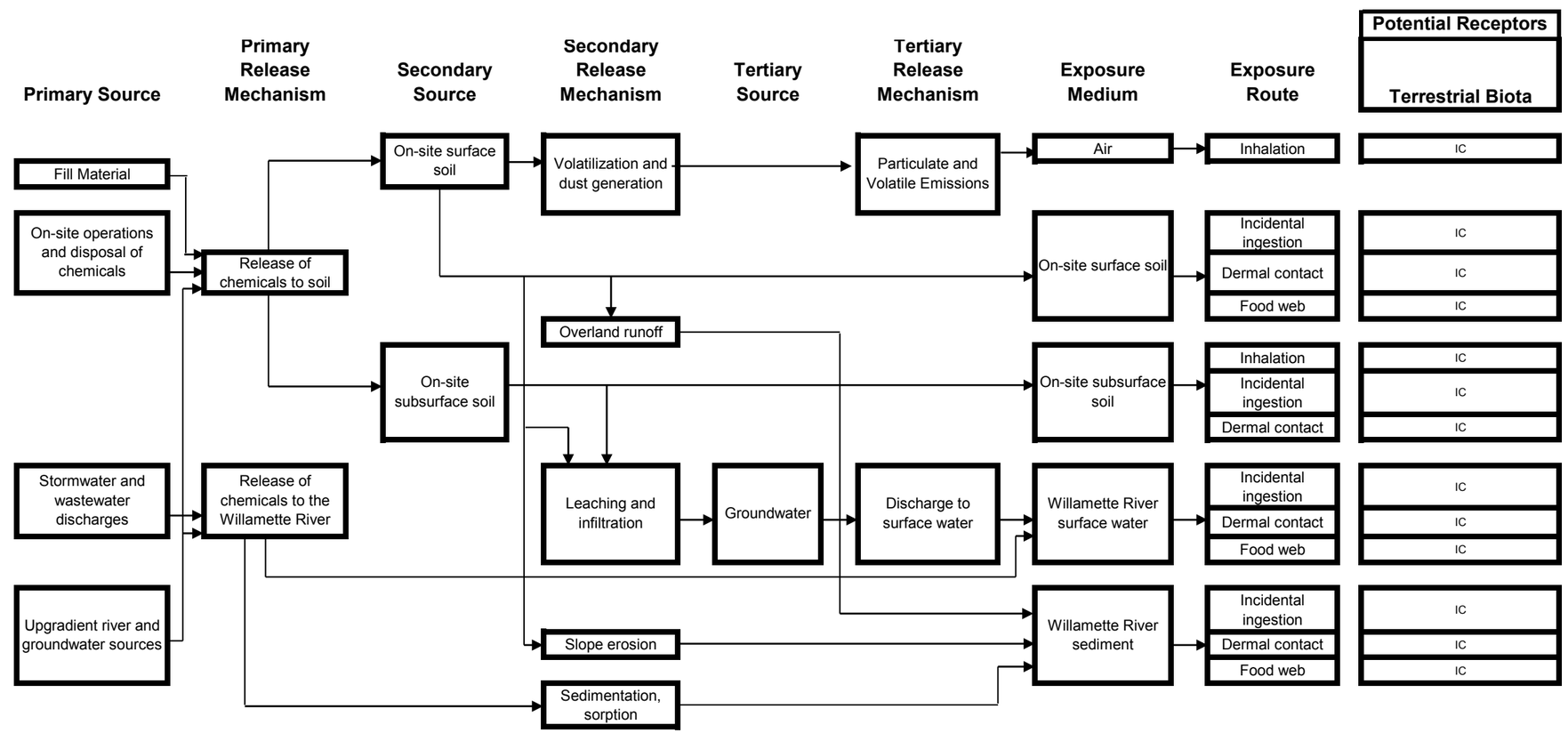
3.6 REMEDIAL INVESTIGATION OBJECTIVES

Based on the CSM, as summarized above, six primary objectives were defined for the RI:

1. Determine if the site is a source of contamination to the Willamette River;
2. Determine if the upland portions of the site present unacceptable risks to human health or the environment;
3. Determine if off-site sources of contamination are impacting the site;
4. Determine if the upland portions of the site are contaminated from historic dredge material placement;
5. Determine the adequacy and completeness of previous remedial activities; and
6. Characterize potential sediment contamination in support of USACE sediment management activities and on-going LWG studies.

Existing data (prior to the RI) was not adequate for evaluating the above identified investigation objectives. On-site samples of upland soil, groundwater, surface water, and sediment; and samples of sediment from the Willamette River along the northeast shoreline of the Moorings, were collected and analyzed for the COIs discussed previously. Specific sampling objectives, locations, rationale, and analytical parameters for each media are discussed in Section 4.0 as follows.

- Upland Soil Investigation (Section 4.1, page 4-2)
- Upland Groundwater Investigation (Section 4.2, page 4-35)
- Upland Surface Water and Sediment Investigation (Section 4.3, page 4-41)
- Willamette River Sediment Investigation (Section 4.4, page 4-55)



Legend:
On-site defined as upland portion of U.S. Moorings site
● = complete pathway
○ = potentially complete pathway
IC = incomplete pathway
Aquatic biota includes plankton, invertebrates, and fish.
(1) All Offsite/In-river risk calculations will be a LWG effort.

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U.S. GOVERNMENT MOORINGS

REMEDIAL INVESTIGATION

Figure 3-6

Ecological Conceptual Site Model

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4.0 SITE INVESTIGATION

As discussed in Section 1, the objectives of this RI were to conduct investigatory activities of the soil, groundwater, surface water, and sediment at the Moorings site to:

1. Determine if the site is a source of contamination to the Willamette River;
2. Determine if the upland portions of the site present unacceptable risks to human health or to the environment;
3. Determine if off-site sources of contamination are impacting the site;
4. Determine if the upland portions of the site are contaminated by historic dredge material placement;
5. Determine the adequacy and completeness of previous remedial activities; and
6. Characterize potential sediment contamination in support of USACE sediment management activities and on-going LWG studies.

This Section of the report describes the RI activities associated with the field activities and is organized as follows:

- Upland Soil Investigation (Section 4.1, page 4-2)
- Upland Groundwater Investigation (Section 4.2, page 4-33)
- Upland Surface Water and Sediment Investigation (Section 4.3, page 4-41)
- Willamette River Sediment Investigation (Section 4.4, page 4,55)
- Field Activities, Observations, and Deviations from Work Plan (Section 4.5 page 4-64, Section 4.6, page 4-71, Section 4.7, page 4-73, Section 4.8, page 4-73)

All investigation activities were completed in general accordance with the approved *Management Plan for the Remedial Investigation U.S. Government Moorings, Portland, Oregon* (KTA/TEC 2008)[4]. Deviations from this plan are listed in Section 4.8 (page 4-73) of this document. The Management Plan included a Work Plan and Sampling and Analysis Plan (SAP) Section. The SAP also included chapters discussing the Field Sampling Plan (FSP) and a Quality Assurance Project Plan (QAPP).

[4] This document is available per request by contacting USACE Seattle District.

4.1 UPLAND SOIL INVESTIGATION

As discussed in Section 3.3.1 (page 3-4), the upland soil area was classified into two separate areas, the Industrial Area (to the south) and the MIS Area (to the north).

- The Industrial Area (south of Building 17) was investigated using a traditional, discrete sampling RI approach due to the number and type of potential contamination sources (Section 3.3.1, page 3-4) in this portion of the site. The Industrial Area is where a majority of the industrial activities occur and is almost entirely paved, and was subject to the earliest fill placement.
- The northern part of the site, including Building 17, was investigated using an MIS approach. The MIS Area is primarily later fill material (Section 2.4.3, page 2-8), is essentially asphalt and gravel surfaced, has historically been used as a storage and warehouse area for dredge parts, and has had limited industrial activity with the exception of open air sandblasting.

Figure 4-1 (page 4-11) delineates the Industrial and MIS Areas. Table 4-1 (page 4-3) summarizes the sampling approach and rational for the upland soil investigation. A description of the soil investigation activities is provided in the following Sections: Sections 4.1.1 (Industrial Area, page 4-7) and 4.1.2 (MIS Area, page 4-17).

Table 4-1 Remedial Investigation Objectives and Strategy - Soil/Subsurface Sampling

Data Requirements	Location/ Management Unit	Investigation Objectives	Investigation Strategy	Decision Criteria
Determine if the upland portion of the site is contaminated. If contaminants are present, determine exposure point concentrations of COPCs to support risk or source control management decisions.	Industrial Area	Determine if the shallow soils (< 4' bgs) pose an unacceptable risk to construction workers involved in the excavation and repair of underground utility lines.	Traditional discrete sampling approach in areas that have been identified as potential release locations (former USTs, dry wells, industrial process areas, etc.). Samples will be collected in 4 ft intervals until native material is encountered. Analyses will include: • VOCs • SVOCs • Pesticides • PCBs • Cyanide (selected locations) • Metals • TPH	• Compare data to USEPA Region 6 industrial soil preliminary remediation goals (PRGs) (0.1 of the PRG for non-cancer effects) and JSCS soil/stormwater sediment screening level values (SLVs). • If detected constituents < USEPA Region 6 PRGs, no further sampling is anticipated. • If soil contaminant levels exceed Region 6 PRGs or JSCS soil/stormwater sediment SLVs, the need for additional sampling will be evaluated by the technical team. (This may include groundwater, synthetic precipitation leaching procedure (SPLP), smaller MIS units, etc.). • Perform standard risk calculation using exposure point concentrations for results greater than Region 6 PRGs for construction worker exposures. All soil samples will be archived for future dioxin analysis as needed. • If any VOCs are detected, evaluate Vapor Intrusion pathway with Johnson-Ettinger model.
		Determine if deeper soils are a source of groundwater contamination.		If gross contamination is identified by sampling crew, the need for additional sampling will be evaluated by the technical team. (This may include groundwater or additional soils sampling or stepouts, etc.) All soil samples will be archived for future dioxin analysis as needed.

Table 4-1 Remedial Investigation Objectives and Strategy - Soil/Subsurface Sampling

Data Requirements	Location/ Management Unit	Investigation Objectives	Investigation Strategy	Decision Criteria
Determine if the upland portion of the site is contaminated. If contaminants are present, determine exposure point concentrations of COPCs to support risk or source control management decisions.	Fence Line MU (0.08 Acres [AC])	Determine if the Upper Unit (0-0.5 feet bgs), the erodible soils, are a possible source of ongoing contamination to the river and/or pose an unacceptable risk to construction workers involved in the excavation and repair of underground utility lines.	Upper Unit (0-0.5 feet) Characterize Upper Unit horizon using MIS sampling strategy. Based on the Management Unit's size, 25 MIS locations were be sampled. Samples will be homogenized into a single aliquot for chemical analysis. Analyses will include: • SVOCs • PCBs • TPH • Pesticides • Metals • Organobutyltins	• Compare MIS data to USEPA Region 6 industrial soil PRGs (0.1 of the PRG for non-cancer effects) and JSCS Soil/Stormwater Sediment SLVs. • If MIS detected constituents < USEPA Region 6 PRGs, no further sampling is anticipated. • If MIS soil contaminant levels exceed Region 6 PRGs or JSCS soil/stormwater sediment SLVs, the need for additional sampling will be evaluated by the technical team. (This may include groundwater, SPLP, smaller MIS units, etc.) • Perform standard risk calculation using MIS results greater than Region 6 PRGs for construction worker exposures. • If gross contamination is identified by sampling crew, an immediate evaluation by the technical team will be conducted to discuss segregation from the balance of the MIS. All soil samples will be archived for future dioxin analysis as needed.
	Laydown Area (0.52 AC)	Determine if the shallow soils (< 5' bgs) pose an unacceptable risk to construction workers involved in the excavation and repair of underground utility lines	Characterize Upper Unit horizon using MIS sampling strategy. Based on the Management Unit's size, 38 MIS locations will be sampled. Samples will be homogenized into a single aliquot for chemical analysis. Analyses will include: • SVOCs • Pesticides • PCBs • TPH • Metals • Organobutyltins	• Compare MIS data to USEPA Region 6 industrial soil PRGs (0.1 of the PRG for non-cancer effects) and JSCS soil/stormwater sediment SLVs: • If MIS detected constituents < USEPA Region 6 PRGs, no further sampling is anticipated. • If MIS soil contaminant levels exceed Region 6 PRGs or JSCS soil/stormwater sediment SLVs, the need for additional sampling will be evaluated by the technical team. (This may include groundwater, SPLP, smaller MIS units, etc.)

Table 4-1 Remedial Investigation Objectives and Strategy - Soil/Subsurface Sampling

Data Requirements	Location/ Management Unit	Investigation Objectives	Investigation Strategy	Decision Criteria
Determine if the upland portion of the site is contaminated. If contaminants are present, determine exposure point concentrations of COPCs to support risk or source control management decisions.	Laydown Area continued			• Perform standard risk calculation using MIS results greater than Region 6 PRGs for construction worker exposures. • If gross contamination is identified by sampling crew, an immediate evaluation by the technical team will be conducted to discuss segregation from the balance of the MIS. All soil samples will be archived for future dioxin analysis as needed.
		Determine if shallow or deep soils are a source of groundwater contamination	Same as Shallow Soils	If gross contamination is identified by sampling crew, an immediate evaluation by the technical team will be conducted to discuss segregation from the balance of the MIS. All soil samples will be archived for future dioxin analysis as needed.
	North Logistics Area (0.3 AC)	Investigation Objectives as above for Laydown Area	Investigation Strategy as above for Laydown Area	Decision Criteria as above for Laydown Area
	South Logistics Area (0.4 AC)			
	Sandblast Area (0.05 AC)	Verify prior removal activity was effective in removing all sandblast residue.	Investigation Strategy as above for Laydown Area, except 7 MIS locations will be used to characterize a single shallow soil horizon at 1-5 feet bgs, immediately below the evacuation. Analyses will include: • SVOCs • PCBs • TPH • Pesticides • Metals • Organobutyltins	Decision Criteria as above for Laydown Area shallow soils.

Table 4-1 Remedial Investigation Objectives and Strategy - Soil/Subsurface Sampling

Data Requirements	Location/ Management Unit	Investigation Objectives	Investigation Strategy	Decision Criteria
Determine if the upland portion of the site is contaminated. If contaminants are present, determine exposure point concentrations of COPCs to support risk or source control management decisions.	Prior Cleanup Area (0.1 AC)	Verify prior removal activity was effective in removing all petroleum staining and residue.	Investigation Strategy as above for Laydown Area, except 8 MIS locations will be used to characterize a single shallow soil horizon at 1-5 feet bgs, immediately below the evacuation. Analyses will include: • SVOCs • PCBs • TPH • Pesticides • Metals • Organobutyltins	Decision Criteria as above for Laydown Area shallow soils.
Determine if the upland portion of the site is contaminated. If contaminants are present, determine exposure point concentrations of COPCs to support risk or source control management decisions.	Slump (0.03 AC)	Investigation Objectives as above for Laydown Area	Investigation Strategy as above for Laydown Area	Decision Criteria as above for Laydown Area

4.1.1 Industrial Area

The specific RI objectives pertinent to the Industrial Area soils investigation were to:

- Determine if the site is a source of contamination to the Willamette River;
- Determine if the upland portions of the site present unacceptable risks to human health or the environment. Specifically, determine if the near-surface (i.e., Upper Unit) site soils pose an unacceptable risk to construction workers involved in the excavation and repair of underground utility lines; and
- Determine if off-site sources of contamination are impacting the site (i.e., the neighboring property to the south, Olympic pipeline, the adjacent railway, ODOT roadways).

4.1.1.1 Sample Locations

Twenty sample locations were selected to characterize the contamination in the Industrial Area. Table 4-2 below lists the goal of each sample location, which are illustrated in Figure 4-2 (page 4-13). Table 4-3 (page 4-9) describes sampling events at each of the 20 sampling locations.

Table 4-2 Potential Contaminant Source and Sample Location Cross Reference

Potential Contaminant Source	Sample Locations
Conduct confirmation sampling to determine if there is existing evidence of a release from two former USTs.	8, 9, 10, 15
Determine if there is evidence of existing contamination caused by industrial housekeeping and activities (Building 15 and 19) with associations of hazardous materials.	2, 3, 4, 11, 12, 18, 19
Determine if there is evidence of site contamination caused by three past transformers that may have used PCB-containing fluids.	1, 2, 4, 5, 6, 7, 11, 14, 17
Determine if a drywell used for on-site diversion of stormwater runoff has evidence of contamination.	13, 13DW
Determine if the former creek channel represents a potential migration pathway for contaminants.	2, 3, 4, 18, 19, 12, 16, 17
Determine if contaminants from the neighboring property to the south are migrating to Moorings.	1, 11, 12, 16, 17, 20
Conduct confirmation sampling based on a previous investigation. (Section 2.9.1.3, page 2-28)	14

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Table 4-3 Industrial Area Sample Locations

Sample Number	Blind ID	Date Collected	Sample Depth[2]	Analysis[1]							
				VOCs	SVOCs	PCBs	Pesticides	CN	Metals	Organo-butyltins	TPH
SB-01-1	11		1-4'								
SB-01-2	12		4-8'								
SB-01-3	13	3-7-08	8-12'	X	X	X	X	X	X	NA	X
SB-01-5	15		16~20'								
SB-01-2-FD	120		4-8'								
SB-02-2	22		4-8'								
SB-02-3	23	3-6-08	8-12'	X	X	X	X	X	X	X[3]	X
SB-02-4	24		12~16'								
SB-03-2	32		4-8'								
SB-03-3	33	3-5-08	8-12'	X	X	X	X	X	X	X[3]	X
SB-03-4	34		12-16'								
SB-03-5	35		16~ 20'								
SB-04-1	41		1-4'								
SB-04-2	42	3-4-08	4-8'	X	X	X	X	X	X	X[3]	X
SB-04-3	43		8-12'								
SB-04-4	44		12~16'								
SB-05-1	51		1-4'								
SB-05-2	52		4-8'								
SB-05-3	53	3-6-08	8-12'	X	X	X	X	X	X	X[3]	X
SB-05-4	55		12~16'								
SB-05-2-FD	520		4-8'								
SB-06-1	61		1-4'								
SB-06-2	62	3-4-08	4-8'	X	X	X	X	X	X	X[3]	X
SB-06-3	63		8-12'								
SB-06-4	64		12~16'								
SB-07-1	71		1-4'								
SB-07-2	72	3-5-08	4-8'	X	X	X	X	X	X	X[3]	X
SB-07-3	76		8-12'								
SB-7-4	74		12~16'								
SB-08-1	81		1-4'								
SB-08-2	82	3-4-08	4-8'	X	X	X	X	X	X	X[3]	X
SB-08-3	83		8-12'								
SB-08-4	84		12~16'								
SB-09-1	91		1-4'								
SB-09-2	92	3-5-08	4-8'	X	X	X	X	X	X	X[3]	X
SB-09-3	93		8-12'								
SB-09-4	94		12~16'								
SB-10-1	101		1-4'								
SB-10-2	102	3-5-08	4-8'	X	X	X	X	X	X	X[3]	X
SB-10-3	103		8-12'								
SB-10-4	104		12~16'								

Table 4-3 Industrial Area Sample Locations

Sample Number	Blind ID	Date Collected	Sample Depth[2]	Analysis[1]							
				VOCs	SVOCs	PCBs	Pesticides	CN	Metals	Organo-butyltins	TPH
SB-11-1	111	3-7-08	1-4'	X	X	X	X	X	X	NA	X
SB-11-2	112		4-8'								
SB-11-3	113		8-12'								
SB-11-4	114		12~16'								
SB-11-2 FD	1120		4-8'								
SB-12-1	121	3-8-08	1-4'	X	X	X	X	X	X	NA	X
SB-12-2	122		4-8'								
SB-12-3	123		8-12'								
SB-12-4	124		12~16'								
SB-13-1	131	3-6-08	1-4'	X	X	X	X	NA	X	X[3]	X
SB-13-2	132		4-8'								
SB-13-3	133		8-12'								
SB-13-4	134		12~16'								
SB-14-1	141	3-3-08	1-4'	X	X	X	X	X	X	X[3]	X
SB-14-2	142		4-8'								
SB-15-1	151	3-6-08	1-4'	X	X	X	X	NA	X	NA	X
SB-15-2	152		4-8'								
SB-15-3	153		8-12'								
SB-15-5	155		16~20`								
SB-15-2-FD	1520		4-8'								
SB-16-1	161	3-9-08	1-4'	X	X	X	X	X	X	NA	X
SB-16-2	162		4-8'								
SB-16-3	163		8-12'								
SB-16-4	164		12~16'								
SB-17-1	171	3-10-08	1-4'	X	X	X	X	X	X	NA	X
SB-17-2	172		4-8'								
SB-18-1	181	3-8-08	1-4'	X	X	X	X	NA	X	NA	X
SB-18-2	182		4-8'								
SB-18-3	183		8-12'								
SB-18-4	184		12~16'								
SB-18-3-FD	1830		8-12'								
SB-19-1	191	3-8-08	1-4'	X	X	X	X	NA	X	NA	X
SB-19-2	192		4-8'								
SB-19-3	193		8-12'								
SB-19-4	194		12~16'								
SB-19-2-FD	1920		8-12'								
SB-20-1	201	3-13-08	80-85'	X	X	NA	NA	X	NA	NA	X

Notes:
NA Not Analyzed
CN cyanide
FD field Duplicate
[1] Refer to Appendix A-1, Table 1-a for a list of analytes
[2] feet bgs
[3] The Management Plan did not indicate that analysis would occur. The chain of custody (CoC) mistakenly requested analysis.

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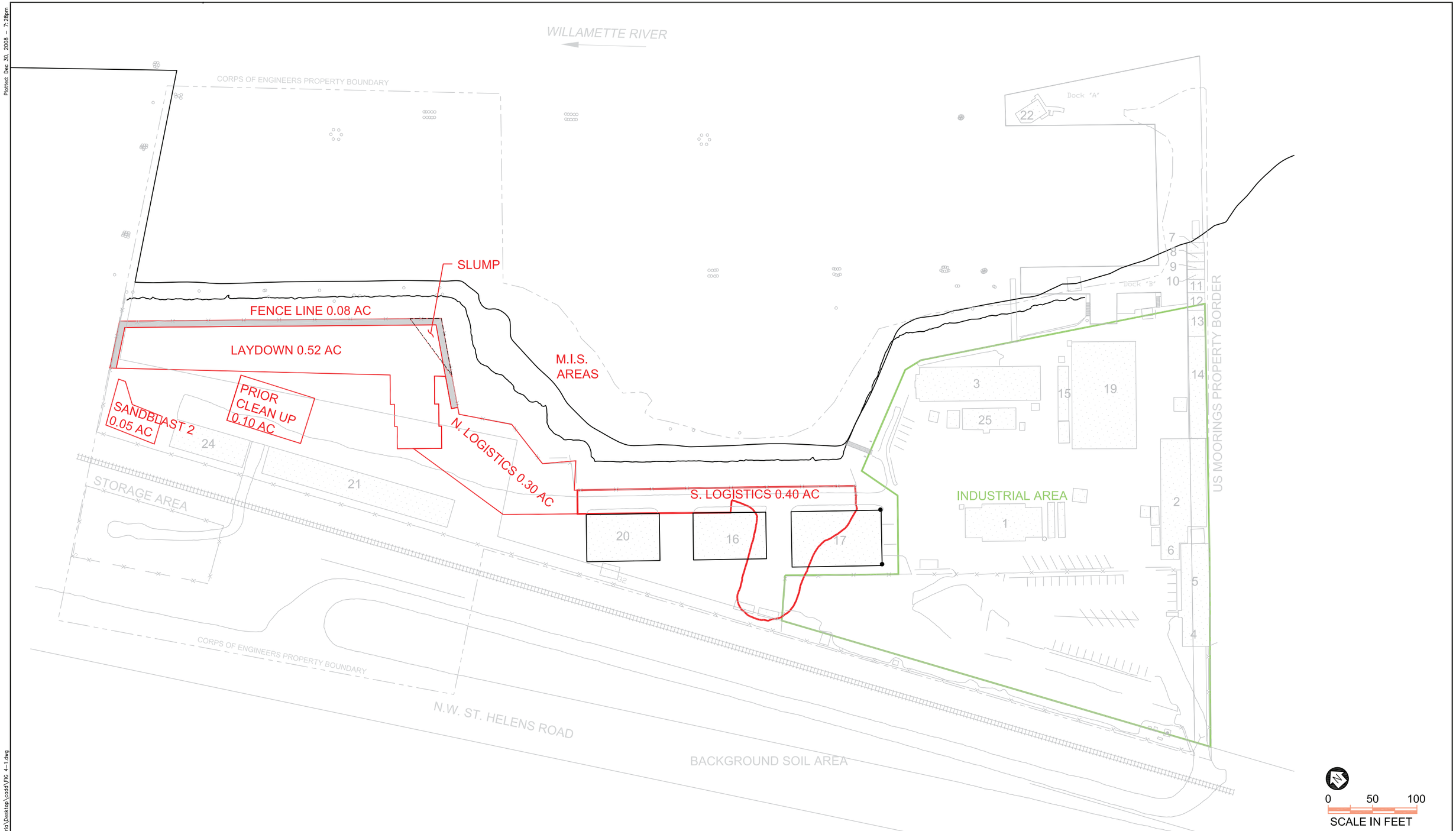

No.	DATE	BY	REVISION
A	XX/XX/XX	XXX	

JOB No.	DESIGNED:	PROJ. ENGINEER:
SCALE:	DRAWN BY:	APPROVED BY:
	CHECKED BY:	DATE:

WARNING
0 1/2 1
IF BAR DOES NOT MEASURE 1" AT FULL SIZE, THEN SCALES ON DRAWING NOT TO SCALE.

TEC Inc.
1450 114th Ave S.E.
Suite 220
Bellevue, Wa 98004
425.453.4040
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US GOVERNMENT MOORINGS

REMEDIAL INVESTIGATION

INDUSTRIAL AND MIS MANAGEMENT UNIT AREAS

DRAWING NUMBER: FIGURE 4–1

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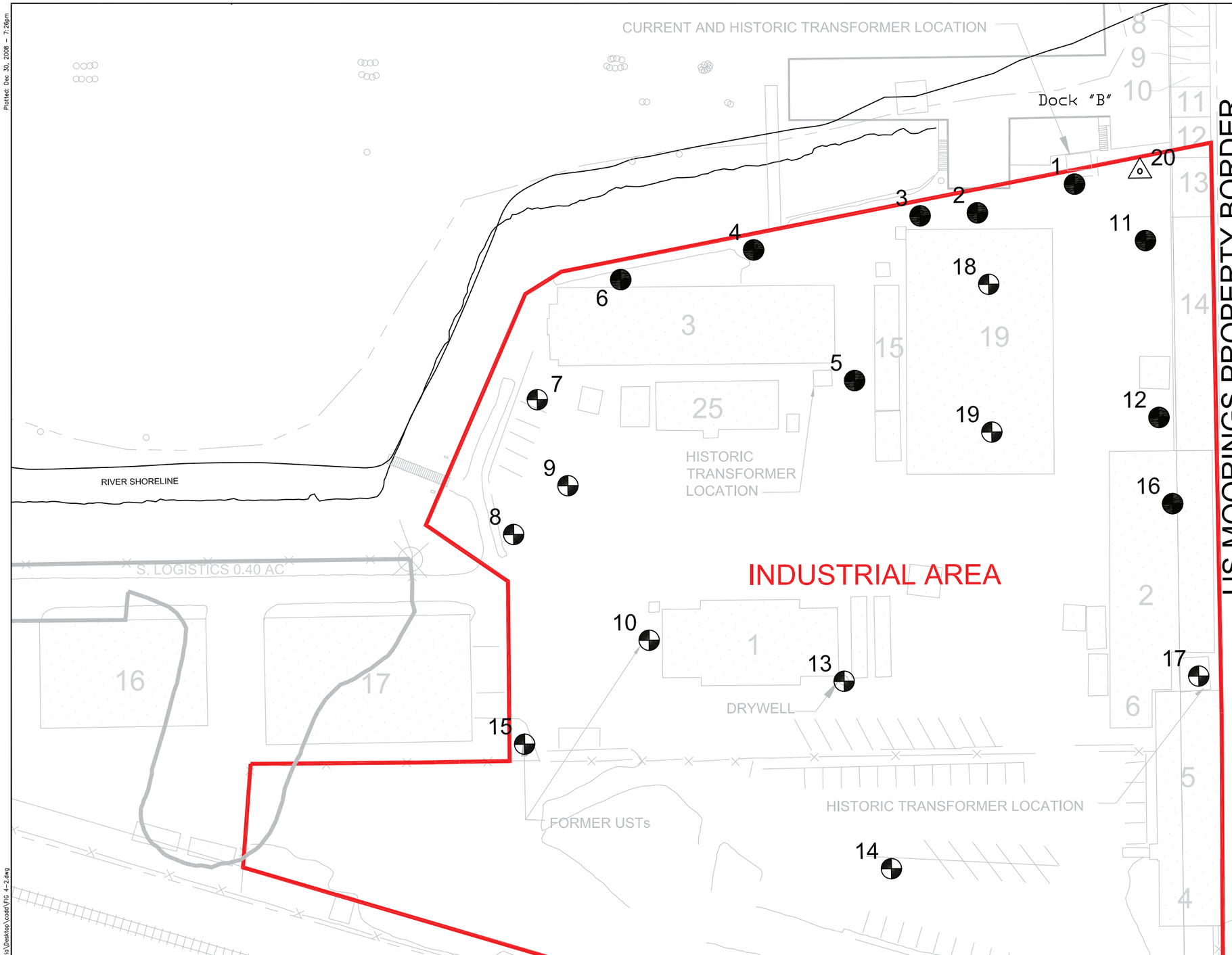

LEGEND

Dolphin/Pile

1993 Cleanup Areas

BUILDING DESIGNATIONS

1 Training Room
2 Welding Shop
3 Carpentry and Electrical Shop
4 Plant Section Office
5 Plant Section Engineering Office
6 Locker and Rest Room
7 Dock Office
8 Lunch Room
9 Lunch Room
10 Rigging Storage Room
11 Electrical Equipment Room
12 Storage Room
13 Paint Shop
14 Dock Storage
15 Oil and Paint Storage
16 Logistics Warehouse Building B
17 Logistics Warehouse Building A
18 Dock Crane
19 Machine Shop
20 Logistics Warehouse Building C
21 Logistics Warehouse Building D
22 Crane House
23 Water Service
24 Logistics Warehouse Building E
25 Hydrographic Surveys Trailer

SOIL & GROUNDWATER SAMPLING LOCATIONS

SOIL SAMPLE LOCATION

SOIL/GROUNDWATER SAMPLE LOCATION

ADVANCE TO BEDROCK (GROUND WATER ONLY)

0 50

SCALE: 1"=50'

No.	DATE	BY	REVISION

JOB No.	DESIGNED:	PROJ. ENGINEER:
SCALE:	DRAWN BY:	APPROVED BY:
	CHECKED BY:	DATE:

WARNING

0 1/2 1

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US GOVERNMENT MOORINGS

REMEDIAL INVESTIGATION WORK PLAN

SOIL AND GROUNDWATER SAMPLING LOCATIONS INDUSTRIAL AREA

DRAWING NUMBER: FIGURE 4–2

CAD FILE NUMBER:

SHEET: OF

REV.

Plotted: Dec 30, 2008 – 7:26pm

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4.1.1.2 Soil Sampling Methodology

Surface and subsurface sample collection was conducted in the Industrial Area via soil borings with a GeoProbe® direct push technology (DPT) rig. A 2.25 inch outside diameter, four foot long, stainless steel Macro-Core® soil sampler, fitted with a new clean disposable poly vinyl chloride (PVC) liner provided for collection of undisturbed soil samples as well as observation of soil lithology on a continuous basis throughout each boring (see Appendix C-3 for the boring logs). Sample horizons started at a depth of 1-foot and were collected in 4-foot intervals (1-4, 4-8, 8-12, etc.) until either groundwater or the native soil interface (NSI) was encountered. Soil cores were screened using olfactory observations and with the use of a Photo Ionization Detector (PID). Soil samples to be analyzed for VOCs were collected using an Encore® sampling system immediately after screening for organic vapors, from the location in the core that presented the most visibly contaminated material. For all other non-VOC constituents, soil was collected from the entire sampling interval, homogenized in a large stainless steel bowl, and placed into appropriate containers for analysis.

4.1.1.2.1 Surface Soil Samples

Seventeen surface soil samples were collected from 19 borings (SB-01 through SB-19) (Figure 4-2, page 4-13). Surface soil sampling depth was 1 - 4 feet bgs. Samples were not collected from the 0 to 1 foot range as the entire sampling area is paved with asphalt. Two locations, SB-02 and SB-03, had recovery problems and the 1 - 4 foot interval was not sampled. See Table 4-3 (page 4-9) for sample analyses and sample horizons.

4.1.1.2.2 Subsurface samples

Sixty-five subsurface soil samples were collected from 20 borings (SB-01 through SB-20) (Figure 4-2, page 4-13). At location SB-01 the 12 - 16 foot interval could not be sampled due to low sample recovery. Sample location SB-17 had refusal at 9.5 feet bgs, so no other sample beyond 8 feet was collected. Samples were not obtained from location SB-14 from the 8 - 12 foot and 12 - 16 foot depths due to recovery issues. A single sample was collected at SB-20 from the 80 to 85 foot interval, which was determined to be at or just above the soil/basalt interface. See Table 4-3 (page 4-9) for sample analyses and sample horizons.

4.1.1.3 Concrete Boring Procedures

A 6 or 12 inch diameter diamond tipped steel core barrel attached to a DPT rig was used to core through asphalt and concrete located around the site. The core barrel(s) was affixed to the rig using an auxiliary auger attachment allowing the barrel to spin freely. Water was used to cool the barrel during the drilling process through an injection system. After completing the process, the core barrel was raised and the concrete/asphalt plug removed. A shop vacuum was used to remove any asphalt/concrete pieces and water left behind during the coring process. The larger 12-inch core barrel was used in places where Quality Assurance/Quality Control (QA/QC) samples were to be obtained or in areas where low recovery was suspected. The larger core barrel allowed the drill rig to advance two separate borings in the same location if needed for QA/QC reasons. Figure 4-3 (page 4-16) illustrates a sample concrete boring.

4.1.1.3.1 Building 20

Soil borings conducted in Building 20 were patched using approximately 2 to 3 feet of concrete with five 3-foot pieces of rebar added for stability. This was done because at every location in the building, sloughing of the very fine dry sand had occurred. The large amount of concrete used was to fill the voids caused by the displaced sands. The rebar pieces were used to avoid cracking due to the heavy weight of the forklift that worked in the area. Figure 4-4 (page 4-16) illustrates a sample concrete boring.

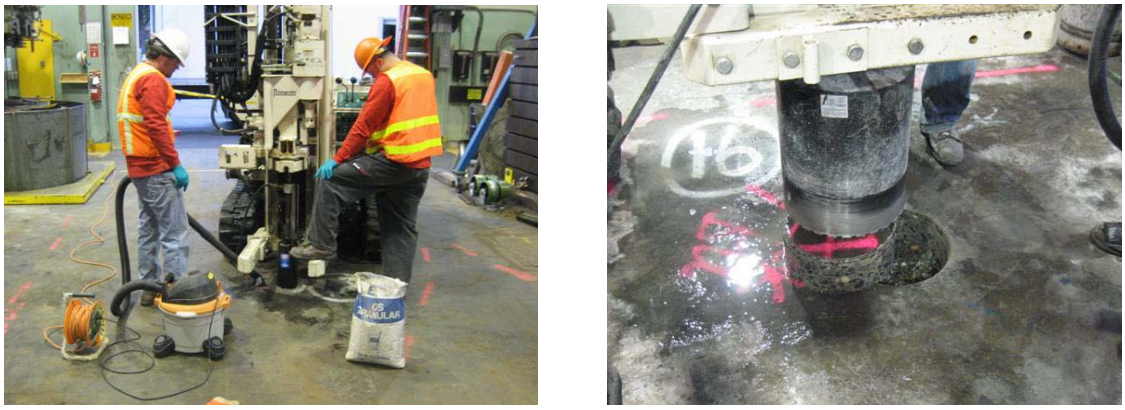


Figure 4-3 Sample Concrete Boring

Figure 4-4 Building 20 Concrete Boring

4.1.1.3.2 Concrete Borehole Patching Procedure

Once the soil boring was completed, approximately one foot of concrete was applied and given a brushed finish. If a soil boring was completed in an asphalt area, it was completed using approximately one foot of dyed black concrete to match the surrounding area.

4.1.1.4 Soil Contingency Samples

After review of the initial data showed elevated concentrations of total cyanide in nine wells located in the Industrial Area, the USACE decided to conduct additional groundwater sampling to further delineate the cyanide plume in groundwater (Section 4.2.2, page 4-35). Two of these locations (SB-24 and SB-31) were located downgradient of the two former UST tanks. These locations were also analyzed for TPH in groundwater and soils in order to fill in data gaps related to potential contamination from the former UST.

Table 4-4 below lists the contingency sample location information. These locations are also shown on Figure 4-7 (page 4-37) in Section 4.2.2 (page 4-35).

Table 4-4 Additional Industrial Area TPH Sampling

Sample Number	Blind ID	Date Collected	Sample Depth[1]
SB-24-1	241	8-7-08	1-4'
SB-24-2	242		4-8'
SB-24-3	243		8-12'
SB-24-4	244		12~16'
SB-24-2 FD	2410		1-4'
SB-31-1	311		1-4'
SB-31-2	312		4-8'
SB-31-3	313		8-12'
SB-31-4	314		12~16'

[1] feet bgs

Additional samples were collected in the vicinity of SB-15 in a third sampling event to confirm the original findings and to better define the lateral extent of soil contamination. The details of this sampling event are presented in Appendix E.

4.1.2 Multi-Increment Sampling

The objectives of the MIS Area soils investigation were also three-fold:

- Determine if the near-surface (i.e., Upper Unit) site soils pose an unacceptable risk to construction workers involved in the excavation and repair of underground utility lines;
- Determine if deeper site soils (i.e., Lower Unit) are a source of groundwater contamination; and
- Determine the adequacy and completeness of previous remedial activities.

The MIS approach used to characterize the northern portion of the site was a directive from the USEPA. The USEPA insisted on this approach due to the concern that sediment from heavily contaminated upstream activities might have been dredged and placed in the upland portion of Moorings. (Fill activities are discussed in Section 2.4.3, page 2-8.) The concern was that

pockets of NAPL might have and may still exist in the heterogeneous fill material used to bring the northern portion of Moorings up to current grade. The USACE agreed to use this sampling approach only in areas that were suspected of using previously contaminated dredged materials to create additional land. A description of MIS rationale and site-specific MIS decisions follows.

4.1.2.1 MIS Sampling Background

The purpose of collecting, preparing, and analyzing a multi increment sample is to provide a repeatable and accurate measure of the average concentrations of constituents of interest within a sample area. DQOs are required for each decision unit that determines the types and numbers of samples required. Sufficient amount of sample material must be collected from the sample area to account for compositional heterogeneity and additionally, a sufficient number of sub samples utilizing a systematic random methodology must be taken to account for distributional heterogeneity.

Typical uses of accurate, average values are as follows.

- Exposure point concentrations within human health or ecological risk assessments;
- Delineation of nature and extent of contamination;
- Characterization sampling of a potential waste material; and
- Closure sampling of a remediated area to provide legally defensible, scientifically based evidence that satisfactory remediation has been accomplished.

The likelihood of determining small scale hot spots of contamination by conventional discrete sampling is extremely low, unrepeatable, and legally indefensible. MIS, alternatively, provides a much greater probability of determining representative, repeatable, and legally defensible contamination within a reasonably sized area (Gemperline 1999).

4.1.2.2 Management Unit Definition Rational

Historical evidence shows that the MIS Area was filled to a depth ranging from 10 feet to a maximum of approximately 20 feet using material dredged from the river during the 1925 and/or 1945 fill activities (Section 2.4.3, page 2-8; Figure 2-8, page 2-13; and Figure 2-9, page 2-15).

The MIS Area was initially subdivided into five MUs based on estimated common physical, chemical, and operational characteristics to provide a measure of the average concentrations of constituents of interest to facilitate the MIS approach. Figure 4-5 (page 4-21) shows the original 5 MU areas.

For instance, The Laydown MU is approximately 0.5-acres in size and was filled to a maximum depth of 18 feet towards the water's edge. (Estimated fill contours are depicted in Figure 2-8, page 2-13). The material used to fill in this land portion was dredged from the river for navigational requirements.

The appropriate samples would be taken from 3 horizons, starting from the surface and ending at the native soil interface. Samples were homogenized into a single aliquot for chemical analysis for each horizon per MU (Section 4.1.2.5, page 4-32).

Field conditions necessitated the reevaluation of the MIS Area into 7 MUs (Figure 4-1, page 4-11). Changes to MUs are discussed in Section 4.1.2.3 (page 4-19) in more detail. The objectives of the final seven MUs are listed in Table 4-5 (page 4-19). A brief description of the MUs follows.

Table 4-5 RI Objectives for Each Management Unit

Objective	Management Unit						
	SL	NL	LD	FL	SP	PC	SB
1. Determine if the site is a source of contamination to the Willamette River.	X	X	X	X	X		
2. Determine if the upland portions of the site present unacceptable risks to human health.	X	X	X	X	X	X	X
4. Determine if upland portions of the site are contaminated by historic dredge material placement.	X	X	X				
5. Determine the adequacy and completeness of previous remedial activities.						X	X

Notes
SL South Logistics NS North Logistics LD Laydown
FL Fence line SP Slump PC Prior Clean-up SB Sandblast

4.1.2.2.1 Determination of Sub-Sampling Locations within MIS Sampling Area

In order to provide a repeatable and accurate measure of the average concentrations of constituents of interest with in a sample, each MU was broken into individual sub-sampling locations depending on the size of each MU. In general, when using a MIS approach, approximately 30 sub-samples should be taken in an area of 0.5 acres. In areas where the total size was larger than 0.5 acres or less than 0.5 acres, the sample density was changed to include more or less locations to account for compositional heterogeneity. See Section 4.1.2.4 (page 4-23) for each MU size and sub-sampling aliquots respectively.

4.1.2.2.2 MIS Quality Control/Quality Assurance Samples

In order to measure repeatability of field collection techniques, a triplicate sample was collected in the Laydown MU using the same field collection techniques to allow statistical analysis to be done on the MIS sampling process. The triplicate sample included the original sample, a second sample collected approximately 8.5 feet to the north of the original, and a third sample collected 16.5 feet to the east from the original location. Additional aliquots were collected from the second and third locations within the Laydown MU at the upper horizon. See Figure 4-6C (page 4-28) for the triplicate layout.

4.1.2.3 Management Unit Description

4.1.2.3.1 South Logistics

The South Logistics MU is a 0.40-acre plot located just north of the Industrial Area in which 23 final MIS locations were sampled and composited for analysis. Field sampling activities in the South Logistics Area took place 14 March through 18 March 2008 and samples were sent to the laboratory for analysis. Per borehole log records, the South Logistics MU was filled with dredge material to an approximate depth of 8 to 17 feet.

Subsequently, sub-sampling began in the North Logistics area on March 30 at Locations 61-67. During sample collection at these locations, it was noted that the material (i.e., brown sands) collected appeared to be the same as what was found in the South Logistics MU. Discussion of this issue with USEPA and USACE resulted in the decision that the land area around North Logistics MU Locations 61-67 should be added to the South Logistics MU. Any future actions taken in the South Logistics MU would also be applied to this area. As composite samples from the South Logistics MU had already been sent to the laboratory, no additional sub-samples would be collected and analyzed from Locations 61-67.

4.1.2.3.2 North Logistics

The North Logistics MU is located between the South Logistics and Laydown MUs. The final North Logistics MU is a 0.30-acre plot in which 22 MIS locations were sampled. Per borehole log records, it was filled with dredge material to an approximate depth of 8 to 20 feet.

During the sampling activities in this area, initiated 30 March 2008, it was noted that sample material collected from Locations 61 - 67 had similar characteristics to those previously collected from the South Logistics MU. A decision was made by the USEPA and the USACE that the area around sample Locations 61 - 67 would be removed from the North Logistics MU footprint and added to the Sough Logistics MU (discussed above). Similarly, sub-sampling Locations 31 - 34, 36, 37, 40, and 41 were determined to be significantly different from the rest of the North Logistics MU. With concurrence of the USEPA and the USACE, these locations were made part of the Laydown MU.

Additionally, the Management Plan called for a sample horizon of 0 to 1 feet for samples collected in this MU. (Sample horizons are discussed in more detail in Section 4.1.2.5.2, page 4-32) However, during field activities, it was noted that the North Logistics Area was either paved with asphalt or covered in hard packed gravel ranging in depth from 6 inches to 9 inches (see also 4.1.1.2.1, page 4-15). This horizon was removed from sampling activities with concurrence of the USEPA and the USACE.

4.1.2.3.3 Laydown

The Laydown MU is a 0.60-acre plot located at the north end of the site adjacent to the water. This area was filled with dredge material to an approximate depth of 10 to 15 feet per historical drawings and photos. The fill/NSI was not conclusive from borings in this MU. Thirty-eight locations were sampled in this area. As indicated previously, this MU was expanded by 8 sub-samples as dictated by field conditions (Section 4.1.2.3.2, page 4-20).

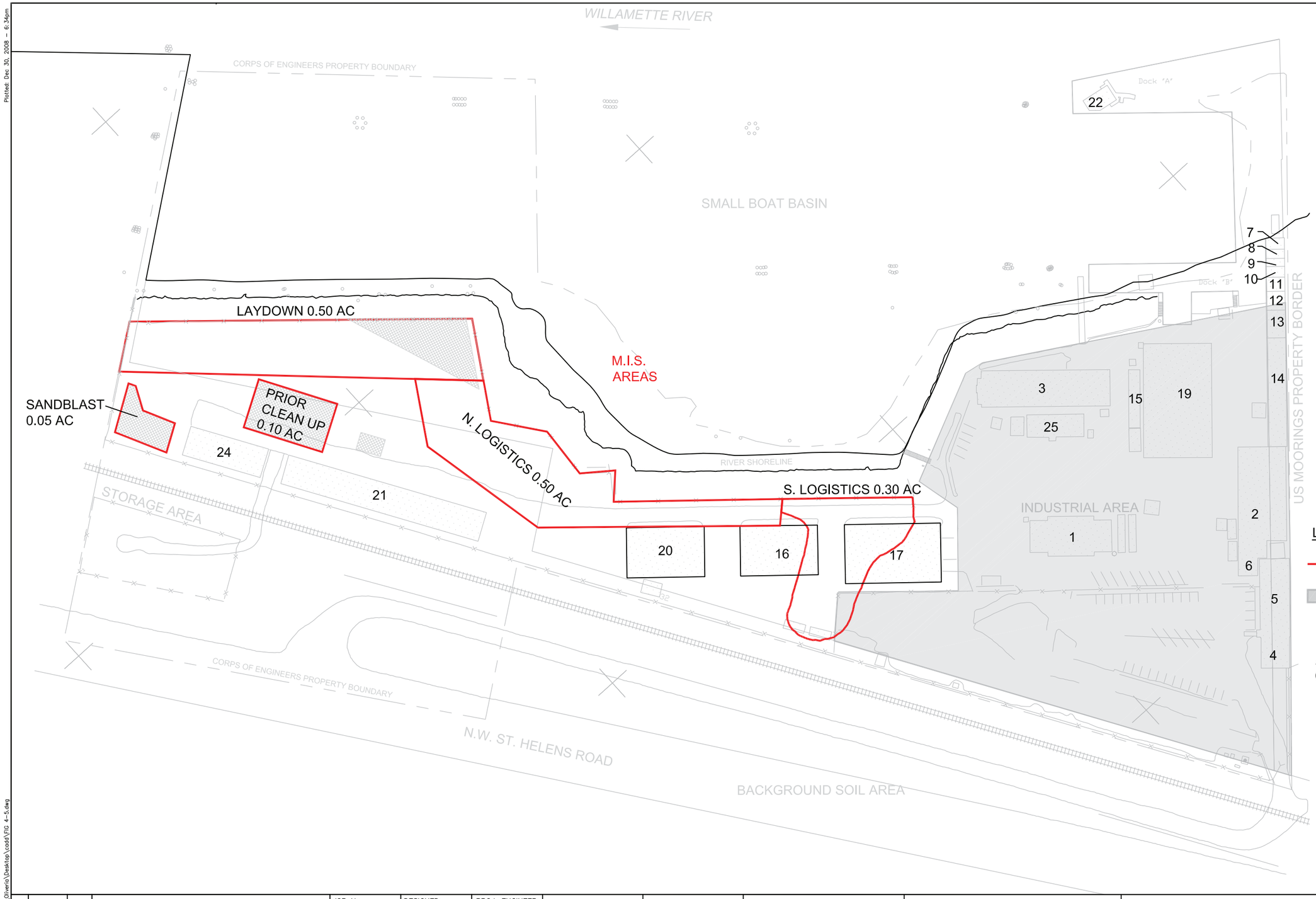
As with the North Logistics discussed above, the sample horizon of 0 to1 feet was removed as the entire MU was covered in hard packed gravel.

4.1.2.3.4 Fence Line

The Fence Line MU was established to substitute for the lack of available erodible soils in the 0 to 1 foot horizon in the North Logistics and Laydown MUs. A new MU was established along the northeast edge of the property, in the area between the hard packed gravel and hard armored shoreline. An approximately 1 to 3 foot wide area exists, which is covered with loose gravel and stormwater runoff sediment. Sub-samples in this MU were collected only in the 0 to 6 inch horizon. The Fence Line area is a 0.08-acre plot in which 25 locations were sampled.

4.1.2.3.5 Slump

In the area of the southeast corner of the Laydown MU, a triangular section of land sloughed off to the Willamette River and was repaired using clean fill material. During the course of the Laydown MIS sample collection, it was noted that the material collected for three locations (SB-30, SB-15, and SB-14) in this area was different (yellow sands) from any other samples collected in the Laydown, or any other MU, and was recognized as the slump repair material. Upon discussion, the USEPA and USACE agreed to develop a new MU for this area. The Slump MU is a 0.03-acre plot in which included these three locations.



BUILDING DESIGNATIONS

1 Training Room
2 Welding Shop
3 Carpentry and Electrical Shop
4 Plant Section Office
5 Plant Section Engineering Office
6 Locker and Rest Room
7 Dock Office
8 Lunch Room
9 Lunch Room
10 Rigging Storage Room
11 Electrical Equipment Room
12 Storage Room
13 Paint Shop
14 Dock Storage
15 Oil and Paint Storage
16 Logistics Warehouse Building B
17 Logistics Warehouse Building A
18 Dock Crane
19 Machine Shop
20 Logistics Warehouse Building C
21 Logistics Warehouse Building D
22 Crane House
23 Water Service
24 Logistics Warehouse Building E
25 Hydrographic Surveys Trailer

LEGEND

MIS MANAGEMENT UNITS

INDUSTRIAL AREA (DISCREET SAMPLING ONLY)

AREA 0.56 AC — DESIGNATION AND ACRE OR AREA

0 50 100
SCALE IN FEET

No.	DATE	BY	REVISION

JOB No.	DESIGNED:	PROJ. ENGINEER:
SCALE:	DRAWN BY:	APPROVED BY:
	CHECKED BY:	DATE:

WARNING
0 1/2 1
IF BAR DOES NOT MEASURE 1" AT FULL SIZE, THEN SCALES ON DRAWING NOT TO SCALE.

TEC Inc.
1450 114th Ave S.E.
Suite 220
Bellevue, Wa 98004
425.453.4040
425.454.7043 fax

US GOVERNMENT MOORINGS

REMEDIAL INVESTIGATION

PLANNED MANAGEMENT UNITS
MIS AREA

DRAWING NUMBER: FIGURE 4–5
CAD FILE NUMBER:
SHEET: OF
REV.

Plotted: Dec 30, 2008 – 6:34pm
File: C:\Documents and Settings\Oliveria\Desktop\cadd\FIG 4-5.dwg

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4.1.2.3.6 Removal Action Confirmation Sampling

Two MIS-like MUs in the northern part of the site were created to assess past clean-up efforts. In order to be consistent with other sampling activities being executed in the northern part of the site, these areas were treated in a MIS-like manner, despite their small size and few sample locations. The Removal Action Confirmation Sampling MUs had only one horizon of 1 to 5 feet. The reasoning for this was twofold:

1. The 0 to 1 foot interval was inaccessible due to a 6 to 9 inch layer of asphalt/concrete paving or hard packed gravel, and
2. The goal of these MUs was to conduct confirmation sampling of a previous removal action that removed material in the 0 to 1 foot range, therefore soil immediately below the removed horizon was sampled.

Prior Clean-Up

The Prior Clean-up MU is a 0.10-acre plot located to the west of the Laydown MU and was sampled as part of the RI to verify the efficiency of part of the 1993 removal action (discussed in Section 2.9.1.3.1, page 2-29). In order to assess the efficiency of the past removal action 8 MIS surface soil samples were collected.

Sandblast

The Sandblast Area is a 0.05-acre plot located in the northwestern most corner of the site and was sampled as part of the RI to verify the efficiency of a different part of the 1993 removal action (Section 2.9.1.3.1, page 2-29). In order to assess the efficiency of the past removal action 7 MIS surface soil samples were collected.

4.1.2.4 MIS Sample Grid

A sampling grid for each MIS Area was created in a computer-aided design (CAD) format, which depicted each location, distance between points, and the distance from buildings to each western point. The sampling grids were established in the field using CAD Figures and a survey tape. A more detailed description of each sample grid is provided below. The total number of sample locations depended on the size of each MU and is summarized in Table 4-6, page 4-25. Sample locations are illustrated on Figures 4-6A through 4-6F (pages 4-26 through 4-31).

4.1.2.4.1 South Logistics MU Sample grid

The sampling grid in this MU was set up using a CAD rendered drawing to locate each sampling point that was visually identified and marked on the ground with paint. This area was completed in this manner due to its smaller size and relative ease to locate each sampling point (Figure 4-6A, page 4-26).

4.1.2.4.2 North Logistics MU Sample Grid

In this MU, Location 61 was used as the starting point to begin marking the grid locations. Location 61 was set approximately 7 feet off the northeast corner of Building 20. Once this point was set, Locations 62 through 67 and 57 through 60 were spaced every 25 feet parallel to Building 20. The next row was created by identifying Location 53 by measuring 25 feet northeast of Location 57. Locations 54 through 56 and 52 were spaced every 25 feet. The third row was created by measuring 25 feet east of the midpoint between Locations 52 and 53 and setting Location 48. After Location 48 was set, Locations 49 through 51, 46, and 47 were

evenly spaced every 25 feet. Locations 40 through 45 and 36 through 39 were set the same way as the third row. Locations 33 through 35 were shifted to the north because Location 35 was depicted on the drawing as being partially down the armored rock wall. Locations 33 and 34 were spaced 25 feet from Locations 33 through 35 (Figure 4-6B, page 4-27).

4.1.2.4.3 Laydown MU Sample Grid

Location 15 was used as the starting point to create the grid for the Laydown MU. Location 15 was also depicted to be partially down the armored rock wall and was adjusted to 20 feet west of the fence line along the river and near the south fence. All other locations (1 through 14) were measured in 25.7-foot increments from Location 15. Locations 16 through 30 were measured 32.8 feet away from the eastern fence line and spaced 25.7 feet from each other (Figure 4-6C, page 4-28).

4.1.2.4.4 Slump MU Sample Grid

The Slump MU had three specific locations identified from the previously established Laydown MU grid (Figure 4-6D, page 4-29).

4.1.2.4.5 Fence Line MU Sample Grid

The Fence Line MU sampling grid was set up by marking a fence pole, located approximately 10 feet southeast of Location 35. Using Location 35 as a starting point, 25 individual locations were evenly spaced along the fence line (Figure 4-6E, page 4-30).

4.1.2.4.6 Removal Action Confirmation Sampling Grids

Prior Cleanup MU Sample Grid

Location 103 was located in line with south wall of building 24, 28 feet from building corner. Location 104 was located 20 feet from Building 21, and 25 feet from location 103. Locations 102, 105, and 98 through 101 were located from the first two locations (Figure 4-6F, page 4-31).

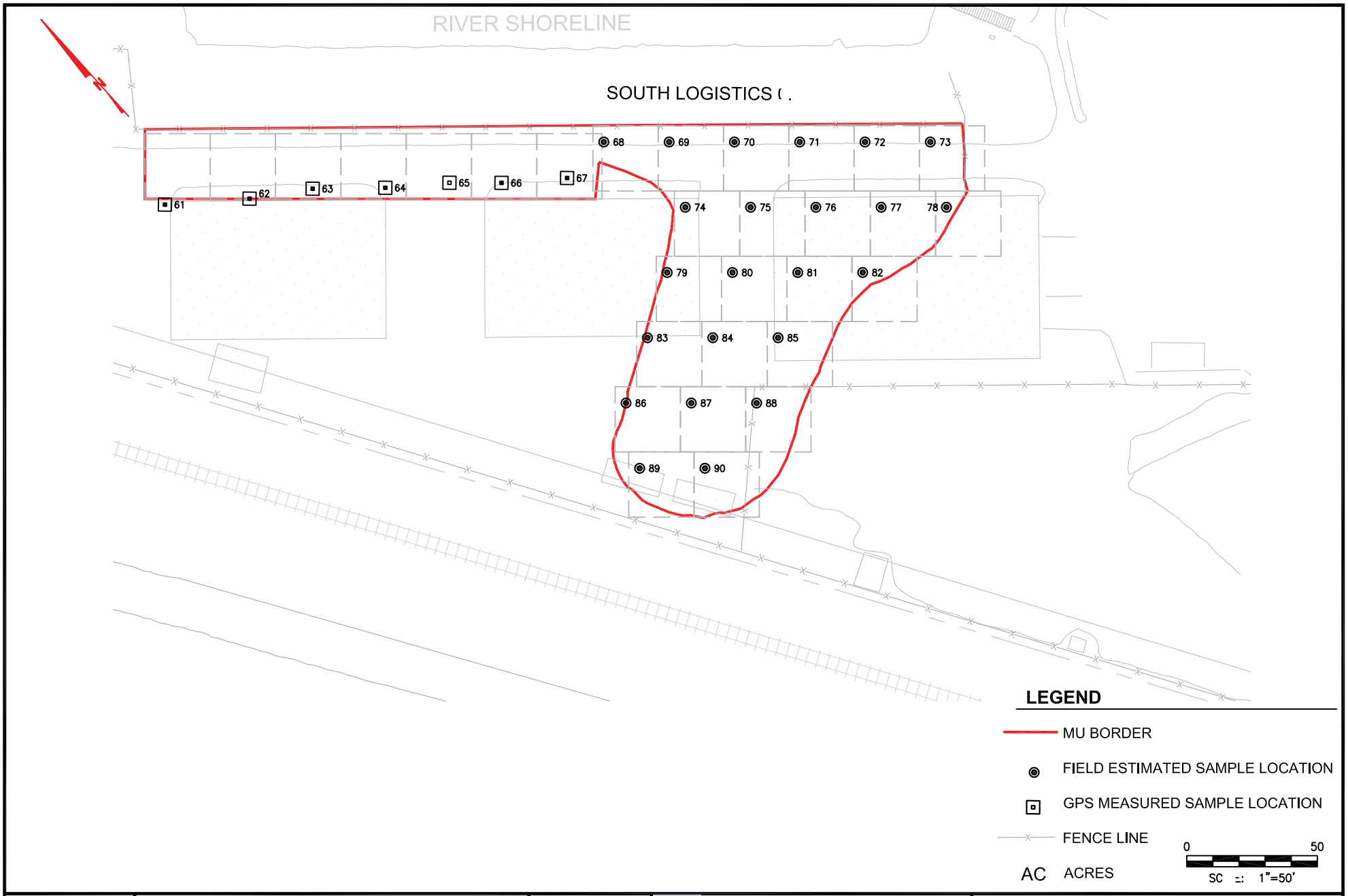
Sandblast MU Sample Grid

Location 94 was located 28 feet off the north corner of Building 24 and offset 6 feet to the east. Locations 91 through 93 and 95 through 97 were marked off using Location 94 as a guide (Figure 4-6F, page 4-31).

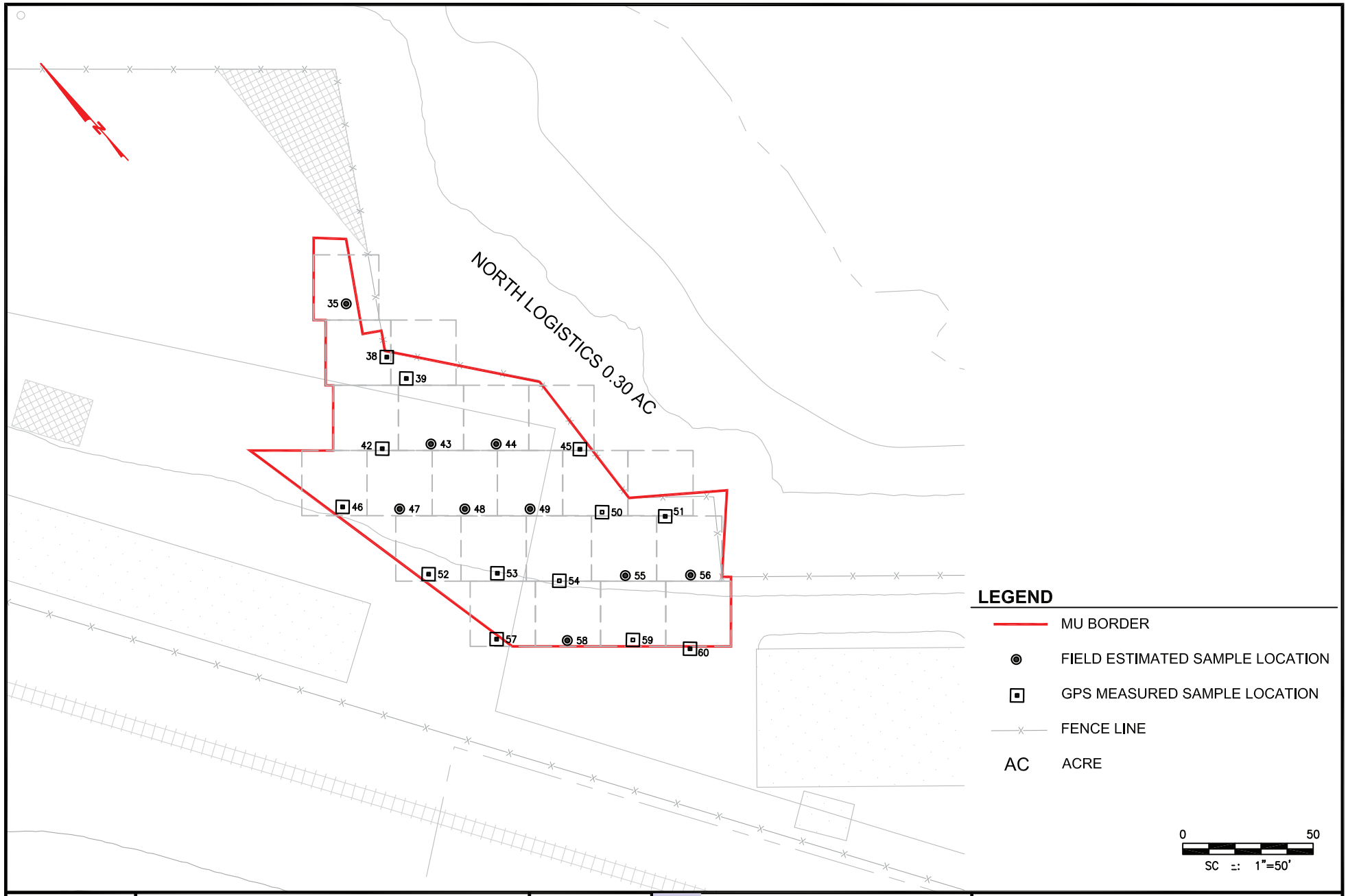
Table 4-6 MIS Samples

MU	Sample Number	Blind ID	Dredged Material Depth[1,2]	Sample Depth[1]	# of Samples	Sample Date	Sub-Sample Collection Date Range	Analysis[3]							
								VOC	SVOC	PCB	Pesticides	CN	Metals	Organo-butyltins	TPH
South Logistics	SB-SL-001	3000	8' ~ 17'	1' - 5'	23	3-14-08	3-14-08 to 3-23-08	NA	X	X	X	NA	X	NA	X
	SB-SL-002	3001		5' - 10'											
	SB-SL-003	3002		10' ~ 15											
North Logistics	SB-NL-01	5000	8' ~20'	1' - 5'	22	3-26-08	3-25-08 to 3-30-08	NA	X	X	X	NA	X	X	X
	SB-NL-02	5001		5' ~ 10'											
Laydown	SB-LD-01	6000	10' ~15'	1' - 5'	37	3-31-08	3-31-08 to 4-5-08	NA	X	X	X	NA	X	X	X
	SB-LD-02	6001		5' ~10'	38										
Field Triplicates	SB-MIS-T1-01	8000		1' - 5'	37	4-5-05	4-5-08 to 4-7-08								
	SB-MIS-T1-02	8001													
Fence Line	SB-FL-01	11000	N/A	0' - 6"'	25	4-9-08	4-9-08	NA	X	X	X	NA	X	X	X
Slump	SB-SP-01	7000	N/A	1' - 5'	3	3-31-08	3-31-08 to 4-1-08	NA				NA			
Prior Clean-up	SB-PC-01	4000	N/A	1' - 5'	8	3-25-08	3-25-08, 3-28-08	NA	X	X	X	NA	X	X	X
Sandblast	SB-SB-01	9000	N/A	1' - 5'	7	4-8-08	4-8-08	NA	X	X	X	NA	X	X	X

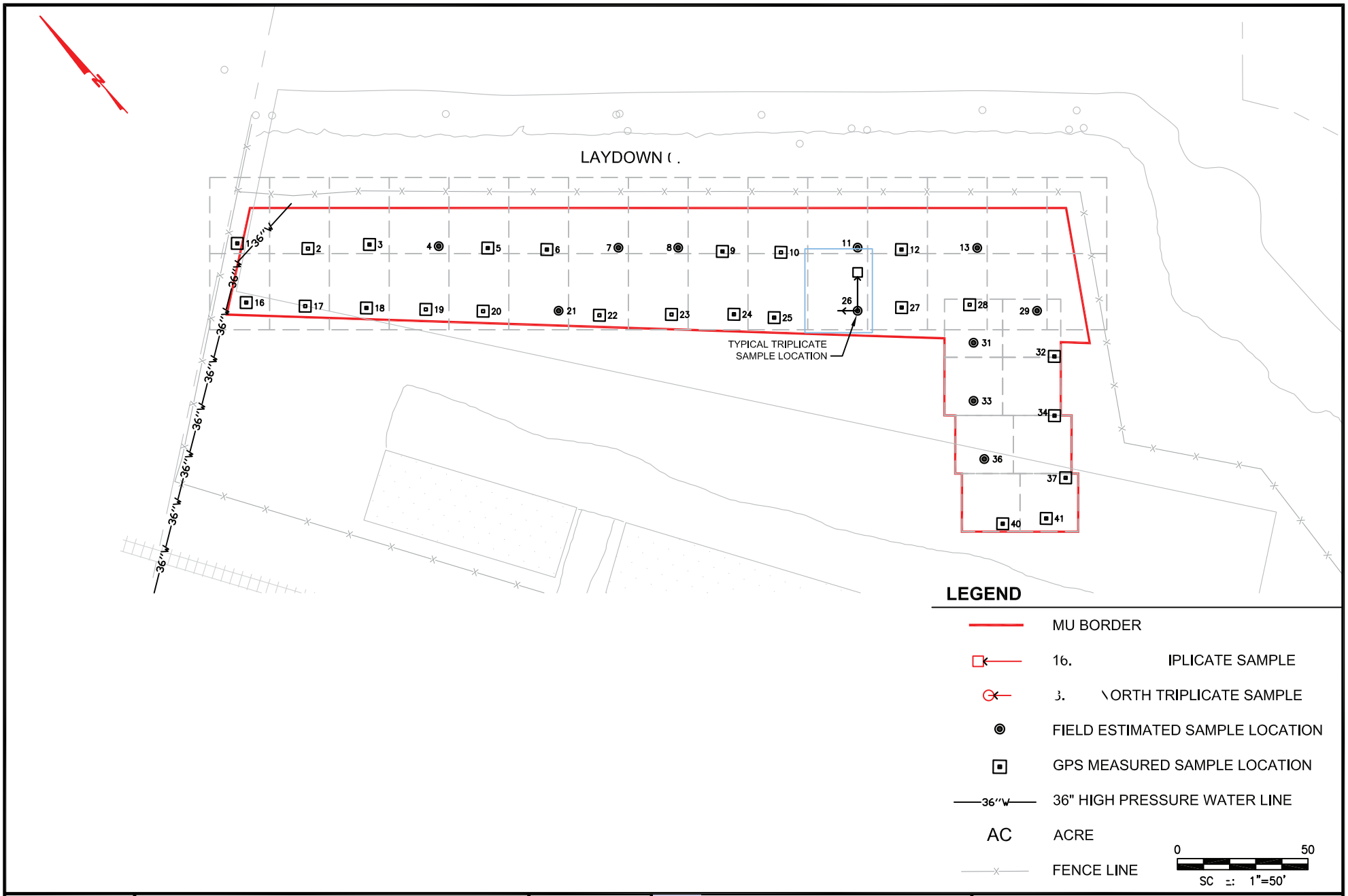
Notes
N/A Not Applicable
NA Not Analyzed
1 feet bgs
2 estimated
3 Refer to Appendix A, Table 1-b for a list of analytes



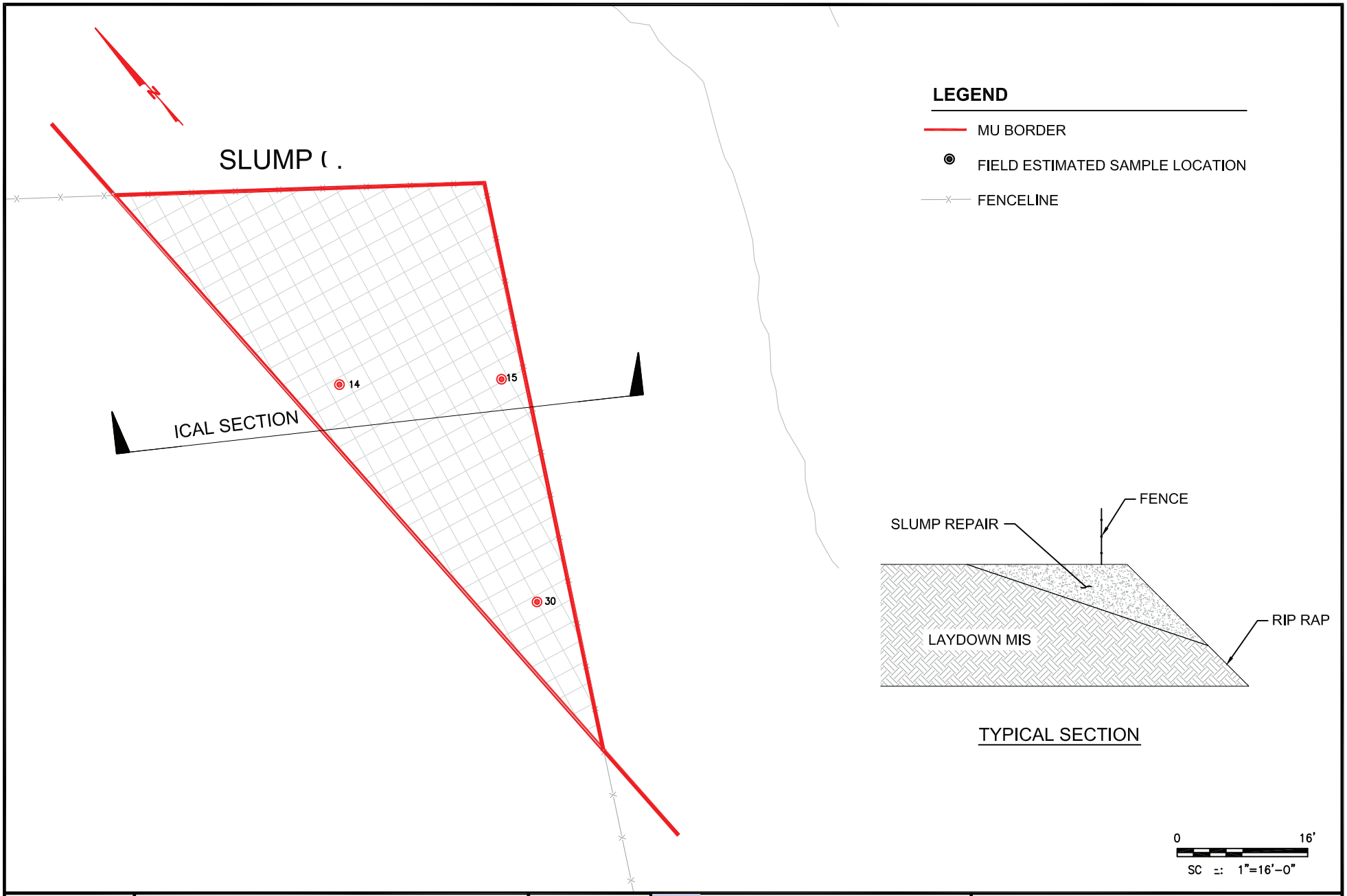
F -	ISTICS MU SAMPLING LOCATIONS	D-T: -4-09 DR M-0 CH: K-1	TEC inc 1450 114th Ave llevue, Wa 98004 42	ENT MOORINGS REMEDIAL INVESTIGATION



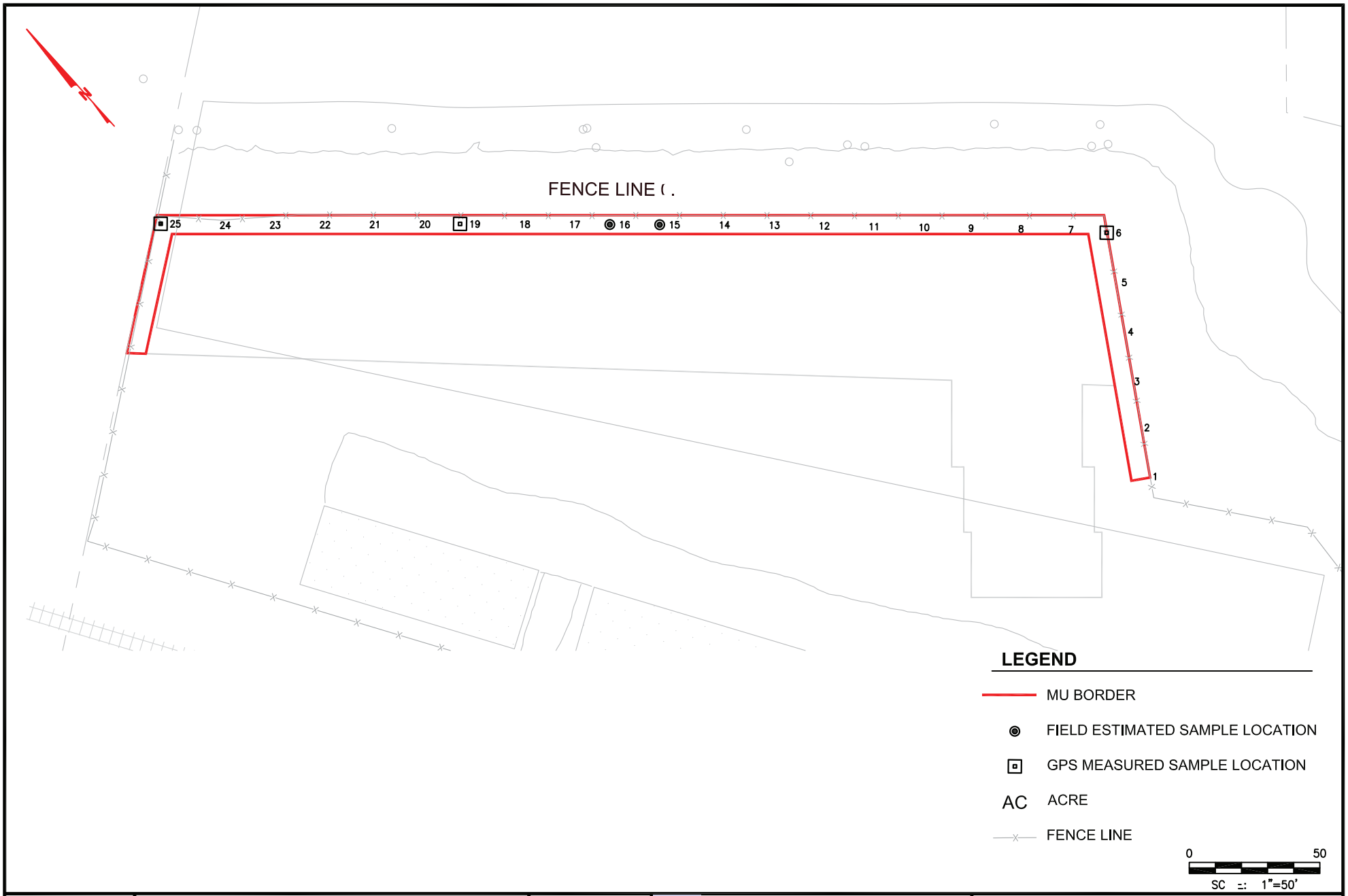
F -	\ORTH LOGISTIC MU SAMPLING LOCATIONS	D-T: -4-09 DR M-0 CH: K-1	TEC inc 1450 114th Ave llevue, Wa 98004 42	\ ENT MOORINGS REMEDIAL INVESTIGATION



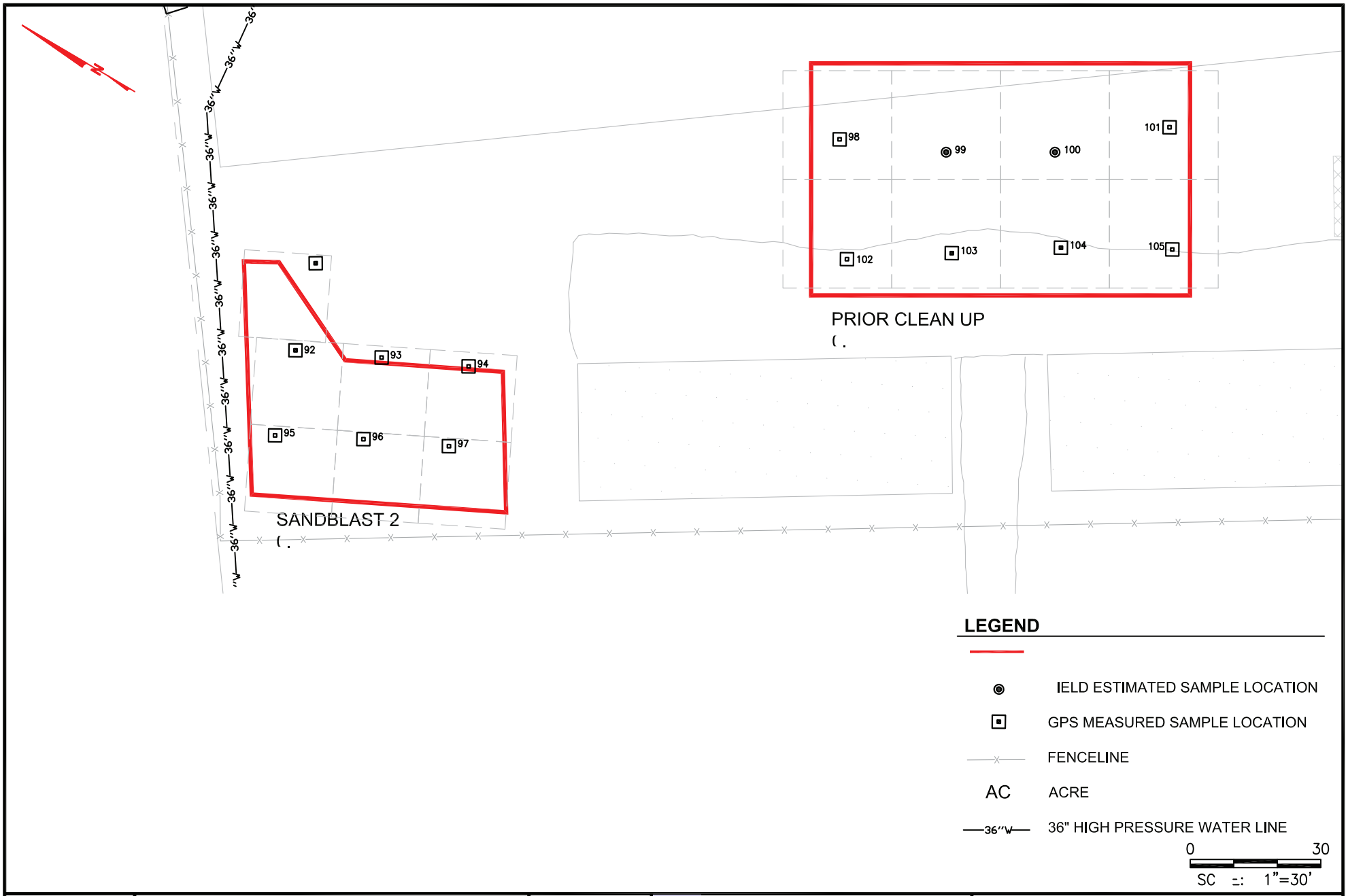
F	MU SAMPLING LOCATIONS	D-T: -4-09 DR M-D CH: K:	TEC inc 1450 114th Ave llevue, Wa 98004 425	ENT MOORINGS REMEDIAL INVESTIGATION



F -	ING LOCATIONS	D-T: -4-09 DR M-0 CH: K:	TEC inc 1450 114th Ave llevue, Wa 98004 425	ENT MOORINGS REMEDIAL INVESTIGATION



F -	CE LINE MU SAMPLING LOCATIONS	D-T: -4-09 DR M-D CH: K:	TEC inc 1450 114th Ave llevue, Wa 98004 425	ENT MOORINGS REMEDIAL INVESTIGATION



Fi -	IVITY CONFIRMATION SAMPLING LOCATION	D-T= -4-09 DR M=0 CH= K=1	TEC inc 1450 114th Ave llevue, Wa 98004 425	ENT MOORINGS REMEDIAL INVESTIGATION

4.1.2.5 MIS Sample Methodology

Surface and subsurface soil samples were collected from the MIS Area using a DPT drill rig (discussed in Section 4.1.1.2, page 4-15). After a core was removed from each horizon, the core was split lengthwise using a core knife. A stainless steel spoon was used to collect a small amount of soil (approximately 4 ounces) from the center of the entire length of the core. The material was homogenized in a stainless steel bowl and placed into an appropriate laboratory container for analysis. Sample aliquots were collected sequentially from each specified horizon in one boring location before moving to a new location. All boring locations were sampled concurrently during the sample collection range presented in Table 4-6 (page 4-25).

4.1.2.5.1 Fence Line MU

As discussed in Section 4.1.2.3.4 (page 4-20), only one sample horizon was collected in the Fence Line MU. This sample was collected directly from the soil using a stainless steel spoon. The material from each sub-sampling location was placed into a stainless steel bowl; homogenized, and placed in an appropriate sampling container. The sample was labeled in the same method as the other MUs.

4.1.3 MIS Contingencies

A review of the MIS data showed slightly elevated concentrations of benzo(a)pyrene and arsenic that exceeded screening criteria (Table 7.2.2, pages 7-15 and 7-16) in the shallow soils (1'-5' bgs). Concentrations of these two compounds in deep soils (5'-10' bgs and 10' bgs – NSI) were lower than the surface soils. Per the decision criteria set forth in the remedial investigation objectives and strategy for subsurface soil sampling (Table 4.1 page 4-4) the need for additional samples (both GW and smaller MIS units) was evaluated and determined to be of little value in further characterizing the site. Consequently no additional samples were collected.

4.1.4 MIS Sample Labeling

Each MU was assigned a unique series of numbers (Table 4-6, page 4-25). For example, the South Logistics MU was assigned the 3000 series.

Within each MU, up to three sample horizons were used to evaluate the fill material. The number of horizons selected was based on the estimated depth of dredge material established from historic documentation (Section 2.4.3, page 2-8).

The first horizon sampled was a four-foot increment of 1 to 5 feet (except for the Fence Line MU, discussed above) and was given the first number of the series (e.g., 3000). Additional sampling horizons were collected in five-foot increments and assigned sequential numbers.

Within each MU, multiple subsample locations were selected for sampling (Section 4.1.2.2.1, page 4-19; Section 4.1.2.4, page 4-23). Each location, within each MU, was also given a sequential number, which was used as a suffix to identify the sub-sample aliquots of a whole MIS sample. For example, the South Logistics MU had 23 sample locations.

- Material collected from 1 to 5 feet was assigned subsample IDs 3000-1, 3000-2, 3000-3, through 3000-23.
- Material collected from 5 to 10 feet was assigned subsample IDs 3001-1, 3001-2, 3001-3, through 3002-23.

- Material collected from 10 feet to NSI was assigned subsample IDs 3002-1, 3002-2, 3002-3, through 3002-23.

Samples were placed into individual containers, labeled in this manner, and sent to the laboratory. Details regarding sample identification and labeling are provided in Section 4.5.1 (page 4-64). This process was repeated in all the MIS MUs at every horizon. The laboratory combined all samples at each location in the same horizon (e.g., 3000-1 through 3000-23) into one composite for further processing and analysis.

The soil horizons sampled at each MU are located in Table 4-6 (page 4-25).

4.1.5 Upland Soil Description and Field Screening

Soils encountered in borings, both in the Industrial Area and MIS Area, were described in the field using the Unified Soil Classification System (USCS). All soil cores were screened in the field using personnel observations (i.e., visual or odor) and with the use of a PID for organic vapors in accordance with the approved Management Plan (KTA/TEC 2008) and the approved Accident Prevention Plan (KTA/TEC 2008a) for this project.

4.1.6 Lithology Documentation

The lithology for GeoProbe® locations was continuously logged during drilling activities (see Appendix C-3 for the borehole logs). Information collected on the borelogs (Appendix C-3) included borehole location; drilling information; odors and visual contamination; information such as logging intervals, recovery; and sample description information.

Lithologic descriptions of unconsolidated materials encountered in the boreholes were described in accordance with American Society for Testing and Materials (ASTM) (ASTM 1990). Descriptive information recorded included:

- Identification of the predominate particles size and range of particle sizes;
- Percent of gravel, sand, fines, or all three;
- Description of grading and sorting of coarse particles;
- Particle angularity and shape; and
- Maximum particle size or dimension (identification of the USCS group symbol was also used).

Additional information recorded on the logs included the depth of the water table, caving or sloughing of the borehole, changes in drilling rate, presence of organic materials, and other noteworthy observation or conditions. Photographs of soil cores are provided in the Photo Log in Appendix C-4.

Table 4-7 Remedial Investigation Objectives and Strategy - Groundwater

Data Requirements	Location	Investigation Objectives	Investigation Strategy	Decision Criteria
If soil sampling in upland areas demonstrate presence of COPCs, determine if shallow groundwater is contaminated.	Industrial Area	Determine if the site is contributing contamination to the river.	Collect 6 groundwater samples near the shoreline at locations downgradient of suspected sources. Analyze samples for: • VOCs • SVOCs • Pesticides • PCBs • Cyanide • Metals • TPH • TSS	• If detected constituents < MCLs and < JSCS groundwater/surface water/stormwater water quality criteria, then no further investigative actions will be taken. • If > MCLs and > JSCS groundwater/surface water/wtormwater water quality criteria, the technical team will evaluate the need for additional sampling. (This may include additional characterization and/or source delineation in the context of all data generated for the site.) • If any VOCs are detected, evaluate Vapor Intrusion pathway with Johnson-Ettinger model.
	Off Site Sources	Determine of off-site sources are contributing to contamination on the site.	Collect groundwater samples from 4 locations near the SE property boundary. Analyze samples for: • VOCs • SVOCs • Pesticides • PCBs • Metals • TPHs • TSS	Decision criteria as above for Industrial Area
	Contingency Sampling	Determine the extent and nature of cyanide in groundwater.	Collect groundwater samples from 10 locations. Analyze samples for: • Cyanide (WAD) 4500-CN-1 • Cyanide (WAD) OIA 1677 • Cyanide (Free)9213 • Cyanide (total) USEPA 335.4 • Cyanide (amenable) SM 4500 CN G	Decision criteria as above for Industrial Area

Notes:
MCL maximum contaminant level WAD weak acid dissociable

4.2 UPLAND GROUNDWATER INVESTIGATION

Groundwater-related investigation activities including installation and sampling of temporary monitoring wells were conducted as a component of the upland soil boring activities in the Industrial Area (Section 4.1.1, page 4-7). The specific RI objectives pertinent to the groundwater investigation were to:

- Determine if the site is a source of contamination to the Willamette River;
- Determine if off-site sources of contamination are impacting the site (i.e., former activities on neighboring property to the south, Olympic pipeline, the adjacent railway, ODOT roadways); and

Determine human health risk from potential future use of groundwater as a drinking water source by on-site workers and determine compliance with applicable or relevant and appropriate requirements (ARARs).Sample locations are shown on Figure 4-2 (page 4-13). A description of groundwater-related investigation activities at the Moorings is provided below. Table 4-7 (page 4-34) summarizes the sampling approach and rational for the upland groundwater investigation.

4.2.1 Sample Locations

Temporary wells were installed in the surficial fill WBZ in ten Industrial Area boreholes as shown in Table 4-9 (page 4-36). Table 4-8 below describes the rational for each sample location.

Table 4-8 Potential Contaminant Source and Sample Location Cross Reference

Potential Contaminant Source	Sample Locations
Determine if the former creek channel represents a potential migration pathway	2, 3, 4, 12
Samples collected along the riverbank to determine if groundwater flowing from the site is contaminating the river.	1, 2, 3, 4 5, 6
Samples collected along Moorings/GASCO boundary to determine if contaminants are migrating to the Moorings property	5, 11, 12, 16

4.2.2 Groundwater Contingencies

A review of the initial data showed elevated concentrations of cyanide (total) in nine wells located in the Industrial Area. The USACE decided that additional groundwater samples (Table 4.10, page 36) should be collected to further delineate the cyanide plume. Two of the additional locations (SB-24 and SB-31) were located downgradient of the two former USTs. These locations were also analyzed for TPH compounds in order to fill in data gaps related to potential contamination from the former USTs.

Ten additional temporary wells were located in the Industrial Area (Figure 4-7, page 4-37). The newly installed wells were analyzed for five different cyanide methods (discussed in Section 5.5.5, page 5-104) to match similar protocols currently being conducted at the GASCO site. Temporary wells were installed, samples collected, and wells abandoned using the same methodology as the initial groundwater sampling event.

A third sampling event was also conducted to verify the findings at SB15 and to determine if groundwater in the vicinity of this location was contaminated by petroleum products. The details of this sampling event may be found in the Draft Supplemental Remedial Investigation Report, attached as Appendix E.

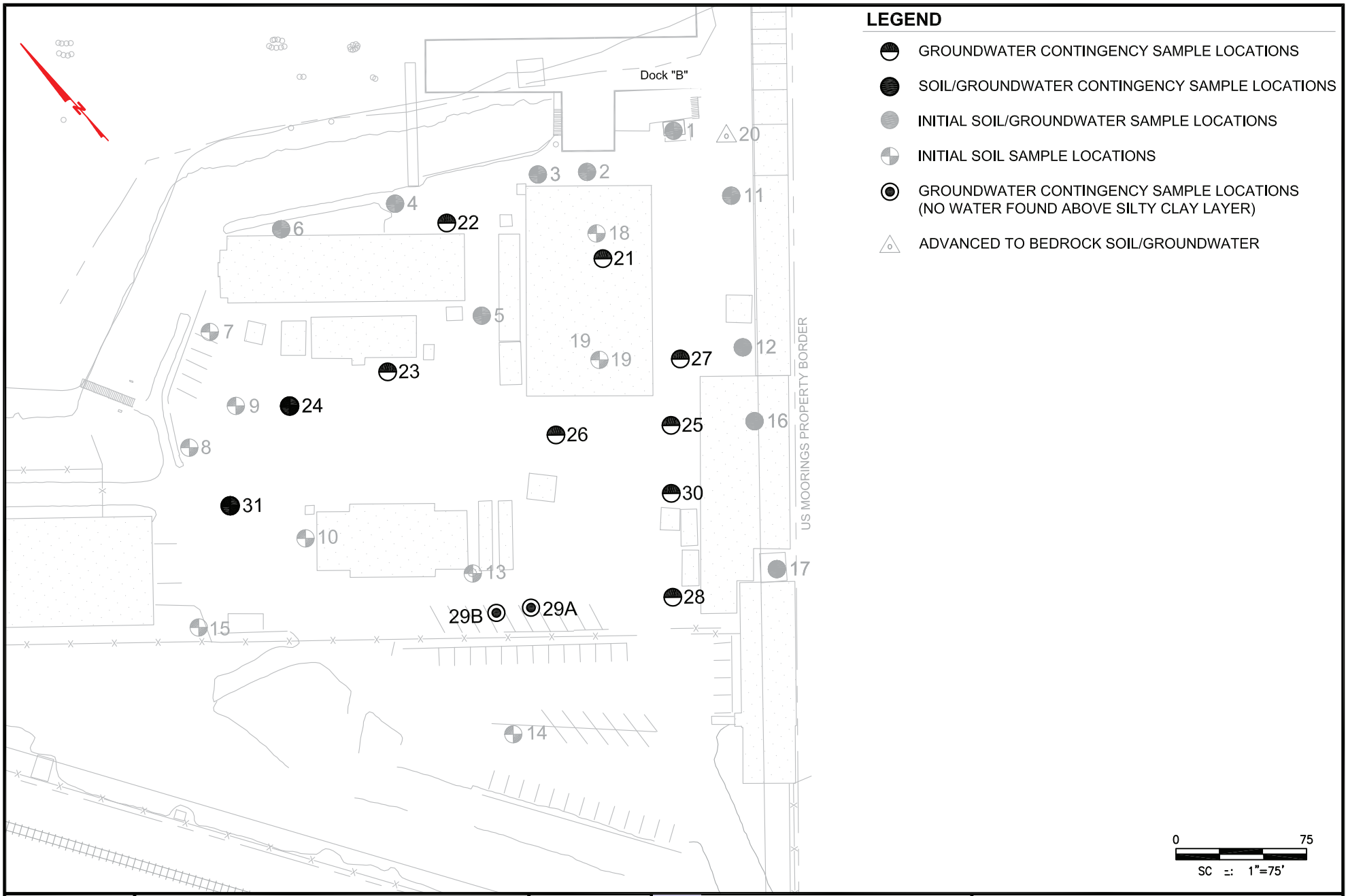
Table 4-9 Groundwater Sampling Locations

Sample Number	Blind ID	Installation Date	Date Collected	Screened Interval[1]	Water Level[1]	Analysis[2]							
						VOC	SVOC	PCB	Pesticides	CN	Metals	TSS	TPH
GW-1	16	3-7-08	3-8-08	8-18	9.26	X	X	X	X	X	X	X	X
GW-2	25	3-6-08	3-7-08	10-20	12.65	X	X	X	X	X	X	X	X
GW-3	36	3-5-08	3-6-08	8-18	14.53	X	X	X	X	X	X	X	X
GW-4	45	3-4-08	3-6-08	13-28	14.08	X	X	X	X	X	X	X	X
GW-5	55	3-6-08	3-7-08	10-20	13.00	X	X	X	X	X	X	X	X
GW-5-FD	56	N/A	3-7-08	10-20	13.00	X	X	X	X	X	X	X	X
GW-6	65	3-4-08	3-5-08	9-24	14.51	X	X	X	X	X	X	X	X
GW-20	202	3-13-08	3-13-08	75-85	21.64	X	X	X	X	X	X	X	X
GW-11	115	3-7-08	3-8-08	8-18	10.99	X	X	X	X	X	X	X	X
GW-12	125	3-8-08	3-9-08	8-18	11.33	X	X	X	X	X	X	X	X
GW-16	165	3-9-08	3-10-08	10-20	9.99	X	X	X	X	X	X	X	X
GW-16-FD	166	N/A	3-10-08	10-20	9.99	X	X	X	X	X	X	X	X

Table 4-10 Groundwater Contingency Sampling Locations

Sample Number	Blind ID	Installation Date	Date Collected	Screened Interval [1]	Water Level [1]	Analysis[2]	
						CN	TPH
GW-21	210	8-5-2008	8-6-08	9-19	12.86	X	
GW-22	220	8-5-08	8-6-08	10-20	14.40	X	
GW-23	230	8-6-08	8-7-08	7-17	14.48	X	
GW-24	240	8-5-08	8-7-08	10-20	13.93	X	X
GW-24-FD	245	N/A	8-7-08	10-20	13.93	X	X
GW-25	250	8-5-08	8-7-08	10-20	11.52	X	
GW-26	260	8-5-08	8-6-08	12-22	14.30	X	
GW-27	270	8-6-08	8-7-08	8-18	11.74	X	
GW-28	280	8-5-08	8-6-08	10-20	11.55	X	
GW-30	300	8-6-08	8-7-08	15-20	11.20	X	
GW-31	310	8-7-08	8-7-08	8-18	13.62	X	X

Notes:
1 feet bgs
2 Please refer to Appendix A, Table 1-c for a list of analytes
GW Groundwater
N/A Not Applicable



Fi -	\DWATER CONTINGENCY SAMPLING LOCATIONS	DAT : DRAWN: CHECKE):	TEC inc 1450 114th Ave llevue, Wa 98004 425	\ ENT MOORINGS REMEDIAL INVESTIGATION

4.2.3 Temporary Well Installation and Groundwater Sampling Methodology

Temporary monitoring wells were installed in the Industrial Area using a track mounted direct-push GeoProbe® rig. The temporary wells were installed in the same borehole after soil sampling was completed at each location using a dual tube system to minimize heaving or collapse of the borehole during the installation. Temporary wells consisted of 0.75" PVC pipe with 10 to 15 foot screen lengths and contained 0.010-inch slots (10 slot).

The temporary wells were set at depths ranging from 18 to 28 feet bgs across the site. As discussed in Section 4.1.1.2.2 (page 4-15), a temporary well could not be set at Location SB-17 due to refusal at 9.5-foot bgs. SB-17 was located in a constricted area and a normal drill rig could not gain access. A small dolly rig was brought in to drill at this location but due to the small size and light weight of the machine, it was not able to penetrate past 9.5-foot bgs.

A temporary well was also set at Location SB-20 which was selected to check for the possible presence of NAPL at the bedrock surface. NAPL has been detected at bedrock on the former GASCO site, which borders the Moorings to the south. The temporary well was completed to a total depth of 85 feet bgs and screened from 75-85 feet bgs.

Upon installation, each temporary well was allowed to settle for 24 hours prior to sampling.

A low-flow, minimal drawdown technique was used for groundwater sampling activities at each location. The minimal drawdown technique minimized stress and disturbance on the groundwater formation, therefore collection of a representative sample of the groundwater was achieved. This technique was successful with the use of a water level indicator (WLI), allowing field personnel to measure groundwater levels during the purging and sampling processes. The water level measurements during purging and sampling allowed personnel to ensure flow-rate remained constant. A peristaltic pump with Teflon-lined tubing was used to obtain each sample. The depth to groundwater withdrawal, or intake depth, was fixed at mid-screen depth or slightly above mid-screen depth.

Stabilization parameter measurements were collected during low-flow purging and sampling with use of a flow-through cell and in-line multi-probe meter, at approximately 5-minute intervals. Purging continued until all parameters achieved the minimum stability criteria in at least two consecutive measurements. Parameter measurements recorded during purging were conductivity, temperature, pH, dissolved oxygen (DO), turbidity, salinity, and oxygen reduction potential (ORP). Water quality parameters are presented in Table 4-11 (page 4-40).

Information collected on each temporary well water quality parameter sheet also included purge rate, water level, and cumulative volume of groundwater purged from well at each interval. After pH, temperature, and conductivity measurements stabilized within 10 percent in at least two consecutive measurements, a sample was collected for analysis. Samples collected for dissolved metals were field filtered using an in-line 0.45-micron filter with Teflon tubing attached to the peristaltic pump.

All wells were properly abandoned in accordance with Oregon Administrative Rules (OAR) 690-240-475. Temporary monitoring wells (GW-01 through GW-19) were abandoned by first removing the well casing and screen material for the borehole. Dry bentonite chips were poured into the well from the bottom up and hydrated in two foot lifts to within 1-foot bgs. The top portion of the boring was filled using concrete to match the surrounding area. In areas where holes were drilled through asphalt, black dye was added to the concrete mix and applied to the top portion of the boring. Temporary monitoring well GW-20 was abandoned in the same

manner as the other wells but bentonite grout was used instead of chips per OAR 690-240-475. A tremie pipe was used to fill the well up from the bottom, thus displacing the water with grout. The grout was allowed to settle for 24 hours and the remaining space (approximately 3 feet bgs) was filled to within 1-foot bgs with bentonite chips and hydrated. The top portion was completed using dyed concrete to match the surrounding asphalt.

Table 4-11 Final Physiochemical Readings

Well ID	Blind Sample ID	Date	Time	Total Purge [1]	Depth to Water [2]	Temp (°C)	pH	Sp. Cond. (mS/cm)	Turbidity (NTU)	DO (mg/L)	eH (mV)	Salinity (%)
SURFACE WATER												
ODOT Outfall	1051	3/13/2008	850	NA	NA	6.97	4.90	0.74	27.40	14.55	185	0.00
French Drain	1052	3/13/2008	755	NA	NA	9.01	5.39	0.041	3.40	13.66	177	0.00
GROUNDWATER												
1	16	3/8/2008	905	0.8	11.41	13.70	5.91	1.46	7.90	0.00	161	0.10
2	25	3/7/2008	1000	1.2	14.16	14.41	8.92	0.345	8.30	0.00	-43	0.00
3	36	3/6/2008	1220	0.7	16.53	12.28	8.05	0.158	0.00	0.00	16	0.00
4	45	3/6/2008	855	0.3	16.08	13.99	4.07	1.03	0.00	0.76	292	0.00
5	55	3/7/2008	1345	0.9	13.25	13.15	6.12	0.445	4.50	2.04	164	0.00
6	65	3/5/2008	1155	1.4	14.51	13.64	9.44	0.329	4.90	1.86	-105	0.00
11	115	3/8/2008	1415	2.6	13.14	12.33	5.74	1.35	254.00	0.01	69	0.10
12	125	3/9/2008	845	0.5	11.83	11.44	6.69	1.00	0.00	0.49	35	0.00
16	165	3/10/2008	905	1.3	9.99	13.41	7.44	2.11	6.10	3.37	-15	0.10
20	202	3/14/2008	925	1.5	22.92	12.00	9.43	2.75	8.10	0.28	-145	0.10
Groundwater Contingency Locations												
21	210	8/6/2008	1525	0.8	13.78	16.42	5.09	0.837	34.10	0.00	89	0.04
22	220	8/6/2008	905	1.1	15.70	15.92	4.64	0.999	30.40	0.00	157	0.05
23	230	8/7/2008	915	0.5	15.29	14.94	5.03	0.272	0.00	0.00	73	0.01
24	240	8/7/2008	755	0.5	14.81	15.66	6.13	0.319	0.00	0.00	-64	0.01
25	250	8/6/2008	1125	0.7	12.35	14.94	4.67	0.589	37.30	0.00	117	0.02
26	260	8/6/2008	1020	0.8	15.17	15.05	4.10	0.487	55.30	0.00	205	0.02
27	270	8/7/2008	1135	1.2	12.57	14.86	4.25	0.691	0.00	0.00	122	0.03
28	280	8/6/2008	1225	0.7	12.97	15.37	5.82	0.185	36.90	0.00	37	0.01
30	300	8/7/2008	1005	0.5	12.04	14.30	6.06	0.255	0.00	0.00	-54	0.01
31	310	8/7/2008	1235	0.9	14.45	16.20	6.14	0.292	0.00	0.00	-58	0.01

Notes:
1 gal - gallon
2 feet (btoc) - below top of casing
mS/cm - milli siemen/centimeter
NTU - nephelometric turbidity units
mg/L - milligrams per liter
mV - millivolts

4.3 UPLAND SURFACE WATER AND UPLAND SEDIMENT INVESTIGATION

The following sections discuss upland surface water and upland sediment activities of the Moorings RI.

4.3.1 Upland Surface Water Sampling

Upland surface water sampling activities were conducted in support of the following RI objectives. Table 4-12 (page 4-42) summarizes the sampling approach and rational for the Upland Soil investigation.

- Determine if the site is a source of contamination to the Willamette River.
- Determine if off-site contamination is impacting the site.

4.3.1.1 Surface Water Sample Locations

Three surface water locations were selected for sampling to determine if point source discharges are impacting the Willamette River. Table 4-13 (page 4-43) lists the samples taken as part of the upland surface water investigation. Figure 4-8 (page 4-47) illustrates the sample locations. The three samples included:

- An ODOT catch basin located off site to the west of the site, between Building 20 and the railroad tracks, and connected to the river via a drainage pipe that runs under Moorings. Unless the drainage pipe is leaking, it is unlikely that the stormwater flowing from the ODOT catch basin would have any negative impact on the site. However, the discharge may be affecting the Willamette River as the drainage pipe discharges directly into the river.
- A location on the bulkhead wall where water is seeping through the riprap was identified as the Seep location. The seep is only visible when the tide is relatively low and it is likely that water is seeping from the entire area behind the riprap, but only comes through it at this one location in sufficient volume to be collected.
- The French drain that transports stormwater runoff from the Laydown MU.

In addition, field activities were conducted to determine if current and/or historic surface water conveyance systems are still functional and acting as potential preferential contaminant transport pathways.

4.3.1.2 Surface Water Sampling Methodology

Two aliquots each were taken from the ODOT catch basin and French drain. The first aliquot was used to measure physio-chemical readings that are reported in Table 4-11 (page 4-40). The second aliquot was sent to the laboratory for analysis. One aliquot was taken from the seep location and was sent to the lab for analysis. In order to analyze for dissolved metals from these locations, an extra lab supplied bottle was filled at each location using the grab sample. A peristaltic pump with an in-line 0.45-micron filter attached with Teflon tubing was used to transfer each sample from the non-preserved bottles into the preserved bottles for analysis.

Table 4-12 Remedial Investigation Objectives and Strategy - Upland Surface Water

Data Requirements	Location	Investigation Objectives	Investigation Strategy	Decision Criteria
Determine if surface water exiting the site is contributing to contamination of the Willamette River	Laydown and Central Areas	Determine if the site is contributing contamination to the river via surface water runoff.	Sample French drain location once to determine if COIs are leaving the site through stormwater discharges. Collect surface water and sediment and analyze for: • SVOCs • Pesticides • PCBs • Metals • TPHs	• If detected constituents < groundwater/surface water/stormwater water quality screening criteria in the JSCS then no additional investigative action required. • If detected constituents > groundwater/surface water/stormwater water quality screening criteria in the JSCS then additional Best Management Practices housekeeping practices will be evaluated.
		Determine if the site is contributing contamination from the Seep.	Collect Seep sample. Analyze sample as for French Drain.	• Same Decision criteria as above
	ODOT Catch Basin	Determine if highway runoff is contributing contamination to the river.	Collect stormwater runoff sample for catch basin adjacent to Mooring site. Analyze sample as for French Drain.	Review analytical results against JSCS criteria and inform ODOT of results.
Determine if current and/or historic surface water conveyance systems are still functional. For systems no longer needed, determine abandonment requirements.	Historic Stormwater Conveyance Systems	Determine if the site is contributing contamination to the river.	Smoke test all current and historic outfalls to verify the upstream portion has been capped. Test results will also be used to verify that stormwater is not infiltrating the system and discharging to the river due to cracks in paved surfaces, foundations, or the stormwater piping systems.	• If old outfall systems are found to not be properly capped, then a proper abandonment plan will be developed • If the upland portion of the stormwater system is capped but the smoke test shows evidence of leaking, then a removal action will be considered for the system (i.e., excavation). • If the system is capped on the upland side and no evidence of leaking is detected, then the sediment located in outfall will be sampled and analyzed. If detected constituents > surface water risk based concentrations (RBCs), then removal or abandonment actions will be considered.

Table 4-13 Upland Surface Water Samples

Sample Location	Sample ID	Blind Sample ID	Date	Sample Depth	Analyis [1]							
					VOC	SVOC	PCB	Pesticides	CN	Metals	Organobutyltins	TPH
ODOT Catch Basin	SW-ODOT-01	1051	03-13-08 [2]	N/A	NA	X	X	X	NA	X	NA	X
French Drain	SW-FD-01	1052	03-13-08[2]	N/A								
Seep Location	SW-SEEP-01	12000	04-03-08[3]	N/A								

Notes:
N/A Not Applicable
NA Not Analyzed
[1] Please refer to Appendix A Table 1d for a list of analytes
[2] Sample Collected during a rain event
[3] Seep sample collected at low tide.

4.3.1.3 Catch Basins and Stormwater Outfalls

The Moorings also has an integrated network of catch basins and stormwater outfalls. The site has been divided into five drainage areas labeled 1 through 5 on Figure 2-13 (page 2-37).

- Drainage Area 3 includes the entire site with the exception of the Industrial Area. This area drains directly to the Willamette River via surface (sheet) runoff. However, this runoff is funneled to a relatively small area within the North Logistics MU. It is expected that infiltration is minimal.
- Drainage areas 1 and 4 drain the northern half of the Industrial Area. Stormwater is collected by three storm drains, which run via a subsurface piping system to a 500-gallon oil/water separator, where the water is treated. The treated stormwater then runs through a 6-inch diameter underground PVC pipe to the Willamette River.
- Drainage areas 2 and 5 drain the southern half of the Industrial Area. Stormwater is collected by eight storm drains, which run via a subsurface piping system to a 500-gallon oil/water separator, where the water is treated. The treated stormwater then runs through a 6-inch diameter underground PVC pipe to the Willamette River.

Prior to 2000, all stormwater outfalls discharged directly into the Willamette River. At that time, two new oil/water separators associated with the stormwater conveyance system were installed in 2000, replacing an existing unit. Stormwater discharge currently runs through the oil/water separators, providing pretreatment prior to discharge into the river.

4.3.1.4 Historic Outfall Testing Activities

As part of the surface water investigation historic surface water conveyance systems were tested to determine if the systems were still functional and could therefore be acting as a contaminant transport pathway. Smoke and dye testing was conducted to:

- Determine if upstream portions of unused or abandoned conveyance systems were capped;
- Verify that stormwater is not infiltrating the system and discharging to the river due to cracks in paved surfaces, foundations, or the stormwater piping system; and
- Validate that active outfalls are depicted on USACE, LWG, and ODOT drawings are properly identified and functional.

Eighteen current and historic outfalls were identified using drainage maps provided by the USACE and the LWG (Figure 4-9, page 4-49) and then field verified by conducting a visual inspection of all outfalls located on the Moorings property. In addition, three LWG outfalls (WR-445, WR-444, WR-091) which were identified on the LWG Drainage Map (Figure 4-9, page 4-49) but not identified on USACE Figures were field verified. Existing outfalls are illustrated on Figure 4-10 (page 4-51). A cross-reference of USACE outfall numbers to LWG outfall numbers is included in Appendix B, Outfall Testing Memo.

Of the 21 outfalls identified, 13 were either smoke or dye tested to confirm if the outfall was active or inactive. The remaining eight outfalls were confirmed as active or abandoned by visual inspection in the field.

Results of all testing was completed and recommended actions were submitted to the USACE and provided in Appendix B.

4.3.1.4.1 Smoke Testing

On April 22, 2008, Cowlitz Clean Sweep, working as a subcontractor to TEC, completed smoke testing. Ten outfalls were selected for smoke testing. The smoke testing activity is described in the Outfall Status Memo (Appendix B). All ten outfalls were evaluated and their status (active or inactive) confirmed.

4.3.1.4.2 Dye Testing

TEC/USACE personnel conducted dye testing at three of the four major ODOT outfalls (USACE Outfalls 12, 14, and 15, Figure 4-10, page 4-51) on April 8 and 9, 2008 to ensure that there are no additional outfalls from the ODOT storm drains into the Willamette River as well as to complete goals listed in Section 4.3.1 (page 4-41). The ODOT outfalls are primarily used to drain water from the hillside and St. Helens Road/Highway 30 located upgradient from the site.

Testing was completed by creating a solution of red dye tablets mixed with potable water and discharging the solution into upstream locations of each outfall. Personnel were stationed at each outfall discharge location and participating staff would be notified once the dye reached the Willamette River. All three tested outfalls were verified and no additional outfall locations were identified.

The fourth outfall (USACE Location 18, Figure 4-10, page 4-51) is an ODOT outfall used to drain water from the highway. This was not field tested due to inaccessibility.

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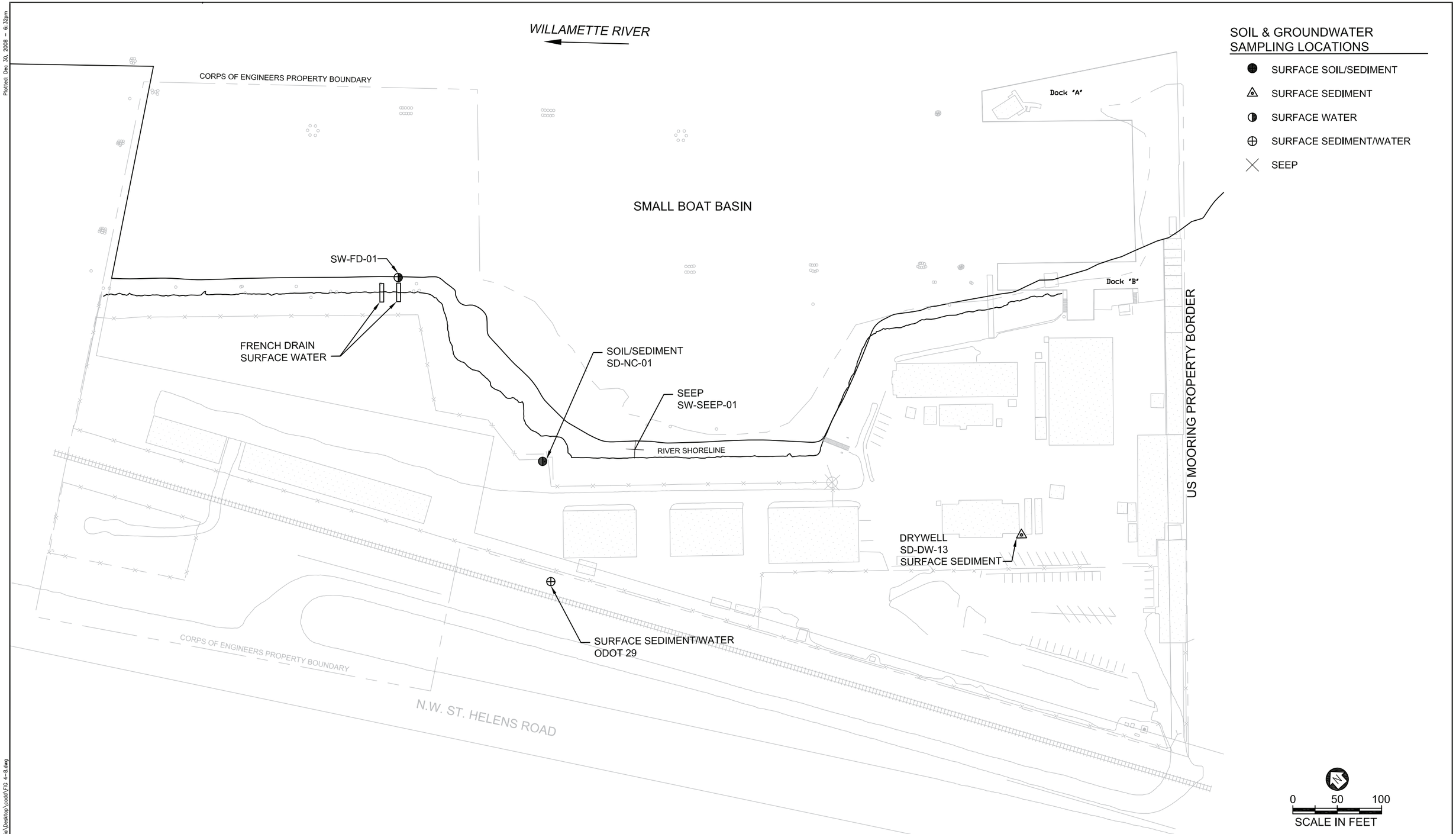

No.	DATE	BY	REVISION

JOB No.	DESIGNED:	PROJ. ENGINEER:
SCALE:	DRAWN BY:	APPROVED BY:
	CHECKED BY:	DATE:

WARNING
0 1/2 1
IF BAR DOES NOT MEASURE 1" AT FULL SIZE, THEN SCALES ON DRAWING NOT TO SCALE.

TEC Inc.
1450 114th Ave S.E.
Suite 220
Bellevue, Wa 98004
425.453.4040
425.454.7043 fax

US GOVERNMENT MOORINGS

REMEDIAL INVESTIGATION

UPLAND SURFACE WATER AND
UPLAND SEDIMENT LOCATIONS

DRAWING NUMBER: FIGURE 4–8
CAD FILE NUMBER:
SHEET: OF
REV.

File: C:\Documents and Settings\Oliveria\Desktop\cadd\FIG 4-8.dwg

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TEC Inc.
1450 114th Ave SE
Bellevue, Wa 98004
425

US GOVERNMENT MOORINGS

REMEDIAL INVESTIGATION

OUTFALL VERIFICATION MAP
PROVIDED BY LWG

DRAWING NUMBER: F RF 4-9

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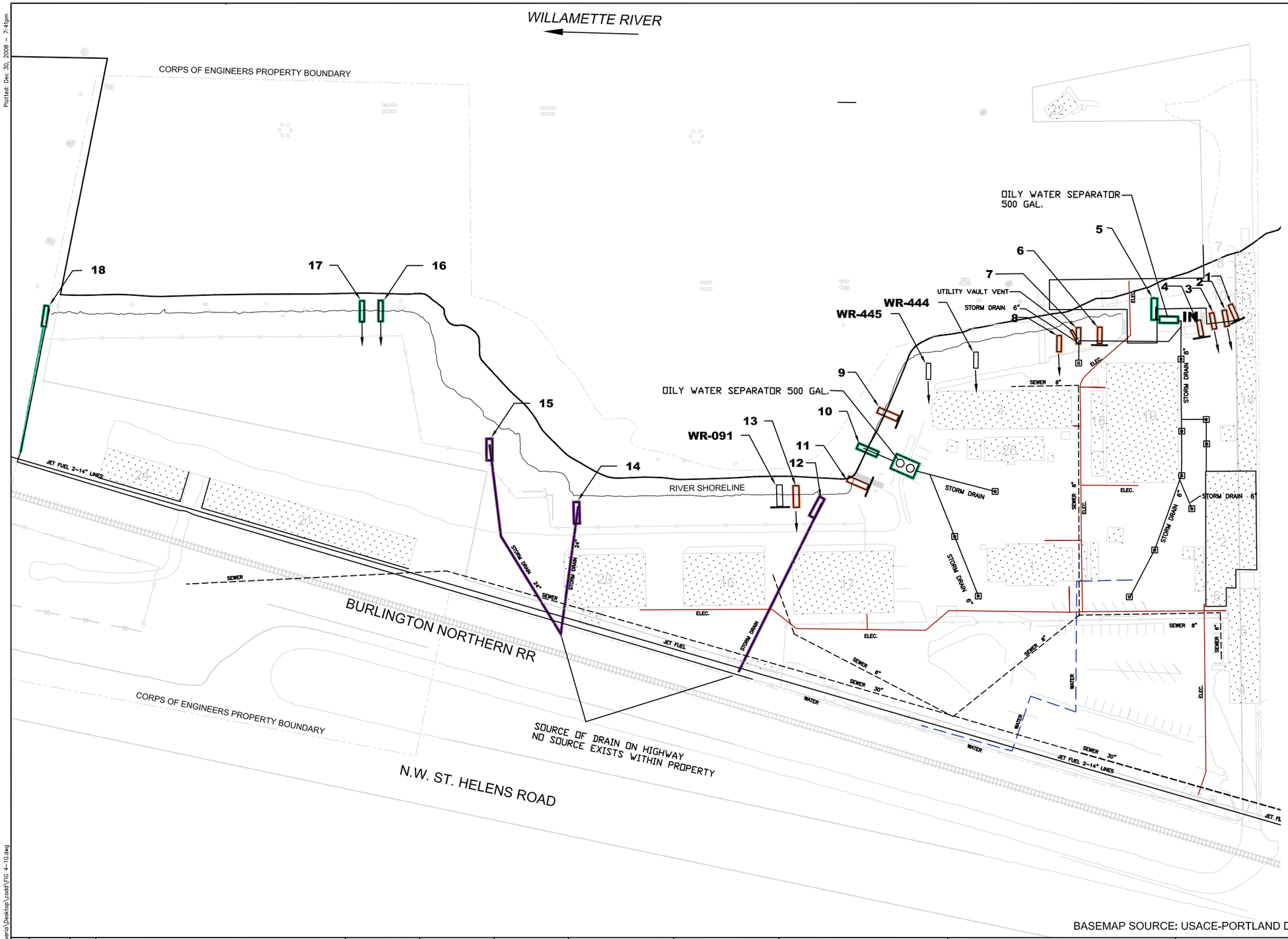

OUTFALLS

1 6" PVC drainage from yard shop roof
2 6" PVC drainage from yard shop roof
3 12" steel roof drain (abandoned)
4 4" steel unknown drain (abandoned and capped)
5 6" PVC oily water separator outfall B
6 Steel machine shop sink drain (abandoned)
7 Utility vault vent
8 12" steel roof drain bldg. 3, former battery drain
9 4" steel storm water outfall (abandoned)
10 6" PVC oily water separator outfall A
11 4" steel storm water outfall (abandoned)
12 Concrete outfall from DOT
13 6" PVC warehouse roof drain
14 Storm drain from DOT
15 Storm drain from DOT
16 6" PVC french drains
17 6" PVC french drains
18 24" steel (Storm drain in from DOT)

Provided by LWG:

WR-444 Active outfall (4") Corrugated plastic, Drains (1) downspout to bldg. 3, located behind smoker shack.

WR-445 Active outfall (4") Corrugated plastic, Drains (1) downspout to bldg. 3, located NE corner.

WR-091 Unknown (8") Concrete, Attempted to dye and smoke test this location to verify its orgin. Pipe appears to be capped or plugged ~2' up gradinet but could not be verified.

LEGEND

- DYE TESTED
- SMOKE TESTED
- VISUALLY VERIFIED
- NOT ACTIVE/ABANDONED
- ACTIVE OUTFALL
- STORMDRAIN LINE
- STORMDRAIN INLET
- SEWER LINE

NOTE:
A more detailed description can be found in the Outfall Testing Memo which is included in Appendix

0 50 100
SCALE IN FEET

BASEMAP SOURCE: USACE-PORTLAND DISTRICT(MOORINGS_DRAINAGE MAP FIG 3.DWG)

No.	DATE	BY	REVISION

JOB No. | DESIGNED: | PROJ. ENGINEER:
SCALE: | DRAWN BY: | APPROVED BY:
CHECKED BY: | DATE:

WARNING
0 1/2 1
IF BAR DOES NOT MEASURE 1" AT FULL SIZE, THEN SCALES ON DRAWING NOT TO SCALE.

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US GOVERNMENT MOORINGS

REMEDIAL INVESTIGATION

SMOKE AND DYE TESTING LOCATIONS

DRAWING NUMBER: FIGURE 4-10
CAD FILE NUMBER:
SHEET: OF
REV.

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4.3.2 Upland Sediment Activities

Upland sediment sampling activities were conducted in support of RI objectives:

- Determine if the site is a source of contamination to the Willamette River; and
- Determine if off-site contamination is impacting the site.

Sediment samples were collected as part of the investigation to determine if highway runoff of sediment through stormwater discharges is contributing contamination to the river. A summary of the sampling approach and rational for the upland sediment investigation is included as part of Table 4-14 (page 4-54).

4.3.2.1 Upland Sediment Sample Locations

Three sediment sampling locations were selected, an ODOT catch basin sample, a drywell sample, and the North Logistics runoff sample. Table 4-15 (page 4-54) lists the samples taken as part of the upland sediment investigation. Figure 4-8 (page 4-47) illustrates the sample locations.

- The ODOT catch basin is located west of the site. The discharge from the catch basin runs under Moorings and exits in the Willamette River. Similar to the surface water sample (Section 4.3.1.1, page 4-41), a sediment sample was collected to assess if drainage is affecting the Willamette River.
- The Drywell sample was added as an additional sampling activity as discussed in Section 4.8.1.2.1 (page 4-74). The drywell has been in operation for approximately 40 or more years per Moorings personnel and has been recognized as a possible source of subsurface contamination.
- The third sample, North Logistics Runoff, was also added as an additional sample (also discussed in Section 4.8.1.2.2, page 4-74). This location was selected because evidence of surface water run-off was noticed due to sedimentation built up just east of the fence line. It was noted during rainy days prior to the actual sample collection that runoff from the concrete surface between Building 20 and to the north to the approximate center of Building 21, funnels to this location and leaves the site at this point.

4.3.2.2 Upland Sediment Sampling Methodology

One sample from each location was collected for analysis by obtaining a sufficient amount of material, homogenizing the material in a large stainless steel bowl, and aliquoting the sample into appropriate containers for analysis.

- A surface sediment sample was collected from the ODOT catch basin (Location 29 on Figure 4-8, page 4-47) using a stainless steel spoon, from the 0 to 3 inch interval as large rocks were found just below the sediment.
- The drywell sludge was collected by removing the drywell's perforated top grate using a digging bar to gain access. After removing approximately one foot of material and pushing the remaining material to the side, it was noted that the drywell had a perforated bottom plate approximately 3 feet bgs. After the discovery, a discussion was held between USACE and TEC personnel and it was decided that a sample at depth (2 to 3

feet bgs) would be taken directly from the drywell, in addition to the adjacent soils samples from Location 13.

- A sample was collected from the 0 to 1 foot interval in the area of the obvious runoff discharge.

Table 4-14 Remedial Investigation Objectives and Strategy – Upland Sediment

Data Requirements	Location	Investigation Objectives	Investigation Strategy	Decision Criteria
Determine if the near-shore sediments are contaminated. Provide data to support on-going USACE sediment management activities and LWG studies.	Upland catch basin adjacent to Moorings site.	Characterize sediments in ODOT catch basin and outfall to determine if highway runoff is an ongoing source of contamination to the waterway.	Surface sediment sample will be analyzed for: • SVOCs • Pesticides • PCBs • Metals • TPH	• Review analytical results against JSCS Soil and Stormwater Sediment Values and inform ODOT of results. • All sediment samples will be archived for future dioxin analysis as needed.

Table 4-15 Upland Sediment Sample Information

Sample Location	Sample ID	Blind Sample ID	Date Collected	Sample Depth[1]	Analysis[2]							
					VOC	SVOC	PCB	Pest	CN	Metals	Organo-butyltins	TPH
ODOT	SD-ODOT-CB	1050	3-13-08	0 - ~3”	NA	X	X	X		X	X	X
Drywell	SD-DW-13	13DW	3-6-08	2 - 3’	NA	X	X		X			X
Runoff	SD-NL-01	10000	4-4-08	0 - ~1’	NA	X	X	X		X		X

Notes:
NA Not Analyzed
Pest Pesticides
1 feet bgs
2 Please refer to Appendix A Table 1d for a list of analytes

4.4 WILLAMETTE RIVER SEDIMENT INVESTIGATION

The objectives of the Moorings sediment investigation were two-fold:

- To determine if the near-shore sediments are contaminated; and
- Provide data to support on-going USACE sediment management activities and LWG studies.

Multiple surface and subsurface sediment samples were collected from the Willamette River to further characterize sediment contamination, provide data to support on-going USACE sediment management activities, and to support LWG in-water studies.

To accomplish these objectives, samples were collected from the Willamette River in four areas along the Moorings shoreline discussed in Section 4.4.1 below. Table 4-16 (page 4-57) summarizes the sampling approach and rational for each area and a summary of the investigation activities is presented in the following sections. A more detailed description of sampling activities, analytical results, collection procedures, and deviations are provided in Appendix D, In-Water Sediment Sampling Cruise Report.

4.4.1 Sample Locations

A complete list of sediment samples collected is included in Table 4-17 (page 4-59) and provides the station locations (latitude and longitude), sampling method, and other acquisition information. Planned and actual station sampling locations are shown in Figure 4-11 (page 4-61).

4.4.1.1 Under Dock Area

Under-dock stations were identified to characterize sediment in an area with no previous sampling or historical data (Figure 2-12, page 2-35) and to provide information on the physical properties of the sediment for potential dock-piling replacement. Two locations under each Dock A and Dock B were selected for surface and subsurface sampling, SDUD-1, -2, -26, and -27, from which a total of 16 samples were collected (Table 4-17, page 4-59).

Two stations under Dock C were planned (SDBH 3 and SDBH 4). As discussed in Section 4.4.1.4 (page 4-56, no sample was collected from Station SDBH 3 due to recovery issues. A substitute surface sediment sample was collected from the nearby Dredge Area C Station 25 and labeled SDDC 25-1 (Table 4-23, page 4-76).

A geotechnical core was collected from under Dock C and is shown on Figure 4-11 (page 4-61) as SDUD 4-1 (Table 4-23, page 4-76). As discussed in Section 4.4.1.4 (page 4-56), no surface sediment sample was collected from Station SBBH-4. A new surface sediment sample station was decided on, located just east of Dock C (Table 4-23, page 4-76).

4.4.1.2 Dredge Prisms

Three dredge prisms (with three sampling locations each) (Figure 4-11, page 4-61) were selected to help characterize areas associated with potential maintenance dredging activities. Overall characterization of the river was also supported with the Dredge Area samples. Stations were identified by the dredge area and station as follows.

- Dredge Area A: SDDA Stations 17 – 19

- Dredge Area B: SDDB Stations 20 – 22
- Dredge Area C: SDDC Stations 23 – 25

As noted in Section 4.8 (page 4-73), the sampling intervals for Station SDDC 25 are different from those prescribed in the Work Plan. The plan called for compositing the 10 to 12 foot and the 12 to 15 foot below mudline intervals. The actual intervals composited were 5 to 8 and 8 - 12 feet below mudline, due to the fact that the core only penetrated to 12 feet below mudline.

4.4.1.3 ODOT Outfall

ODOT Outfall is a single station located immediately adjacent to an ODOT storm drain outfall. This station is identified as ODOT 28. A surface and subsurface sample was collected to assess potential contribution of the ODOT storm drain from St. Helen's Road to the river.

The surface sediment collection station is approximately 100 feet in shore from the geotechnical core sampling locations. This was due to the fact that 1) surface sediment was collected first, and 2) it was not physically possible to deploy the core sampler in close to the surface sediment station.

4.4.1.4 Bulkhead

Fourteen surface sediment locations (Locations SDBH-4 through SDBH 16, and SDDC 25-1, Figure 4-11, page 4-61) were selected along the bulkhead located downstream of the dock to the northern property line. Samples in this area were selected to:

- Characterize nearshore sediments located down gradient of known and unknown outfalls.
- Determine if upland sources are contaminating the river through storm drain outfalls.
- Determine if COPCs exist in near-shore sediments, identify potential sources of the contaminants (if present), and to support USACE sediment management activities.

The samples collected along the bulkhead include SDBH 4-1 through SDBH 16-1 and SDDC 25-1.

As discussed in the Section 4-8 (page 4-73), Deviations from the Work Plan, the following changes were made to sampling locations in the field.

- No sample was collected from the planned sample location SDBH 3 due to recovery issues. A substitute surface sediment sample was collected from the nearby Dredge Area C, Location 25 and labeled SDDC 25-1. All subsequent references to Bulkhead samples include sample SDDC 25-1 as well as samples from Locations 4 through 16.
- Sufficient sediment could not be collected from Station SDBH 4, under Dock C. A new sample station was decided on, just east of Dock C. All subsequent references to Bulkhead samples include sample SDBH 4-1.

Table 4-16 Remedial Investigation Objectives and Strategy - Sediment

Data Requirements	Location	Investigation Objectives	Investigation Strategy	Decision Criteria
Determine if the near-shore sediments are contaminated. Provide data to support on-going USACE sediment management activities and LWG studies.	Bulkhead samples in front of site. (Sample locations SDBH 3-16)	These samples will be collected to characterize the sediments located down gradient of known outfalls, unknown outfalls, a potential preferred pathway (old creek channel), and the former sandblasting area.	Surface sediment samples (0-1 feet) will be collected from the boat basin and analyzed for: • VOC • SVOCs • Metals • PCBs • Pesticides • Cyanide • TPH • Organobutyltins • Pre-dredging analyses (e.g. TOC, grain size, etc.)	• Data will be turned over to be included in the Portland Harbor Superfund Project process. No action will be taken independent of the Portland Harbor Superfund Project process. • Data will be evaluated for COPCs consistent with site activities to determine requirements for additional remedial investigation efforts. • All sediment samples will be archived for future dioxin analysis as needed.
	Under Dock (Sample locations SDUD 1-2, 26-27)	These samples will be used to characterize sediment in an area with no historical data.	Sediment samples will be collected under the dock and analyzed for: • VOCs • SVOCs • PCBs • Pesticides. • Cyanide • Metals • TPH • Organobutyltins Both surface (0-1 feet) and deep (1-6 feet) samples will be collected at all four locations	Same as Bulkhead Samples
	Dredge Prisms A, B, C (Sample locations SDDA/SDDB/SDDC 17-19, 20-22, 23-25)	Characterize contaminant level in dredge area sediments, determine appropriate dredge depth, identify need for capping after dredging and determine appropriate dredge material disposal.	Surface (0-1 feet) and deep (>1 foot, multiple intervals) sediment samples will be collected from dredge prism A and deep sediment samples (>4 feet, multiple intervals) will be collected from dredge prisms B and C and analyzed for: • SVOCs • PCBs • Pesticides • Metals	Same as Bulkhead Samples

Table 4-16 Remedial Investigation Objectives and Strategy - Sediment

Data Requirements	Location	Investigation Objectives	Investigation Strategy	Decision Criteria
	Dredge Prisms cont.		• Organobutyltins • TPH • Pre-dredging analyses (e.g. TOC, grain size, etc.)	
	In river small boat basin in front of ODOT outfall.	Characterize sediments in ODOT catch basin and outfall to determine if highway runoff is an ongoing source of contamination to the waterway.	Surface and deep sediment samples will be collected and analyzed for • SVOCs • Pesticides • PCBs • Metals • Organobutyltins • TPH	• Review analytical results against JSCS Soil and Stormwater Sediment Values and inform ODOT of results. • All sediment samples will be archived for future dioxin analysis as needed.

Table 4-17 Willamette River Sediment Samples

Station Location	Sample ID	Station Location [a]	Sample I.D.	Date	Time	Latitude (North) (NAD 1983) [d]	Longitude (West) (NAD 1983) [d]	CoreTube Penetration (ft)	Acquisition (ft)	Recovery (%)	Estimated Mudline Elevation (feet CRD) [a]	Measured Mudline Elevation (feet CRD) [b]	Sample Elevation Depth[b] (feet CRD)	Core Sample Interval * (ft)	Sample Method
Sediment Core Samples															
Dredge Area A	SD-DA	17	SDDA 17-1	4/17/2008	14:09:12	45 34.89061	122 45.68144	surface grab	0.9	---	–24	-33.4	-33.4 to -34.4	0 to 1	0.25 m^2 Power Grab
			SDDA 17-2	4/20/2008	14:09:12	45 34.89140	122 45.68089	13.0	10.7	82.0		-24.0	-25 to -32	1 to 7	4-inch core
			SDDA 17-3										-32 to -35	7 to 9	4-inch core
			SDDA 17-4										-35 to -38	9 to 12	4-inch core
	SD-DA	18	SDDA 18-1	4/18/2008	14:24:05	45 34.90890	122 45.72670	surface grab	1.0	---	–20	-18.1	-18 .1 - 19.1	0 to 1	0.25 m^2 Power Grab
			SDDA 18-2	4/20/2008	11:40:41	45 34.90835	122 45.72617	19.0	16.8	88.0		-20.0	–21 to –31	1 to 11	4-inch core
			SDDA 18-3										–31 to –33	11 to 13	4-inch core
			SDDA 18-4										–33 to –36	13 to 16	4-inch core
	SD-DA	19	SDDA 19-1	4/18/2008	15:23:40	45 34.92792	122 45.76319	surface grab	1.0	---	–22	-20.1	-20.1 to -21.1	0 to 1	0.25 m^2 Power Grab
			SDDA 19-2	4/19/2008	16:28:26	45 34.92827	122 45.76495	15.0	12.0	80.0		-21.9	-22.9 to -31.9	1 to 9	4-inch core
			SDDA 19-3										–31.9 to –33.9	9 to 11	4-inch core
			SDDA 19-4										–33.9 to –36.9	11 to 14	4-inch core
Dredge Area B	SD-DB	20	SDDB 20-3	4/19/2008	13:35:58	45 34.90835	122 45.75158	13.0	13.0	100.0	–13	-15.1	-21.1 to -23.1	6 to 8	4-inch core
			SDDB 20-4										-23.1 to 26.1	8 to 11	4-inch core
		21[d]	SDDB 21-3	4/19/2008	10:53:39	45 34.90210	122 45.78017	13.0	12.3	94.6	–15	-10.4	-14.4 to -16.4	4 to 6	4-inch core
			SDDB 21-4										-16.4 to -19.4	6 to 9	4-inch core
		22[d]	SDDB 22-3	4/19/2008	12:09:37	45 34.88465	122 45.75362	11.0	9.3	84.0	–13	-14.8	-20.8 to -22.8	6 to 8	4-inch core
			SDDB 22-4										-22.8 to -25.8	8 to 11	4-inch core
Dredge Area C	SD-DC	23	SDDC 23-3	4/20/2008	10:26:05	45 34.88416	122 45.71358	19.0	16.4	86.0	–7	–7	–19 to –21	12 to 14	4-inch core
			SDDC 23-4										–21 to –24	14 to 17	4-inch core
		24	SDDC 24-3	4/19/2008	14:15:56	45 34.87557	122 45.72050	15.0	13.0	87.0	–9	-8.6	-18.6 to -20.6	10 to 12	4-inch core
			SDDC 24-4										-20.6 to -23.6	12 to 15	4-inch core
		25	SDDC 25-1	4/17/2008	9:16:26	45 34.86492	122 45.72676	surface grab	1.0	---	-9	-9.5	-9.5 to -10.5	0 to 1	0.25 m^2 Power Grab
			SDDC 25-3	4/19/2008	15:24:28	45 34.86844	122 45.73106	12.0	8.0	66.6			-14.5 to -17.5	5 to 8	4-inch core
			SDDC 25-4										-17.5 to -21.5	8 to 12	4-inch core
ODOT Outfall	SD-OF	28	SDDOF 28-1	4/18/2008	17:09:38	45 34.91237	122 45.85028	surface grab	1.0	---	Unknown	0.6	0.6 to -0.6	0 to 1	0.25 m^2 Power Grab
			SDDOF 28-2	4/20/2008	8:12:23	45 34.92000	122 45.83330	13.0	9.5	73.0		-1.2	-1.2 to -6.2	1 to 6	4-inch core
UNDER DOCK															
Under Dock Sampling	SD-UD	1	SDUD 1 - 1	4/15/2008	13:55:00	45 34.8808376	122 45.7023507	surface grab	1.0	---	Unknown	-3.8	-3.8 to -4.8	0 to 1	0.1 m^2 van Veen
			SDUD 1 - 2			45 34.8795058	122 45.6999802	See Geological Borehole Log				-7.9	-8.9 to -14.9	1 to 6	Geoprobe 2-inch core
			SDUD 1 - 3										-14.9 to -20.9	6 to 12	Geoprobe 2-inch core
			SDUD 1 - 4										-20.9 to -28.9	12 to 20	Geoprobe 2-inch core
		2	SDUD 2 - 1	4/15/2008	15:25:00	45 34.8673762	122 45.7184358	surface grab	1.0	---	Unknown	-4.4	-4.4 to -5.5	0 to 1	0.1 m^2 van Veen
			SDUD 2 - 2			45 34.8664591	122 45.7170625	See Geological Borehole Log				-7.9	-8.9 to -14.9	1 to 6	Geoprobe 2-inch core
			SDUD 2 - 3										-14.9 to -20.9	6 to 12	Geoprobe 2-inch core
			SDUD 2 - 4										-20.9 to -28.9	12 to 20	Geoprobe 2-inch core
		26	SDUD 26-1	4/13/2008	12:42:00	45 34.8920768	122 45.7125163	surface grab	11.8	---	Unknown	-3.5	-3.5 to -4.5	0 to 1	0.1 m^2 van Veen
			SDUD 26-2			45 34.8935188	122 45.7124978	See Geological Borehole Log				-12.9	-13.9 to -19.9	1 to 6	Geoprobe 2-inch core
			SDUD 26-3										-19.9 to -25.9	6 to 12	Geoprobe 2-inch core
			SDUD 26-4										-25.9 to 33.9	12 to 20	Geoprobe 2-inch core
		27	SDUD 27-1	4/14/2008	11:14:00	45 34.8870238	122 45.6914241	surface grab	11.8	---	Unknown	-7.9	-7.9 to -8.9	0 to 1	0.1 m^2 van Veen
			SDUD 27-2	4/13/2008	14:00	45 34.8866065	122 45.6922676	See Geological Borehole Log				-12.9	-13.9 to -19.9	1 to 6	Geoprobe 2-inch core
			SDUD 27-3										-19.9 to -25.9	6 to 12	Geoprobe 2-inch core
			SDUD 27-4										-25.9 to 33.9	12 to 20	Geoprobe 2-inch core
		4	SDUD 4	4/15-	---	45 34.8758496	122 45.7540926	Under dock SPT station. See Geological Borehole Log							

Table 4-17 Willamette River Sediment Samples

Station Location	Sample ID	Station Location [a]	Sample I.D.	Date	Time	Latitude (North) (NAD 1983) [d]	Longitude (West) (NAD 1983) [d]	CoreTube Penetration (ft)	Acquisition (ft)	Recovery (%)	Estimated Mudline Elevation (feet CRD) [a]	Measured Mudline Elevation (feet CRD) [b]	Sample Elevation Depth[b] (feet CRD)	Core Sample Interval * (ft)	Sample Method
BULKHEAD															
Bulkhead	SD-BH	3	Not possible to collect underdock sample at SDUD 3 due to rip rap. Collected a surface sample at SDDB 25, ca. 50 ft. outboard of SDUD 3												
	SD-BH	4	SDBH 4-1	4/18/2008	13:47:00	45 34.8786	122 45.7504	surface grab	1.0	---	-2	-11.2	-11.2 to -12.2	0 to 1	0.25 m^2 Power Grab
	SD-BH	5	SDBH 5-1	4/17/2008	10:47:34	45 34.87967	122 45.76706	surface grab	1.0	---	-2	-8.6	-8.6 to -9.6	0 to 1	0.25 m^2 Power Grab
	SD-BH	6	SDBH 6-1	4/17/2008	11:29:13	45 34.88544	122 45.77929	surface grab	1.0	---	-2	-10.4	-10.4 to -11.4	0 to 1	0.25 m^2 Power Grab
	SD-BH	7	SDBH 7-1	4/17/2008	13:19:41	45 34.88432	122 45.80519	surface grab	1.0	---	-2	-1.9	-1.9 to -2.9	0 to 1	0.25 m^2 Power Grab
	SD-BH	8	SDBH 8-1	4/17/2008	14:53:10	45 34.88349	122 45.82155	surface grab	0.8	---	-2	0.3	0.3 to -0.7	0 to 1	0.25 m^2 Power Grab
	SD-BH	9	SDBH 9-1	4/17/2008	15:49:32	45 34.88983	122 45.84248	surface grab	0.7	---	-2	1.1	1.1 to 0.1	0 to 1	0.25 m^2 Power Grab
	SD-BH	10	SDBH 10-1	4/17/2008	16:51:09	45 34.90544	122 45.86098	surface grab	1.0	---	-2	0.5	0.5 to -0.5	0 to 1	0.25 m^2 Power Grab
	SD-BH	11	SDBH 11-1	4/18/2008	8:53:30	45 34.92097	122 45.86307	surface grab	1.0	---	-2	0.2	0.2 to -0.8	0 to 1	0.25 m^2 Power Grab
	SD-BH	12	SDBH 12-1	4/18/2008	9:23:12	45 34.93770	122 45.86325	surface grab	1.0	---	-2	-0.6	-0.6 to -1.6	0 to 1	0.25 m^2 Power Grab
	SD-BH	13	SDBH 13-1	4/18/2008	9:48:51	45 34.94956	122 45.87352	surface grab	1.0	---	-2	0.9	0.9 to -0.1	0 to 1	0.25 m^2 Power Grab
	SD-BH	14	SDBH 14-1	4/18/2008	10:36:11	45 34.96086	122 45.89677	surface grab	1.0	---	-2	-0.6	-0.6 to -1.6	0 to 1	0.25 m^2 Power Grab
	SD-BH	15	SDBH 15-1	4/18/2008	11:28:03	45 34.96729	122 45.90545	surface grab	1.0	---	-2	-1.6	-1.6 to -2.6	0 to 1	0.25 m^2 Power Grab
	SD-BH	16	SDBH 16-1	4/18/2008	12:00:02	45 34.98284	122 45.92863	surface grab	1.0	---	-2	-0.5	-0.5 to -1.5	0 to 1	0.25 m^2 Power Grab
FIELD REPLICATES															
Under Dock	SD-UD	29	SDUD 29-1	4/14/2008	11:44:00	45 34.8870238	122 45.6914241	surface grab	1.0	---	---	-7.9	Field Duplicate of SDUD 27-1		
ODOT Outfall	SD-OF	30	SDOF 30-1	4/18/2008	17:10:00	45 34.9122	122 45.8500	surface grab	1.0	---	---	0.6	Field Duplicate of SDOF 28-1		
Dredge Area A	SD-DA	31	SDDA 31-1	4/20/2008	11:40:00	45 34.9084	122 45.7262	core	19.0	80.0	-20	-20.0	Field Duplicate of SDDA 18-2		
Surface Water Samples															
Dredge Area B [e]	SW-DB	21	SWDB 21	4/23/2008	11:00:00			---	---	---	–15	–15	-12	N/A	Peristaltic Pump

Notes:

a Mudline elevations estimated from the 2002 U.S. Moorings bathymetric map, provided in Appendix A of the Work Plan.

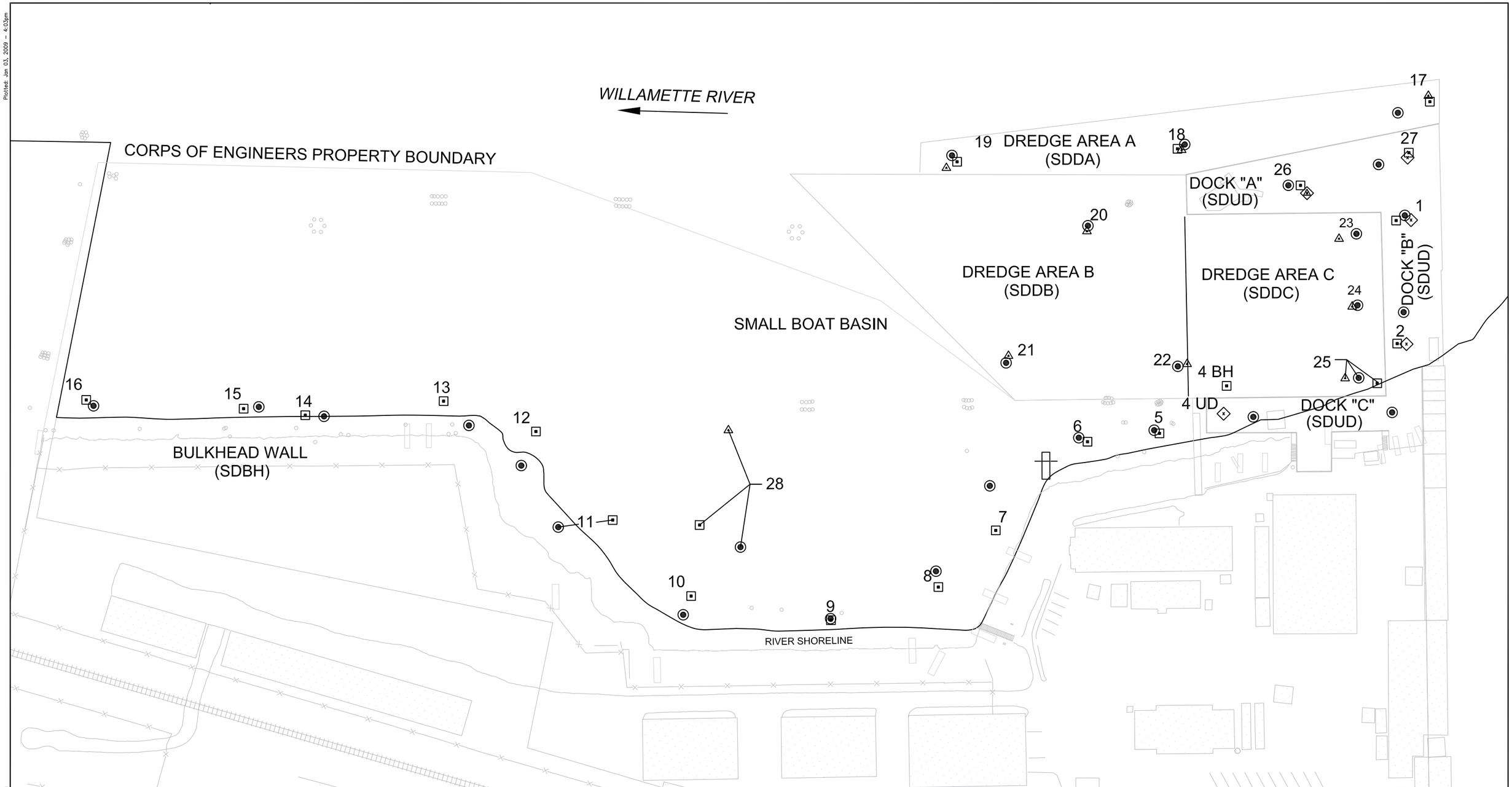
b Measured mudline elevations are based on field lead-line measures, corrected for CRD based on tide gage measures taken from either the gage on Dock C or at the small boat dock.

c Underdock surface samples were collected with a van Veen grab; subsurface samples with a GeoProbe®. Dredge area and bulk head surface samples were collected with the Power Grab from the R/V Nancy Ann; subusrface samples collected by Vibracore. [c]

d DGPS readings are in North American Datum (NAD) for 1983

e 60 liters of surface water were collected at from 3 feet above the mudline for the DRET procedure.

N/A not applicable



LEGEND

- GPS MEASURED SURFACE SEDIMENT FINAL LOCATION
- GPS MEASURED DEEP SEDIMENT FINAL LOCATION
- PLANNED LOCATION
- GPS MEASURED GEOTECNICAL CORE SAMPLE LOCATION

0 40 80
SCALE IN FEET

No.	DATE	BY	REVISION

JOB No.	DESIGNED:	PROJ. ENGINEER:
SCALE:	DRAWN BY:	APPROVED BY:
	CHECKED BY:	DATE:

SEE LLC
Science & Engineering for the Environment

TEC Inc.
1450 114th Ave S.E.
Suite 220
Bellevue, Wa 98004
425.453.4040
425.454.7043 fax

US GOVERNMENT MOORINGS

REMEDIAL INVESTIGATION

IN–WATER SEDIMENT
SAMPLING LOCATIONS

DRAWING NUMBER: FIGURE 4–11
CAD FILE NUMBER:
SHEET: OF
REV.

Plotted: Jan 03, 2009 – 4:03pm
File: C:\Documents and Settings\Oliveria\Desktop\cadd\FIG 4-11.dwg

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4.4.2 Sample Methodology

All in-water samples were collected from the *R/V Nancy Ann.* The procedures used for the collection are detailed in Appendix D, Cruise Report.

4.4.2.1 Surface Sediment Samples

Surface sediment samples (Bulkhead, Dredge Area A, Under Dock and ODOT Outfall) were collected from the 0 to 1 foot horizon by using a 0.25 m^2 power Grab Sampler and homogenized in a large stainless steel bowl and placed into appropriate containers for analysis.

4.4.2.2 Subsurface Sediment Samples

Subsurface sediment samples (Dredge Areas and ODOT Outfall) were collected using a custom built vibracorer with a 4-inch diameter core barrel. Sampling intervals were selected based upon the 2002 bathymetric survey (USACE 2002a). In Dredge Area B and Area C, subsurface sediment samples were collected from lower depths as recent data is available for the upper depths (2002 U.S. Moorings Sediment Data; Section 2.9.2.7, page 2-33; Figure 2-12, page 2-35).

Once the sample was collected, the core was sectioned into four-foot lengths, covered with foil, and capped and sealed. Segments were stored on ice until processed on shore. Once on shore, cores were split lengthwise, logged, a sample was collected and homogenized in a large stainless steel bowl, and placed into appropriate containers for analysis.

4.4.2.3 Under Dock

No available boats were able to fit underneath the dock due to the dock infrastructure (e.g., beams, cross bracing, water pipes). Consequently, sampling was done from either catwalks underneath the dock (surface sediments) or through an opening created by USACE personnel on the dock (subsurface sediments).

Under Dock surface sediments were collected using a 0.1 m^2 Van Veen sampler hand deployed from catwalks located under the dock. Samples were collected as close as possible to the opening created (as discussed in the following section) for subsurface samples. Hand collection was necessary as the sampling vessel was able to fit underneath the dock due to the dock infrastructure (e.g., beams, cross bracing, water pipes).

Under Dock subsurface sediment samples and geological core samples were collected using a GeoProbe® DPT Rig. Sampling methodology for this equipment is discussed in Section 4.1.1.2 (page 4-15). USACE personnel removed wood planking from the dock to create an approximately one square foot opening for field personnel to lower the sampling equipment. Subsurface samples were collected using a split-spoon sampler and compositing the samples over the Management Plan required intervals.

4.4.2.4 Navigation and Positioning

A differential global positioning system (DGPS) was used to navigate to, occupy, and document all in-water stations aboard the *R/V Nancy Ann*. A Trimble 4000 RS DGPS utilizing the U.S. Coast Guard differential signal from Astoria, Oregon, was interfaced to a computer running software enabling real-time plan view navigation to the required sampling locations.

Prior to the start of field collections during each day of survey operations, a known horizontal control point was occupied to ensure the accuracy of the positioning and navigation systems.

For each station, the corresponding water depths were also recorded. The vertical datum for in-water tasks was the CRD as discussed in Section 2.1 (page 2-1).

For the under dock samples, a Trimble Pro XR DGPS in “backpack” configuration was utilized to verify sample locations (this process is discussed in Appendix D, Cruise Report).

4.5 GENERAL FIELD PROCEDURES

The following Sections describe general field activities used for all areas of the upland investigations.

4.5.1 Sample Identification and Labeling

Upland samples collected in the field as part of this project were identified using a unique blind identification (ID) number that was sent to the lab. In the Industrial Area, a unique number was generated using the soil boring or groundwater location and adding a number after the location ID corresponding with each interval (e.g., 1 through 4). For groundwater samples, the process was repeated using the next available number after each soil boring was completed (e.g., 5 or 6). For QC samples (i.e., field duplicates) a zero was added after the sample location and boring number.

In the MIS Area, a unique ID number was assigned to each management unit (e.g., 3000) and subsequent numbers were generated for each horizon sampled (e.g., 1 through 3).

The sample identification numbers, including the sample type, station number, interval, and an identification of sample types (i.e., primary, field duplicate, etc.) was entered into the field logbook as a cross reference of the unique IDs.

Example 1 Industrial Area:	The unique ID number 101 represents the sample collected from soil boring 10 at the first sample interval (e.g., 1 - 4 feet).
Example 2 Groundwater:	Groundwater collected at location GW-11 has a unique ID of 115 (111, 112, 113, and 114 were the four soil samples collected from the 1-4, 4-8, 8-12, and 12-16 foot bgs intervals). 115 was the fifth sample collected from this location
Example 3 MIS Areas:	The sub-sample collected from the upper horizon (e.g., 1-5 feet) at South Logistics Location 76 would be, 3000-1.

Table 4-24 (page 4-80) references Sample ID, by Sample Location, to its Blind ID number for the upland investigation.

Sediment samples were labeled with the location and depth information, without a blind ID.

4.5.2 Field and Laboratory Quality Control Samples

Field duplicates, matrix spike/matrix spike duplicates (MS/MSD), rinsates, VOC trip blanks, and temperature blanks were all collected in accordance with the approved Management Plan and are included in Table 4-25 (page 4-81).

4.5.3 Sample Handling Procedures

After samples were placed in appropriately labeled containers, they were immediately transferred to ice filled coolers to keep them out of the direct sunlight and to maintain a temperature of four degrees centigrade. The sample coolers were kept either in the TEC van

while sampling or placed in an on-site office, which was locked by TEC at the end of every shift. Sample coolers left over night were properly iced and sealed using custody seals. Sample coolers were picked up and delivered daily to the lab using a lab-employed courier.

Disposable nitrile gloves were used by personnel collecting and handling the samples and were changed frequently and in between each sample collection to avoid cross contamination.

Chain of Custody (CoC) forms were completed to accompany each cooler from the field to the laboratory. The date, time, sample location, number of containers, and analysis to be performed was recorded on each CoC. Samples were hand delivered by field staff to the laboratory at the conclusion of the sampling event. Copies of the CoCs are provided in Appendix A-4.

4.5.4 GPS Data

Global positioning system (GPS) coordinate data was gathered in the field using a Trimble Pro XR system (Trimble) at boring locations throughout the site. The GPS coordinates were collected in the upland area after drilling and sampling activities had been completed. After the field event, material and large pieces of equipment that were housed in these areas were moved back to their original locations, which made finding some of the locations very difficult. Paint used to mark some of the locations wore off and the metal spikes used in the gravel areas had been removed over time. Tables 4-19 and 4-20 (pages 4-66 and 4-67) document the measured GPS coordinates for all locations that could still be conclusively identified in the field at the time of measurement.

The manufacturer's stated accuracy for a Trimble unit is 0.5 meters. Subsequent to the contingency sampling, Weddle Surveying gathered survey and elevation data at eight borehole locations in the Industrial Area. The elevation data was obtained in the Industrial Area to aid in groundwater contouring. The comparison of the GPS data gathered by TEC with the Trimble to the survey data gathered by Weddle Surveying shows that the measured GPS coordinates from the initial sampling round in February 2008 in the Industrial Area appear to be offset by a mean of approximately 1.41 feet, within the stated accuracy of the unit (Table 4-18, page 4-66). It can be assumed that the GPS coordinates for other locations, not surveyed, are within similar accuracy.

Table 4-18 Trimble GPS Location Deviation from Surveyed Points

Location	Weddle Survey Data		Trimble Pro XR GPS Data		Dist. between points (ft)	Deviation (ft)	
	Northing	Easting	Northing	Easting		North	East
7	706100.746	7622658.504	706101.36	7622655.646	2.924	-0.614	2.858
11	705957.471	7622939.528	705957.321	7622939.311	0.264	0.150	0.217
14	705802.923	7622642.304	705804.009	7622640.897	1.778	-1.086	1.407
15	705996.585	7622534.916	705996.568	7622534.934	0.025	0.017	-0.018
20	705978.753	7622959.974	705979.578	7622959.942	0.826	-0.825	0.032
24	706057.048	7622651.833	706057.128	7622649.855	1.980	-0.080	1.978
26	705955.087	7622752.372	705955.816	7622748.954	3.495	-0.729	3.418
28	705822.198	7622742.934	705822.198	7622742.934	0	0.000	0.000
				Mean	1.41	-0.396	1.24

Table 4-19 Industrial Area GPS Trimble Locations

Date	Location	GPS	
		Northing	Easting
2-27-08	1	706002.681	7622927.809
	2	706030.158	7622885.266
	3	706059.024	7622848.909
	4	706089.686	7622782.022
	5	706010.898	7622778.268
	6	706124.996	7622724.072
	8	706068.798	7622609.514
	9	706070.104	7622636.432
	10	705986.639	7622616.076
	12	705888.904	7622874.103
	13	705907.304	7622669.845
	16	705855.694	7622815.922
	17	705779.307	7622818.578
	18	706040.212	7622842.578
	19	705924.505	7622823.651
8-7-08	21	706026.154	7622878.084
	22	705055.685	7622792.958
	23	706011.810	7622711.509
	25	705885.518	7622815.885
	27	705917.956	7622857.075
	29	705863.790	7622686.895
	30	705860.953	7622776.823
	31	706023.773	7622603.925

Table 4-20 MIS Trimble GPS Locations

Sample ID	Date	Northing	Easting	Sample ID	Date	Northing	Easting
SL				NL			
SB-61	2-27-08	706268.276	7622308.172	SB-35	4-23-08	706460.161	7622282.006
SB-62	2-27-08	706248.477	7622333.915	SB-38	4-23-08	706434.449	7622279.077
SB-63	2-27-08	706235.260	7622354.496	SB-39	4-23-08	706421.555	7622295.066
SB-64	2-27-08	706217.066	7622375.535	SB-42	4-23-08	706420.466	7622254.303
SB-65	2-27-08	706202.199	7622395.158	SB-45	4-23-08	706369.991	7622310.813
SB-66	2-27-08	706188.931	7622410.032	SB-46	4-23-08	706413.857	7622228.129
SB-61	2-27-08	706268.276	7622308.172	SB-50	4-23-08	706346.287	7622301.135
SB-62	2-27-08	706248.477	7622333.915	SB-51	4-23-08	706329.014	7622318.165
SB-63	2-27-08	706235.260	7622354.496	SB-52	4-23-08	706372.698	7622235.652
SB-64	2-27-08	706217.066	7622375.535	SB-53	4-23-08	706355.293	7622253.577
SB-65	2-27-08	706202.199	7622395.158	SB-54	4-23-08	706337.519	7622271.430
SB-66	2-27-08	706188.931	7622410.032	SB-57	4-23-08	706336.759	7622238.581
SB-67	2-27-08	706173.638	7622430.051	SB-59	4-23-08	706301.818	7622277.431
SB-68	2-27-08	706175.392	7622445.972	LD			
SB-69	4-23-08	706155.872	7622465.728	SB-01	4-23-08	706765.210	7622051.744
SB-70	4-23-08	706143.480	7622481.973	SB-02	4-23-08	706743.373	7622072.981
SB-71	4-23-08	706123.123	7622504.658	SB-03	4-23-08	706727.103	7622093.901
SB-72	4-23-08	706104.865	7622525.463	SB-05	4-23-08	706692.173	7622130.908
SB-73	4-23-08	706090.856	7622541.504	SB-09	4-23-08	706624.123	7622205.462
SB-74	4-23-08	706112.950	7622481.590	SB-10	4-23-08	706607.112	7622224.014
SB-75	4-23-08	706120.748	7622473.875	SB-12	4-23-08	706573.603	7622263.551
SB-76	4-23-08	706080.986	7622501.666	SB-16	4-23-08	706743.639	7622037.716
SB-77	4-23-08	706095.033	7622516.820	SB-18	4-23-08	706707.573	7622074.798
SB-78	4-23-08	706074.183	7622542.208	SB-19	4-23-08	706690.147	7622093.479
SB-79	4-23-08	706109.588	7622466.091	SB-20	4-23-08	706673.220	7622111.383
SB-80	4-23-08	706091.325	7622463.083	SB-22	4-23-08	706638.695	7622147.607
SB-81	4-23-08	706071.325	7622463.083	SB-23	4-23-08	706618.409	7622171.112
SB-82	4-23-08	706051.325	7622463.083	SB-24	4-23-08	706600.637	7622191.224
SB-83	4-23-08	706105.389	7622409.472	SB-25	4-23-08	706588.068	7622203.193
SB-84	4-23-08	706090.369	7622426.923	SB-27	4-23-08	706554.906	7622247.043
SB-85	4-23-08	706065.113	7622438.999	SB-28	4-23-08	706538.377	7622268.997
SB-86	4-23-08	706096.304	7622385.150	SB-32	4-23-08	706495.591	7622282.155
SB-87	4-23-08	706072.882	7622405.158	SB-34	4-23-08	706476.297	7622265.147
SB-89	4-23-08	706077.521	7622377.214	SB-37	4-23-08	706453.351	7622251.109
SB-90	4-23-08	706060.844	7622390.797	SB-40	4-23-08	706456.548	7622217.773
				SB-41	4-23-08	706445.836	7622233.277

Table 4-20 MIS Trimble GPS Locations

Sample ID	Date	Northing	Easting	Sample ID	Date	Northing	Easting
FL				SB			
MIS FL 6	4-23-08	706529.355	7622329.353	SB-91	4-23-08	706719.984	7622029.759
MIS FL 13	4-23-08	706624.035	7622238.812	SB-92	4-23-08	706713.858	7622010.262
MIS FL 19	4-23-08	706703.783	7622149.642	SB-93	4-23-08	706695.960	7622018.871
MIS FL 25	4-23-08	706774.239	7622069.630	SB-94	4-23-08	706677.710	7622027.260
PC				SB-95	4-23-08	706707.975	7621991.037
SB-98	4-23-08	706630.706	7622115.372	SB-96	4-23-08	706690.049	7622000.584
SB-101	4-23-08	706566.821	7622156.329	SB-97	4-23-08	706672.296	7622009.159
SB-102	4-23-08	706615.276	7622092.486	SB-91	4-23-08	706719.984	7622029.759
SB-103	4-23-08	706595.230	7622105.889	SB-92	4-23-08	706713.858	7622010.262
SB-104	4-23-08	706574.283	7622119.797	SB-93	4-23-08	706695.960	7622018.871
SB-105	4-23-08	706552.031	7622132.437	SB-94	4-23-08	706677.710	7622027.260
				SB-95	4-23-08	706707.975	7621991.037
				SB-96	4-23-08	706690.049	7622000.584
				SB-97	4-23-08	706672.296	7622009.159

4.5.5 Summary of Investigation-Derived Waste Characterization

Investigation-derived waste (IDW) generated by this project generally consisted of soil cuttings, personal protective equipment (PPE), groundwater, and decontamination/rinse water. All IDW was containerized in drums, which were segregated by media, and stored in an on-site USACE approved hazardous waste storage area. All drums were properly labeled with their contents, date, where the waste came from, and generation dates. A hazardous waste determination was completed for all on-site drums using the analytical data collected during the project. All drums, except three soil drums were deemed non-hazardous waste from the waste determination. Soil samples (listed by blind ID), 13DW (chromium and lead), 183 (chromium), 121 (lead), 131 (lead), 161 (lead), and 191 (lead), which were contained in the three drums exceeded the 20x TCLP levels. The three drums were handled as hazardous waste and disposed of accordingly. The IDW Determination is presented in Tables 4-21 and 4-22 (pages 4-69 and 4-70).

4.5.6 Accident Prevention Plan Adherence

Upland sampling activities were conducted in accordance with the TEC site specific Accident Prevention Plan, Appendix B. Site-specific health and safety activities discussed in the plan (e.g., plan concurrence signature sheet, visitor sign in sheet, daily health and safety meetings, and job hazard analyses) are maintained in the project folder but are not included in this report.

Table 4-21 Investigation Derived Waste Determination April 2008

U.S. Moorings Site Investigation
HAZARDOUS WASTE DETERMINATION
(Developed by KTA Associates, Inc.)

Waste Name: US Moorings Investigative Derived Waste (IDW) | Date: 4-11-08

Is the Waste Hazardous as Defined by Oregon Administrative Rules ("OAR") Chapter 340, Division 101 (includes RCRA Hazardous Waste Definition)?
Yes No X, Except for Soil represented by Soil Samples 13 DW, 183, 121, 131, 161 and 191.

Products Included in the Waste: Soil and Groundwater Obtained from US Moorings Site

Source of Information use for Hazardous Waste Determination (attached): Soil and Groundwater Analytical Data.

Waste Generation Description: KTA/TEC has conducted an investigation at the US Moorings Site in Portland, OR in accordance with a US Corps of Engineers and USEPA format. The site is owned by the U.S. government and managed/operated by the U.S. Corps of Engineers.
The waste subject to this determination is investigative derived waste (IDW). The IDW consists of: (1) soil obtained from temporary well development and soil sampling efforts, (2) groundwater from the development of temporary wells and (3) personnel protective equipment, decontamination waters and sampling equipments.
The waste determination, provided as follows, relies of analytical laboratory results based on analysis of the soils and groundwater evaluated as part of this investigation.

Analysis

1. Does the waste exhibit the ignitability, corrosivity, or reactivity characteristics as defined by 40 CFR § 261.21-23?
   Yes No X

Explanation:
The soils and groundwater do not exhibit the ignitability characteristic. This is due the soils not being ignitable under any condition in the presence of normal temperature or pressure. The groundwater contains limited to no volatile organic compounds, which allows the generator to confidently state that flashpoint will not be less than 140F.
None of the constituents detected in the analytical results indicate that the corrosivity or reactivity characteristics will be exhibited.

2. Does the waste contain contaminants that fail the TCLP level as defined by 40 CFR § 261.24?
   Yes No X, Except for Soil represented by Soil Samples 13 DW, 183, 121, 131, 161 and 191.

Explanation: The analytical data consists of total concentrations and is attached to this determination via electronic spreadsheets. The groundwater analytical results may be compared directly to the TCLP levels. It is conservative given the leaching procedure to compare the total soil analytical results (mg/kg) to 20 x the TCLP levels.
None of the groundwater analytical results exceed the TCLP levels. Therefore, the groundwater does not exhibit the toxicity characteristic.
The soil analytical results do not exceed the 20 x TCLP levels with the following exceptions, which do exceed this level: Soil Samples 13DW (Chromium and Lead), 183 (Chromium), 121 (Lead), 131 (Lead), 161 (Lead) and 191 (Lead). As stated above, the approach of assessing whether the soil samples exceed TCLP is conservative. It is possible that the samples will not exceed TCLP levels if an actual TCLP leaching test is conducted. However, it may be less expensive to simply treat the limited amount of soil characterized by these samples (which exceed the 20 x TCLP level) as hazardous waste (as compared to conducting additional sampling).
The chromium and lead levels identified above for the soil samples do not result in the personnel protective equipment, decontamination waters and sampling equipment to exceed TCLP given at least a 15 to 1 dilution (very conservative estimate) resulting from the presence of the non hazardous materials (i.e., the PPE, decon waters and sampling equipment).

3. Is the waste a listed waste as identified in 40 CFR § 261.30-.34? Yes No X

Explanation: The soil and groundwater are no listed waste nor are then known to contain listed waste.

4. Does the Waste fall under the Additional Waste Definitions included in OAR 340-101-033?
   Yes No X

Explanation: ODEQ requirements indicate that if the waste contains over 3 percent of a constituent identified in 40 CFR § 261.33(e) or 10 percent of a constituent identified in 40 CFR § 261.33(f), the waste must be classified as an Oregon hazardous waste. This indicates that the groundwater or soil would have to contain at least 30,000 mg/l or 30,000 mg/kg of a constituent, respectively, before it would potentially be an Oregon hazardous waste. None of the samples exceed these levels for constituents identified in 40 CFR § 261.33(e) or 40 CFR § 261.33(f).
Therefore, the waste is does not fall under the Additional Waste Definition.

Table 4-22 Investigation Derived Waste Determination November 2008

U.S. Moorings Site Investigation
HAZARDOUS WASTE DETERMINATION
(Developed by KTA Associates, Inc.)

Waste Name: US Moorings Investigative Derived Waste (IDW) | Date: 11-5-08

Is the Waste Hazardous as Defined by Oregon Administrative Rules ("OAR") Chapter 340, Division 101 (includes RCRA Hazardous Waste Definition)?
Yes X (soil) No X (purge/decon water) - The groundwater (i.e., purge water) and decontamination water is not a hazardous waste; the soil cuttings are potentially hazardous waste.

Products Included in the Waste: Groundwater and Soil Obtained from US Moorings Site

Source of Information use for Hazardous Waste Determination (attached): Groundwater Analytical data from this investigation (attachment 1[2]) and the previous investigation (attachment 2 [Table 4-21]) and Soil Analytical data from the previous investigation (attachment 2). The previous investigation data and resulting waste determination is described in our 4-11-08 waste determination (attachment 2).

Waste Generation Description: KTA/TEC has conducted an investigation at the US Moorings Site in Portland, OR in accordance with a US Corps of Engineers and USEPA format. The site is owned by the U.S. government and managed/operated by the U.S. Corps of Engineers.
The waste subject to this determination is investigative derived waste (IDW). The IDW consists of: (1) (1) groundwater (i.e., purge water) from the development of temporary wells, (2) decontamination waters (which are combined with the groundwater) and (3) soil obtained from temporary well development. This IDW was generated during field sampling efforts that occurred during early August 2008. The specific materials subject to this determination follow.
(1) 1 – 55 gallon drum of soil cuttings associated with Locations (21,22,23,24,25,26,27,28,29,29A,30 & 31).
(2) 2 – 55 gallon drums or groundwater from purging of wells and water used to decontaminate sampling equipment (from all locations).

Analysis

1. Does the waste exhibit the ignitability, corrosivity, or reactivity characteristics as defined by 40 CFR § 261.21-23? Yes No X
Explanation:
The soils and groundwater do not exhibit the ignitability characteristic. This is due the soils not being ignitable under any condition in the presence of normal temperature or pressure. Based on data from the previous investigation, the groundwater contains limited to no volatile organic compounds, which allows the generator to confidently state that flashpoint will not be less than 140F.
None of the constituents detected in this investigation or the previous investigation indicate that the corrosivity or reactivity characteristics will be exhibited.

2. Does the waste contain contaminants that fail the TCLP level as defined by 40 CFR § 261.24? Yes X (soil) No X (purge/decon water). The groundwater (i.e., purge water) and decontamination water do not have constituents that fail TCLP levels; analytical results from the *previous investigation* for soils at the site indicate that constituents may be present that fail TCLP levels.
Explanation:
The analytical data for both investigations consists of total concentrations. The data from these investigations is attached to this determination (attachment 1 and attachment 2). The groundwater analytical results may be compared directly to the TCLP levels. The soil data (mg/kg) may be compared to 20 x the TCLP level. This soil evaluation assumes that 100% of the TCLP constituents will be leached from the soil. This is a conservative approach given that all the TCLP constituents are unlikely to be leached from the soil.
None of the groundwater analytical results exceed the TCLP levels. Therefore, the groundwater does not exhibit the toxicity characteristic.
Analytical data from the previous investigation indicated that some of the soil contained TCLP constituents that exceed TCLP levels. This included exceedances for Chromium and Lead. As stated above, the approach of assessing whether the soil samples exceed TCLP is conservative. It is possible that the samples will not exceed TCLP levels if an actual TCLP leaching test is conducted. However, it will be less expensive to simply treat the limited amount of soil characterized by these samples (which exceed the 20 x TCLP level) as hazardous waste (as compared to conducting additional sampling).

3. Is the waste a listed waste as identified in 40 CFR § 261.30-.34? Yes No X
Explanation: The soil and groundwater are no listed waste nor are then known to contain listed waste.

4. Does the Waste fall under the Additional Waste Definitions included in OAR 340-101-033? Yes No X
Explanation:
ODEQ requirements indicate that if the waste contains over 3 percent of a constituent identified in 40 CFR § 261.33(e) or 10 percent of a constituent identified in 40 CFR § 261.33(f), the waste must be classified as an Oregon hazardous waste. This indicates that the groundwater or soil would have to contain at least 30,000 mg/l or 30,000 mg/kg of a constituent, respectively, before it would potentially be an Oregon hazardous waste. None of the samples exceed these levels for constituents identified in 40 CFR § 261.33(e) or 40 CFR § 261.33(f).
Therefore, the waste is does not fall under the Additional Waste Definition.

[2] Contingency Analytical data. This data can be found in Appendix A-1, Tables 1a and 1c

4.6 NOTABLE FIELD OBSERVATIONS

4.6.1 Blue Water at Temporary Well GW-16

During groundwater sampling activities on March 10, 2008, at temporary well GW-16 located inside the Welding Shop (Building 2), water with a blue tint was encountered (Figure 4-12, page 4-72). Purging began at GW-16 at 0800. Normal procedures were followed for purging the temporary well. The well was screened from 10 to 20 feet bgs and the pump intake was set at 15 feet bgs, which is mid screen. During purging, physiochemical measurements were collected every five minutes with a water quality meter. The parameters stabilized for three consecutive readings and sampling started an hour after purging began. An environmental sample and a field duplicate were planned for collection. When the first high density polyethylene (HDPE) bottle was being filled (approximately 2.5 hours after sampling began), it was observed that the groundwater entering the bottle was noticeably blue. The tip of the tubing from which the groundwater sample flowed was also slightly tinted blue. PID measurements from down the hole, from the purging bucket, the environment around the well, and the breathing zone were in the 0.3-0.6 ppm range.

It was also observed that the samples filtered through a 0.45 micron filter were not tinted blue. After sampling, a PID reading was taken again around the purge water bucket and was measured at 1.5 ppm. Shortly afterward, field personnel used an interface probe to determine if the well contained NAPL. At the groundwater surface in the temporary well casing, the probe reacted to what might have been a thin layer of product. At a depth of 10.14 feet, water was detected and continued to a depth of 13.02 feet, at which point the tone from the probe changed, indicating the presence of product. The changed tone remained while the probe was lowered to the bottom of the well, indicating the presence of light non-aqueous phase liquids (LNAPL). The interface probe was reeled back to the ground surface, but did not have a petroleum product smell, nor did it produce a sheen when placed in-water.

Photos were taken to document the visual appearance of the samples. Observations were also made that acid preserved groundwater samples had a brownish tint to them. Pieces of the Teflon lined polyethylene tubing were saved and photographed to document the color change they exhibited during sampling activities at GW-16. When the PVC well casing was removed from the borehole, it was tinted blue as well.

On March 11, 2008, field personnel again tested GW-16 with a PID and interface probe. The measurement with the PID was 0.0 ppm. The interface probe again detected what appeared to be a thin layer of product at the groundwater surface. Apparent “product” was again detected at a depth of 13.02 feet bgs. A call was made to the interface probe manufacturer to discuss possibilities of instrument interferences. The manufacturer explained that light reflecting/ refracting off particles in the groundwater might provide a false reading. The well was again measured with the interface probe and the same outcome resulted at the same depths. Two measurements with a Draeger tube were collected to determine if hydrogen cyanide (HCN) was present at the temporary well head. Measurements were 0.0 ppm for each sample.

Samples were collected at varying depths in the well (11, 15, and 19 feet) in an attempt to sample the “product” The sample jars containing the groundwater were left undisturbed for a 24 hour period to allow settling of any particles. After the 24 hour period water was also added to the samples to visually observe if separation would occur. No sheen or separation was present. It was concluded that the oil/water interface probe was providing an errant reading, as no indication or NAPL was ever detected.

Figure 4-12 Blue Water

4.6.2 Tarry Material

During the drilling of SB-16, a 1-inch wide diameter tarry material was observed at the top of the soil core from 1 - 4 feet.

4.6.3 Hydrogen Sulfide Odor

During the drilling of the boreholes SB-11 and SB-12, the smell of hydrogen sulfide was noticed. It appeared to be the strongest in the 8 - 12 foot interval soil cores in both borings.

4.6.4 Metal Fragments

During the 1 to 5 foot depth direct push operations in SB-49, SB-50, SB-51, SB-54, SB-55, and SB-56, it was observed that there were a significant number of metal fragments throughout the entire length of the soil cores.

4.6.5 Hydrocarbon Odor

During the drilling of SB-15, a hydrocarbon/petroleum smell was noticed. There was no odor in the 0 to 4 foot core, but the smell was observed in the 4 - 8 foot core and a PID measurement of 540 ppm was observed. The PID value decreased to 320 ppm in the 8 - 12 foot core. The PID readings on the 12 - 16 foot and 16 - 20 foot cores were 0 ppm and the 20 - 24 foot core had a PID reading of 3 ppm.

PID readings above zero were also noted in the 0 to 4 foot cores of SB-18 and SB-19. A measurement of 3.9 ppm was recorded in both locations. Also, a PID reading of 2 ppm was observed in the 20 - 24 foot core at SB-06.

4.7 TERRESTRIAL HABITAT

It should be noted that during the field activities in March/April 2008, a pair of Canada geese, which are common to the Portland Metropolitan area year-round (Audubon 2008a), nested under a loading dock (Dock A), a semi-secluded area. The Moorings does provide a habitat preferred by Canada geese; wide open, simple landscapes with low vegetation and open water (HSUS 2008). Additional landscapes, also present on site, attractive to Canada geese include:

- an absence of well-developed layers of native vegetation;
- trees, shrubs, and non-native plants arranged in sparse patterns, rather than natural clumps; and
- "hard" edges between habitat features or plant "communities," rather than the "soft" edges and gradual transitions typical of natural landscapes (HSUS 2008).

While not a permanent habitat, it is possible that migratory geese may potentially use the site for nesting in the future.

4.8 DEVIATIONS FROM THE MANAGEMENT PLAN

All investigation activities were completed in general accordance with the approved Management Plan. Deviations from this plan that were implemented during field activities are listed below.

4.8.1 Additional Samples

4.8.1.1 Upland Surface Water Seep Sample

During the investigation, a seep location was identified just east of the South Logistics Area approximately 30 feet from the ODOT outfall (Location 14, Figure 2-13, page 2-37). After the seep identification, an on-site meeting was conducted between the KTA/TEC Field Investigation Manger, USACE Representative, and USEPA representative to determine if an additional sample should be collected from this location. A sample was collected after digging a hole in the riverbank sand and using a disposable sample container as a grab sampler. Sampling methodology for this sample is discussed in Upland Surface Water Activities, Section 4.3.1.2 (page 4-41).

4.8.1.2 Upland Sediment Samples

Sampling methodology for the following two samples are discussed in Section 4.4.2.1 (page 4-63).

4.8.1.2.1 Drywell Sludge Sample

The original location for sample SB-13 (upland soil and groundwater using a drill rig) was located in an on-site drywell. The original location was moved approximately 2 feet west of Building 1 to allow sufficient room for the drill rig and upland soil samples were taken. An additional sample of the sludge at the bottom of the drywell (Sample ID SD-DW-13 on Figure 4-8, page 4-47) was collected per USACE request.

4.8.1.2.2 North Logistics Runoff

An additional sample, the North Logistics Runoff (Sample SD-NL-01 on Figure 4.8, page 4-47) was added per direction of the USEPA and concurrence of the USACE. During periods of rain, stormwater runoff from the concrete surface upland from Building 20 and from the north to the center of Building 21, funnels to this location prior to leaving the site.

4.8.2 MIS Management Units

4.8.2.1 Management Unit Reevaluations

The MIS area was initially subdivided into five MUs based on estimated common characteristics. Field conditions necessitated the division of the MIS area into seven MUs. The reasoning behind the new units is discussed below.

4.8.2.1.1 Fence Line

The original Management Plan intended for collection of erodible soils (0-1 foot bgs) in the Laydown and North Logistics Areas. During field activities, it was determined that the 0 to 1 foot bgs horizon was unable to be sampled in these two MUs because it consists of either asphalt, concrete, or a 6 to 9 inch layer of hard packed gravel. A decision was made between the USACE and USEPA that the erodible soil interval would not be collected in these areas.

A new MU was established along the northeast edge of the property in the area between the hard packed gravel and hard armored shoreline. An approximately 1 to 3 foot wide area is covered with gravel and stormwater sediment run off. Samples in this MU were only taken in the 0 to 6 inch horizon in substitution for the lack of 0 to 1 foot horizon in the North Logistics and Laydown MU. This deviation is also discussed in Section 4.1.2.3.4 (page 4-20).

4.8.2.1.2 Slump Management Unit

During the course of the Laydown MIS sample collection, a layer of yellow sands was discovered during the collection three samples (SB-30, SB-15, SB-14) in the southeast corner of the MU. This material was different from any other samples collected in the Laydown Area or in any other MU previously collected. This area sloughed off into the river years prior and was repaired using clean fill material. A French drain system was also installed in the same area to drain away the water and prevent another slope failure. Upon discussion, the USEPA and USACE agreed to develop a new MU for this area. This deviation is also discussed in Section 4.1.2.3.5 (page 4-20).

4.8.2.2 Reassignment of certain North Logistics Sample Locations

While drilling in the North Logistics MU, the field team encountered fill at approximately 1.5 to 6 feet bgs that was distinctly different from any other fill previously encountered on site. The material appeared to be general construction debris/fill consisting of various gravels (different sizes and color) along with occasional asphalt particles and some metal debris. After

researching the site history, it was determined that the construction debris appeared to represent material placed during the development and use of this site as the shoreward portion of the historic marine boatway used for small craft maintenance. As a consequence of this specific fill discovery, two changes were made to sub-sample locations in the North Logistics MU.

The original North Logistics MU locations SB-31 through SB-34, SB-36 through SB-37, and SB-40, and SB-41 were assigned to the Laydown MU because the fill material in those locations matched the fill material in other Laydown Area sub-sample locations.

The original North Logistics Area sub-sample Locations SB-61 through SB-67 were reassigned to the South Logistics Area. These were also moved because the fill material did not match the other material in the North Logistics MU, but was generally the same as throughout the South Logistics MU. The sample horizons were also changed to 1 to 5 feet, 5 to 10 feet, and 10 feet to NSI. These sub-samples were logged, but were not collected as the South Logistics MU sample had been submitted to the laboratory greater than 10 days prior.

The North Logistics MU sample horizons were also changed to only include the collection of samples from 1 to 5 foot and 5 feet to NSI. The vertical delineation was required due to the lack of clear interface with dredge material fill underlying the construction fill. The Laydown Area sample horizons were also changed to 1 to 5 foot and 5 foot to NSI. This deviation is also discussed in Section 4.1.2.3.2 (page 4-20).

4.8.2.3 Sample Location Adjustment

Several sampling locations in the Laydown and Prior Clean-up MUs were adjusted in the field due to the presence of a 36” high-pressure waterline running through the north end of the property. The waterline was discovered after TEC conducted a second utility check using the City of Portland Water Bureau to locate the line. A more thorough description of the adjustments is provided in Table 4-23 (page 4-76).

4.8.3 In-Water Sediment

Surface and subsurface sample elevation depths at some stations do not have direct correspondence due to differences in time of collection and position occupied. For example, at SDDA 17, the surface sample was collected using the Power Grab from a depth of -33.4 feet CRD, whereas the subsurface sample cores were collected on a different occasion at -25 – 32 (SDDA 17-2). While every attempt was made to re-occupy the exact same position for core collection, the differences in horizontal location resulted in these apparent differences in depth of sample.

4.8.4 Dye Testing

Dye testing at three major ODOT outfalls was conducted to verify they were still functioning properly and that they were not connected to any other outfalls in the river.

4.8.5 Field Authorized Changes

Table 4-23 (page 4-76) lists changes made during activities due to conditions discovered in the field.

Table 4-23 Field Deviations

AREA/LOCATION	DEVIATION	RATIONALE
UPLAND SOIL INDUSTRIAL AREA		
Industrial Area	Soil sampling intervals were changed from 3 intervals to 4 intervals.	The Management Plan initially specified 3 intervals of drilling to a depth of approximately 12' bgs to meet either NSI or groundwater. During the field event in the Industrial Area it was determined the depth of 12' was not deep enough to reach the NSI and groundwater. A fourth interval (12-16') was added to the program.
SB-01	Drilled two holes in close proximity to one another;SB-01A and SB-01B.	The second boring was required to collect sufficient material for quality control sample purposes.
SB-11	Drilled two holes in close proximity to one another;SB-11A and SB-11B.	The second boring was required to collect sufficient material for quality control sample purposes.
SB-13	Sample Location was moved approximately 2' upgradient (west).	Borehole location was moved 2' upgradient from the center of the drywell, because an overhang on the building impeded the operation of the GeoProbe DPT rig.
SB-15	Drilled two holes in close proximity to one another; SB-15A and SB-15B.	The second boring was required to collect sufficient material for quality control sample purposes.
SB-16	Drilled two holes in close proximity to one another; SB-16A and SB-16B.	The second boring was required to collect sufficient material for quality control sample purposes.
SB-18	Drilled two holes in close proximity to one another; SB-18A and SB-18B.	The second boring was required to collect sufficient material for quality control sample purposes.
SB-19	Drilled two holes in close proximity to one another; SB-19A and SB-19B.	The second boring was required to collect sufficient material for quality control sample purposes.
	UPLAND SOIL SAMPLES NOT COLLECTED	
SB-01	The 12-16' horizon was not sampled.	A sample from this horizon could not be collected due to poor recovery. An extra interval (16-20') was collected.
SB-02	The 1-4' horizon was not sampled.	This horizon was not collected due to poor recovery due to rocks and cobbles.
SB-03	The 1-4' horizon was not sampled.	This horizon was not collected as the upper interval material was mostly rocky material so no sample was collected from this location. An extra interval (16-20') was added and sampled.
SB-14	The 8-12' and 12-16' horizons were not sampled.	The horizons were not collected as the NSI was determined at approximately 7' bgs.
SB-15	The 12-16' horizon not sampled.	A sample from this horizon could not be collected due to poor recovery. An extra interval (16-20') was collected.
SB-17	The 8-12' and 12-16' horizons were not sampled.	Drilled to a depth of 9.3': Met refusal at basalt gravel was unable to bore deeper. The 4-8' horizon was changed to 4-9' for this sample

Table 4-23 Field Deviations

AREA/LOCATION	DEVIATION	RATIONALE
UPLAND SOIL MIS		
South Logistics Area		
SB-SL-82-3	The 10-15' horizon was not sampled.	This horizon was not collected due to poor recovery.
North Logistics Area		
North Logistics Area	A new soil/sediment sample was collected from 0 to 1' bgs.	This USEPA directive was given because there was evidence of surface runoff.
North Logistics Area	Sample locations 31-34, 36-37, and 40-41 were added to the Laydown Area, and removed from the North Logistics Area.	The locations were relocated because the samples did not contain construction fill, but contained materials similar to that of the Laydown Area.
North Logistics Area	Sample locations 61-67 were added to the South Logistics Area, and removed from the North Logistics Area.	The locations were moved because the samples were comprised of the same material as that of the South Logistics Area.
Laydown Area		
LD-SB-17	Sample Location moved ~3' to the north.	This boring location was moved due to a 36" Portland Water Bureau main below ground surface of the originally planned location.
LD-SB-02	Sample not taken beyond 7 ft.	Drilling crew hit concrete at this location ~7' bgs. The location was near the 36" water line so the sampler was not advanced.
	Sample locations 14, 15, 30 were removed from the Laydown area MU. A new MU (Slump) was created	A new MU was created as these samples contained different material than any other sample in the Laydown Area or in any other MU previously collected.
Prior Clean-up		
PC-SB-91	Sample location moved ~10' southeast.	These boring locations were moved due to a 36" Portland Water Bureau main below ground surface of the originally planned location.
PC-SB-92	Sample location moved ~3' southeast.	
PC-SB-95	Sample location moved ~2' southeast.	

Table 4-23 Field Deviations

AREA/LOCATION	DEVIATION	RATIONALE
UPLAND GROUNDWATER		
GW-20	Installation of temporary well instead of planned drive point to sample groundwater.	Due to fine granules of material in the formation and a small screen size on the drive point, sampler was unable to recover groundwater from the well. It was determined the screen on the drive point became clogged and was not allowing groundwater to infiltrate the drive point sample space. A temporary well was installed instead and sample collection was successful.
GW-17	No sample collection occurred at this location.	A groundwater sample could not be obtained at this location due to insufficient water. The temporary well was only set at approximately 9.3' bgs as the drill rig met refusal at basalt gravel (see SB-17 above). Several attempts were made to sample this location but were unsuccessful.
GW-29	No sample collection occurred at this location.	Water was not located at the original SB-29 after drilling to 20' bgs. A second boring was completed approximately 20 feet south of the original location in attempt to obtain groundwater. Groundwater was not encountered in the second location either.
IN-WATER SEDIMENT		
Under Dock		
SDUD - 01, -02, -26, and -27	Samples were moved.	Surface sediment collections were collected from the gangway under the dock. The surface sediment samples were attempted to be collected using DPT rig equipped with a box core and/or from a core tube. The surface sediment was not able to be retained using either method due to the unconsolidated material. A Van Veen sampler was used to collect the samples but need to be hand deployed so the locations were moved under the gangway.
SDUD-03	No sample collection occurred at this location. Sample was replaced with Sample ID SDDC-25-1.	Large rocks and cobble prevented the collection of a sample; six attempts were made.
SDUD-04	No sample collection occurred at this location.	No sample was collected due to excessive blow counts and interference from riprap and debris. A geotechnical core was collected from under the dock instead (SDUD 4-1)
SDUD-26	Equipment change from CDI's 2-inch collector to the 0.1 sq meter Van Veen.	The mini-box core could not retain any sample after four attempts. Switching to the Van Veen allowed for proper sample recovery.
Geotechnical	Discontinued geotechnical borings	USACE advised field crew to discontinue geotechnical borings based upon poor recoveries and heaving sands.
ODOT Outfalls		
SDOF 28 Subsurface	Sample location moved due to inaccessibility.	The Vibra-core sampler could not be deployed in the shallow water so the sampling station was moved approximately 100 ft in-shore.
SDOF 28	Sample Location moved ~80' feet.	Water level was too low to deploy Vibra-core instrument for sample collection.

Table 4-23 Field Deviations

AREA/LOCATION	DEVIATION	RATIONALE
Dredge Areas		
SDDC 25	Change in sample horizons.	The original sample horizons called for compositing at mudline -10 to -12' and -12 to -15'. The core was only penetrated to -12 feet. The actual horizons composited were at mudline -5 to -8' and -8 to -12'. This was changed because the core only penetrated to 12 ft below mudline.
SDDC 25	Sample penetration not at or beyond required 65-100% recovery at Mudline - 9.5 to -10.5 ft CRD.	Refusal was encountered at mudline -10'; a second core was attempted but encountered resistance at the same depth. Sample was collected.
SDDA 17	Additional sample at Location 17 at request of USACE	USACE representative Sandy Lemlich requested station 17 to be sampled due to its close proximity to the neighboring property to the south.
SDDB 21	Location 21 was measured at -10 ft CRD instead of -15 ft. Sample depth was adjusted at this site to collect more material.	Depth to mudline not within measurement of 0.5 ft when checked with lead line vs. work plan measurement.
Bulkhead		
SDBH-03	Surface sediment sample SDBH-03 could not be collected. The sample was collected from Location 25 instead.	The surface material under the dock was comprised of rip rap and cobble; no sediments were present. After consultation with USACE, it was determined that an additional surface sediment sample would be collected at Location 25, designated SD-DC-25-1 and analyzed with other Bulkhead samples.
SDBH-04	Sample Location moved due to inaccessibility	A sample could not be obtained from this location because the bulkhead material extended under the dock preventing sample collection. SDBH-04 was collected just east of Dock C.

Table 4-24 Blind ID Reference Table

INDUSTRIAL AREA SOIL						INDUSTRIAL AREA GROUNDWATER	
SAMPLE ID	BLIND SAMPLE ID		SAMPLE ID	BLIND SAMPLE ID		SAMPLE ID	BLIND SAMPLE ID
SB-01-1	11		SB-13-1	131		GW-1	16
SB-01-2	12		SB-13-2	132		GW-2	25
SB-01-3	13		SB-13-3	133		GW-3	36
SB-01-5	15		SB-13-4	134		GW-4	45
SB-02-2	22		SB-14-1	141		GW-5	55
SB-02-3	23		SB-14-2	142		GW-6	65
SB-02-4	24		SB-15-1	151		GW-11	115
SB-03-2	32		SB-15-2	152		GW-12	125
SB-03-3	33		SB-15-3	153		GW-16	165
SB-03-4	34		SB-15-5	155		GW-20	202
SB-03-5	35		SB-16-1	161		Contingency	Sampling
SB-04-1	41		SB-16-2	162		GW-21	210
SB-04-2	42		SB-16-3	163		GW-22	220
SB-04-3	43		SB-16-4	164		GW-23	230
SB-04-4	44		SB-17-1	171		GW-24	240
SB-05-1	51		SB-17-2	172		GW-25	250
SB-05-2	52		SB-18-1	181		GW-26	260
SB-05-3	53		SB-18-2	182		GW-27	270
SB-05-4	54		SB-18-3	183		GW-28	280
SB-06-1	61		SB-18-4	184		GW-30	300
SB-06-2	62		SB-19-1	191		GW-31	310
SB-06-3	63		SB-19-2	192		Field	Duplicates
SB-06-4	64		SB-19-3	193		GW-5	56
SB-07-1	71		SB-19-4	194		GW-16	166
SB-07-2	72		SB-20-1	201		MIS AREA SOIL	
SB-07-3	73		*Contingency*	*Sampling*		SAMPLE ID	BLIND SAMPLE ID
SB-07-4	74		SB-24-1	241		SB-SL-001	3000
SB-08-1	81		SB-24-2	242		SB-SL-002	3001
SB-08-2	82		SB-24-3	243		SB-SL-003	3002
SB-08-3	83		SB-24-4	244		SB-NL-01	5000
SB-08-4	84		SB-31-1	311		SB-NL-02	5001
SB-09-1	91		SB-31-2	312		SB-LD-01	6000
SB-09-2	92		SB-31-3	313		SB-LD-02	6001
SB-09-3	93		SB-31-4	314		SB-MIS-T1-01	8000
SB-09-4	94		*Field*	*Duplicates*		SB-MIS-T1-02	8001
SB-10-1	101		SB-01-2	120		SB-FL-01	11000
SB-10-2	102		SB-05-1	510		SB-SP-01	7000
SB-10-3	103		SB-11-2	1120		PC-SB-01	4000
SB-10-4	104		SB-15-2	1520		SB-SB-01	9000
SB-11-1	111		SB-16-4	1640		UPLAND SURFACE WATER	
SB-11-2	112		SB-18-3	1830		SW-ODOT-01	1051
SB-11-3	113		SB-19-2	1920		SW-FD-01	1052
SB-11-4	114		*Contingency*	*Duplicates*		SW-SEEP-01	12000
SB-12-1	121		SB-24-1	2410		UPLAND SURFACE SEDIMENT	
SB-12-2	122		GW-24	245		SD-ODOT-CB	1050
SB-12-3	123					SD-DW-13	13DW
SB-12-4	124					SD-NL-01	10000

Table 4-25 Quality Control Sample Reference Table

Sample ID	Blind ID	Date	Time	Depth	Comments
Industrial Area					
Duplicate Samples (soil)					
SB-05-1	510	3/6/08	1030	0-4' bgs	
SB-01-2	120	3/7/08	940	4-8' bgs	
SB-11-2	1120	3/7/08	1348	4-8' bgs	
SB-18-3	1830	3/8/08	847	8-12' bgs	
SB-15-2	1520	3/9/08	1140	4-8' bgs	
SB-16-4	1640	3/9/08	1015	12-16' bgs	
Duplicate Samples (groundwater)					
GW-5	56	3/7/08	1415	16.62' btoc	
GW-16	166	3/10/08	945	15.00' btoc	
Duplicate Samples (soil contingencies)					
SB-24-1	2410	8/7/08	920	1-4' bgs	
Duplicate Samples (groundwater contingencies)					
GW-24	245	8/7/08	755	16.60' btoc	
MS/MSD Samples					
SB-04-1	41	3/4/08	1325	0-4' bgs	
GW-6	65	3/5/08	1155	19.00' btoc	
SB-11-1	111	3/7/08	1300	0-4' bgs	
SB-12-3	1400	3/8/08	1400	8-12' bgs	
SB-15-5	155	3/9/08	1220	16-20' bgs	
SB-17-1	171	3/10/08	1515	0-4' bgs	
MS/MSD Samples (contingencies)					
GW-22	220	8/6/08	905	17.92' btoc	
Rinsate Samples					
Rin-001	1000	3/6/08	1640	NA	Rinsate from core liner
Rin-002	1001	3/6/08	1700	NA	Rinsate from bowl
Rin-003	1002	3/8/08	1600	NA	Rinsate from bowl
Rin-004	1003	3/11/08	1625	NA	Rinsate from core liner (Organobutyltins only)
Rin-005	1004	3/14/08	730	NA	Rinsate from bowl
Rin-006	1005	3/26/08	715	NA	Rinsate from tubing
Rin-009	13000	8/7/08	13000	NA	Rinsate from Peristaltic Pump and tubing (contingencies)
Trip Blanks					*Laboratory Serial Number*
Industrial Area	TB 12	2/28/08	915	NA	not recorded
Industrial Area	TB 17	2/28/08	853	NA	37189
Industrial Area	TB 18	3/4/08	756	NA	37190
Industrial Area	TB 14	3/5/08	1155	NA	37186
Industrial Area	TB 09	3/6/08	855	NA	37181
Industrial Area	TB 10	3/6/08	805	NA	37182
Industrial Area	TB 01	3/7/08	805	NA	37140
Industrial Area	TB 08	3/7/08	1000	NA	37180
Industrial Area	TB 07	3/8/08	805	NA	37179
Industrial Area	TB 13	3/8/08	1200	NA	Not recorded
Industrial Area	TB 16	3/8/08	905	NA	37188
Industrial Area	TB 11	3/9/08	845	NA	37183
Industrial Area	TB 15	3/9/08	1015	NA	37187
Industrial Area	TB 01	3/10/08	800	NA	37173

Table 4-25 Quality Control Sample Reference Table

Sample ID	Blind ID	Date	Time	Depth	Comments
Industrial Area	TB 02	3/10/08	715	NA	37174
Industrial Area	TB 04	3/12/08	700	NA	37176
Industrial Area	TB 05	3/14/08	925	NA	37177
Industrial Area	TB 06	3/14/08	730	NA	37178
Industrial Area	TB 01	3/26/08	700	NA	37207
Trip Blanks (contingencies)					
Industrial Area	TB 01	8/7/08	650	NA	
MIS QC Samples A					
LD-SB-32A	8000	4/5/08	1500	1-5'	
MIS QC Samples B					
LD-SB-41B	8001	4/5/08	1335	1-5'	
Laydown Area Rinsate Samples					
Rin-007	1006	4/3/08	1545	N/A	Rinsate from bowl
Sand Blast Area Rinsate Samples					
Rin-008	1007	4/8/08	855	N/A	Rinsate from bowl
In-Water Outfall Duplicate of SD-OF-28-1					
SD-OF-30-1		4/18/08	1710	0-1'	
In-Water Under Dock Duplicate of SD-UD-27-1					
SD-UD-29-1		4/14/08	1144	0-1'	
In-Water Dredge Area Duplicate of SD-DA-18-2					
SD-DA-31-1		4/20/08		1-11'	

Notes:

bgs	below ground surface	GW	Groundwater	Rin	Rinsate	TB	Trip Blank
btoc	below top of casing	LD	Laydown	SB	Soil Boring	N/A	Not Applicable

5.0 INVESTIGATION RESULTS

This section summarizes the results of the Moorings RI field investigation activities. For ease of review, the discussion is organized as follows:

- Summary of Sample Analytical Results (Section 5.1, page 5-1);
- Site Geology/Hydrogeology (Section 5.2, page 5-89);
- Surface Water (Section 5.3, page 5-90);
- Sediment Lithology (Section 5.4, page 5-90); and
- Summary of Data Quality Reviews (Section 5.5, page 5-102).

In general, this section focuses on straightforward documentation of the RI findings. For example, it includes overall summaries of sample analytical results, identifies the most frequently detected analytes in each environmental media, and documents the concentration ranges of the detected analytes. It also identifies the major geologic, hydrologic, and lithologic features of the site

In comparison, Section 6 interprets these findings in relation to the CSM described in Section 3 and discusses the nature and extent of contamination at the site, including potential contaminant sources and migration pathways. Finally, Section 7 provides a more detailed discussion of the sample analytical results that exceeded risk-based screening criteria.

5.1 SUMMARY OF SAMPLE ANALYTICAL RESULTS

As described in Section 4, the Moorings RI consisted of four main field activities:

- Upland Soil Investigation, including the Industrial Area Soil Investigation and the MIS Area Soil Investigation (Figure 4.2, page 4-13; Figures 4-6A-F, pages 4-26 through 4-31);
- Upland Groundwater Investigation (Figure 4-2, page 4-13);
- Upland Surface Water and Sediment Investigation (figure 4-8, page 4-47); and
- Willamette River Sediment Investigation (Figure 4-11, page 4-61).

Sample analytical results for each are summarized below. Appendix A contains a complete listing of all analytical data collected during the RI, including reporting limits for non-detected analytes.

5.1.1 Industrial Area Soil Investigation Sample Results

The Industrial Area was investigated using a traditional, discrete sampling approach as described in Section 4.1.1 (page 4-7). Soil samples were collected from a total of 22 borehole locations during two separate field events. In the first event, a total of 71 samples (excluding field duplicates) were collected from multiple soil horizons at locations SB-01 through SB-19 (Figure 4-2, page 4-13, and Table 4-3, page 4-9) and analyzed for VOCs, PAHs, non-PAH SVOCs, PCBs, pesticides, cyanide (total), metals, organobutyltins, and TPHs (TPH-Diesel and TPH-Motor Oil). A single sample was also collected from location SB-20 (Figure 4-2, page 4-

13, and Table 4-3, page 4-9) at a depth of 80-85 foot bgs and analyzed for the same list of parameters.

During the second event, a total of eight samples (excluding field duplicates) were collected from four soil horizons at locations SB-24 and SB-31 (Figure 4-7, page 4-37, and Table 4-10, page 4-36). These samples were collected to further investigate conditions downgradient of former USTs and therefore were only analyzed for TPH-Gasoline, TPH-Diesel and TPH-Motor Oil.

The following subsections highlight the key findings in the Industrial Area soil sampling activity. For simplicity and consistency, the detected analytes and their frequency of detection are identified for each analytical group and soil horizon. In addition, concentration ranges are provided for the 4 most frequently detected analytes in each soil horizon. Finally, because metals and PAHs were detected nearly ubiquitously across the site, those subsections identify the detected concentration ranges of the analytes that exceeded screening criteria, regardless of the frequency of detections.

Table 5-1 (page 5-13) summarizes the analytical results for borehole Locations SB-01 through SB-20. The data in Table 5-1 (page 5-13) is organized to simulate the spatial relationships of the boreholes across the Industrial Area. It should be noted that all soil samples collected from the 1 - 4 foot horizon were screened against human health and ecological receptor risk criteria. Sample locations that exceed a risk criterion are identified in this section and evaluated more fully in Section 7.

5.1.1.1 VOCs

VOCs were detected at all locations and in all soil horizons throughout the Industrial Area (69 of 72 samples). Of the 22 different VOC analytes detected, toluene was the most frequently detected compound (36 of the 72 samples) and carbon disulfide was the second most frequently detected compound (24 of the 72 samples). Locations SB-15 and SB-19 had the greatest number of detectable VOC concentrations, with 16 of 22 VOCs detected in SB-15 and 15 of 22 VOCs detected in SB-19.

Figures 5-1 (page 5-18) and 5-2 (pages 5-19) illustrate the distribution of toluene and benzene in the Industrial Area soils, respectively. Although both VOCs are widely distributed in the soil, no obvious spatial or vertical trends are apparent and no locations stand out as obvious hot-spots.

VOCs were not detected in any location at concentrations that exceeded the screening criteria.

VOCs in the 1 - 4 Foot Horizon. Fourteen of the 17 samples collected in the 1-4 foot soil horizon had detectable concentrations of VOCs. The most frequently detected compounds included:

- Toluene – Eight of 17 samples at concentrations ranging from 0.14 µg/kg to 1.0 µg/kg (Figure 5-1, page 5-18).
- m,p-Xylene – Six of 17 samples at concentrations ranging from 0.22 µg/kg to 1.1 µg/kg.
- Benzene – Five of 17 samples at concentrations ranging from 1 µg/kg to 2.7 µg/kg (Figure 5-2, page 5-19).
- Dichlorodifluoromethane – Five of 17 samples at concentrations ranging from 0.25 µg/kg to 1.6 µg/kg.

- tetrachloroethene (PCE) - Four of 17 samples.
- Trichlorofluoromethane and 2-butanone – Two of 17 samples.

VOCs in the 4 - 8 Foot Horizon. Seventeen of the 19 samples collected in this horizon had detectable concentrations of VOCs. The most frequently detected compounds included:

- Toluene – Nine of 19 samples at concentrations ranging from 0.32 µg/kg to 1.2 µg/kg (Figure 5-1, page 5-18).
- Dichlorodifluoromethane - Four of 19 samples at concentrations ranging from 0.28 µg/kg to 3.3 µg/kg.
- Trichlorofluoromethane – Four of 19 samples at concentrations ranging from 0.15 µg/kg to 0.22 µg/kg.
- Carbon disulfide – Four of 19 samples at concentrations ranging from 0.13 µg/kg to 0.8 µg/kg.
- Benzene – Three of 19 samples at concentrations ranging from 1.1 µg/kg to 1.6 µg/kg (Figure 5-2, page 5-19).
- PCE and m,p-xylene – Two of 19 samples.

It should be noted that location SB-15-2 exhibited VOC concentrations that were substantially higher than the balance of the site. For example, ethylbenzene, m,p-xylene, o-xylene and isopropylbenzene were detected at this location at concentrations of 97,000 µg/kg, 310,000 µg/kg, 8,700 µg/kg, and 33,000 µg/kg, respectively. A third sampling event was conducted to confirm the findings of SB-15-2 (Appendix E). Soil sample results confirmed the presence of elevated levels of ethylbenzene and xylenes at concentrations similar to those initially detected.

VOCs in the 8 - 12 Foot Horizon. All 17 samples collected in this horizon had detectable concentrations of VOCs. The most frequently detected compounds included:

- Toluene - Nine of 17 samples at concentrations ranging from 0.31 µg/kg to 3.5 µg/kg (Figure 5-1, page 5-18).
- Carbon disulfide - Five of 17 samples at concentrations ranging from 0.22 µg/kg to 9.1 µg/kg.
- Benzene - Five of 17 samples at concentrations ranging from 1 µg/kg to 2.6 µg/kg (Figure 5-2, page 5-19).
- Dichlorodifluoromethane - Four of 17 samples at concentrations ranging from 0.25 µg/kg to 34 µg/kg.
- PCE and trichlorofluoromethane - Three of 17 samples.

VOCs in the 12 - 16 Foot Horizon. All 15 samples collected in this horizon had detectable concentrations of VOCs. The most frequently detected compounds included:

- Carbon disulfide – Twelve of 15 samples at concentrations ranging from 0.098 µg/kg to 7.2 µg/kg.

- Toluene – Nine of 15 samples at concentrations ranging from 0.31 µg/kg to 0.71 µg/kg (Figure 5-1, page 5-18).
- Dichlorodifluoromethane - Five of 15 samples at concentrations ranging from 0.24 µg/kg to 61 µg/kg.
- Trichlorofluoromethane and m,p-xylene – Four of 15 samples.
- 2-butanone - Two of 15 samples.

VOCs in the 16 - 20 Foot Horizon. Only three samples were collected in this horizon due to sample recovery issues in locations SB-01, SB-03, and SB-15. All three samples had detectable concentrations of VOCs. Benzene, carbon disulfide, toluene, ethylbenzene, m,p-xylene and o-xylene were each detected in two samples; naphthalene and isopropylbenzene were each detected in one sample.

VOCs in Soil Boring 20. Two VOCs were detected in sample SB-20-1, carbon disulfide and toluene had detectable concentrations.

5.1.1.2 PAHs

Six or more PAH compounds were detected in 71 of 72 soil samples collected in the Industrial Area. Twenty samples had detectable concentrations of all 19 PAHs. These included twelve samples in the 1 - 4 foot horizon, one in the 4 - 8 foot horizon, one in the 8 - 12 foot horizon, four in the 12 - 16 foot horizon, and two in the 16 - 20 foot horizon. The most frequently detected PAHs are as follows:

- Benzo(b)fluoranthene, benzo(a)pyrene, and indeno(1,2,3-cd)pyrene were each detected in 71 of 72 samples.
- Benzo(k)fluoranthene, benzo(a)anthracene, chrysene, fluoranthene, and pyrene were each detected in 70 of the 72 samples.

Figures 5-3 (page 5-20) through 5-5 (page 5-22) illustrate the spatial distribution of LPAH, HPAH, and total PAH (TPAH) concentrations in the Industrial Area soils. In general, the HPAHs were detected more frequently than low molecular weight LPAHs. LPAH compounds include naphthalene, 2-methylnaphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene and anthracene. HPAH compounds include fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, dibenz(a,h)anthracene, and benzo(g,h,i)perylene.

Four PAHs were detected in concentrations that exceeded human health protective screening criteria (i.e. benzo(b)fluoranthene, indeno(1,2,3-cd)pyrene, dibenz(a,h)anthracene, and benzo(a)pyrene). Only the shallow soil horizon soils were screened against the human health protective screening criteria because it was assumed that contact with soils below 4 feet was improbable.

Figure 5-6 (page 5-23) depicts the spatial distribution of the benzo(a)pyrene concentrations. Benzo(a)pyrene was chosen as an indicator for PAH contamination because it is the most toxic PAH to humans of the PAHs sampled and screened. Benzo(a)pyrene concentrations exceeded the screening criteria at nine locations.

PAHs in the 1 - 4 Foot Horizon. All 17 samples collected in this horizon had detectable concentrations of at least 15 PAHs. The most frequently detected PAH compound was

benzo(a)pyrene, which was detected in all 17 samples at concentrations ranging from 21 µg/kg to 1700 µg/kg. Benzo(a)pyrene concentrations exceeded screening criteria at nine locations (Figure 5-6, page 5-23). Benzo(b)fluoranthene, indeno(1,2,3-cd)pyrene and dibenz(a,h)-anthracene were each detected once at a concentration that exceeded the screening criteria.

HPAH concentrations in this horizon were highest at location SB-16-1.

PAHs in the 4 - 8 Foot Horizon. All 19 samples collected in this horizon had detectable concentrations of at least 10 PAHs. Benzo(a)pyrene was detected in all 19 samples at concentrations ranging from 1.4 µg/kg to 1900 µg/kg.

HPAH concentrations in this horizon were highest at location SB-10-2.

PAHs in the 8 - 12 Foot Horizon. All 17 samples collected in this horizon had detectable concentrations of at least 10 PAHs. Benzo(a)pyrene was detected in all 17 samples at concentrations ranging from 1.6 µg/kg to 800 µg/kg.

HPAH concentrations in this horizon were highest at location SB-10-3.

PAHs in the 12 - 16 Foot Horizon. All 16 samples collected in this horizon had detectable concentrations of at least six PAHs. Benzo(a)pyrene was detected in all 17 samples at concentrations ranging from 4.9 µg/kg to 1800 µg/kg.

HPAH concentrations in this horizon were highest at location SB-10-4.

PAHs in the 16 - 20 Foot Horizon. All three samples collected in this horizon had detectable concentrations of at least 7 PAHs.

5.1.1.3 Non-PAH SVOCs

Non-PAH SVOCs were detected in all soil samples in the Industrial Area. Of the 18 different non-PAH SVOC compounds detected, bis(2-ethylhexyl)phthalate was the most frequently detected (53 of the 72 samples). Diethyl phthalate was the second most frequently detected non-PAH SVOCs (33 of the 72 samples).

No non-PAH SVOCs exceeded the screening criteria for soils in the Industrial Area.

Non-PAH SVOCs in the 1 - 4 Foot Horizon. All 17 samples collected in this horizon had detectable concentrations of at least one of the 12 non-PAH SVOCs detected. The most frequently detected compounds included:

- Carbazole - 13 of 17 samples at concentrations ranging from 2.9 µg/kg to 110 µg/kg.
- bis(2-Ethlyhexyl)phthalate - 11 of 17 samples at concentrations ranging from 7.5 µg/kg to 120 µg/kg.
- Diethyl phthalate – Nine of 17 samples at concentrations ranging from 1.3 µg/kg to 3.7 µg/kg.

Other non-PAH SVOCs detected in the shallow soil horizon included pentachlorophenol (8 of 17 samples), benzyl alcohol (5 of 17 samples), 2,4,5-trichlorophyenol (3 of 17 samples), and benzoic acid and phenol (2 of 17 samples each).

Samples SB-05-1 and SB-10-1 had the greatest number of detected non-PAH SVOCs in this horizon (6 each).

Non-PAH SVOCs in the 4 - 8 Foot Horizon. Eighteen of the 19 samples collected in this horizon had detectable concentrations of at least one of the 14 non-PAH SVOC analytes detected. The most frequently detected compounds included:

- bis(2-Ethlyhexyl) phthalate - 16 of 19 samples at concentrations ranging from 8.4 µg/kg to 81 µg/kg.
- Diethyl phthalate - 11 of 19 samples at concentrations ranging from 1.5 µg/kg to 7.5 µg/kg.
- Carbazole - Eight of 19 samples at concentrations ranging from 1.5 µg/kg to 160 µg/kg.

Other non-PAH SVOCs detected in this soil horizon included benzyl alcohol (7 of 19 samples), phenol (4 of 19 samples), 2,4,5-trichlorophenol (3 of 19 samples), and benzoic acid, pentachlorophenol, 4-methylphenol, and butyl benzyl phthalate (2 of 17 samples each).

Sample SB-02-2 had the greatest number of detected non-PAH SVOCs in this horizon (8). In comparison, no non-PAH SVOCs were detected in sample SB-06-2.

Non-PAH SVOCs in the 8 - 12 Foot Horizon. All 17 samples collected in this horizon had detectable concentrations of at least one of the ten non-PAH SVOC analytes detected. The most frequently detected compounds included:

- bis(2-Ethlyhexyl)phthalate - 14 of 17 samples at concentrations ranging from 7.3 µg/kg to 55 µg/kg.
- di-n-Octyl phthalate - 12 of 17 samples at concentrations ranging from 7.3 µg/kg to 73 µg/kg.
- Benzyl alcohol - Five of 17 samples at concentrations ranging from 2.8 µg/kg to 5.9 µg/kg.

Other non-PAH SVOCs detected in this soil horizon included phenol and diethyl phthalate (3 of 17 samples each), and carbazole, 2,4,5-trichlorophenol and pentachlorophenol (2 of 17 samples each).

Sample SB-05-3 had the greatest number of detected non-PAH SVOCs in this horizon (5).

Non-PAH SVOCs in the 12 - 16 Foot Horizon. All 15 samples collected in this horizon had detectable concentrations of at least one of the nine non-PAH SVOC analytes detected. The most frequently detected compounds included:

- bis(2-Ethlyhexyl)phthalate - 11 of 15 samples at concentrations ranging from 8.7 µg/kg to 60 µg/kg.
- Diethylphthalate - Eight of 15 samples at concentrations ranging from 1.4 µg/kg to 3.3 µg/kg.
- Benzyl alcohol - Four of 15 samples at concentrations ranging from 3.6 µg/kg to 4.4 µg/kg.

Other non-PAH SVOCs detected in this soil horizon included carbazole and 4-methylphenol (3 of 15 samples) and phenol (2 of 15 samples).

Sample SB-02-4 had the greatest number of detected non-PAH SVOCs in this horizon (5). No non-PAH SVOCs were detected in sample SB-18-4.

Non-PAH SVOCs in the 16 - 20 Foot Horizon. All three samples collected in this horizon had detectable concentrations of at least two of the five non-PAH SVOC analytes detected. The most frequently detected compounds included:

- Diethylphthalate - Two of 3 samples at concentrations ranging from 1.4 µg/kg to 3.3 µg/kg.
- Carbazole - Two of 3 samples at concentrations ranging from 1.6 µg/kg and 1.9 µg/kg.

Sample SB-01-5 had the greatest number of detected non-PAH SVOCs in this horizon (3).

Non-PAH SVOCs in Soil Boring 20. Three non-PAH SVOCs were detected in sample SB-20-1: benzyl alcohol, diethyl phthalate and bis(2-ethylhexyl)phthalate.

5.1.1.4 PCBs

Two different PCBs, Aroclor® 1254 and 1260 were detected in the Industrial Area soils. Neither was detected at a concentration that exceeded screening criteria.

PCBs in the 1 - 4 Foot Horizon. Four of the 17 samples collected in this horizon (SB-15-1, SB-16-1, SB-18-1 and SB-19-1) had detectable concentrations of PCBs. Aroclor® 1260 was detected in four samples at concentrations ranging from 5.5 µg/kg to 81 µg/kg. Aroclor® 1254 was detected in one sample at a concentration of 2.4 µg/kg.

PCBs in the 4 - 8 Foot Horizon. Two of the 19 samples collected in this horizon (SB-15-2 and SB-18-2) had detectable concentrations of PCBs. Aroclor® 1260 was detected in the two samples at concentrations ranging from 1.9 µg/kg to 4.5 µg/kg.

PCBs in the 8 - 12 Foot Horizon. One of the 17 samples collected in this horizon (SB-19-3) had a detectable concentration of a PCB. Aroclor® 1260 was detected in one sample at a concentration of 2.6 µg/kg.

PCBs in the 12 - 16 Foot Horizon. One of the 15 samples collected in this horizon (SB-19-4) had a detectable concentration of a PCB. Aroclor® 1260 was detected in one sample at a concentration of 4.7 µg/kg.

PCBs in the 16 - 20 Foot Horizon. No PCBs were detected in this horizon in the Industrial Area soils.

5.1.1.5 Pesticides

Pesticides were detected in 33 of the 72 soil samples collected in the Industrial Area. Of the 27 pesticides detected, 4,4'-DDT was the most frequently detected (24 of the 72 samples) and 4,4'-DDE was the second most frequently detected (21 of the 72 samples).

No pesticides were detected at concentrations that exceeded the screening criteria.

Pesticides in the 1 - 4 Foot Horizon. Twelve of the 17 samples collected in this horizon had detectable concentrations of pesticides. The most frequently detected compounds included:

- 4,4'-DDT - 12 of 17 samples at concentrations ranging from 0.31 µg/kg to 43 µg/kg.
- 4,4'-DDE - 11 of 17 samples at concentrations ranging from 0.07 µg/kg to 3.5 µg/kg.
- 2,4'-DDT - Nine of 17 samples at concentrations ranging from 0.22 µg/kg to 12 µg/kg.

Other pesticides detected in this soil horizon included 2,4'-DDD (7 samples), and endosulfan beta and gamma chlordane (3 samples each). The largest calculated sum of DDx detected in this horizon was 58.3 µg/kg in sample SB-16-1. No pesticides were detected in samples SB-08-1, SB-09-1, SB-13-1, SB-14-1 or SB-17-1.

Pesticides in the 4 - 8 Foot Horizon. Nine of the 19 samples collected in this horizon had detectable concentrations of pesticides. The most frequently detected compounds included:

- 4,4'-DDT - Seven of 19 samples at concentrations ranging from 0.46 µg/kg to 3 µg/kg.
- 4,4'-DDE - Six of 19 samples at concentrations ranging from 0.074 µg/kg to 2.6 µg/kg.
- 2,4'-DDT - Six of 19 samples at concentrations ranging from 0.038 µg/kg to 0.9 µg/kg.
- 2,4'-DDD – Four of 19 samples at concentrations ranging from 0.055 µg/kg to 0.68 µg/kg.
- Gamma-BHC - Four of 19 samples at concentrations ranging from 0.049 µg/kg to 0.26 µg/kg.

Endrin ketone was detected in three samples. The largest calculated sum of DDx detected in this horizon was 8.38 µg/kg in sample SB-15-2.

Pesticides in the 8 - 12 Foot Horizon. Five of the 17 samples collected in this horizon had detectable concentrations of pesticides. The most frequently detected compounds included:

- 4,4'-DDT - Three of 17 samples at concentrations ranging from 0.45 µg/kg to 0.88 µg/kg.
- 4,4'-DDE - Three of 17 samples at concentrations ranging from 0.15 µg/kg to 0.38 µg/kg.
- 2,4'-DDT - Two of 17 samples at concentrations ranging from 0.2 µg/kg and 0.45 µg/kg.

Pesticides in the 12 - 16 Foot Horizon. Five of the 15 samples collected in this horizon had detectable concentrations of pesticides. 4,4'-DDT, 2,4'-DDE, endrin ketone, and β-BHC were detected in two samples each.

Pesticides in the 16 - 20 Foot Horizon. Two of the three samples collected in this horizon had detectable concentrations of pesticides. Endosulfan alpha, alpha-chlordane, dieldrin, 2,4'-DDE, trans-nonachlor were detected in one sample each.

5.1.1.6 Cyanide (total)

Cyanide (total) was detected in 42 of 55 samples collected as part of the first sampling event. Samples from locations SB-13, SB-15, SB-18, and SB-19 were not analyzed for cyanide. Of the 42 samples that had detectable concentrations of cyanide (total); nine were in the 1 - 4 foot horizon; thirteen were in the 4 - 8 foot horizon; 9 were in the 8 - 12 foot horizon; 9 were in the 12 - 16 foot horizon; and two were in the 16 - 20 foot horizon.

Figure 5-7 (page 5-24) illustrates the distribution of cyanide (total) throughout the Industrial Area soils. As can be seen, cyanide concentrations in samples from locations SB-1, SB-11, SB-12, SB-16, and SB-17 along the Moorings/GASCO site boundary were elevated in comparison to the other Industrial Area soil sample locations.

Cyanide in the 1 - 4 Foot Horizon. Cyanide (total) was detected in nine of the 13 samples collected in this horizon at concentrations ranging from 190 µg/kg to 61,000 µg/kg. The maximum detected concentration occurred on the southern portion of the site in sample SB-16-1 (61,000 µg/kg). This value is approximately seven times greater than any other sample in this horizon. Cyanide (total) was not detected in samples SB-07-1, SB-8-1, SB-9-1, or SB-14-1.

Cyanide in the 4 - 8 Foot Horizon. Cyanide (total) was detected in 13 of the 15 samples collected in this horizon at concentrations ranging from 70 µg/kg to 12,600 µg/kg. The maximum detected concentrations are located along the southern border of the site, extending slightly northward to sample SB-02-2. Cyanide (total) was not detected in samples SB-9-2 or SB-14-2.

Cyanide in the 8 - 12 Foot Horizon. Cyanide (total) was detected in nine of the 13 samples collected in this horizon at concentrations ranging from 130 µg/kg to 13,900 µg/kg. The maximum detected concentrations are located along the southern border, extending slightly northward to sample SB-02-3 on the eastern site boundary. Cyanide (total) was not detected in samples SB-05-3, SB-08-3, or SB-09-3.

Cyanide in the 12 - 16 Foot Horizon. Cyanide (total) was detected in nine of the 12 samples collected in this horizon at concentrations ranging from 130 µg/kg to 11,800 µg/kg. The maximum detected concentrations are in SB-16-4 trending almost directly north to samples SB-04-4 and SB-06-4 in the northeast corner of the Industrial Area. Cyanide (total) was not detected in samples SB-07-4, SB-08-4, or SB-09-4.

Cyanide in the 16 - 20 Foot Horizon. Cyanide (total) was detected in two of three samples collected in this horizon at a concentration of 170 µg/kg. Cyanide (total) was not detected in sample SB-15-5.

5.1.1.7 Metals

Thirteen different metals were detected in 71 of the 72 soil samples collected in the Industrial Area. Arsenic was detected in 71 samples and in concentrations that exceeded the screening criteria in 17 samples. Lead was detected in 71 samples and exceeded the screening criteria in five samples. Antimony was detected in 71 samples and exceeded the screening criteria in one sample.

Figures 5-8 and 5-9 (pages 5-25 and 5-26) illustrate the distribution of arsenic and lead in the Industrial Area soils, respectively. In general, arsenic appears to be uniformly distributed both spatially and vertically with no obvious hot-spots. In comparison, lead concentrations at locations SB-1, SB-11, SB-12, and SB-16 near the Moorings/GASCO site boundary are generally elevated in relation to the remainder of the Industrial Area sample locations.

Metals in the 1 - 4 Foot Horizon. All 17 samples collected in this horizon had at least 11 detectable concentrations of the 13 metals analyzed. The most frequently detected metals included:

- Antimony – 17 of 17 samples at concentrations ranging from 100 µg/kg to 8,300 µg/kg, with one sample (SB-12-1) that exceeded the screening criteria by more than a factor of 10.
- Arsenic – 17 of 17 samples at concentrations ranging from 1,870 µg/kg to 14,900 µg/kg. Concentrations in all 17 samples exceeded the screening criteria, with the concentration in sample SB-01-1 more than eight times the screening level.

- Lead – 17 of 17 samples at concentrations ranging from 6,680 µg/kg to 1,155,000 µg/kg. Samples from 5 locations at concentrations that exceeded the screening criteria.

Chromium, copper, manganese, mercury, nickel, and zinc were also detected in all 17 samples. Cadmium in was detected in 16 samples, silver was detected in 15 samples, and selenium in four samples.

Metals in the 4 - 8 Foot Horizon. All 19 samples collected in this horizon had at least ten detectable concentrations of the 13 metals analyzed. The most frequently detected metals included:

- Antimony – 19 of 19 samples at concentrations ranging from 90 µg/kg to 642,000 µg/kg.
- Arsenic – 19 of 19 samples at concentrations ranging from 2,200 µg/kg to 10,000 µg/kg.
- Lead – 19 of 19 samples at concentrations ranging from 3,090 µg/kg to 37,900 µg/kg.

With the exception of except cadmium (15 of 19 samples), silver (13 of 19 samples) and selenium (three of 19 samples), all other metals were detected in all 19 of the samples in this horizon.

Metals in the 8 - 12 Foot Horizon. All 17 samples collected in this horizon had at least ten detectable concentrations of the 13 metals analyzed. The most frequently detected metals included:

- Antimony – 17 of 17 samples at concentrations ranging from 80 µg/kg to 240 µg/kg.
- Arsenic – 17 of 17 samples at concentrations ranging from 1,900 µg/kg to 6,520 µg/kg.
- Lead – 17 of 17 samples at concentrations ranging from 2,470 µg/kg to 62,900 µg/kg.

With the exception of cadmium (13 of 17 samples), silver (14 of 17 samples) and selenium (two of 17 samples), all other metals were detected in all 17 samples in this horizon.

Metals in the 12 - 16 Foot Horizon. All 15 samples collected in this horizon had at least ten detectable concentrations of the 13 metals analyzed. The most frequently detected metals included:

- Antimony -15 of 15 samples at concentrations ranging from 70 µg/kg to 320 µg/kg.
- Arsenic - 15 of 15 samples at concentrations ranging from 1,720 µg/kg to 6,800 µg/kg.
- Lead - 15 of 15 samples at concentrations ranging from 3,000 µg/kg to 15,400 µg/kg.

With the exception of cadmium (12 of 15 samples), silver (7 of 15 samples) and selenium (one of 15 samples), all other metals were detected in all 15 samples.

Metals in the 16 - 20 Foot Horizon. All three samples collected in this horizon had at least 11 detectable concentrations of the 13 metals analyzed. The most frequently detected metals included:

- Antimony - Three of three samples at concentrations ranging from 130 µg/kg to 150 µg/kg.

- Arsenic - Three of three samples at concentrations ranging from 1,900 µg/kg to 2,570 µg/kg.
- Lead – Three of three samples at concentrations ranging from 5,650 µg/kg to 10,500 µg/kg.

With the exception of mercury (two of three samples) and selenium (no detections), all other metals were detected in all three samples.

5.1.1.8 Organobutyltins

Organobutyltin analyses were requested for 14 locations in the Industrial Area (40 total samples). Organobutylins were not included in the analytical suite for samples from locations SB-01, SB-11, SB-12, or SB-15 through SB-19.

Nine locations exhibited detectable results, with either dibutyltin (DBT) or monobutylin (MBT) detected in 22 of the 40 samples analyzed. Of the two organobutyltins detected, DBT was the most frequently detected (24 of 40 samples), followed by MBT (three of 40 samples).

No detected concentrations of organobutylins exceeded the screening criteria.

Organobutyltins in the 1 - 4 Foot Horizon. Five of the nine samples collected in this horizon had detectable concentrations of organobutyltins. DBT was detected in five samples at concentrations ranging from 0.22 µg/kg to 3.8 µg/kg. MBT was detected in one sample at a concentration of 2.3 µg/kg.

Organobutyltins in the 4 - 8 Foot Horizon. Six of the 11 samples collected in this horizon had detectable concentrations of organobutyltins. DBT was detected in six samples at concentrations ranging from 0.17 µg/kg to 3 µg/kg. MBT was detected in one sample at a concentration of 0.26 µg/kg.

Organobutyltins in the 8 - 12 Foot Horizon. Six of the ten samples collected in this horizon had detectable concentrations of organobutyltins. DBT was detected in six samples at concentrations ranging from 0.17 µg/kg to 7.6 µg/kg. MBT was detected in one sample at a concentration of 0.41 µg/kg.

Organobutyltins in the 12 - 16 Foot Horizon. Six of the ten samples collected in this horizon had detectable concentrations of organobutyltins. DBT was detected in concentrations ranging from 0.19 µg/kg to 1.9 µg/kg.

5.1.1.9 Total Petroleum Hydrocarbons

TPHs were detected in 64 of 74 samples collected across the Industrial Area, and in all horizons. Locations SB-01 through SB-19 were analyzed for TPH-Diesel and TPH-Motor Oil during the first sampling event (Table 5-1, page 5-13). Locations SB-24 and SB-31 were analyzed for TPH-Diesel, TPH-Motor Oil, and TPH-Gasoline during the second sampling event (Table 5-2, page 5-17).

TPH-Diesel was the most frequently detected TPH (56 of 74 samples) and TPH-Motor Oil was the second most frequently detected TPH (53 of 74 samples).

TPH in the 1 - 4 Foot Horizon. All 19 samples collected in this horizon had detectable concentrations of TPHs. TPH-Diesel was detected in 18 samples at concentrations ranging from 1,800 µg/kg to 57,000 µg/kg. TPH-Motor Oil was detected in 18 samples at concentrations

ranging from 4,600 µg/kg to 280,000 µg/kg. TPH-Gasoline was detected in one sample at a concentration of 2,000 µg/kg.

TPH in the 4 - 8 Foot Horizon. Twenty of 21 samples collected in this horizon had detectable concentrations of TPHs. TPH-Diesel was detected in 16 samples at concentrations ranging from 1,400 µg/kg to 76,000 µg/kg. TPH-Motor Oil was detected in 16 samples at concentrations ranging from 1,700 µg/kg to 720,000 µg/kg. No TPHs were detected in sample SB-19-2.

TPH in the 8 - 12 Foot Horizon. Seventeen of 19 samples collected in this horizon had detectable concentrations of TPHs. TPH-Diesel was detected in 15 samples at concentrations ranging from 1,500 µg/kg to 31,000 µg/kg. TPH-Motor Oil was detected in 13 samples at concentrations ranging from 4,400 µg/kg to 480,000 µg/kg. No TPHs were detected in samples from locations SB-16-3 or SB-18-3.

TPH in the 12 - 16 Foot Horizon. Thirteen of 17 samples collected in this horizon had detectable concentrations of TPHs. TPH-Diesel was detected in 11 samples at concentrations ranging from 1,800 µg/kg to 22,000 µg/kg. TPH-Motor Oil was detected in ten samples at concentrations ranging from 1,500 µg/kg to 100,000 µg/kg. No TPHs were detected in samples from locations SB-08-4, SB-13-4, SB-15-4, SB-18-4, or SB-19-4.

Table 5-1 Summary of Industrial Area Soil Detections (µg/kg)

Borehole	17		16				12				11				1				2			3				4				6				7			
Sample Depth (feet)	1-4	4-9	1-4	4-8	8-12	12-16	1-4	4-8	8-12	12-16	1-4	4-8	8-12	12-16	1-4	4-8	8-12	16-20	4-8	8-12	12-16	4-8	8-12	12-16	16-20	1-4	4-8	8-12	12-16	1-4	4-8	8-12	12-16	1-4	4-8	8-12	12-16
Volatile Organic Compounds (VOCs)																																					
cis-1,2-Dichloroethlyene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dichlorodifluoromethane	-	-	-	-	-	-	-	-	-	-	0.26 J	-	-	-	-	-	-	-	-	-	-	3.3 J	-	-	-	1.6 J	-	0.59 J	3 J	-	-	3.1 J	0.24 J	0.36 J	-	-	0.9 J
Trichlorofluoromethane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.18	-	-	-	-	0.23 J	0.18 J	-	0.19 J	-		-	-	-	-	-	0.22 J	-	0.13 J	-	-	-	0.18 J
1,1-Dichloroethene (1,1-DCE)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbon Disulfide	-	0.8 J	-	-	-	2.8 J	-	0.13 J	-	7.2	-	-	-	1.4 J	-	-	-	0.84 J	-	-	0.15 J	-	9.1	0.67 J	4.2 J	-	-	0.47 J	-	-	-	0.31 J	0.15 J	-	-	0.22 J	-
Acrylonitrile	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2-Butanone (MEK)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.7 J	-	-	-	-	-	-	-	-	-	4.4 J	-	-	-	-	5.6 J	-	-	-
Chloroform	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.28 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,1,1-Trichloroethane (TCA)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.34 J	-	-	-	-	-	-	-	-	-
Benzene	-	-	-	-	-	-	1 J	-	-	-	-	-	-	-	1.2 J	1.6 J	-	4.7 J	1.5 J	-	-	-	2.6 J	-	1.8 J	-	-	1.2 J	-	2 J	-	1.4 J	-	2.7 J	1.1 J	1 J	-
Trichloroethene (TCE)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Toluene	-	0.41 J	-	0.49 J	0.31 J	0.35 J	0.45 J	0.47 J	0.34 J	0.51 J	0.96 J	-	3.5 J	0.51 J	0.34 J	0.36 J	0.35 J	.45 J	0.32 J	1 J	0.7 J1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
trans-1,3-Dichloropropene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4-Methyl-2-Pentanone (MIBK)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		0.63 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tetrachloroethene (PCE)	-	-	-	-	-	-	0.82 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.8 J	-	-	-	-	-	-	-	-	-
Ethylbenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.1 J	0.3 J	-	-	-	-	-	-	-	-	-	-	-
m,p-Xylene	-	-	-	-	-	-	0.22 J	-	-	-	0.33 J	-	-	-	-	-	-	-	-	-	-	-	-	-	0.31 J	1.1 J	0.24 J	-	0.44 J	0.32 J	-	-	-	0.27 J	-	-	-
o-Xylene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.58 J	0.33 J	-	-	-	-	-	-	-	-	-	-	-
Isopropylbenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,4-Dichlorobenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Naphthalene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	46 J	-	-	-	-	-	-	-	-	-	-	-	-
Acrolein	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SVOCs																																					
Phenols and Substituted Phenols																																					
2,4,6-trichlorophenol	-	-	0.42 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2,4,5-Trichlorophenol	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.3 J	4.8 J	-	6.5 J	3.4 J	-	-	-	-	-	-	-	-	2.8 J	2.1 J	-
Pentachlorophenol	-	-	5.2 J	-	-	-	-	-	-	-	0.26 J	-	-	-	0.28 J	-	-	-	-	-	-	-	-	-	-	0.26 J	-	-	-	-	-	-	-	-	0.66 J	0.64 J	-
Polycyclic Aromatic Hydrocarbons (PAHs)																																					
Naphthalene	7.9	1.1 J	150	8.2	1.2 J	12	120	0.55 J	3.4	26	43	-	-	-	13	-	6.4	36	1.4 J	1.6 J	1.1 J	-	-	-	320	14	1.5 J	1.4 J	80	17	1.9 J	1.2 J	0.9 J	-	-	-	-
2-Methylnaphthalene	1.6 J	-	53	1.2 J	-	0.61 J	38	-	-	1.7 J	35	0.92 J	0.8 J	6.7	3.5	0.56 J	0.59 J	5.5	1.9 J	0.93 J	0.93 J	-	-	-	6.9	2.7	0.55 J	-	7	2.9	0.61 J	-	-	-	-	-	-
1-Methylnaphthalene	0.89 J	-	26	0.62 J	-	0.58 J	19	-	-	1.5 J	20	0.74 J	0.64 J	8.1	2.1 J	-	0.44 J	3.5	0.86 J	0.77 J	0.77 J	-	-	-	6.9	1.4 J	0.62 J	-	5.6	1.9 J	0.41 J	-	-	-	3.1	-	-
Acenaphthylene	3.6	0.6 J	110	1.1 J	0.56 J	1.5 J	30	0.6 J	0.77 J	0.64 J	9.1	1.5 J	3.8	9.5	6.2	2 J	1.9 J	10	4.9	2.9	2.9	12	3.5	3.9	1.2 J	13	4.5	0.95 J	3	13	2.7	0.9 J	0.4 J	2.8	10	1.7 J	2
Acenaphthene	-	-	11	0.23 J	-	0.96 J	2.7	0.26	-	0.6 J	1.2 J	0.46 J	-	13	2.3 J	-	-	37	1.1 J	0.69 J	1 J	1.7 J	2.2	1.8 J	4.5	1.4 J	0.58 J	-	5.1	5.4	0.75 J	-	-	1.2 J	4	0.92 J	1.1 J
Fluorene	0.65 J	-	26	-	-	1.2 J	10	-	-	1.5 J	3	1.4 J	0.76 J	15	1.8 J	-	-	20	1.1 J	0.65 J	1.4 J	2.2	1.1 J	2	6.7	2.1 J	1.6 J	-	15	3.9	1.1 J	-	-	0.79 J	7.4	0.84 J	1.4 J
Dibenzofuran	-	-	9.9	-	-	-	8.3	-	-	2.5	4.4	0.84 J	-	2.3 J	1.1 J	-	-	2.5 J	-	0.73 J	0.65 J	0.83 J	-	0.62 J	0.82 J	0.61 J	-	-	1.8 J	1.4 J	-	-	-	-	2 J	0.73 J	0.71 J
Phenanthrene	26	4.9	1400	13	0.98 J	12	270	6.6	1.6 J	4.3	100	19 J	8	260	44	4	5.2	240	23	17	13	63	28	24	6.1	70	24	4.1	29	110	24	3.4	2 J	33	120	21	13
Anthracene	3.6	1.1 J	94	1.5 J	-	3.5	45	1 J	0.63 J	1.2 J	10	2.9	4.1	58	7.2	1.4 J	1.4 J	58	6.1	5	6.7	12	6.9	7.9	1.9	14	8.2	1.1 J	6.8	20	6.1	0.95 J	0.72 J	6.6	34	3.4	5.4
Fluoranthene	89	11	3,500	31	3.9	49	460	9.2	15	9.2	220	23	29	760	78	15	19	550	87	78	46	240	88	110	24	300	57	13	48	390	55	13	7	130	170	47	29
Pyrene	130	16	4,200	41	5.2	84	670	14	19	14	380	24	36	1100	130	31	34	800	160	110	75	370	130	230	26	500	68	21	61	570	73	21	9.7	190	250	67	35
Benzo(b)fluoranthene	120	13	4,500	41	3.8	38	540	6.5	17	7.6	410	16	33	370	150	88	84	270	110	64	38	370	100	110	20	440	44	14	34	480	43	18	7.6	120	120	47	21
Benzo(k)fluoranthene	38	3.9	1,500	12	1.4 J	13	160	2.4 J	6.6	2.5	110	5.5	11	110	39	25	23	84	34	20	12	120	31	33	7.8	130	16	4.3	13	140	14	5.3	2.5	36	35	11	8.3
Benzo(a)anthracene	40	5.8	1,500	15	2.8	23	230	5.4	14	5	140	11	20	210	55	16	18	160	53	27	25	140	50	58	20	180	39	8.1	33	230	31	8	4.6	53	82	22	24
Chrysene	52	8.5	2,200	21	2.7	30	350	6.3	14	6	190	12	21	280	100	23	24	210	60	40	28	230	70	73	18	280	42	14	35	310	35	11	5	74	110	34	24
Benzo(a)pyrene	74	7.3	1,700	20	3	42	470	5.9	17	7.1	360	13	30	460	110	63	61	330	100	61	41	350	110	130	19	450	46	14	32	490	43	18	6.5	130	120	43	24
Indeno(1,2,3-cd)pyrene	150	13	4,500	43	3.2	40	820	5.5	14	6.9	450	12	24	400	180	120	120	290	130	71	35	460	100	120	11	520	33	11	17	520	37	19	5.7	150	100	47	11
Dibenz(a,h)anthracene	12	1.3 J	520	4.3	0.31 J	3.5	72	0.75 J	1.9 J	0.7 J	45	2 J	3.5	26	20	9.6	9.1	19	14	5.2	2.9	44	10	8.3	2.2	50	4.2	1.5 J	3.6	47	4	1.8 J	0.61 J	11	14	8.2	2.5
Benzo(g,h,i)perylene	160	15	4,000	41	3.4	46	850	6.8	14	7.9	530	12	23	450	210	140	140	330	130	81	36	490	120	130	9	570	33	13	16	540	41	22	6.7	160	110	59	9.2
TPAH	910 J	100 J	30,000	300 J	33 J	400 J	5170	72 J	140 J	110 J	3060 J	160 J	250 J	4540	1150 J	540 J	550 J	3450 J	920 J	590 J	370 J	2900 J	850 J	1040 J	500 J	3540 J	420 J	120 J	450 J	3900 J	410 J	140 J	60 J	1100 J	1300 J	410 J	210 J
Organonitrogen Compounds, Halogenated Compounds, Phenols and Substituted Phenols, Oxygen-Containing Compounds																																					
Aniline	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phenol	-	4.5 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	51	22 J	17 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzyl Alcohol	-	-	-	2.9 J	2.8 J	-	-	2.9 J	-	3.6 J	-	-	-	-	-	-	-	-	7.7 J	5.9 J	4.2 J	-	-	-	-	4.3 J	-	2.9 J	-	2.8 J	-	-	-	2.8 J	-	-	3.7 J
4-Methylphenol (p-Cresol)	-	-	-	-	-	-	-	-	-	-	-	-	-	17	-	-	-	5 J	3.2 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.2 J
2,4-Dimethylphenol	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzoic Acid	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	170 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4-Chloroaniline	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diethyl Phthalate	1.6 J	1.5 J	-	-	-	-	-	-	-	-	1.6 J	-	-	-	3.7 J	2.4 J	-	1.4 J	7.5 J	-	2.1 J	5.1 J	-	-	-	1.7 J	-	-	1.6 J	1.3 J	-	1.4 J	-	1.5 J	2 J	4.2 J	1.4 J
N-Nitrosodiphenylamine	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.4 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbazole	-	-	110	1.8 J	-	2.5 J	18 J	-	-	-	10	-	-	-	4.3 J	-	-	1.9 J	3.9 J	-	-	8.1	2.6 J	-	1.6 J	8.5 J	-	-	2.2 J	12	-	-	-	-	3.3 J	-	-
di-n-butyl Phthalate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Butyl Benzyl Phthalate	-	-	-	-	-	-	-	5.4 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.3 J	-	-	-	-	-	-	-	-	-
3,3'-Dichlorobenzidine	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
bis (2-Ethylhexyl) phthalate	-	-	-	8.4 J	-	8.7 J	-	10 J	7.3 J	10 J	30	24	46	-	120	12 J	17 J	-	27	-	16 J	65	13 J	12 J	-	11 J	13 J	13 J	9 J	-	-	11 J	11 J	7.9 J	33	55	-
di-n-octyl Phthalate	-	-	-	-	-	-	-	-	9.9	-	-	-	12	-	-	-	10	-	-	10	9.9	-	73	-	-	-	-	-	-	-	-	9.8	-	-	-	16	-
PCBs																																					
Aroclor 1254	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aroclor 1260	-	-	28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total PCBs	-	-	28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Notes:
" -" Not Detected; A complete list of all analytical results is included in Appendix A, Table 1-a.
J detected value and the reported concentration is an estimated value

Table 5-1 Summary of Industrial Area Soil Detections (µg/kg)

Borehole	19				18				5				9				8				10				15				13				14		20
Sample Depth (feet)	1-4	4-8	8-12	12-16	1-4	4-8	8-12	12-16	1-4	4-8	8-12	12-16	1-4	4-8	8-12	12-16	1-4	4-8	8-12	12-16	1-4	4-8	8-12	12-16	1-4	4-8	8-12	16-20	1-4	4-8	8-12	12-16	1-4	4-8	80-85
Volatile Organic Compounds (VOCs)																																			
cis-1,2-Dichloroethlyene	-	-	-	0.85 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dichlorodifluoromethane	-	-	-	-	-	-	-	-	-	-	-	-	-	0.71 J	0.25 J	-	0.58 J	0.28 J	-	61 J	-	-	-	0.27 J	-	-	34 J	-	-	-	-	-	0.25 J	0.35 J	-
Trichlorofluoromethane	-	-	-	-	-	0.16 J	-	-	-	-	0.25 J	-	-	-	-	-	-	0.15 J	-	-	-	-	-	-	-	-	-	-	0.26 J	0.17 J	-	0.2 J	-	-	-
1,1-Dichloroethene (1,1-DCE)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbon Disulfide	1.9 J	-	0.23 J	0.74 J	-	-	-	1.2 J	-	-	-	0.49 J	-	-	-	0.49 J	-	0.63 J	-	-	-	0.18 J	-	0.25 J	-	-	-	-	-	-	-	0.098 J	-	-	2.2 J
Acrylonitrile	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.32 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2-Butanone (MEK)	-	-	-	6.6 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.3 J	-	-	-	-	-	-	-	-	-	4.1 J	-	-	-	-
Chloroform	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,1,1-Trichloroethane (TCA)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzene	2.3 J	-	-	1.3 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.1 J	-	-	-	-	-	-	-	-	-	-	-	-
Trichloroethene (TCE)	-	-	-	6.3 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Toluene	0.57 J	0.41 J	0.48 J	0.31 J	0.14 J	0.67 J	0.36 J	0.39 J	0.38 J	1.2 J	0.81 J	0.6 J	-	-	-	-	-	-	-	-	-	-	-	-	0.36 J	-	-	0.41 J	1 J	0.33 J	0.65 J	0.65 J	-	-	0.16 J
trans-1,3-Dichloropropene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.4 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4-Methyl-2-Pentanone (MIBK)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tetrachloroethene (PCE)	4.7 J	1.1 J	0.7 J	-	1.2 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.6 J	5.1 J	6.1 J	2 J	-	-	-	-	-	-	-	-	-	-	-
Ethylbenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	97,000 J	1.6	1.1 J	-	-	-	-	-	-	-
m,p-Xylene	-	-	-	-	-	-	-	-	0.69 J	-	-	0.51 J	-	-	-	0.59 J	-	-	-	-	-	-	-	-	-	310,000 J	0.91	3.8 J	-	-	-	-	-	-	-
o-Xylene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8,700 J	22 J	0.57 J	-	-	-	-	-	-	-
Isopropylbenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	33,000 J	300 J	.47 J	-	-	-	-	-	-	-
1,4-Dichlorobenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.21 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Naphthalene	-	-	-	-	-	-	-	-	1.3	0.92	-	0.46	-	-	-	-	-	-	-	-	-	-	-	-	-	66,000 J	-	-	-	-	-	-	-	-	-
Acrolein	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.81 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SVOCs																																			
Phenols and Substituted Phenols																																			
2,4,6-trichlorophenol	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.35 J	-	-	-	-	-	-	-	-	-	-	-	-	-
2,4,5-Trichlorophenol	-	-	-	-	-	-	-	-	-	-	-	-	4.3 J	-	-	-	-	-	-	-	5 J	2.8 J	-	-	-	-	-	-	-	-	-	-	-	-	-
Pentachlorophenol	0.34 J	-	-	-	-	-	-	-	0.39 J	-	-	-	-	-	-	-	-	-	-	-	0.44 J	1.8 J	1.9 J	0.48 J	0.21 J	-	-	-	-	-	-	-	-	-	-
Polycyclic Aromatic Hydrocarbons (PAHs)																																			
Naphthalene	17	7.2	2.1 J	2.1 J	15	4.2	1.5 J	0.83 J	1.3 J	0.92 J	1.2 J	0.46 J	-	-	-	-	6.3	2.6	0.8 J	2.6	-	-	-	47 =D	19	530	440	.92 J	0.92 J	0.97 J	1.4 J	0.89 J	2.4	0.9 J	-
2-Methylnaphthalene	4.5	0.82 J	0.48 J	0.42 J	7.6	1.5 J	0.53 J	-	1.9 J	0.81 J	0.64 J	-	-	-	-	-	2.1 J	0.59 J	-	1.2 J	-	6.2	-	15 D	6.6	1300	1600	1.2 J	1.3 J	-	-	-	0.59 J	-	-
1-Methylnaphthalene	3.4	0.43 J	-	-	4.4	0.93 J	-	-	1.1 J	0.57 J	0.7 J	-	1.9 J	0.76 J	-	-	1.1 J	0.6 J	-	0.76 J	-	4.8	2.6	8.9 D	4.7	660	830	0.74 J	0.59 J	-	-	-	-	-	-
Acenaphthylene	13	3.6	0.67 J	1.1 J	9.6	2 J	1.1 J	0.62 J	5.8	3.3	2.6	0.94 J	9.5	2.7	-	4.1	12	3.5	-	5.9	6.1	5.6	5.6	2.6 J	15	17	-	-	5.9	-	0.29 J	0.93 J	0.8 J	-	-
Acenaphthene	1.2 J	-	0.42 J	0.53 J	0.66 J	-	0.25 J	-	2.1 J	0.49 J	0.41 J	0.4 J	4.4	1.3 J	-	1.3 J	2.9	7.5	-	0.67 J	10	110	35	170 D	8.8	11	8.4	-	1 J	0.23 J	0.26 J	-	-	-	-
Fluorene	4.2	0.54 J	-	-	1.6 J	-	-	-	1.4 J	0.5 J	2.2 J	-	5.7	1.1 J	-	2.9	2.4 J	2.2 J	-	1.7 J	7.3	61	19	110 D	6.1	11 J	13	-	1.3 J	-	-	-	-	-	-
Dibenzofuran	2.2 J	-	-	-	1.3 J	-	-	-	0.86 J	-	-	-	-	-	-	1 J	0.65 J	-	-	-	2.6	36	7.6	50 D	2.6	2.5	1.5 J	-	0.9 J	-	-	-	-	-	-
Phenanthrene	100	15	3.2	5.3	49	11	6.1	0.95 J	46	14	42	4.7	130	23	0.91 J	36	86	82	1.2 J	51	160	1000 D	380	1500 D	140	110	30	-	39	1.7 J	2.7	2.9	4.3	-	-
Anthracene	16	3.4	1.1 J	2 J	8.7	1.9 J	1.1 J	0.51 J	10	3.9	11	1.9 J	63	3.7	-	12	23	13	-	20	33	260	90	400 D	24	22	8.5	-	8.6	-	-	1.8 J	0.84 J	-	-
Fluoranthene	320	79	13	22	190	38	19 J	4.8	150	65	54	18	220	77	2.1	69	230	190	3	110	400	2300 D	900 D	2600 D	480	350	24	-	140	4.5	7.7	6.5	15	1.4 J	-
Pyrene	450	140	20	38	300	66	31	8.1	230	110	75	24	290	120	2.6	87	290	240	3.1	150	560	2700 D	1100 D	3000 D	670	470	31	-	200	5.9	11	12	25	1.9 J	-
Benzo(b)fluoranthene	450	140	10	21	320	68	19	5	190	85	31	16	160	87	1.7 J	44	180	96	1.9 J	66	440	1900 D	770 D	1800 D	560	400	15	0.27 J	210	6.5	14	8	23	1.7 J	-
Benzo(k)fluoranthene	140	40	2.9	6.1	98	20	6.3	1.5 J	56	25	10	5.1	53	25	0.5 J	16	56	30	0.83 J	24	150	710	280	660 D	170	120	4.5	-	68	2 J	4.3	2.7	6.3	0.44 J	-
Benzo(a)anthracene	180	50	5.6	10	120	27	10 J	2.8	87	32	35	14	100	36	1.1 J	51	110	56	2.2 J	86	280	1500 D	550	1500 D	250	170	10	-	72	3.4	4.4	9.3	8.5	0.76 J	-
Chrysene	280	60	6.9	14	150	41	14	3	120	47	42	17	130	41	0.97 J	49	130	67	1.9 J	90	360	1700 D	670	1800 D	320	250	12	-	90	3.3	5.7	12	11	0.97 J	-
Benzo(a)pyrene	370	120	12	22	310	62	20	4.9	170	86	28	13	170	91	1.6 J	47	180	110	1.8 J	75	430	1900 D	800	1800 D	540	380	11	0.23 J	180	4.7	10	7.3	21	1.4 J	-
Indeno(1,2,3-cd)pyrene	470	180	12	23	410	84	22	4.8	200	100	16	9.7	160	100	1.5 J	24	160	97	1 J	33	410	1200 D	660	1100 D	600	430	13	0.27 J	250	4.6	14	3.4	26	1.6 J	-
Dibenz(a,h)anthracene	46	15	0.93 J	1.8 J	43	8.7	2.2 J	0.42 J	22	7.6	3.1	1.9 J	15	9.8	-	5	16	7.6	-	7.8	71	400	120	230 D	61	40	1.6 J	-	20	0.65 J	1.7 J	0.84 J	2 J	-	-
Benzo(g,h,i)perylene	510	200	14	27	480	98	24	5.4	210	120	14	8.3	180	120	2.2	20	170	110	0.88 J	29	380	1100 D	630	980 D	640	480	18	-	270	4.9	17	3.3	28	2.1 J	-
TPAH	3400 J	1050 J	100 J	200 J	2500 J	530 J	180 J	44 J	1510 J	700 J	370 J	140 J	1700 J	740 J	15 J	470 J	1660 J	1100 J	19 J	750 J	3700	17000	7020	17800 J	4520	5750 J	3070 J	17 J	1560 J	43 J	95 J	72 J	175 J	13 J	-
Organonitrogen Compounds, Halogenated Compo																																			
Aniline	-	-	-	-	-	-	-	-	-	-	-	-	-	27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phenol	-	2.7 J	3.4 J	-	-	-	-	-	73	20 J	21 J	24 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	72	-	-	-	-	-	-
Benzyl Alcohol	-	2.8 J	-	-	-	3.2 J	3.2 J	-	-	4.1 J	4.6 J	4.4 J	-	-	-	-	3.7 J	-	-	-	-	-	-	-	-	-	-	-	6.6 J	2.9 J	-	-	3.3 J	3.3 J	2.6
4-Methylphenol (p-Cresol)	-	-	-	-	-	-	-	-	-	-	-	-	-	16	-	3.5 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2,4-Dimethylphenol	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	35	-	-	-	-	-	-	-	-
Benzoic Acid	-	-	-	-	-	-	-	-	210	100 J	100 J	110 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	170 J	-	-	-	-	-	-
4-Chloroaniline	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.2 J	-	-
Diethyl Phthalate	-	-	-	-	-	-	-	-	1.3 J	2 J	-	-	-	1.8 J	-	1.4 J	-	1.7 J	-	1.7 J	1.6 J	2.4 J	-	1.8 J	1.7 J	-	-	3.3 J	-	1.7 J	1.4 J	2.5 J	-	1.6 J	2.1
N-Nitrosodiphenylamine	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbazole	14 J	2.3 J	-	-	8.1 JD	1.5 J	-	-	6 J	-	-	-	2.9 J	-	-	-	-	-	-	-	21	160	58	230	19	19	-	-	5.2 J	-	-	-	-	-	-
di-n-butyl Phthalate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Butyl Benzyl Phthalate	12 J	-	-	3.4 J	-	5.6 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3,3'-Dichlorobenzidine	-	-	-	-	-	-	-	-	-	-	-	-	-	15 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
bis (2-Ethylhexyl) phthalate	16 J	15 J	-	-	-	23	7.3 J	-	10 J	11 J	13 J	13 J	7.5 J	41	28	24	14 J	9.4 J	10 J	35	16	81	55	60	8.5 J	10 J	8.4 J	15 J	17 J	23	41	-	-	-	33
di-n-octyl Phthalate	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-	-	9.9	-	-	-	8.1	-	-	-	-	-	-	-	-	-	-	-	-
PCBs																																			N/A
Aroclor 1254	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.4 J	-	-	-	-	-	-	-	-	-	-
Aroclor 1260	81	-	2.6	4.7	5.3	1.9 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.5	4.5	-	-	-	-	-	-	-	-	-
Total PCBs	81	-	2.6	4.7	5.3	1.9 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.9 J	4.5	-	-	-	-	-	-	-	-	-

Notes:
" -" Not Detected; A complete list of all analytical results is included in Appendix A, Table 1-a.
J detected value and the reported concentration is an estimated value

Table 5-1 Summary of Industrial Area Soil Detections (µg/kg)

Borehole	17		16				12				11				1				2			3				4				6				7			
Sample Depth (feet)	1-4	4-9	1-4	4-8	8-12	12-16	1-4	4-8	8-12	12-16	1-4	4-8	8-12	12-16	1-4	4-8	8-12	16-20	4-8	8-12	12-16	4-8	8-12	12-16	16-20	1-4	4-8	8-12	12-16	1-4	4-8	8-12	12-16	1-4	4-8	8-12	12-16
Pesticides																																					
α -BHC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hexachlorobenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.18 J	-	-	-	-	-	-	-	-	-	-	-
β -BHC	-	-	-	-	-	0.074 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1 J	-	-	-	-	-	-	-	-
γ -BHC (Lindane)	-	-	5	0.092 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.049 J	-	-	0.19	-	-	-	0.11 J	-	-	0.12 J	-	-	-	-	-	0.26 J	0.089 J	-
δ -BHC	-	-	0.99 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heptachlor	-	-	-	0.13 J	-	-	0.61	-	-	-	0.88	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aldrin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
gamma-Chlordane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.053 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Endosulfan alpha-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03 J	-	-	0.065 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
alpha-Chlordane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.061 J	-	-	-	0.094 J	-	-	.14 J	-	-	-	-	-	-	-	-	-	-	-	-
Dieldrin	-	-	-	0.043 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4,4'-DDE	-	-	3.3	-	-	-	-	-	-	-	0.22	-	-	-	0.36	-	-	-	0.14 J	-	-	0.24 J	0.38 J	-	-	0.83	-	-	-	1.2	0.074 J	-	-	0.07 J	0.22 J	0.21 J	-
Endrin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.088 J	-
Endosulfan beta-	-	-	0.28 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.2	0.12 J	-
4,4'-DDD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.08 J	-	-	-	-	-	-	-	-	-	-	0.057 J	-	-	-	-	-	-	-
Endrin aldehyde	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.26	-	-
Endosulfan sulfate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4,4'-DDT	-	-	43	0.46	-	-	0.65 J	-	-	-	0.74 J	-	-	-	1.2	-	-	-	1.8	-	-	0.98	0.88	-	-	1.5	-	-	-	1.5	-	-	-	0.31	0.46	0.45	-
Endrin ketone	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.11 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.2 J	-	-
Methoxychlor	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Toxaphene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
oxy chlordane	-	-	2.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2,4'-DDE	-	-	-	-	-	-	-	-	-	-	0.2 J	-	-	-	-	-	-	.03 J	-	-	-	-	-	0.083 J	-	-	-	-	0.11 J	-	-	-	-	-	-	-	-
cis -nonachlor	-	-	1.8 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.1	-	-
2,4'-DDD	-	-	-	-	-	-	-	-	-	-	0.11 J	-	-	-	0.12 J	-	-	-	-	-	-	-	-	-	-	0.048 J	-	-	-	-	-	-	-	-	-	-	-
trans -nonachlor	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.043	-	-	-	0.2	-	-	-	-	-	0.17 J	-	-	-	-	-	-	-	-	-	-	-	-
2,4'-DDT	-	-	12	0.13 J	-	-	0.38	-	-	-	0.39 J	-	-	-	0.32	-	-	-	0.35	-	-	-	0.2	-	-	0.36	-	-	-	0.47	0.038 J	-	-	-	-	-	-
DDE [1]	-	-	3.3	-	-	-	-	-	-	-	0.22 J	-	-	-	0.36	-	-	0.03 J	0.14 J	-	-	0.24 J	0.38 J	0.083 J	-	0.83	-	-	0.11 J	1.2	0.074 J	-	-	0.07 J	0.22 J	0.21 J	-
DDD [1]	-	-	-	-	-	-	-	-	-	-	0.11 J	-	-	-	-	-	-	-	0.08 J	-	-	ND	-	-	-	0.05 J	-	-	-	0.057 J	-	-	-	-	-	-	-
DDT [1]	-	-	55	0.59 J	-	-	1 J	-	-	-	1.1 J	-	-	-	1.52	-	-	-	2.2	-	-	0.98	0.88	-	-	1.9	-	-	-	2	0.038 J	-	-	0.31	0.46	0.45	-
DDT -total [2]	-	-	58	0.59 J	-	-	1 J	-	-	-	1.5 J	-	-	-	2 J	-	-	0.03 J	2.4	-	-	1.2 J	1.5 J	0.083 J	-	2.738 J	-	-	0.11 J	3.2	0.11	-	-	0.38 J	0.68 J	0.66 J	-
Chlordane-total [3]	-	-	4.3 J	-	-	-	-	-	-	-	-	-	-	-	0.096 J	-	-	0.061 J	-	-	-	-	-	-	0.17 J	-	-	-	-	-	-	-	-	-	1.1 J	-	-
Endosulfan-total [4]	-	-	0.28 J	-	-	-	-	-	-	-	-	-	-	-	0.03 J	-	-	0.065 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.2	-	-
Cyanide																																					
Cyanide	8,600	12,600	61,000	8,700	13,900	10,100	1,250	4,500	3,660	4,570	500	4,900	6,200	900	600	160 J	5,200	170 J	5,600	1,120	270	410	350	630	170	320	70 J	130 J	11,800	870	280 J	280	10,500	-	70 J	-	-
Metals																																					
Aluminum (pH 6.5-9.0)	1.21E+07	1.28E+07	1.10E+07	1.40E+07	2.48E+07	2.94E+07	1.06E+07	1.16E+07	2.46E+07	3.25E+07	1.25E+07	2.21E+07	2.00E+07	3.00E+07	8.18E+06	1.36E+07	2.02E+07	3.12E+07	1.47E+07	2.12E+07	2.52E+07	9.58E+06	2.23E+07	2.00E+07	3.29E+07	1.45E+07	1.23E+07	1.59E+07	1.41E+07	1.47E+07	1.22E+07	1.57E+07	1.14E+07	1.57E+07	1.88E+07	1.34E+07	2.01E+07
Antimony	90	100	5,860 J	8,300 J	120 J	70 J	642000 J	170 J	100 J	320 J	1,200 J	120 J	80 J	110 J	210 J	120 J	130 J	150 J	130	140	120	460 J	140 J	130 J	130 J	190	150	100	100	150	100	130	80	110 J	120 J	100 J	110 J
Arsenic	3,460	3,400	4,560	4,460	3,280	2,020	3,700	2,500	2,370	2,070	2,250	4,200	3,030	2,130	14,900	2,740	3,620	2,410	3,810 J	2,700 J	1,760 J	2,200	2,200	3,600	1,900	3,100	2,400	1,900	6,800	2,700	2,700	3,200	2,500	2,400	2,800	2,500	2,700
Cadmium	71	56	443	75	140	317	872	83	122	1,030	76	76	95	158	163	174	133	116	150	130	194	110	106	71	89	107	-	72	41	104	-	-	-	73	95	178	71
Chromium, total	20,300	21,100	35,100	25,700	39,300	48,300	30,600	20,800	49,100	53,300	20,200	22,800	24,500	50,000	16,900	18,400	28,000	36,500	16,200	20,200	31,500	19,000	29,300	29,800	34,700	21,800	15,200	22,100	21,100	20,900	17,300	21,900	16,400	22,000	24,100	19,700	24,600
Copper	16,700	17,700	73,300 J	33,500 J	21100 J	26,100 J	528,000 J	14,700 J	23,100 J	28,100 J	80,200 J	22,300 J	22,600 J	29,800 J	24,600 J	18,700 J	29,300 J	44,100 J	18,700	22,300	30,100	23,700	26,100	22,100	29,200	25,800	14,900	18,800	17,000	20,600	16,500	18,700	13,000	21,500	22,200	17,800	22,700
Lead	8,430	6,730	42,9000 J	33,600 J	10,600 J	9,600 J	1,550,000 J	3,180 J	5,500 J	5,100 J	85,400	8,790	6,730	8,550	79,900	28,800	32,100	10,500	12,000	8,950	5,020	31,300	7,930	9,990	6,010	20,800	3,090	62,900	15,400	18,100	4,120	7,250	3,160	6,680	6,810	5,140	5,390
Manganese	207,000	171,000	277,000	245,000	166,000	140,000	402,000	205,000	122,000	114,000	396,000	526,000	138,000	104,000	304,000	363,000	276,000	145,000	387,000	375,000	214,000	284,000	385,000	309,000	115,000	336,000	312,000	374,000	197,000	368,000	350,000	461,000	274,000	367,000	470,000	379,000	388,000
Mercury	20	12	197	29	16	25	477	14	19	23	21	17	23	50	29	59	38	105	17	25	29	99	33	41	54	42	43	19	26	2,790	4,650	41	38	41	48	17	29
Nickel	16,900	10,000	32,800	15,700	14,200	30,500	46,900	14,300	12,000	130,000	22,500	14,000	13,200	35,900	24,700	19,800	21,300	28,700	24,400	21,100	35,100	26,700	27,500	23,100	24,900	33,400	16,800	19,300	18,400	27,100	18,700	23,700	14,300	21,600	25,900	21,900	20,700
Selenium	-	-	-	-	-	-	-	-	-	-	-	-	-	90	-	-	-	140	-	-	-	-	-	-	-	20	30	30	-	50	-	-	-	-	-	-	-
Silver	39 J	48 J	120	13	-	-	4620	-	82	-	136 J	23 J	20 J	60 J	1670 J	28 J	42 J	88 J	75	37	35	88	121	61	76	166 J	-	90 J	-	-	-	-	-	21	29	9	55
Zinc	57,700	55,500	142,000	75,900	99,000	301,000	399,000	67,500	93,100	1,360,000	75,000	81,500	111,000	299,000	71,500	159,000	129,000	110,000	82,800	122,000	149,000	84,500	79,900	58,500	69,900	88,100	47,500	53,900	64,900	83,500	54,900	63,800	43,800	59,300	64,800	55,900	64,300
B *The result is an estimated concentration that is less than the MRL but greater than or equal to the MDL.*																																					
Organobutylins	(Not Analyzed)		(Not Analyzed)				(Not Analyzed)				(Not Analyzed)				(Not Analyzed)																						
Dibutyltin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.24 J	0.17 J	0.61 J	1.1 J	.21 J	-	0.74 J	7.6	0.98 J	0.22 J	0.26 J	-	-	3.8	3	1.1 J	1.9
Monobutyltin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.26 J	0.41 J	-	-	-	-	-	-	-	-	-
TPHs																																					
TPH-Diesel	2,100 J	-	35,000	4,500 J	-	1,800 J	34,000	-	6,200 J	10,000 J	13,000	2,800 J	2,300 J	19,000	37,000	3,900 J	13,000	24,000	24,000	2,200 J	2,100 J	61,000	2,100 J	22,000	3,600 J	57,000	1,400 J	28,000	2,500 J	4,800 J	1,900 J	2,100 J	-	8,800 J	51,000	31,000	2,600 J
TPH-Motor Oil	-	46,000	130,000	-	-	-	190,000	7,000	51,000 J	27,000 J	140,000	-	-	-	280,000	200,000	-	-	540,000	7,600 J	13,000 J	4,200	14,000 J	60,000 J	15,000 J	250,000	4,200 J	250,000	1,500 J	15,000 J	4,300 J	6,200 J	3,500 J	110,000 J	6,400	480,000	27,000 J

Notes:
" -" Not Detected; A complete list of all analytical results is included in Appendix A, Table 1-a.
J detected value and the reported concentration is an estimated value

Table 5-1 Summary of Industrial Area Soil Detections (µg/kg)

Borehole	19				18				5				9				8				10				15				13				14		20
Sample Depth (feet)	1-4	4-8	8-12	12-16	1-4	4-8	8-12	12-16	1-4	4-8	8-12	12-16	1-4	4-8	8-12	12-16	1-4	4-8	8-12	12-16	1-4	4-8	8-12	12-16	1-4	4-8	8-12	16-20	1-4	4-8	8-12	12-16	1-4	4-8	80-85
Pesticides																																			N/A
α -BHC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.51 J	-	-	-	-	-	-	-	
Hexachlorobenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
β -BHC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
γ -BHC (Lindane)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
δ -BHC	0.21 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Heptachlor	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.24	-	-	-	-	-	-	-	-	-	-	-	-	
Aldrin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.12 J	-	-	-	-	-	-	-	-	-	-	-	-	
gamma-Chlordane	0.31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.068 J	-	-	-	-	-	-	-	-	-	
Endosulfan alpha-	0.06 J	-	-	-	0.059 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
alpha-Chlordane	0.14 J	-	-	-	0.061 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.066 J	-	-	-	-	-	-	-	-	
Dieldrin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
4,4'-DDE	0.36	-	-	-	0.12 J	0.099 J		-	0.15 J	-	-	-	-	-	-	-	-	-	-	-	0.19	-	-	0.08 J	3.5	2.6	0.15 J	-	-	-	-	-	-	-	
Endrin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Endosulfan beta-	-	-	-	-	0.091 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.15 J	-	-	-	-	-	-	-	-	-	-	-	-	-	
4,4'-DDD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.29	1.4	0.12	-	-	-	-	-	-	-	
Endrin aldehyde	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Endosulfan sulfate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.41 J	-	-	-	-	-	-	-	-	-	-	-	-	
4,4'-DDT	5.7 J	-	-	0.64 J	1.4 J	0.52 J	-	-	0.9	-	-	-	-	-	-	-	-	-	-	-	1	1	0.72	0.19 J	6.4	3 J	-	-	-	-	-	-	-	-	
Endrin ketone	-	-	0.07 J	0.45 J	-	0.18 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.8	-	0.044 J	-	-	-	-	-	-	-	-	-	-	
Methoxychlor	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.16 J	0.093 J	-	-	-	-	-	-	-	-	
Toxaphene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9.6	-	-	-	-	-	-	-	-	-	
oxy chlordane	0.074 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
2,4'-DDE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.06 J	-	-	-	-	
cis -nonachlor	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
2,4'-DDD	2 J	-	0.052 J	0.099 J	0.24	0.062 J	-	-	0.058 J	-	-	-	-	-	-	-	-	-	-	-	0.065 J	0.68	-	-	0.31 J	0.48 J	-	-	-	0.055 J	-	-	-	-	
trans -nonachlor	-	-	-	-	-	0.07 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.071 J	-	-	-	-	-	-	-	-	-	
2,4'-DDT	-	-	-	-	-	0.1 J	-	-	0.22	-	-	-	-	-	-	-	-	-	-	-	0.34 J	-	0.45	-	1.7	0.9 J	-	-	-	0.062 J	-	-	-	-	
DDE [1]	0.36	-	-	-	0.12 J	0.099 J	-	-	0.15 J	-	-	-	-	-	-	-	-	-	-	-	0.19	-	-	0.08 J	3.5	2.6	0.15 J	-	-	0.06 J	-	-	-	-	
DDD [1]	2		0.052 J	0.099 J	0.24	0.062 J	-	-	0.06 J	-	-	-	-	-	-	-	-	-	-	-	0.065 J	0.68	-	-	0.6 J	1.9 J	0.12 J	-	-	0.055 J	-	-	-	-	
DDT [1]	5.7	-	-	0.64 J	1.4 J	0.62 J	-	-	1.1	-	-	-	-	-	-	-	-	-	-	-	1.3 J	1	1.2	0.19 J	8.1	3.9 J	-	-	-	0.062 J	-	-	-	-	
DDT -total [2]	8.1 J	-	0.052 J	0.74 J	1.8 J	0.78 J	-	-	1.3 J	-	-	-	-	-	-	-	-	-	-	-	1.6 J	1.7	1.2	0.27 J	12 J	8.4 J	0.27 J	-	-	0.18 J	-	-	-	-	
Chlordane-total [3]	0.52 J	-	-	-	0.061 J	0.07 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.14 J	0.066 J	-	-	-	-	-	-	-	-	
Endosulfan-total [4]	0.06 J	-	-	-	0.15 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.15 J	0.41 J	-	-	-	-	-	-	-	-	-	-	-	-	
Cyanide	(Not Analyzed)				(Not Analyzed)																				(Not Analyzed)				(Not Analyzed)						N/A
Cyanide	-	-	-	-	-	-	-	-	190 J	1240	-	5050	-	-	-	-	-	100 J	-	-	300	210 J	840	130 J	-	-	-	-	-	-	-	-	-	-	
Metals																																			N/A
Aluminum (pH 6.5-9.0)	1.12E+07	1.37E+07	2.87E+07	2.01E+07	1.02E+07	1.19E+07	1.96E+07	1.73E+07	1.26E+07	1.82E+07	1.54E+07	1.22E+07	1.70E+07	1.62E+07	8.75E+06	1.42E+07	1.61E+07	1.67E+07	1.13E+07	1.45E+07	1.24E+07	1.37E+07	1.50E+07	1.27E+07	1.79E+07	2.26E+07	2.68E+07	1.43E+07	1.49E+07	1.11E+07	9.89E+06	1.07E+07	2.77E+07	2.34E+07	
Antimony	4930 J	140 J	110	120	340 J	230 J	130 J	100 J	180 J	130	100	100	150 J	100 J	110 J	110 J	150	120	100	110	180 J	160 J	240 J	130 J	280	230	240	150	200	100	110	80	320	420	
Arsenic	3,770	2,280	2,640	2,600	2,940	2,560	2,170	1,720	1870 J	2480 J	2570 J	2500 J	2,600	2,500	2,300	2,100	2,400	2,700	2,500	1,900	2,000	2,300	2,700	2,300	4,560	5,180	6,520	2,570	3,500 J	2,200 J	2,330 J	1,890 J	8,800	10,000	
Cadmium	298	154	175	96	160	149	155	79	195 J	609	401	391	85	63	-	-	84	82	-	97	94	102	304	-	326	499 J	93	121	201	-	-	-	-	-	
Chromium, total	25,900	17,700	35,900	30,500	31,800	20,300	109000 J	31,700	23,400	20,700	17,100	14,600	23,400	22,500	15,200	20,500	22,600	23,000	16,500	20,200	17,100	19,900	23,300	20,000	22,600	27,600	24,900	14,200	18,800	16,200	17,500	15,300	25,400	22,300	
Copper	54500 J	19600 J	30,800	22,000	88900 J	30900 J	28700 J	19500 J	23,100	80,200	17,300	15,900	24,300	19,600	13,800	17,500	22,300	20,900	14,300	17,000	17,300	20,100	24,400	15,400	22,200	24,200	31,600	19,100	25,700	16,600	18,000	14,800	28,500	32,600	
Lead	117000 J	13100 J	8,140	7,000	78900 J	27700 J	13200 J	3470 J	31,800	37,900	11,600	11,700	8,100	5,460	2,470	3,220	9,050	7,240	2,730	3,000	14,900	15,300	17,000	5,080	46,500	43,600	13,300	5,650	139,000	3,450	3,470	3,900	11,400	16,300	
Manganese	328,000	274,000	277,000	219,000	320,000	279,000	227,000	266,000	336,000	408,000	475,000	214,000	402,000	463,000	320,000	262,000	398,000	304,000	329,000	258,000	300,000	359,000	386,000	291,000	623,000	550,000	800,000	624,000	372,000	359,000	341,000	303,000	364,000	800,000	
Mercury	142	17	33	23	62	46	29	23	83	38	14	15	52	31	9	31	93	45	9	12	18 B	22	37	10 B	44	100 J	24	12 B	203	13 B	19 B	22	43	6	
Nickel	32,800	17,800	37,200	50,300	31,800	18,400	26,700	27,600	31,200	23,900	21,200	14,300	19,200	20,100	16,400	21,700	22,400	19,100	17,500	20,700	29,700	30,700	24,600	22,500	39,700	34,600	20,000	14,600	23,800	20,700	16,700	16,200	16,300	21,100	
Selenium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	70	70	110	-	-	-	-	-	-	-	-	-	-	-	-	-	180	60	
Silver	58	-	29	-	91	12	16	-	94 J	19	14	16	73	16	-	-	83 J		22	-	24	20 B	19 B	-	92 J	93 J	125 J	123 J	159	11 B	47	56	-	-	
Zinc	138,000	101,000	132,000	262,000	135,000	125,000	121,000	64,900	113,000	78,800	55,800	49,400	64,100	58,500	47,500	56,200	58,900	57,800	48,500	55,300	63,000	75,300	117,000	56,800	144,000	118,000	93,600	66,500	74,100	54,500	46,900	56,300	70,300	85,700	

B The result is an estimated concentration that is less th

Organobutylins	(Not Analyzed)				(Not Analyzed)																				(Not Analyzed)										N/A
Dibutyltin	-	-	-	-	-	-	-	-	0.85 J	0.33 J	-	0.19 J	0.41 J	-	0.42 J	-	0.62	0.71 J	0.17 J	-	-	-	0.27 J	0.42 J	-	-	-	-	-	-	-	-	-	-	
Monobutyltin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.3 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
TPHs																																			N/A
TPH-Diesel	7,700 J	-	2,100 J	-	37,000	6,900 J	-	-	6,900 J	1,700 J	-	2,800 J	2,800 J	9,300 J	-	1,900 J	1,800 J	1,700 J	1,700 J	-	16,000	76,000	21,000	9,200 J	4,600 J	17,000 J	21,000	-	3,300 J	-	2,200 J	-		-	
TPH-Motor Oil	40,000 J	-	-	-	200,000	46,000 J	-	-	68,000 J	4,300 J	5,900 J	46,000 J	12,000 J	550,000	14,000 J	11,000 J	6,000 J	6,400 J	-	-	190,000	-	160,000	100,000 J	22,000 J	26,000 J	4,400 J	-	51,000 J	7,000 J	32,000 J	-	6,300 J	4,200 J	

Notes:
" -" Not Detected; A complete list of all analytical results is included in Appendix A, Table 1-a.
J detected value and the reported concentration is an estimated value

Table 5-2 Summary of Total Petroleum Hydrocarbons Detections (µg/kg)
Industrial Area Contingency Sampling

Borehole	24				31			
Sample Depth	1-4	4-8	8-12	12-16	1-4	4-8	8-12	12-16
TPH-Diesel	2,200 J	6,400 J	1,500 J	1,800 J	2,000 J	2,900 J	2,900 J	
TPH-Motor Oil	4,600 J	17,000 J	4,700 J	ND	4,900 J	9,900 J	10,000 J	4,100 J
TPH-Gasoline	2,000 J	-	-	-	-	-	-	-

Notes:
- Not Detected
J – Estimated concentration
A complete list of all analytical results is included in Appendix A, Table 1-a.

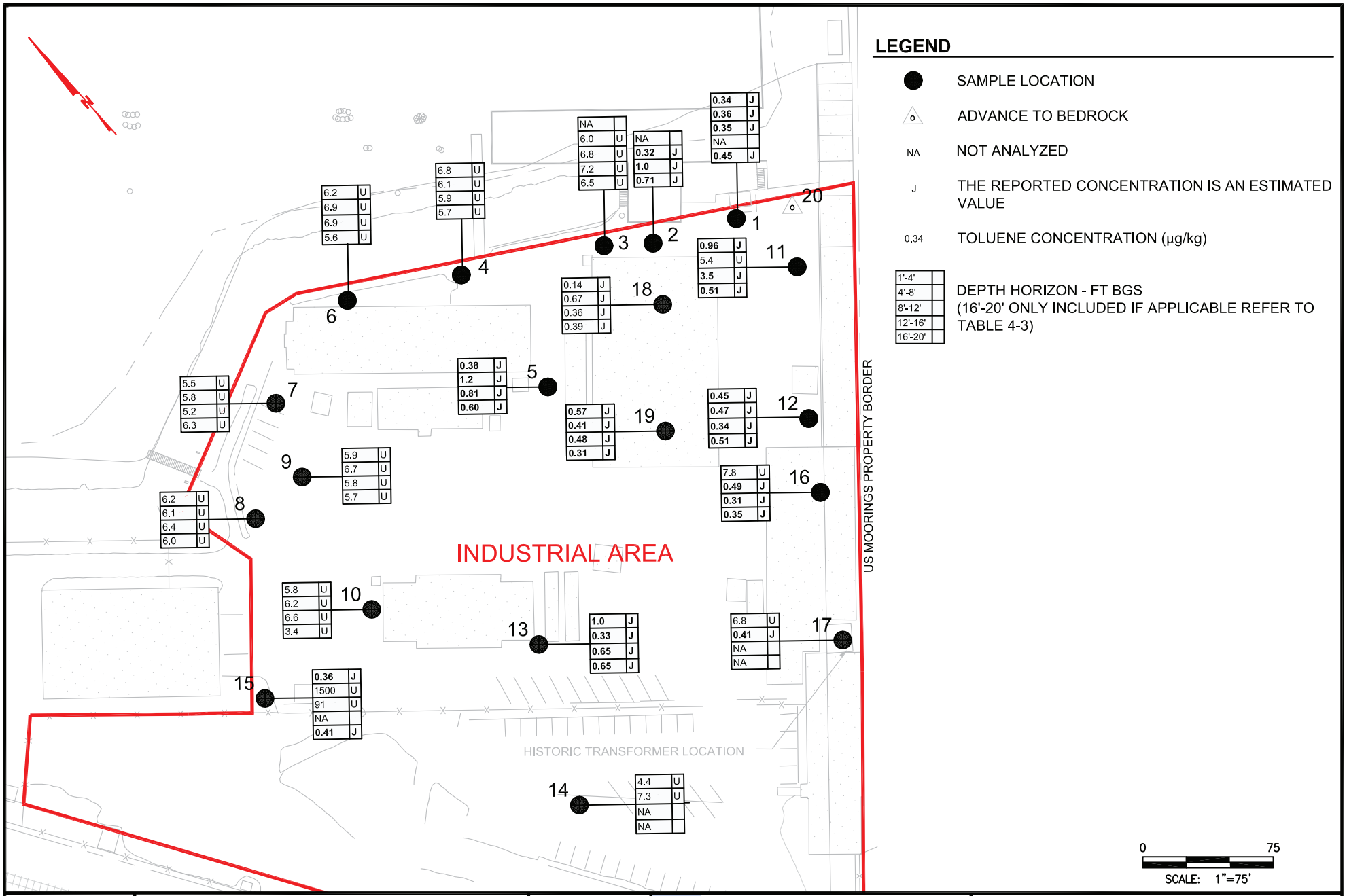

Fig 5-1

INDUSTRIAL AREA
TOLUENE CONCENTRATIONS IN SOIL

DATE: 1-4-09
DRAWN: MEO
CHECKED:

TEC inc.
1450 114th Ave S.E. Suite 220
Bellevue, Wa 98004
425.453.4040 * 425.454.7043 Fax

US GOVERNMENT MOORINGS
REMEDIAL INVESTIGATION

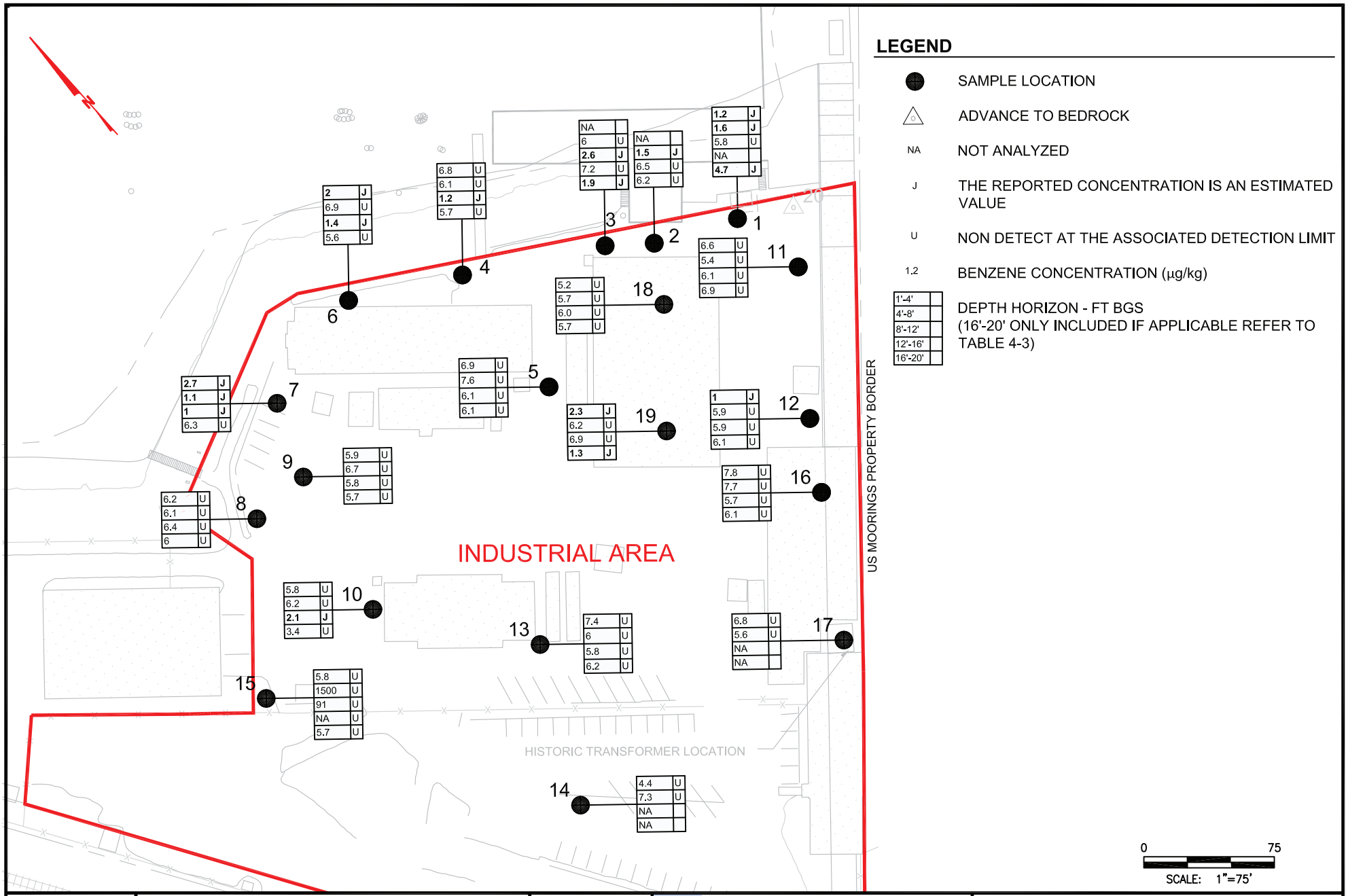

Fig 5-2

INDUSTRIAL AREA
BENZENE CONCENTRATIONS IN SOIL

DATE: 1-4-09
DRAWN: MEO
CHECKED:

TEC inc.
1450 114th Ave S.E. Suite 220
Bellevue, Wa 98004
425.453.4040 * 425.454.7043 Fax

US GOVERNMENT MOORINGS
REMEDIAL INVESTIGATION

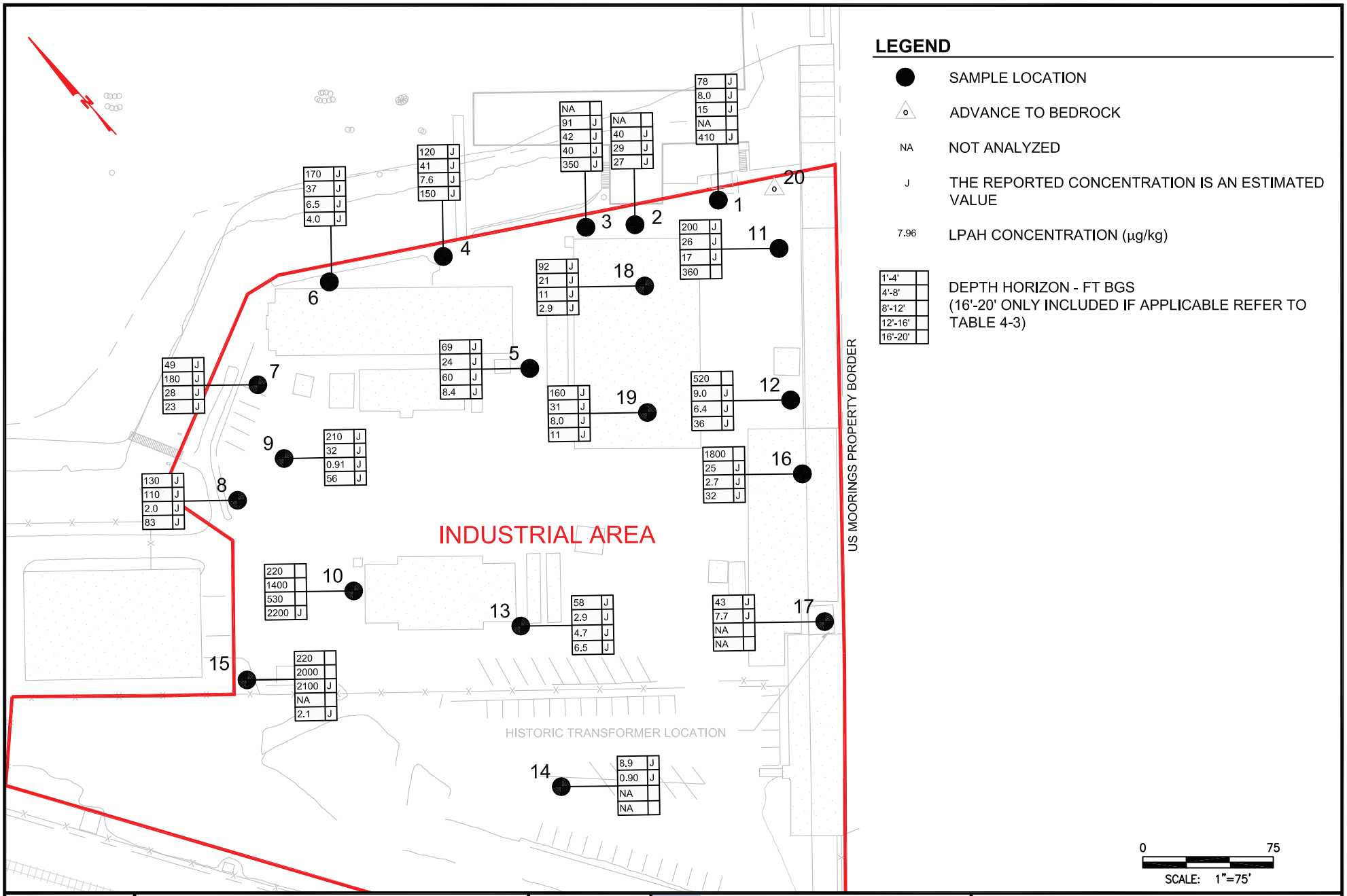

Fig 5-3

INDUSTRIAL AREA
LPAH CONCENTRATIONS IN SOIL

DATE: 1-4-09
DRAWN: MEO
CHECKED:

TEC inc.
1450 114th Ave S.E. Suite 220
Bellevue, Wa 98004
425.453.4040 * 425.454.7043 Fax

US GOVERNMENT MOORINGS
REMEDIAL INVESTIGATION

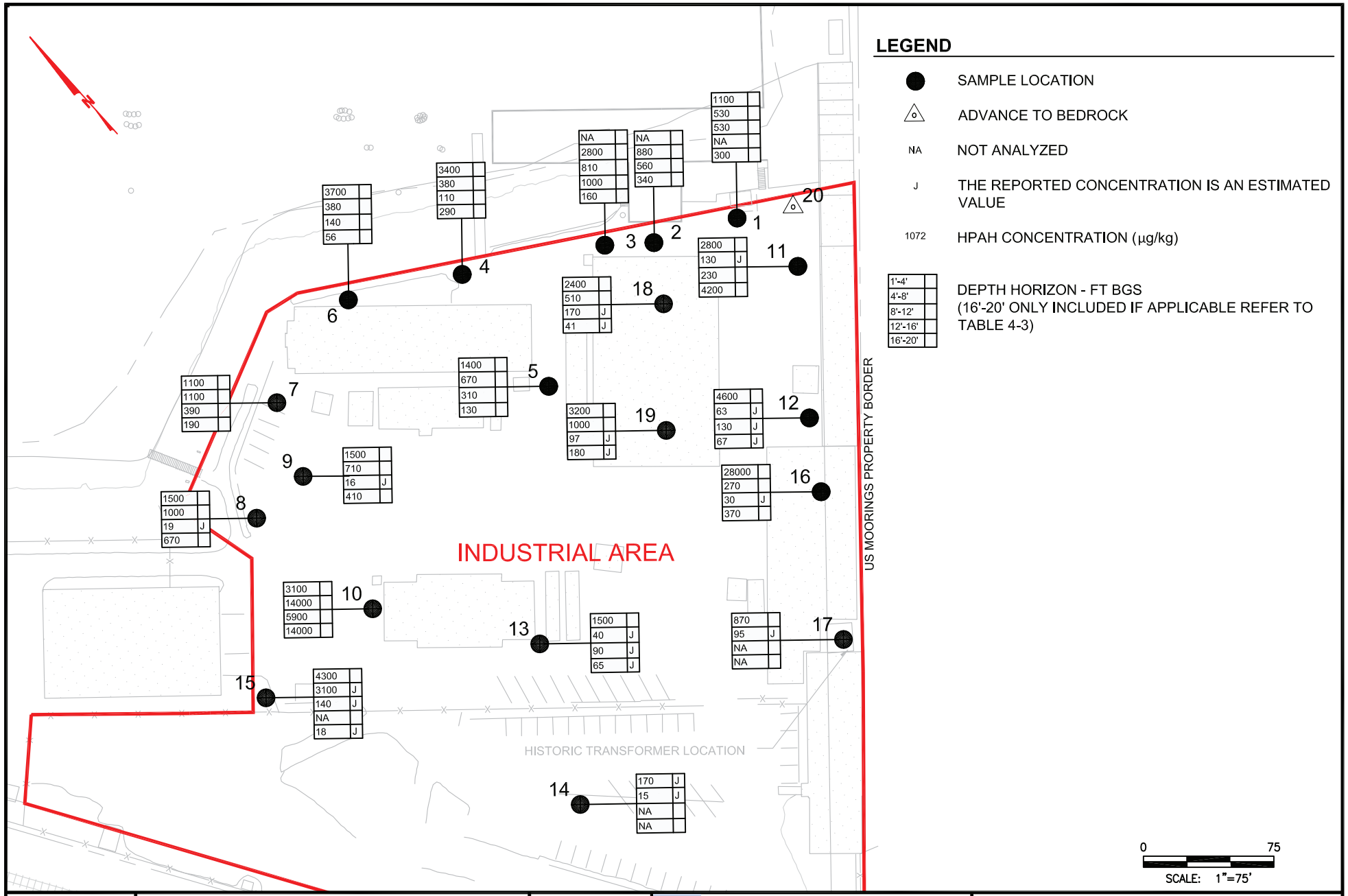

Fig 5-4

INDUSTRIAL AREA
HPAH CONCENTRATIONS IN SOIL

DATE: 1-4-09
DRAWN: MEO
CHECKED:

TEC inc.
1450 114th Ave S.E. Suite 220
Bellevue, Wa 98004
425.453.4040 * 425.454.7043 Fax

US GOVERNMENT MOORINGS
REMEDIAL INVESTIGATION

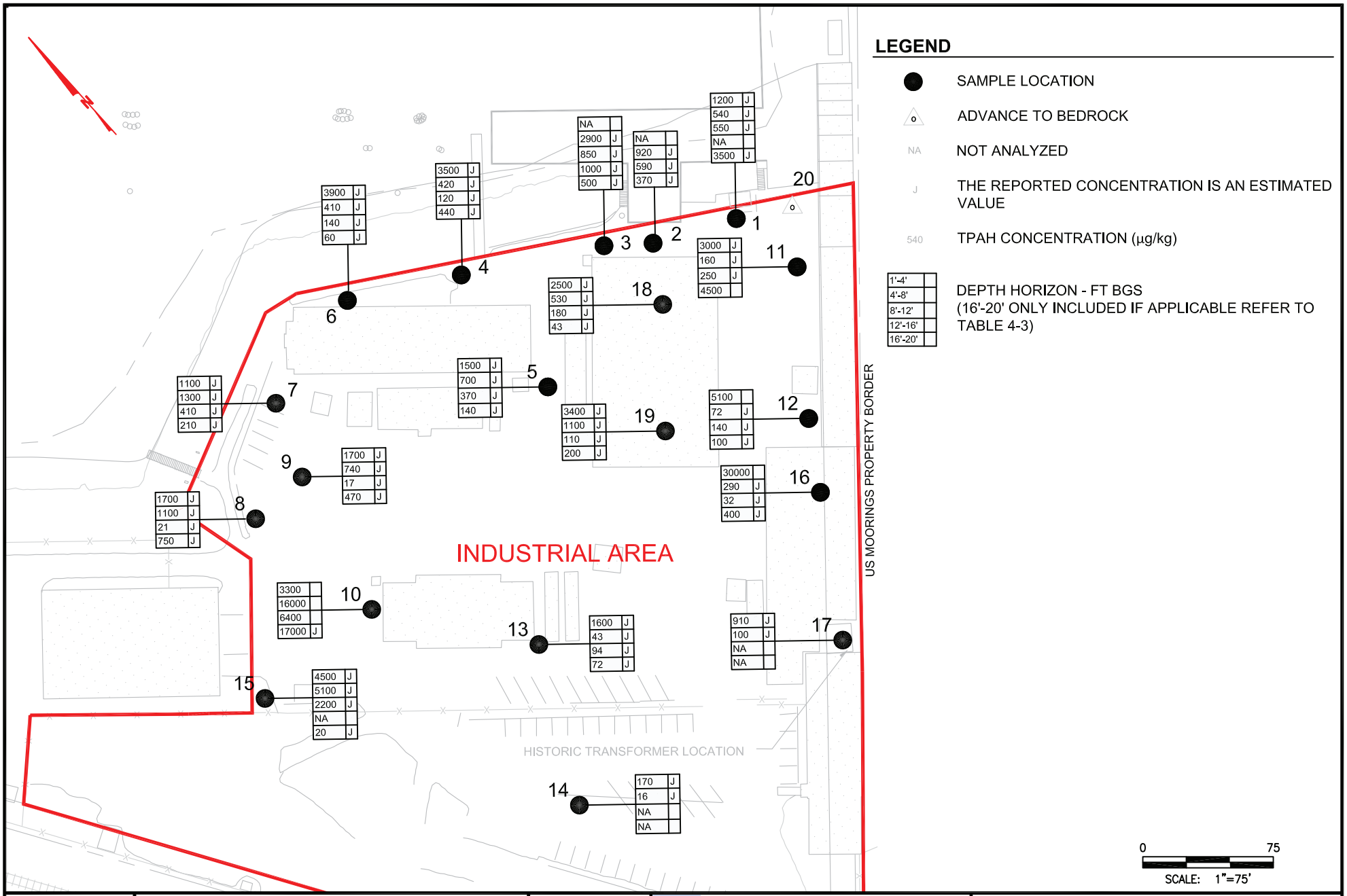

Fig 5-5

INDUSTRIAL AREA
TOTAL PAH CONCENTRATIONS IN SOIL

DATE: 1-4-09
DRAWN: MEO
CHECKED:

TEC inc.
1450 114th Ave S.E. Suite 220
Bellevue, Wa 98004
425.453.4040 * 425.454.7043 Fax

US GOVERNMENT MOORINGS
REMEDIAL INVESTIGATION

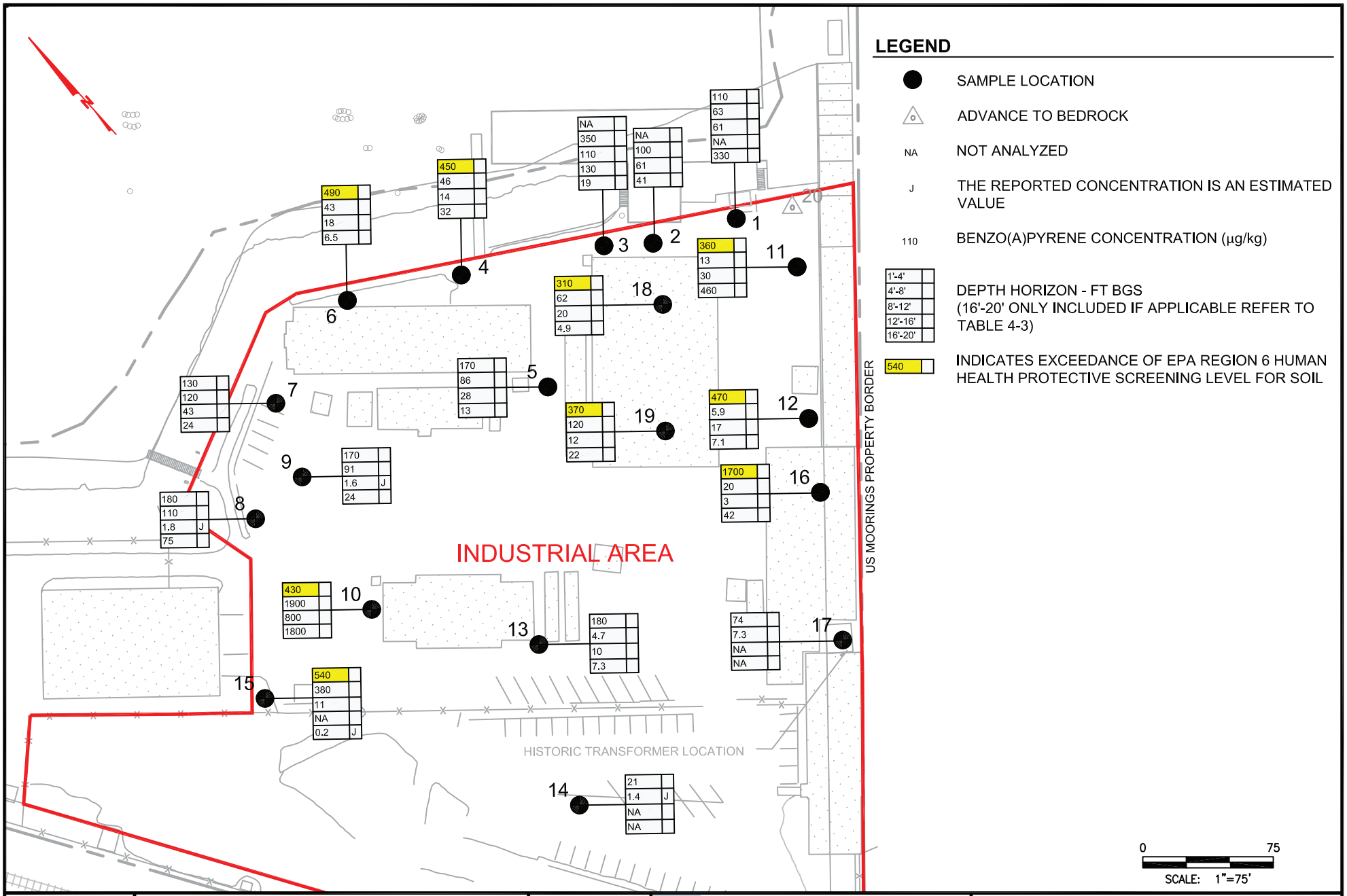

Fig 5-6	INDUSTRIAL AREA BENZO(A)PYRENE CONCENTRATIONS IN SOIL	DATE: 1-4-09 DRAWN: MEO CHECKED:	TEC inc. 1450 114th Ave S.E. Suite 220 Bellevue, Wa 98004 425.453.4040 * 425.454.7043 Fax	US GOVERNMENT MOORINGS REMEDIAL INVESTIGATION

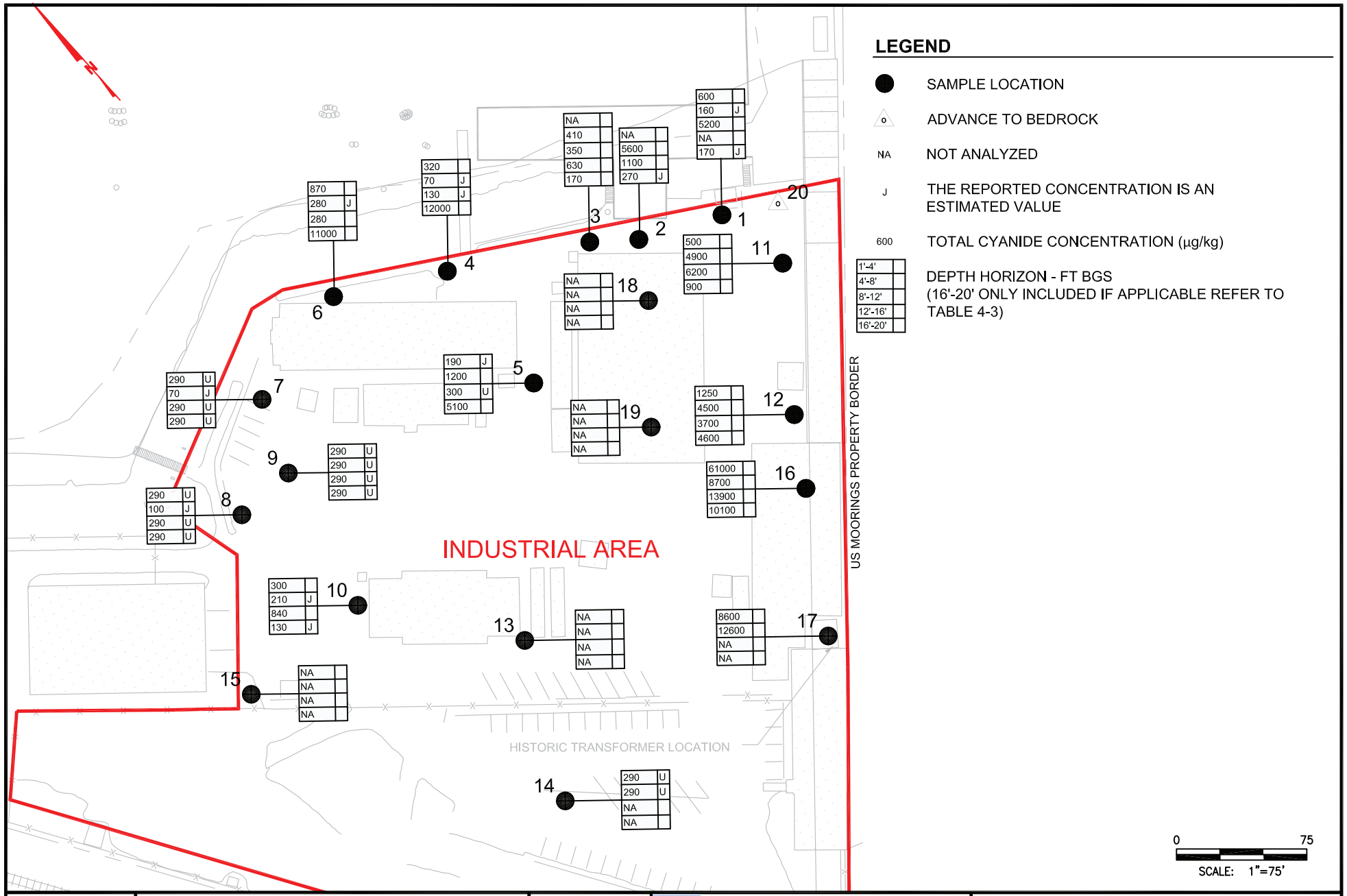

Fig 5-7

INDUSTRIAL AREA

TOTAL CYANIDE CONCENTRATIONS IN SOIL

DATE: 1-4-09

DRAWN: MEO

CHECKED:

TEC inc.

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Bellevue, Wa 98004
425.453.4040 * 425.454.7043 Fax

US GOVERNMENT MOORINGS
REMEDIAL INVESTIGATION

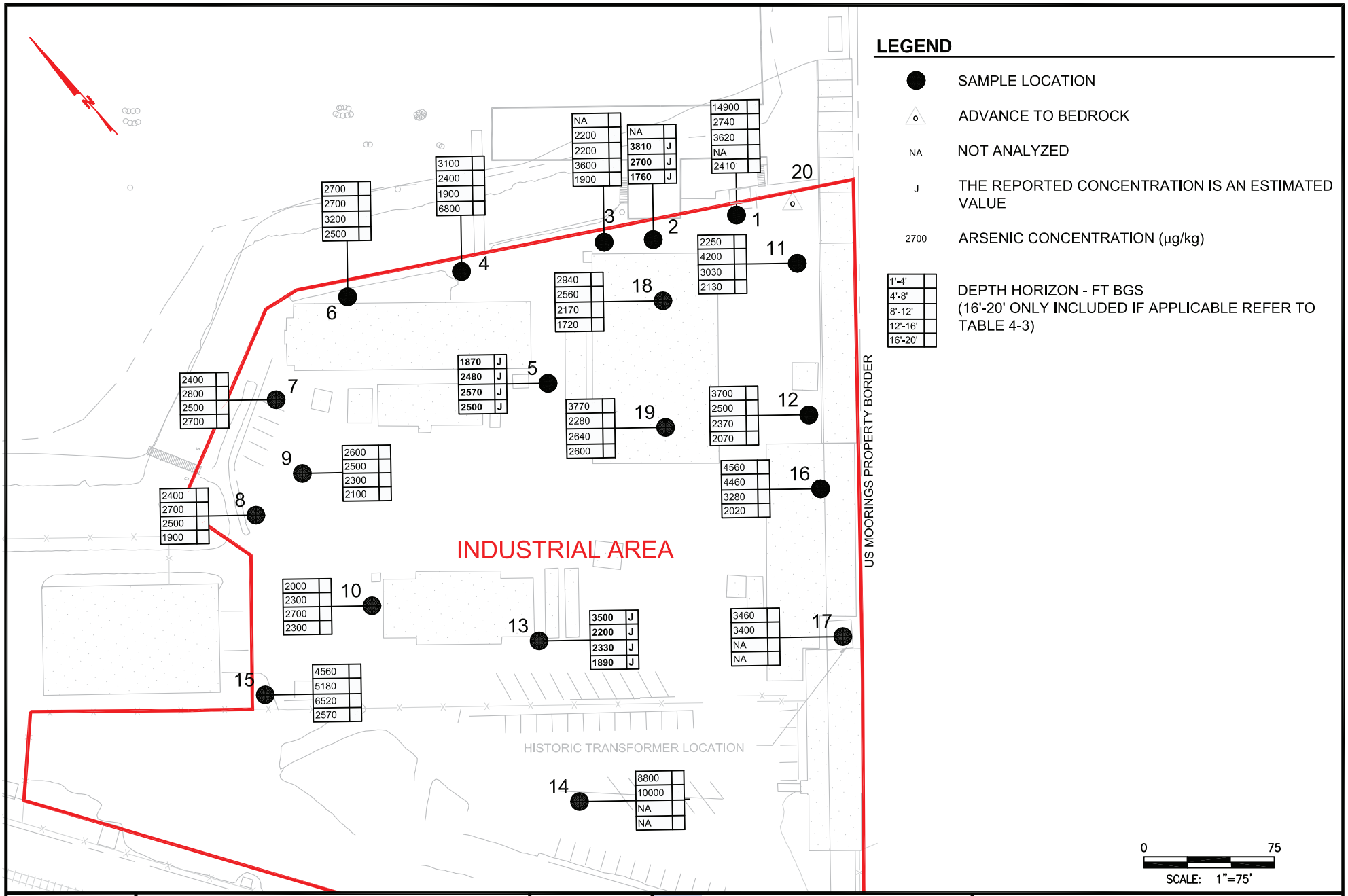


Fig 5-8

INDUSTRIAL AREA
ARSENIC CONCENTRATIONS IN SOIL

DATE: 1-4-09
DRAWN: MEO
CHECKED:

TEC inc.
1450 114th Ave S.E. Suite 220
Bellevue, Wa 98004
425.453.4040 * 425.454.7043 Fax

US GOVERNMENT MOORINGS
REMEDIAL INVESTIGATION

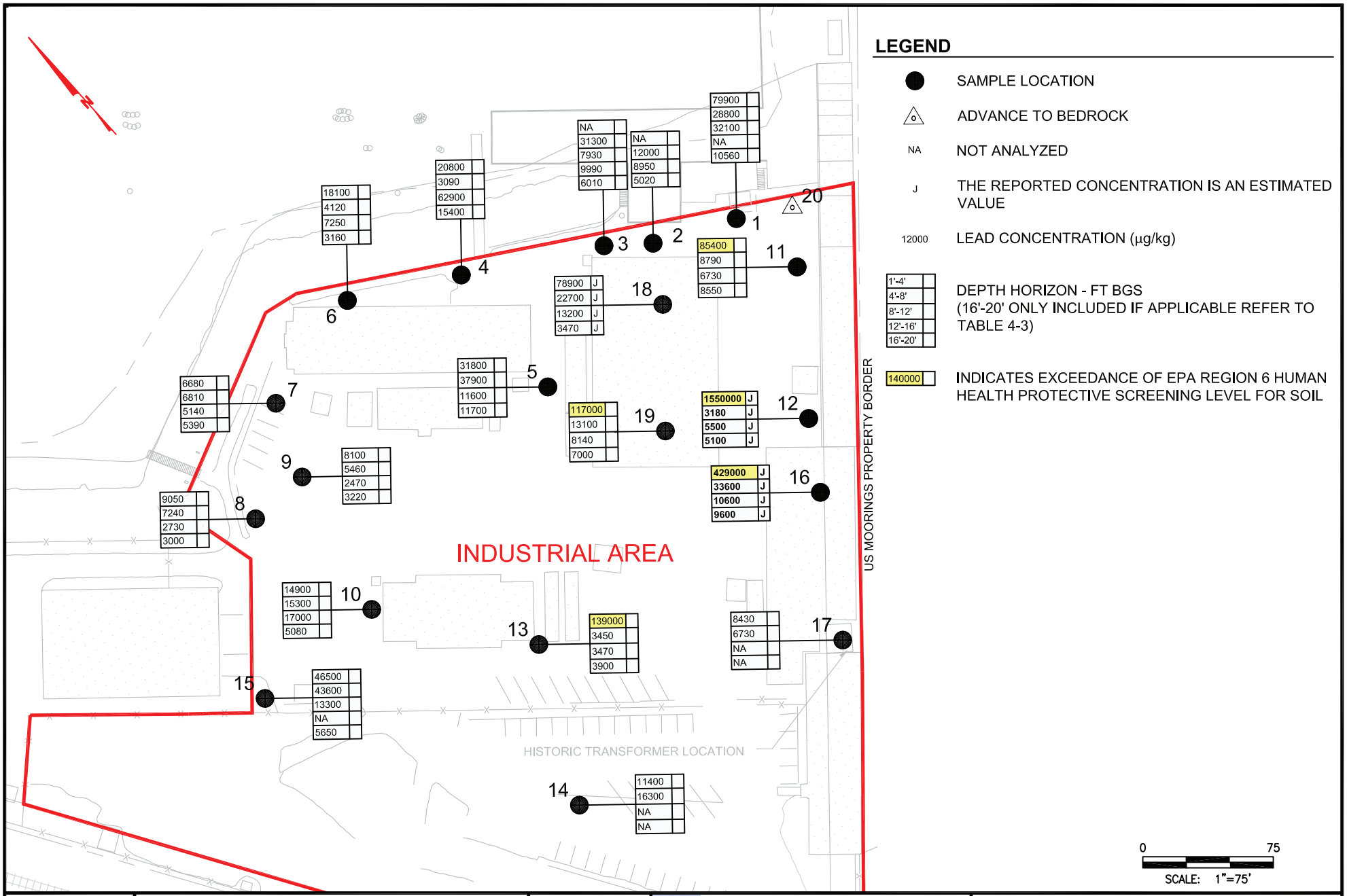


Fig 5-9	INDUSTRIAL AREA LEAD CONCENTRATIONS IN SOIL	DATE: 1-4-09 DRAWN: MEO CHECKED:	TEC inc. 1450 114th Ave S.E. Suite 220 Bellevue, Wa 98004 425.453.4040 * 425.454.7043 Fax	US GOVERNMENT MOORINGS REMEDIAL INVESTIGATION

5.1.2 MIS Area Soil Sample Results

The MIS Area was investigated using a MIS approach as described in Section 4.1.2 (page 4-17). The MIS method involves collecting a series of soil cores from the same depth at specific locations within a systematic random grid area and then compositing the soil aliquots into a single representative sample for physical and/or chemical analyses.

The MIS Area was divided into seven MUs. Table 5-3 (page 5-28) summarizes the sample depth ranges for each MU. Sample cores in the South Logistics, North Logistics, and Laydown MUs were collected in 5 foot intervals until the native soil interface was reached. Sample cores in the Slump, Prior Clean-Up, and Sandblast MUs were collected from the 1 to 5 foot horizon only. The Fence Line MU was sampled in the 0 to 6 inch horizon only.

Samples were analyzed for PAHs, SVOCs, PCBs, pesticides, metals, organobutyltins (except the South Logistics MU), and TPH. Only the MIS samples collected from the upper 5 feet of the soil profile were screened for human health risk. Results of this screening are presented in Section 7.

Tables 5-4 (page 5-33), 5-5 (page 5-35), and 5-6 (page 5-36) summarize the sample results for the shallow zone soil, 5 – 10 foot, and 10 – 15 foot horizons, respectively. Appendix A, Table 1b, presents a complete summary of the data.

The North Logistics, South Logistics, and Laydown MU samples exhibited detectable concentrations of PAHs and metals, with some detections above screening criteria. In comparison, the Slump MU also had detectable levels of various analytes, but none that exceed a screening level. For reference, the Slump MU is an area that was filled with a sandy material from an off-site source (see Section 4.1.2.3.5, page 4-20).

The Fence Line MU exhibited levels of PAHs and metals above the screening criteria. This MU is essentially a strip of loosely packed gravel in the northeast corner of the site that acts as a sediment trap for the Laydown MU and the area of the site west of the Laydown MU. The human health risks associated with these sample results are discussed in Section 7.

The Prior Clean-Up MU exhibited detectable concentrations of PAHs above the screening criteria. This MU was established to assess the effectiveness of a prior cleanup effort related to a petroleum spill. This area did not exhibit concentrations of TPH-Diesel or TPH-Motor Oil above screening levels.

The remainder of this section briefly identifies key analytical results for the MIS Area soil sampling program using a format consistent with that used in Section 5.1.1 (page 5-1) for the Industrial Area.

Table 5-3 MIS Sample Horizons

MU	Estimated Dredged Material Depth[1]	Sample Depth[1]
South Logistics	8 ~ 17'	1 - 5'
		5 - 10'
		10 ~ 15
North Logistics	8 ~20'	1 - 5'
		5 ~ 10'
Laydown	10 ~15'	1 - 5'
		5 ~10'
Fence Line	N/A	0 - 6"'
Slump	N/A	1 ~ 5'
Prior Clean-up	N/A	1 - 5'
Sandblast	N/A	1 - 5'

Notes
[1] feet bgs
N/A Not Applicable

5.1.2.1 PAHs

One or more PAHs were detected in all eleven MIS samples. Six samples had PAH concentrations that exceeded the screening criteria. Benzo(a)pyrene was detected at elevated levels in 5 samples, and dibenz(a,h)anthracene was detected in an elevated level in one sample. Ten HPAH compounds were detected in all 11 of the samples.

PAHs in the Shallow Zone Soil Horizon. Fifteen of the 19 PAHs were detected in all seven MIS samples collected from the shallow soil horizon. The most frequently detected compounds included:

- Benzo(a)pyrene - Seven of seven samples at concentrations ranging from 3.5 µg/kg to 1500 µg/kg. Sample concentrations in five of the MUs exceeded the screening criteria.
- Dibenz(a,h)anthracene - Seven of seven samples at concentrations ranging from 0.44 µg/kg to 250 µg/kg. One sample concentration exceeded the screening criteria.

In general, the total concentration of HPAHs in the Fence Line MU sample was higher than the other MUs. The total concentration of HPAHs in the Slump MU sample was consistently lower than the other MUs.

PAHs in the 5 - 10 Foot Horizon. At least 17 of the 19 PAHs were detected in all three MIS samples collected from this horizon. The most frequently detected compounds included:

- Benzo(a)pyrene - Seven of seven samples at concentrations ranging from 50 µg/kg to 900 µg/kg.
- Dibenz(a,h)anthracene – Seven of seven samples at concentrations ranging from 4.6 µg/kg to 79 µg/kg.

In general, detected concentrations of PAHs in the Laydown MU sample were two to three times greater than the other MU samples in the shallow soil horizon. Detected concentrations of PAHs in the South Logistics MU sample were consistently less than the other MUs.

PAHs in the 10 Foot to Native Soil Interface Horizon. Eighteen of the 19 PAHs were detected in the only MIS sample collected in this horizon, the South Logistics MU. Benzo(a) pyrene was detected at a concentration of 220 µg/kg; dibenz(a,h)anthracene was detected at a concentration of 19 µg/kg; and pyrene was detected at a concentration of 490 µg/kg.

5.1.2.2 Non-PAH SVOCs

Non-PAH SVOCs were detected in all 11 MIS samples. bis(2-ethylhexyl)phthalate was the most frequently detected non-PAH SVOC (11 of 11 samples) and carbazole was the second most frequently detected non-PAH SVOC (9 of 11 samples). The other eight non-PAH SVOCs were detected in one to five samples. No non-PAH SVOCs were detected in the MIS soil samples at concentrations that exceeded the screening criteria.

Non-PAH SVOCs in the Shallow Zone Soil Horizon. Non-PAH SVOCs were detected in all seven MIS samples collected from this horizon. The most frequently detected compounds included:

- bis(2-Ethylhexyl)phthalate - Seven of seven samples at concentrations ranging from 18 µg/kg to 9500 µg/kg.
- Carbazole - Six of seven samples at concentrations ranging from 3.8 µg/kg to 270 µg/kg.
- Diethyl phthalate - Five of seven samples at concentrations ranging from 2.4 µg/kg to 7.3 µg/kg.

Non-PAH SVOCs in the 5 - 10 Foot Horizon. Non-PAH SVOCs were detected in all three MIS samples collected in this horizon:

- bis(2-Ethylhexyl)phthalate was detected in all three sample areas ranging from 24 µg/kg to 130 µg/kg.
- Carbazole was detected in two samples ranging from 6.5 µg/kg to 17 µg/kg.
- Diethyl phthalate was detected in two samples ranging from 1.4 µg/kg to 2.1 µg/kg.

Non-PAH SVOCs in the 10 Foot to Native Soil Interface Horizon. Four non-PAH SVOCs were detected in the only MIS sample collected in this horizon, the South Logistics MU. Notably, bis(2-Ethylhexyl)phthalate was detected at a concentration of 670 µg/kg, and carbazole was detected at a concentration of 2.8 µg/kg.

5.1.2.3 PCBs

PCBs were detected in six of the 11 MIS samples. Three different PCBs were detected, but none at concentrations that exceeded the screening criteria.

PCBs in the Shallow Zone Soil Horizon. PCBs were detected in four of the seven MIS samples in this horizon:

- Aroclor® 1248 was detected in one sample at a concentration of 68 µg/kg.

- Aroclor® 1260 was detected in two samples at a concentration of 1.2 µg/kg and 14 µg/kg.
- Aroclor® 1262 was detected in one sample at a concentration of 50 µg/kg.

PCBs in the 5 - 10 Foot Horizon. Aroclor® 1248 was detected in one of three samples at a concentration of 8.2 µg/kg.

PCBs in the 10 Foot to Native Soil Interface Horizon. Aroclor® 1260 was detected at a concentration of 1.2 µg/kg in the only MIS sample collected from this horizon.

5.1.2.4 Metals

All thirteen metals were detected at least one time in all MIS soil samples. Detected concentrations of arsenic, chromium, and lead exceeded screening criteria.

Metals in the Shallow Soil Horizon. Metals were detected in all seven MIS samples collected in this horizon. Twelve of the 13 metals were detected in all samples. The most frequently detected metals included:

- Arsenic – Seven of seven samples at concentrations ranging from 1,060 µg/kg to 62,900 µg/kg.
- Chromium – Seven of seven samples at concentrations ranging from 17,400 µg/kg to 508,000 µg/kg.
- Lead – Seven of seven samples at concentrations ranging from 5,080 µg/kg to 585,000 µg/kg.

The concentrations for eight of the 13 metals detected in the Fence Line MU sample were eight to ten times greater than the concentrations in the other sample areas.

Metals in the 5 - 10 Foot Horizon. Twelve of 13 metals were detected in this horizon in all three MIS samples. The most frequently detected metals included:

- Arsenic – Three of three samples at concentrations ranging from 2,830 µg/kg to 6,900 µg/kg.
- Chromium – Three of three samples at concentrations ranging from 17,400 µg/kg to 35,900 µg/kg.
- Lead – Three of three samples at concentrations ranging from 38,800 µg/kg to 65,700 µg/kg.

Metals in the 10 Foot to Native Soil Interface Horizon. Ten of the 13 metals were detected in this horizon. Most notably:

- Arsenic was detected at a concentration of 3,120 µg/kg.
- Chromium was detected at a concentration in of 17,200 µg/kg.
- Lead was detected at a concentration of 116,000 µg/kg.

5.1.2.5 Organobutyltins

Three organobutyltins were detected in six of the eight MIS samples that were analyzed for these parameters.

Organobutyltins in the Shallow Soil Horizon. Organobutyltins were detected in four of the six MIS samples collected in this horizon. All three organobutyltins were detected in the Fence Line MU sample.

- DBT was detected in four samples at concentrations ranging from 0.19 µg/kg to 32 µg/kg.
- MBT was detected in two samples at concentrations ranging from 0.64 µg/kg to 25 µg/kg.
- TBT was detected in one sample at a concentration of 14 µg/kg.

Organobutyltins in the 5 - 10 Foot Horizon. Two of three organobutyltins were detected in one MIS sample from this horizon:

- DBT was detected in one sample at a concentration of 0.95 µg/kg.
- TBT was detected in one sample at a concentration of 0.28 µg/kg.

Organobutyltins in the 10 Foot to NSI Horizon. Organobutyltin analyses were not requested for MIS samples from this horizon.

5.1.2.6 Total Petroleum Hydrocarbons

TPHs were detected in all 11 MIS samples. TPH-Diesel was the most frequently detected compound (10 of 11 samples), followed by TPH-Motor Oil (9 of 11 samples). The maximum detected concentrations of TPHs occurred in the North Logistics MU sample.

TPHs in the Shallow Soil Horizon. TPHs were detected in all seven MIS samples collected from this horizon. The most frequently detected compounds included:

- TPH-Diesel - Seven of seven samples at concentrations ranging from 3,000 µg/kg to 140,000 µg/kg.
- TPH-Motor Oil - Six of seven samples at concentrations ranging from 60,000 µg/kg to 450,000 µg/kg.

TPH concentrations in North Logistics MIS sample were at least two times greater than the other sample areas.

TPHs in the 5 - 10 Foot Horizon. Both TPH-Diesel and TPH-Motor Oil were detected in all three samples from this horizon.

- TPH-Diesel - Three of three samples at concentrations ranging from 1,600 µg/kg to 16,000 µg/kg.
- TPH-Motor Oil - Three of three samples at concentrations ranging from 4,400 µg/kg to 65,000 µg/kg.

TPH concentrations in the North Logistics MU in this horizon were at least ten times greater than the other sample areas.

TPHs in the 10 Foot to Native Soil Interface Horizon. Both TPH-Diesel and TPH-Motor Oil were detected in this horizon. TPH-Diesel was detected at a concentration of 3,000 µg/kg and TPH-Motor Oil was detected at a concentration of 7,900 µg/kg.

Table 5-4 Summary of Detections in the Shallow Zone MIS Samples (µg/kg)

	SL	NL	LD	FL	SP	PC	SB
PAHs							
Naphthalene	3.9	96	85	20	1 J	17	33
2-Methylnaphthalene	0.91 J	61	17	13	0.6 J	9.8	14
1-Methylnaphthalene	0.62 J	58	11	12	-	7.3	6.6
Acenaphthylene	3.7	55	15	13	0.3 J	15	13
Acenaphthene	2.7	51	33	160	0.33 J	65	13
Fluorene	1.8 J	69	26	100	-	77	14
Dibenzofuran	-	41	4.5	79	-	32	6.8
Phenanthrene	39	600	270	1,200	2.8	710	150
Anthracene	8.2	110	51	120	-	210	31
Fluoranthene	110	1,000	520	2,700	5.8	910	390
Pyrene	160	1,500	710	2,400	6.5	1,100	570
Benzo(b)fluoranthene	110	980	310	2,000	3.7	620	380
Benzo(k)fluoranthene	36	280	100	630	1.2 J	190	110
Benzo(a)anthracene	57	530	180	1,100	2.5	420	200
Chrysene	80	740	240	1,400	2.5	530	280
Benzo(a)pyrene	98	960	360	1,500	3.5	630	380
Indeno(1,2,3-cd)pyrene	110	980	330	1,200	3.1	580	370
Dibenz(a,h)anthracene	13	120	33	250	0.44 J	72	41
Benzo(g,h,i)perylene	120	1,100	350	970	3.1	570	390
Non-PAH SVOCs							
Carbazole	3.8 J	28	6.5 J	270	-	71	17 J
bis(2-Ethylhexyl) phthalate	9,500	1,600	54	140	18	4,100	350
Phenol	-	2.6 J	-	-	-	5.2 J	-
Diethyl Phthalate	-	2.9 J	2.4 J	-	4.1 J	5.9 J	7.3 J
N-Nitrosodiphenylamine	-	18	-	-	-	-	-
Pentachlorophenol	-	1.9	-	21	-	-	-
4-Methylphenol	-	1.7 J	5.1 J	-	-	5.6 J	-
Benzyl Alcohol	-	-	-	-	-	3.2 J	-
Di-N-Butyl Phthalate	-	-	-	100	-	10	-
Butyl Benzyl Phthalate	-	-	-	38 J	-	-	-
PCBs							
Aroclor 1248	-	68	-	-	-	-	-
Aroclor 1260	1.2 J	-	-	14	-	-	-
Aroclor 1262	-	-	-	-	-	-	50
Pesticides							
γ-BHC (Lindane)	-	0.47 J	-	-	-	0.17 J	-
4,4'-DDE	0.26	2.7 J	0.18	4.2 J	-	-	0.26
4,4'-DDT	1.1	7.7 J	0.56 J	8.7 J	-	0.52 J	-
4,4'-DDD	-	4.5	-	0.44 J	-	-	0.71
2,4'-DDD	-	2.7 J	-	-	-	-	0.3
2,4'-DDE	-	-	-	-	-	0.094 J	-
2,4'-DDT	0.24	2.9 J	-	3.3 J	-	-	-

Table 5-4 Summary of Detections in the Shallow Zone MIS Samples (µg/kg)

	SL	NL	LD	FL	SP	PC	SB
Pesticides, continued							
Endrin	-	0.08 J	-	-	-	-	-
trans-Nonachlor	-	0.064 J	-	0.21	-	-	0.056 J
Mirex	-	-	0.065 J	-	-	-	-
cis-Nonachlor	-	-	-	-	-	0.097 J	0.87 J
Endrin Ketone	-	-	-	0.66 J	-	-	-
gamma Chlordane	-	-	-	-	-	-	0.08 J
alpha Chlordane	-	-	-	-	-	-	0.12 J
Metals							
Aluminum	1.07E+07	2.07E+07	2.08E+07	1.12E+07	1.28E+06	2.35E+07	2.14E+07
Antimony	80	710	180	6,800	70	380 J	320
Arsenic	3,110	6,160	4,140	62,900	1,060	7,180	8,200
Cadmium	94	358	134	1,500	43	171	224
Chromium (T)	17,400 J	30,400	36,400	508,000	18,100	30,600	48,800
Copper	16,000	132,000	34,000	226,000	3,000	239,000 J	46,800
Lead	28,200	203,000 J	36,700 J	585,000 J	5,080 J	75,800	62,800 J
Manganese	320,000	612,000	429,000	896,000	92,900	772,000	728,000
Mercury	32	104	101	52	4	88	101
Nickel	20,200	79,600	30,300	213,000	7,000	23,200	38,100
Selenium	-	-	-	-	-	100	120
Silver	117	173	90	270	12	333 J	94
Zinc	77,000	182,000	84,600	1.12E+06	10,800	148,000	155,000
Organobutyltins							
TBT	NA	-	-	14	-	-	-
DBT	NA	0.19	0.38 J	32	0.23 J	-	-
MBT	NA	0.64	-	25	-	-	-
TPH							
TPH-Diesel	5,200 J	140,000	5,200 J	22,000	3,000 J	44,000	22,000
TPH-Motor Oil	60,000 J	450,000	60,000 J	130,000	-	180,000	76,000 J

Notes:
A complete list of all analytical results is included in Appendix A, Table 1-b.
- Not Detected or Not Analyzed
T - Total
J – Estimated concentration
SL- South Logistics MU
NL-North Logistics
LD – Laydown MU
FL- Fence Line MU
SP- Slump MU
PC - Prior Clean-Up
SB- Sandblast MU

Table 5-5 Summary of Detections in the 5' - 10' Horizon MIS Samples (µg/kg)

	SL	NL	LD
PAHs			
Naphthalene	1.4 J	18	100
2-Methylnaphthalene	0.4 J	4.1	19
1-Methylnaphthalene	-	3.2	14
Acenaphthylene	3.2	18	47
Acenaphthene	1.3 J	14	240
Fluorene	0.68 J	11	110
Dibenzofuran	-	1.6	10
Phenanthrene	18	230	1300
Anthracene	3.5	48	200
Fluoranthene	64	510	1500
Pyrene	100	670	2100
Benzo(b)fluoranthene	48	350	780
Benzo(k)fluoranthene	16	110	230
Benzo(a)anthracene	28	200	520
Chrysene	38	260	670
Benzo(a)pyrene	50	360	900
Indeno(1,2,3-cd)pyrene	50	370	730
Dibenz(a,h)anthracene	4.6	34	79
Benzo(g,h,i)perylene	57	390	710
SVOCs			
bis(2-Ethylhexyl) phthalate	44	130	24
Diethyl Phthalate	-	1.4 J	2.1 J
Carbazole	-	6.5	17
4-Methylphenol	-	-	8.2
PCBs			
Aroclor 1248	-	8.2	-
Pesticides			
2,4'-DDE	0.05 J	-	-
γ-BHC (Lindane)	-	0.17	0.25
4,4'-DDE	-	0.28	-
4,4'-DDD	-	0.82	-
4,4'-DDT	-	0.65 J	0.16 J
2,4'-DDD	-	0.37	0.098 J
2,4'-DDT	-	0.37 J	-
Endrin aldehyde	-	-	0.22 J
Metals			
Aluminum	1.06E+07	2.15E+07	1.67E+07
Antimony	280	240	290
Arsenic	2,830	6,900	4,640
Cadmium	64	152	146
Chromium (T)	17,400 J	29,100	35,900
Copper	15,700	63,900	78,500

Table 5-5 Summary of Detections in the 5' - 10' Horizon MIS Samples (µg/kg)

	SL	NL	LD
Lead	38,800	65,700 J	45,800 J
Manganese	300,000	618,000	457,000
Mercury	-	64	79
Nickel	16,900	28,800	28,000
Selenium	-	-	-
Silver	78	77	143
Zinc	60,800	116,000	94,800
Organobutyltins			
DBT	-	-	0.95 J
TBT	-	-	0.28
TPH			
TPH-Diesel	1,600 J	16,000	1,600 J
TPH-Motor Oil	4,400 J	65,000 J	4,400

Notes:
A complete list of all analytical results is included in Appendix A, Table 1-b.
- Not Detected or Not Analyzed
T – Total
J – Estimated concentration
SL - South Logistics MU
NL- North Logistics MU
LD- Laydown MU

Table 5-6 Summary of Detections in the 10' to Native Soil Interface Horizon MIS Samples, South Logistics MU (µg/kg)

Analyte		Analyte		Analyte	
PAH		PCBs		Metals	
Naphthalene	4.9	Aroclor 1260	1.2 J	Aluminum	1.30E+07
2-Methylnaphthalene	1.2 J	Pesticides		Antimony	100
1-Methylnaphthalene	1.6 J	Lindane	0.12 J	Arsenic	3,120
Acenaphthylene	15	2,4-DDE	0.064 J	Cadmium	101
Acenaphthene	4.4	Other SVOCs		Chromium (T)	17,200 J
Fluorene	5.1	Carbazole	2.8 J	Copper	34,900
Phenanthrene	140	di-n-butyl Phthalate	8.5 J	Lead	116,000
Anthracene	27	butyl Benzyl Phthalate	4.6 J	Manganese	415,000
Fluoranthene	350	bis(2-Ethylhexyl)phthalate	670	Nickel	16,400
Pyrene	490			Silver	48
Benzo(b)fluoranthene	210			Zinc	83,800
Benzo(k)fluoranthene	65			TPHs	
Benzo(a)anthracene	120			TPH-Diesel	3,000 J
Chrysene	160			TPH-Motor Oil	7,900 J
Benzo(a)pyrene	220				
Indeno(1,2,3-cd)pyrene	220				
Dibenz(a,h)anthracene	19				
Benzo(g,h,i)perylene	240				

Notes:
A complete list of all analytical results is included in Appendix A, Table 1-b
T – Total
J – Estimated concentration

5.1.3 Groundwater Sample Results

As discussed in Sections 4.2.1 (page 4-35) and 4.2.2 (page 4-35), groundwater samples were collected during two separate sampling events. During the first event, groundwater samples were collected at ten perimeter soil boring locations within the Industrial Area: SB-01, SB-02, SB-03, SB-20, SB-04, SB-05, and SB-06, SB-11, SB-12, and SB-16. In general, the samples were collected by installing temporary wells at depths ranging from 18 to 28 feet bgs with the exception of SB-20, which was drilled to the bedrock contact at approximately 85 feet bgs. The samples were analyzed for VOCs, PAHs, SVOCs, PCBs, pesticides, TSS, metals, dissolved metals, cyanide (total), and TPHs. Sample locations are shown on Figures 4-2 (page 4-13) and 4-7 (page 4-37).

The second sampling event was intended primarily to fill in data gaps for various cyanide species. It involved collection of ten additional groundwater samples at locations SB-21 through SB-28, SB-30 and SB-31 in the central and western portions of the Industrial Area. These samples were analyzed for cyanide (total), free cyanide, amenable cyanide, and WAD cyanide by Method OIA 1677 and by Method 4500-CN-1. Additionally, samples from locations SB-24 and SB-31 (downgradient of two former USTs) were analyzed for TPH-Diesel, TPH-Motor Oil, and TPH-Gasoline.

Table 5-7 (page 5-40) summarizes the analytical results for the groundwater samples collected during the first sampling event. Table 5-8 (page 5-43) summarizes the results for the second event. All figures illustrating results are located at the end of this section.

A third sampling event (Appendix E) was also conducted to verify the initial findings at SB15 and to determine if groundwater in the vicinity of SB-15 was contaminated by petroleum products.

The following subsections highlight the key findings of the groundwater sampling effort. For simplicity, the three most frequently detected analytes in each analytical group are identified, along with concentrations ranges. Since metals and PAHs were detected so frequently across the site, those subsections identify the analytes (and concentration ranges) that exceeded screening criteria, regardless of the frequency of detections.

5.1.3.1 VOCs

Nine different VOCs were detected in the groundwater samples, and nine of the ten samples had at least one detected compound. Figure 5-10 (page 5-45) illustrates the distribution of benzene and toluene concentrations in groundwater. No obvious plumes can be identified for either of these VOCs. However, samples GW-16 and GW-11 had the greatest number of detected values at a single location, with five VOCs detected at each.

The most frequently detected compounds included:

- Benzene - Seven of 10 samples at concentrations ranging from 0.19 µg/L to 0.94 µg/L. Four samples had concentrations that exceeded the screening criteria (Figure 5-10, page 5-45).
- Carbon disulfide, toluene, PCE, and ethylbenzene were detected in two of 10 samples each.

- PCE was detected in concentrations that exceeded the screening criteria in two samples and carbon disulfide, chloroform and TCE each were detected in concentration that exceeded the screening criteria in one sample.

5.1.3.2 PAHs

All ten groundwater samples had at least three PAH detections, and seven of the ten samples had detections of at least ten PAHs.

The most frequently detected compounds included:

- Naphthalene – Nine of 10 samples at concentrations ranging from 0.0079 µg/L to 6 µg/L. Five samples had concentrations that exceeded the screening criteria (Figure 5-11, page 46).
- Fluorene - Seven of 10 samples at concentrations ranging from 0.0085 µg/L to 0.39 µg/L. Three samples had concentrations that exceeded the screening criteria. (Figure 5-11, page 46)
- Benzo(a)pyrene - Three of 10 samples at concentrations ranging from 0.0085 µg/L to 0.051 µg/L. The concentrations in all 3 samples exceeded the screening criteria (Figure 5-11, page 46).
- Benzo(b)fluoranthene, indeno(1,2,3-cd)pyrene and dibenz(a,h)anthracene were detected in concentrations that exceeded the screening criteria in two samples each.
- Benzo(a)anthracene, chrysene, benzo(f)fluoranthene and benzo(k)fluoranthene were detected in concentrations that exceeded the screening criteria in one sample each.

Figure 5-11 (page 5-46) illustrates the distribution of naphthalene, fluorene, and benzo(a)pyrene concentrations in groundwater. In general, concentrations of all three of these PAHs were higher in samples collected along the Moorings/GASCO site boundary than other samples.

Figure 5-12 (page 5-47) illustrates the distribution of total PAHs in groundwater. TPAHs are also generally elevated along the Moorings/GASCO site boundary in relation to the other groundwater samples. All 19 PAHs were detected in GW-11. The concentrations of four PAHs exceeded the screening criteria in sample GW-16 and the concentrations of 11 PAHs exceeded the screening criteria in GW-11.

5.1.3.3 Non-PAH SVOCs

Nine of ten samples had at least one non-PAH SVOC detection in the shallow groundwater samples. The most frequently detected compounds included:

- 1,3-Dichlorobenzene – Seven of 10 samples at concentrations ranging from 0.039 µg/L to 0.053 µg/L.
- Benzoic acid – Five of 10 samples at concentrations ranging from 1.1 µg/L to 1.2.
- Carbazole – Two of 10 samples at concentrations ranging from 0.025 µg/L to 0.036 µg/L.

No non-PAH SVOCs exceeded the screening criteria in groundwater.

5.1.3.4 PCBs

No PCBs were detected in groundwater.

5.1.4.5 Pesticides

Nine of the ten samples had at least one detection of at least one of the 14 pesticides detected in the shallow groundwater samples. No single pesticide was detected in more than three samples. The maximum number of pesticides at a single location was six at GW-6.

The most frequently detected compounds included:

- Chlordane – Four of 10 samples at concentrations ranging from 0.00035 µg/L to 0.0085 µg/L and three of these concentrations exceeded the screening criteria.
- Aldrin – One sample at a concentration of 0.00027 µg/L which exceeded the screening criteria.
- 2,4'-DDE – One sample at a concentration of 0.0011 µg/L which exceeded the screening criteria.

5.1.3.6 Total Suspended Solids

TSS values were measurable in six samples at concentrations ranging from 117 µg/L to 1,180,000 µg/L.

5.1.3.7 Cyanide

Over the two sampling events, 20 groundwater samples were collected and analyzed for cyanide. All 20 samples had detectable concentrations of at least one species of cyanide. Tables 5-7 (page 5-41) and 5-8 (page 5-44) summarize the data from both events.

Figure 5-13 (page 5-48) illustrates the distribution of total cyanide in the samples. Although several locations appear to have elevated cyanide concentrations in relation to the others, there are no obvious plumes. The most frequently detected cyanide species included:

- Cyanide (total) – 16 of 20 samples at concentrations ranging from 30 µg/L to 2,920 µg/L.
- Cyanide (amenable) – Ten of 10 samples at concentrations ranging from 19.3 µg/L to 2,020 µg/L.
- Cyanide (WAD) – Five of 10 samples at concentrations ranging from 11.2 µg/L to 51.5 µg/L.
- Cyanide (free) was detected in one sample at a concentration of 199 µg/L.

5.1.3.8 Total Metals

All ten samples groundwater samples had detectable concentrations of at least seven of the 13 metals. Figure 5-14 (page 5-49) illustrates the distribution of arsenic and copper in groundwater. Samples GW-01, GW-02, and GW-11 had relatively higher concentrations of both of these metals than the other locations.

The most frequently detected metals included:

- Arsenic – Ten of 10 samples at concentrations ranging from 0.058 µg/L to 4.02 µg/L.

- Zinc – Ten of 10 samples at concentrations ranging from 10.3 µg/L to 5510 µg/L.
- Lead – Ten of 10 samples at concentrations ranging from 0.04 µg/L to 92.3 µg/L. Lead concentrations exceeded the screening criteria in five samples.
- Copper – Ten of 10 samples at concentrations ranging from 0.2 µg/L to 108 µg/L.

Antimony and selenium were the only two detected metals that did not have concentrations that exceeded screening criteria.

5.1.3.9 Dissolved Metals

All ten samples each had detectable concentrations of at least nine of the 13 metals analyzed for groundwater. Samples GW-01, GW-11, GW-12, and GW-16 generally had the highest concentrations of dissolved metals.

The most frequently detected dissolved metals included:

- Dissolved aluminum, arsenic, cadmium, lead, manganese, nickel, and zinc were detected at concentrations that exceeded screening criteria.
- Dissolved arsenic - Ten of 10 samples at concentrations ranging from 0.035 µg/L to 1.1 µg/L. Dissolved arsenic concentrations exceeded the screening criteria in all 10 samples.
- Dissolved zinc - Ten of 10 samples at concentrations ranging from 10.6 µg/L to 3550 µg/L. Dissolved zinc concentrations exceeded the screening criteria in eight samples.
- Dissolved lead - Ten of 10 samples at concentrations ranging from 0.018 µg/L to 11.5 µg/L. Dissolved lead concentrations exceeded the screening criteria in four samples.

5.1.3.10 Petroleum Hydrocarbons

Five of 12 groundwater samples had detectable concentrations of TPHs. TPH-Diesel was detected in two samples at a concentration of 13 µg/L. TPH-Motor Oil was detected in three samples at concentrations ranging from 21 µg/L to 62 µg/L. TPH-Gasoline was detected in one sample at a concentration of 17 µg/L.

These results were confirmed during the third sampling event (Appendix E). TPH-Gasoline was detected in one sample at a concentration of 20 µg/L. TPH-Diesel was detected at two locations at concentrations of 17 and 16 µg/L.

Table 5-7 Summary of Groundwater Detections (µg/L)

Analyte	Borehole									
	16	12	11	1	2	3	4	6	5	20
VOCs										
cis-1,2-Dichloroethlyene	-	-	-	-	0.31 J	-	-	-	-	
Carbon Disulfide	0.4	-	2.3	-		-	-	-	-	
Chloroform	-	-	-	-	0.3 J	-	-	-	-	
Benzene	0.56	-	0.22 J	0.94	-	0.24 J	0.19 J	0.4 J	0.85	
Trichloroethene (TCE)	-	-	-	-	0.67	-	-	-	-	
Toluene	0.33 J	-	0.21 J	-	-	-	-	-	-	
Tetrachloroethene (PCE)	-	-	-	-	0.22 J	-	0.14 J	-	-	
Ethylbenzene	0.14 J	-	0.14 J	-	-	-	-	-	-	
Naphthalene	5.9	2.2	3.9	-	-	0.8 J	-	-	1.9 J	
SVOCs										
PAHs										
Naphthalene	6	1.5	3.3	0.15	0.0079	0.84	0.19	0.16	1.4	
2-Methylnaphthalene	0.19	0.046	0.056	0.0035 J	-	0.0053 J	0.0044 J	-	0.064 J	0.0042 J
1-Methylnaphthalene	0.29	0.06	0.11	0.0065 J	-	0.0075 J	0.01	0.0043 J	0.1	
Acenaphthylene	0.014	-	0.012	-	-	-	0.0086	-	0.0074 J	
Acenaphthene	0.11	0.013	0.019	0.0074 J	-	0.011	0.088	0.0064 J	0.096	
Fluorene	0.39	0.023	0.058	-	-	0.0085	0.3	0.012	0.23	
Dibenzofuran	0.019	-	0.0067 J	-	-		0.022	-	0.021	
Phenanthrene	0.17	0.027	0.035	0.0078 J	-	0.0059 J	0.066	0.014	0.13	
Anthracene	0.18	0.06	0.038	0.017	0.0062 J	0.0043 J	0.049	0.013	0.051	
Fluoranthene	0.045	0.013	0.079	0.005 J		0.01	-	0.009	0.028	
Pyrene	0.06	0.017	0.098	0.01	0.0099	0.022	-	0.017	0.034 J	
Benzo(a)anthracene	0.0082	-	0.056	0.004 J	-	0.0035 J	-	0.003 J	0.011	
Chrysene	0.0034 J	-	0.018	0.0044 J	-	-	-	-	0.011	
Benzo(b)fluoranthene	0.024	0.0077 J	0.034	0.011	-	-	-	-	0.011	
Benzo(k)fluoranthene	0.0054 J	-	0.041	0.0029 J	-	-	-	-	0.0034 J	
Benzo(a)pyrene	-	-	0.051	0.0085	-	-	-	-	0.01	
Indeno(1,2,3-cd)pyrene	0.005 J	-	0.047	0.015	-	-	-	0.0032 J	0.0068 J	
Dibenz(a,h)anthracene	-	-	0.0052 J	-	-	-	-	0.0037 J	-	
Benzo(g,h,i)perylene	0.0054 J	-	0.055	0.019	-	-	-	0.0034 J	0.0067 J	

Table 5-7 Summary of Groundwater Detections (µg/L)

Analyte	Borehole									
	16	12	11	1	2	3	4	6	5	20
Organonitrogen Compounds, Halogenated Compounds, Phenols and Substituted Phenols, Oxygen-Containing Compounds										
1,3-Dichlorobenzene	0.039 J	0.039 J	0.042 J	0.049 J	0.053 J	-	-	0.045 J	0.046 J	
1,4-Dichlorobenzene	-	-	-	-	-	0.053 J	-	-	-	
Benzyl Alcohol	-	-	-	0.089 J	-	-	-	-	-	
Benzoic Acid	1.1 J	-	-	-	1.2 J	1.2 J	1.2 J	-	1.2 J	
Carbazole	-	-	-	-	-	-	0.036 J	-	0.025 J	
Pesticides										
Hexachlorobenzene	-	-	-	-	0.0007 J	-	0.00062	-	-	
β -BHC	-	-	-	-	-	-	-	-	0.0013 J	
γ -BHC (Lindane)	0.0005 J	0.00071	-	-	-	-	-	-	-	
Aldrin	-	0.00027 J	-	-	-	-	-	-	-	
Endosulfan alpha-	-	-	-	-	0.00082 J	0.00063	-	0.0013 J	-	
Endrin aldehyde	-	-	0.00032 J	-	-	-	-	-	-	
Endosulfan sulfate	-	-	-	-	-	0.00046 J	-	-	-	
oxychlordane	-	-	-	-	-	-	-	0.0049 J	0.0054 J	
2,4'-DDE	-	0.0011	-	-	-	-	-			
cis -nonachlor	-	-	-	-	-	-	-	0.0018 J		
trans -nonachlor	-	-	-	0.0024 J	0.00035 J	-	-	0.0018 J		
Hexachloroethane	-	-	0.00029 J	-	-	-	-	-	0.00038 J	
Hexachlorobutadiene	-	-	0.0008	-	-	-	-	-	-	
DDE (1)	-	0.0011	-	-	-	-	-	-	-	
DDT -total (2)	-	0.0011	-	-	-	-	-	-	-	
Chlordane -total (3)	-	-	-	0.0024	0.00035	-	-	0.0085	0.0054	
Endosulfan -total (4)	-	-	-	-	0.00082	0.00109	-	0.0013	-	
Cyanide										
Cyanide (total)[1]	2,990	240	150	30	50	210	1110	240	310	200
TSS										
TSS	-	35,000	1.18E+06	-	3.85E+05	-	-	117	75,000 J	86,000
Metals										
Aluminum (pH 6.5-9.0)	8,040	4,340	74,600	6,410	3,820	35.7	4210	499	3,140	102
Antimony	0.12	0.28	0.1	-	0.03	-	-	-	-	-
Arsenic	0.553	0.247	4.02	1.2	1.43	0.342	0.058	0.231	0.592	4.68

Table 5-7 Summary of Groundwater Detections (µg/L)

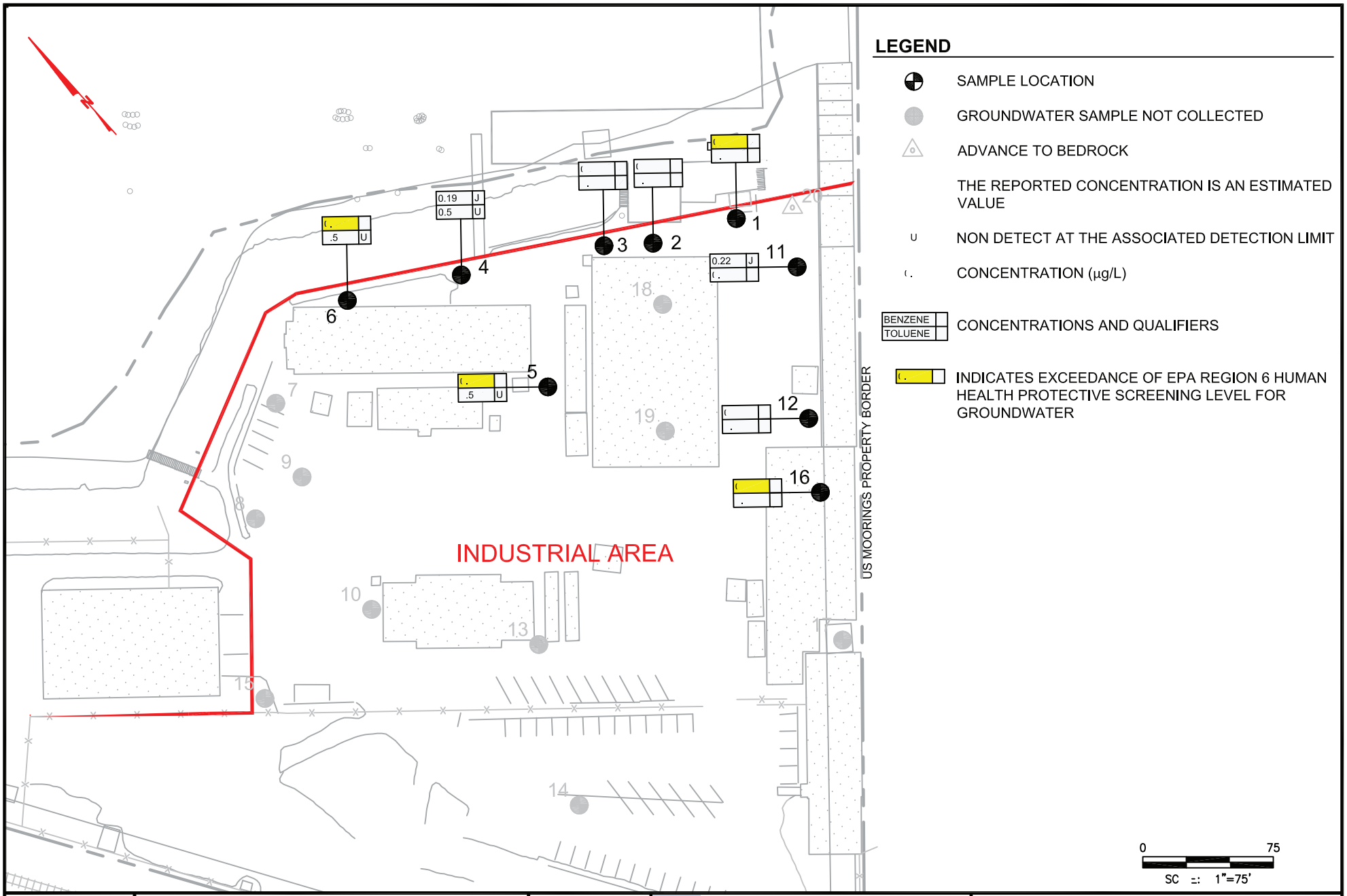
Analyte	Borehole									
	16	12	11	1	2	3	4	6	5	20
Metals, continued										
Cadmium	2.17	1.22	20.9	0.16	0.023	-	0.039	0.017	0.019	-
Chromium, T	7.07	4.3	100	2.03	3.63	0.24	0.65	0.77	1.56	-
Copper	2.66	11.1	108	1.54	4.04	0.2	1.8	0.63	0.99	1.5
Lead	14.1	1.51	92.3	3.28	2.51	0.042	0.04	0.105	0.154 J	0.146
Manganese	804	210	1,770	1,180	478	893	545	875	476	12,000
Mercury	-	-	0.07	-	-	-	-	-	-	-
Nickel	71.5	54.1	212	153	25.4	2.55	8.3	5.88	17.4	2.12
Selenium	1.1	-	-	0.3	-	-	-	-	-	-
Silver	-	-	0.269	-	-	-	-	-	-	-
Zinc	1,250	3,250	5,510	3,580	281	10.3	58.8	52.8	121	33.4
Aluminum, D	7,860	3,840	10,500	6,210	236	170	4,160	137	2,640	2.6
Antimony, D	0.13	0.18	0.04	0.03	0.05	0.05	-	0.02	0.03	-
Arsenic, D	0.525	0.206	0.912	1.02	1.1	0.431	0.035	0.155	0.577	4.71
Metals, continued										
Cadmium, D	2	1.18	1.92	0.153	-	0.009	0.037	0.01	0.02	-
Chromium, D	7.17	3.18	5.15	1.69	0.37	0.54	0.62	0.34	1.08	-
Copper, D	0.74	0.4	0.43	1.1	0.2	0.43	1.77	0.18	0.56	0.8
Lead, D	11.5	1.49	1.96	2.66	0.026	0.335	0.174	0.018	0.022	0.028
Manganese, D	828	221	1530	1,190	456	899	538	870	440	12,000
Mercury, D	-	-	-	-	-	0.2	-	-	-	-
Nickel, D	76.6	51.7	72.7	145	11.7	2.61	8.1	5.35	16.4	2.12
Selenium, D	0.4	-	-	-	-	-	-	-	-	-
Silver, D	0.004	0.003	0.006	0.027	-	-	-	-	-	-
Zinc, D	1130	3120	3340	3550	200	10.6	59.9	55.3	114	31
TPH										
TPH-Diesel	13 J	-	13 J	-	-	-	-	-	-	-
TPH-Motor Oil	-	-	-	21 J	-	-	-	-	-	-

Notes:
T Total, D Dissolved
[1] See Table 6-8 for additional Cyanide analysis
- Not Detected or Not Analyzed; A complete list of all analytical results is included in Appendix A, Table 1-c.

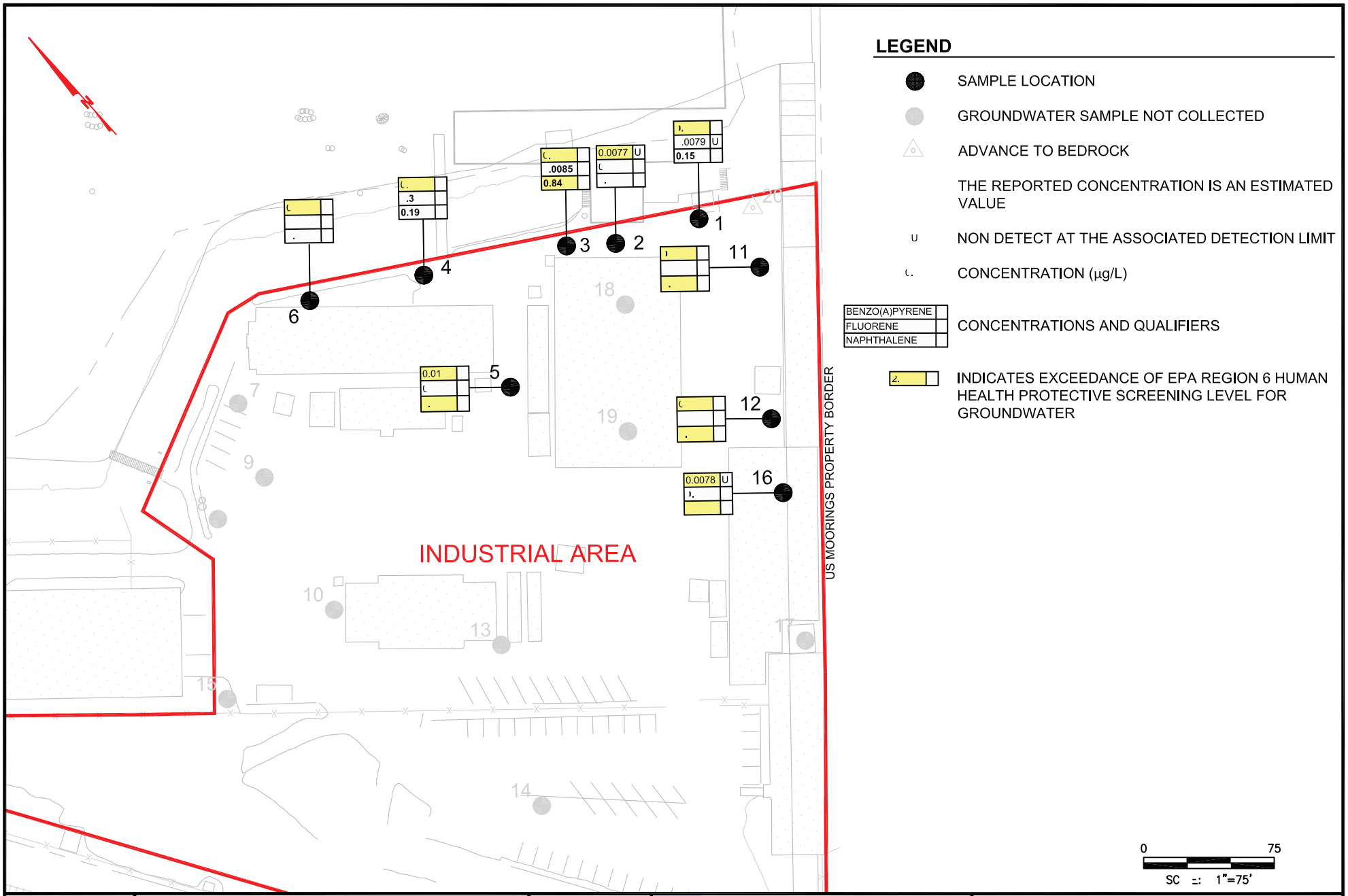
Table 5-8 Summary of Contingency Sample Cyanide Detections (µg/L)

	Sample	GW-21	GW-22	GW-23	GW-24	GW-25	GW 26	GW-27	GW-28	GW-30	GW-31
	Method										
Cyanide (WAD)	4500-CN-1	26	51.5	-	-	13.2	37.8	19.3	-	-	-
Cyanide (Free)	9213	-	-	-	-	-	-	199	-	-	-
Cyanide (total)	EPA 335.4	322	2,320	71	-	180	363	597	30.4	481 *J*	-
Cyanide (WAD)	OIA 1677	18.6	22.5	-	-	-	20.1	11.2	-	-	-
Cyanide (amemable)	SM 4500 CN G	360	2020	57.8	32.2	372	503	255	19.3	70.5	107

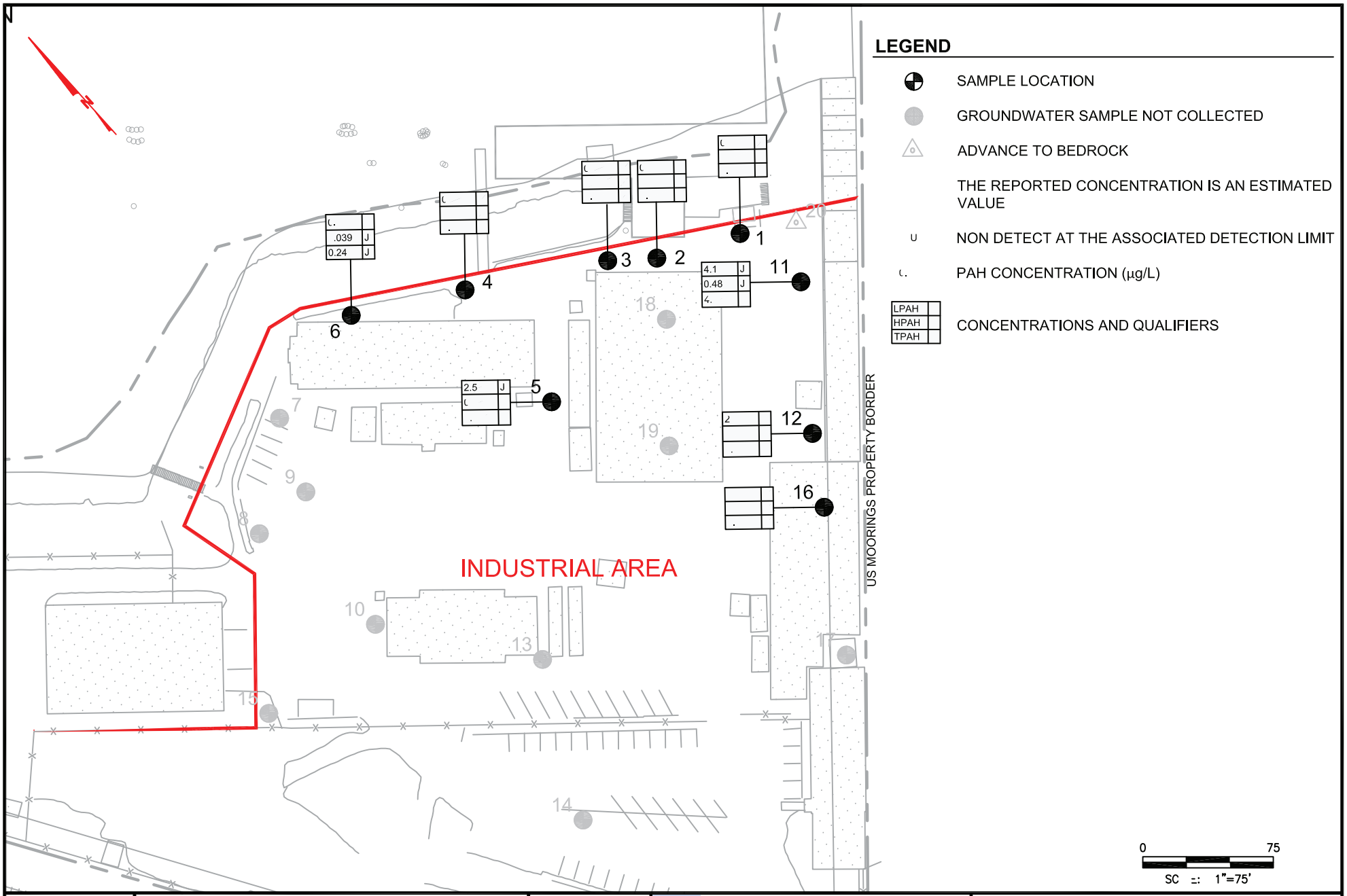
Notes
- Not Detected or Not Analyzed; A complete list of all analytical results is included in Appendix A, Table 1-c.



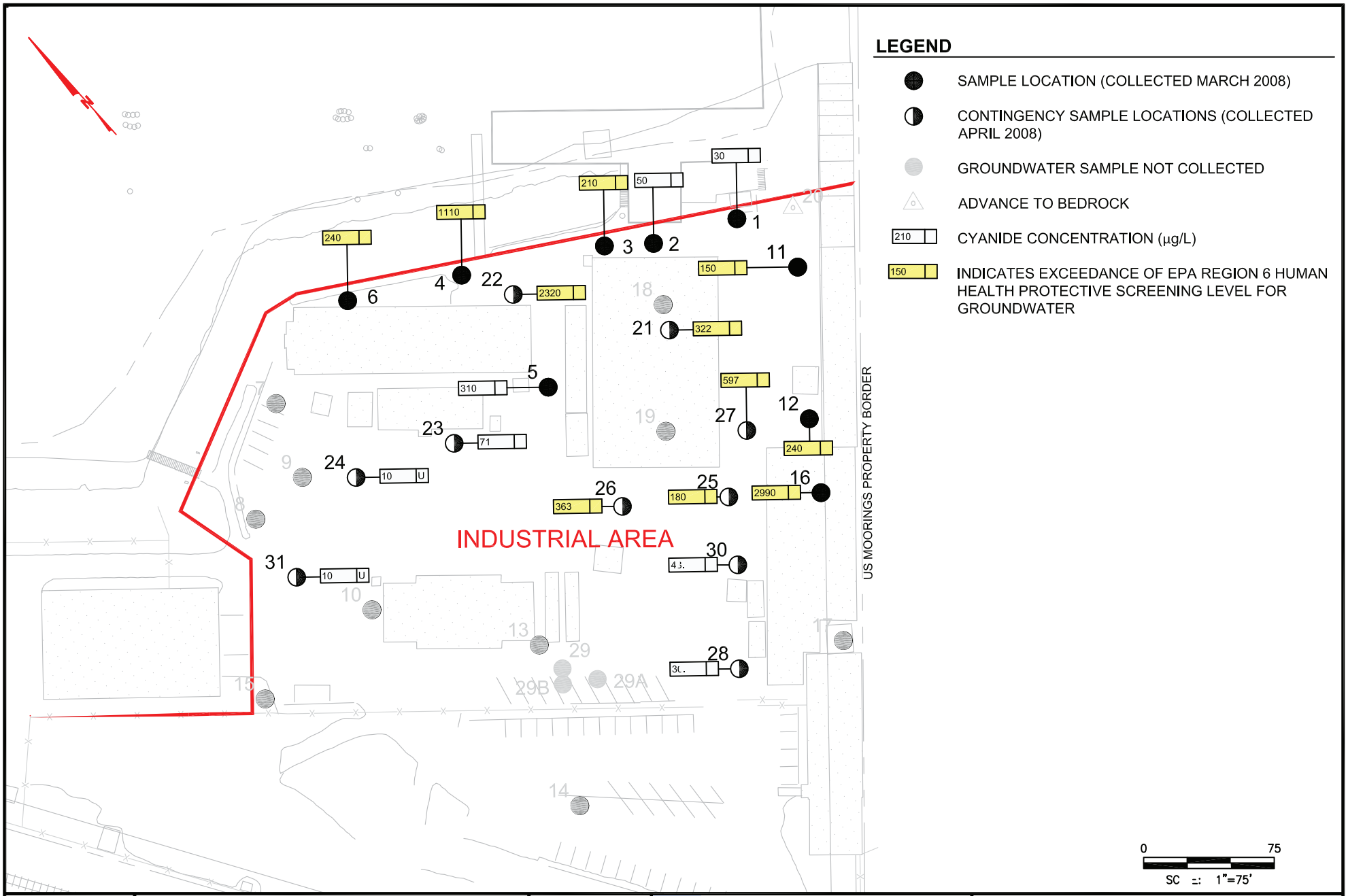
FI -	INDUSTRIAL AREA BENZENE AND TOLUENE CONCENTRATIONS IN GROUNDWATER	DAT : DRAWN: CHECKE :	TEC inc 1450 114th Ave llevue, Wa 98004 42	ENT MOORINGS REMEDIAL INVESTIGATION



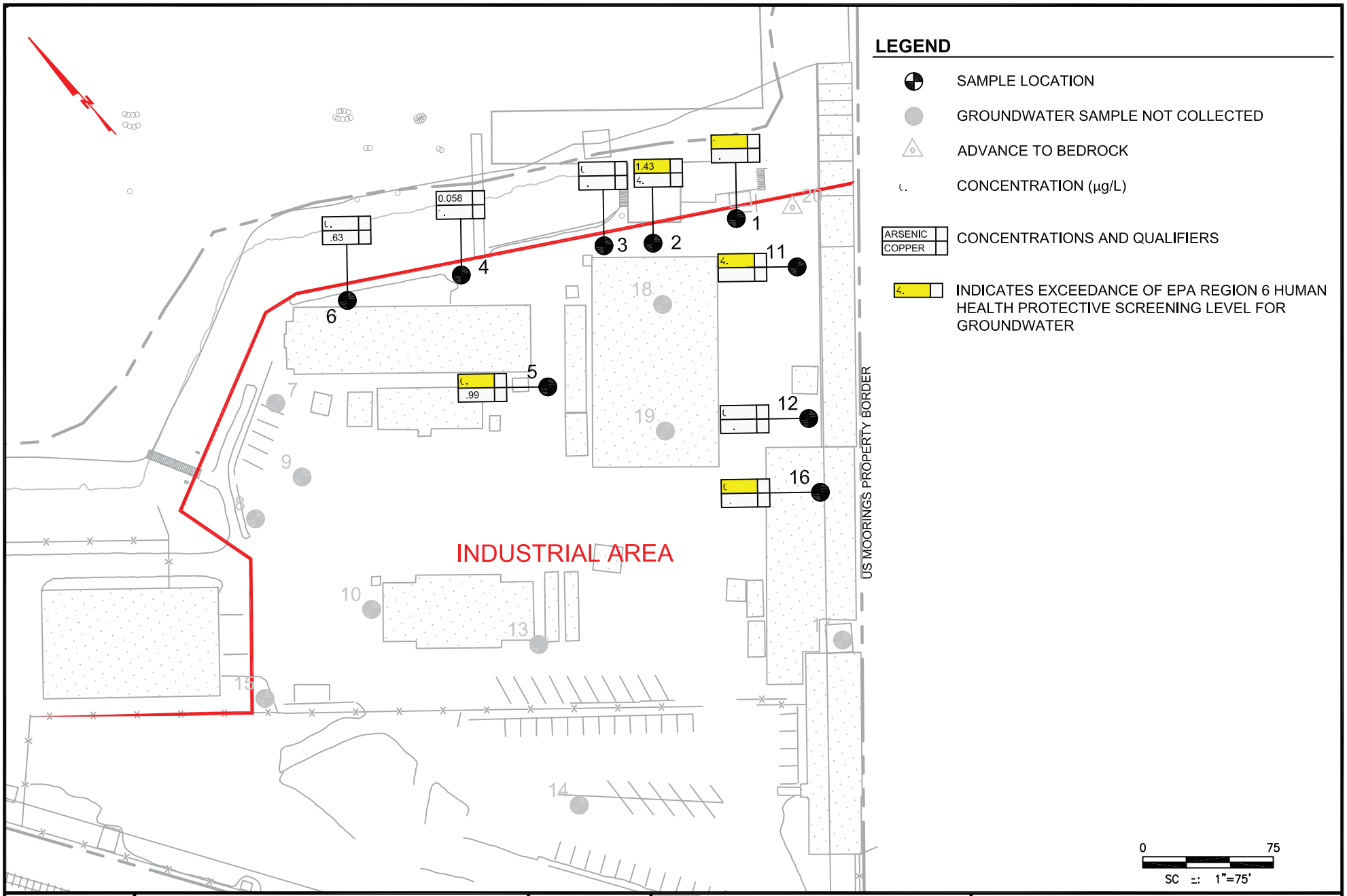
Fi -	INDUSTRIAL AREA BENZO(A)PYRENE, FLUORENE AND NAPHTHALENE CONCENTRATIONS IN GROUNDWATER	DAT : DRAWN: CHECKE):	TEC inc 1450 114th Ave llevue, Wa 98004 42	ENT MOORINGS REMEDIAL INVESTIGATION



FI -	INDUSTRIAL AREA TPAH CONCENTRATIONS IN GROUNDWATER	DAT : DRAWN: CHECKE :	TEC inc 1450 114th Ave llevue, Wa 98004 42	ENT MOORINGS REMEDIAL INVESTIGATION



FI -	INDUSTRIAL AREA TOTAL CYANIDE CONCENTRATIONS IN GROUNDWATER	DAT : DRAWN: CHECKE):	TEC inc 1450 114th Ave llevue, Wa 98004 425	ENT MOORINGS REMEDIAL INVESTIGATION



FI -	INDUSTRIAL AREA ARSENIC AND COPPER CONCENTRATIONS IN GROUNDWATER	DAT : DRAWN: CHECKE :	TEC inc 1450 114th Ave llevue, Wa 98004 42	ENT MOORINGS REMEDIAL INVESTIGATION

5.1.4 Upland Surface Water Sample Results

Upland surface water samples were collected at three locations to determine if surface water flowing off site was contributing to the contamination in the Willamette River: an ODOT outfall located just west of Building 20, the French drain, and a flowing seep along the riprap wall slightly south of the ODOT outfall number 14. Although the seep is most likely groundwater, results of this sample are discussed in this section because the method used to collect the sample was the same as used for the other surface water samples. Sampling locations are identified on Figure 4-8 (page 4-47).

The surface water samples were analyzed for PAHs, other SVOCs, PCBs, pesticides, metals, and TPHs. Table 5-9 (page 5-52) presents a summary of the analytical results. Appendix A, Table 1-d provides a complete listing the data.

In general, PAHs, metals, and dissolved metals were detected in all three samples. The following subsections highlight the key findings within each analyte group. Consistent with the earlier discussions, the most frequently detected analytes and their respective concentration ranges are identified, as well as analytes detected in concentrations that exceeded screening criteria.

5.1.4.1 PAHs

All three samples exhibited detectable concentrations of between four and 16 PAHs. The most frequently detected compounds included:

- Benzo(b)fluoranthene – Three of 3 samples at concentrations ranging from 0.0028 µg/L to 0.04 µg/L. Two concentrations exceeded the screening criteria.
- Benzo(a)pyrene – Two of 3 samples at concentrations of 0.023 µg/L and 0.031 µg/L. Both concentrations exceeded the screening criteria.
- Chrysene, indeno(1,2,3-cd)pyrene and dibenz(a,h)anthracene – Two of 3 samples each at concentrations that exceed the screening criteria.
- Benzo(a)anthracene – One of 3 samples at a concentration that exceeded the screening criteria.

All exceedances of screening criteria occurred in the Seep and French drain samples.

5.1.4.2 Non-PAH SVOCs

Two of the three samples had detections of non-PAH SVOCs. Benzyl alcohol was detected in two samples at concentrations of 0.08 µg/L and 0.22 µg/L. Benzoic acid, di-n-butyl phthalate, diethyl phthalate, and butyl benzyl phthalate were detected in one sample each.

None of the detected concentrations of non-PAH SVOCs exceed the screening criteria.

5.1.4.3 PCBs

No PCBs were detected in the surface water samples.

5.1.4.3 Pesticides

Two of the three samples had detectable concentrations of one or more of the seven tested pesticides. All detections that exceeded screening criteria were in the Seep sample:

- Aldrin was detected at a concentration of 0.00015 µg/L.
- 4'4-DDE was detected at a concentration of 0.00031 µg/L.
- 4'4-DDT was detected at a concentration of 0.0019 µg/L.

5.1.4.4 Metals

All three samples had detectable concentrations of at least nine metals. All three also contained metals at concentrations that exceeded screening criteria.

- Arsenic was detected in all three samples at concentrations ranging from 0.16 µg/L to 0.58 µg/L. All three concentrations exceeded the screening criteria.
- Aluminum was detected in all three samples at concentrations ranging from 132 µg/L to 832 µg/L. Two of the 3 concentrations exceeded the screening criteria.
- Lead was detected in all three samples at concentrations ranging from 1.09 µg/L to 4.05 µg/L. All three concentrations exceeded the screening criteria.
- Copper was detected in two samples at concentrations ranging from 2.66 µg/L to 10.6 µg/L. Two of the three concentrations exceeded the screening criteria.

5.1.4.5 Dissolved Metals

All three samples had detectable concentrations of at least eight dissolved metals. All three also contained dissolved metals at concentrations that exceeded screening criteria.

- Arsenic was detected in all three samples at concentrations ranging from 0.08 µg/L to 0.60 µg/L. All three concentrations exceeded the screening criteria.
- Aluminum was detected in all three samples at concentrations ranging from 30.8 µg/L to 374 µg/L. One of the 3 concentrations exceeded the screening criteria.
- Copper was detected in all three samples at concentrations ranging from 1.36 µg/L to 9.85 µg/L. One of the 3 concentration exceeded the screening criteria.

5.1.4.6 Total Petroleum Hydrocarbons

One of the three samples (the French Drain) had detectable concentrations of TPH compounds. TPH-Diesel was detected at a concentration of 41 µg/L. TPH-Motor Oil was detected at a concentration of 170 µg/L.

Table 5-9 Summary of Upland Surface Water Detects (µg/L)

	French Drain	ODOT Outfall	Seep
SVOC			
Benzyl Alcohol	0.08 J	-	0.22 J
Benzoic Acid	1.3 J	-	-
Diethyl Phthalate	-	-	0.2 J
di-n-butyl Phthalate	-	-	0.2 *J*
butyl Benzyl Phthalate	-	-	0.2 *J*
PAH			
2-Methylnaphthalene	0.0041 J	0.0028 J	-
1-Methylnaphthalene	0.0045 J	-	-
Acenaphthylene	-	-	0.005 J
Acenaphthene	0.017	0.0069 J	-
Fluorene	0.0089	-	-
Dibenzofuran	0.0049 J	-	-
Anthracene	0.011	-	0.0045 J
Fluoranthene	0.049	-	0.034
Pyrene	0.051	0.0052 J	0.049
Benzo(a)anthracene	0.017	-	0.021
Chrysene	0.025	-	0.027
Benzo(b)fluoranthene	0.03	0.0028 J	0.04
Benzo(k)fluoranthene	0.0097	-	0.013
Benzo(a)pyrene	0.023	-	0.031
Indeno(1,2,3-cd)pyrene	0.018	-	0.036
Dibenz(a,h)anthracene	0.0036 J	-	0.0048 J
Benzo(g,h,i)perylene	0.022	-	0.039
Pesticides			
Aldrin	-	-	0.00015 J
4'4-DDE	-	-	0.00031 J
Endrin Aldehyde	0.00042 J	-	-
4'4-DDT	-	-	0.0019 *J*
Total DDE	-	-	0.00031 J
Total DDT	-	-	0.0019 J
Total DDx	-	-	0.00221 J
Metals			
Aluminum (pH 6.5-9.0)	832	132	679
Antimony	0.19	0.26	0.11
Arsenic	0.16	0.58	0.22
Cadmium	0.038	0.017	-
Chromium, total	-	-	2.1
Copper	2.66	10.6	3.12
Lead	2.03	1.09	4.05
Manganese	27	2.23	17.5
Nickel	1	0.7	0.84
Selenium	0.2	0.6	-
Zinc	13.8	2.42	4.62
Dissolved Metals			
Aluminum, Dissolved	374	30.8	34.8
Antimony, Dissolved	0.2	0.24	0.38

Table 5-9 Summary of Upland Surface Water Detects (µg/L)

	French Drain	ODOT Outfall	Seep
Dissolved Metals, continued			
Arsenic, Dissolved	0.14	0.6	0.08
Cadmium, Dissolved	0.056	-	-
Chromium, Dissolved	-	-	0.39
Copper, Dissolved	1.59	9.85	1.36
Lead, Dissolved	0.486	0.3	0.113
Manganese, Dissolved	37.6	1.58	0.95
Nickel, Dissolved	0.91	0.8	0.42
Selenium, Dissolved	-	0.6	-
Zinc, Dissolved	9.11	-	6.18
TPH			
TPH-Diesel	41 J	-	-
TPH-Motor Oil	170 J	-	-

Notes
- Not Detected or Not Analyzed
J – Estimated concentration
A complete list of all analytical results is included in Appendix A, Table 1-d.

5.1.5 Upland Sediment Sample Results

Upland sediment samples were collected from the ODOT catch basin, the Drywell and the Runoff sample. The sampling locations are identified on Figure 4-8 (page 4-47).

Table 5-10 (page 5-55) presents a summary of detects for the upland sediment samples. A complete list of all analytical results is included in Appendix A, Table 1-d. In general, the upland sediment samples were the most contaminated of the upland samples collected on site, exhibiting relatively higher concentrations of PAHs and metals than other upland samples.

5.1.5.1 PAHs

All three samples had detectable concentrations of at least 19 PAHs. In general, PAHs concentrations were greatest in the Drywell sample. Detected concentrations of fluoranthene, pyrene, benzo(a)anthracene, chrysene, indeno(1,2,3-cd)pyrene and benzo(g,h,i)perylene exceeded the screening criteria in the Drywell and Runoff samples. None of the detected concentrations of PAHs in the ODOT catch basin sample exceeded the screening criteria.

5.1.5.2 Non-PAH SVOCs

At least one non-PAH SVOC was detected in each of the three samples.

- bis(2-Ethylhexyl)phthalate was detected in all three samples at concentrations ranging from 210 µg/kg to 9200 µg/kg. The concentration in one sample exceeded the screening criteria
- Di-n-butylphthalate was detected in the one sample at a concentration of 350 µg/kg, which exceeded the screening criteria.
- Eleven non-PAH SVOCs were detected in the Drywell sample. All 11 were detected at concentrations that exceeded the screening criteria.

5.1.5.3 PCBs

At least two PCBs were detected in all three samples. The concentration of total PCBs ranged from 9.8 µg/kg to 1,600 µg/kg. Total PCB concentrations exceeded screening criteria in all three samples. Aroclor® 1248 was detected in the Runoff sample at a concentration of 1,600 µg/kg, which exceeded the screening criteria.

5.1.5.4 Pesticides

Four pesticides were detected in the Runoff sample and nine were detected in the ODOT catch basin sample. Pesticides were not analyzed in the Drywell sample.

- Total DDx exceeded the screening criteria in both samples.
- The 2,4'- and 4,4'- isomers of DDT were detected in both samples at concentrations ranging from 0.56 µg/kg to 23 µg/kg. The sum of the isomers exceeded the screening criteria for total DDT in both samples.
- Detected concentrations of chlordane, total DDD, and total endosulfan exceeded the screening criteria in one sample.

5.1.5.5 Metals

All three samples had detectable concentrations of twelve of the 13 metals.

- Lead was detected in all three samples at concentrations ranging from 30.3 µg/kg to 761,000 µg/kg. All three sample concentrations exceeded the screening criteria.
- Zinc was detected in all three samples at concentrations ranging from 119 µg/kg to 3,760,000 µg/kg. Two of the 3 sample concentrations exceeded the screening criteria.
- Nickel was detected in all three samples at concentrations ranging from 13.3 µg/kg to 162,000 µg/kg. Two of the 3 sample concentrations exceeded the screening criteria.
- Cadmium was detected in two samples at concentrations that exceeded the screening criteria.
- Arsenic, copper, manganese and mercury were each detected one time at a concentration that exceeded the screening criteria.

5.1.5.6 Organobutyltins

Organobutyltins were only analyzed for in the ODOT catch basin sample. No organobutyltins were detected.

5.1.5.7 TPHs

Both TPH-Diesel and TPH-Motor Oil were detected in all three samples. TPH-Diesel was detected at concentrations ranging from 37,000 µg/kg to 790,000 µg/kg. TPH-Motor Oil was detected at concentrations ranging from 370,000 µg/kg to 4,500,000 µg/kg.

Table 5-10 Summary of Upland Sediment Detections (µg/kg)

Analyte	ODOT	Drywell	North Logistics Runoff
PAH			
Naphthalene	1.4 J	290	26
2-Methylnaphthalene	1 J	190	15
1-Methylnaphthalene	0.78 J	91	9.6
Acenaphthylene	1.1 J	67	17
Acenaphthene	3	850	110
Fluorene	1.5 J	490	55
Dibenzofuran	0.8 J	330	34
Phenanthrene	22	6,300	930
Anthracene	5.5	1,000	150
Fluoranthene	52	15,000	2,500
Pyrene	63	15,000	2,600
Benzo(b)fluoranthene	80	19,000	3,400
Benzo(k)fluoranthene	21	6,600	1,200
Benzo(a)anthracene	35	10,000	1,700
Chrysene	36	12,000	2,100
Benzo(a)pyrene	62	15,000	2,700
Indeno(1,2,3-cd)pyrene	67	11,000	2,200
Dibenz(a,h)anthracene	13	2,800	550
Benzo(g,h,i)perylene	72	10,000	2,000
Other SVOC			
Pentachlorophenol	2.3	-	21
Phenol	-	510 J	-
benzyl alcohol	-	2400	-
benzyl acid	-	2,600 J	-
dimethyl Phthalate	-	120 J	-
4-Chlorophenyl-phenyl ether	-	38 J	-
diethyl Phthalate	-	60 J	-
N-nitrosodiphenylamine	-	140 J	41 J
carbazole	-	580	150
di-n-butyl Phthalate	-	350	
butyl Benzyl Phthalate	-	260	41
bis(2-Ethylhexyl) phthalate	760	9,200	210
PCB			
Aroclor® 1242	1.2 J	-	-
Aroclor® 1248	-	-	1,600
Aroclor® 1254	3.8 J	130	-
Aroclor® 1260	4.8	150	-
Pesticides			
Hexachlorobenzene	0.12 J	-	-
y-BHC	-	-	2.4
Heptachlor epoxide	0.12 J	-	-
gamma-Chlordane	0.32 J	-	-
alpha-Chlordane	0.082 J	-	-

Table 5-10 Summary of Upland Sediment Detections (µg/kg)

Analyte	ODOT	Drywell	North Logistics Runoff
Endosulfan sulfate	0.091 J	-	1.4 J
Pesticides, continued			
endrin ketone	-	-	1.1 J
4,4'-DDE	0.14 J	-	-
4,4'-DDD	0.1 J	-	-
2,4'-DDT	0.56 J	-	-
4,4'-DDT	1.1	-	23
Cyanide			
Cyanide (total)	-	3500	-
Metals			
Aluminum	1.18E+07	1.43E+07	1.38E+07
Antimony	270	3,380	1,050
Arsenic	2,950	6,970	5,270
Cadmium	325 J	8,280	2,190
Chromium, total	84,600	369,000	76,600
Copper	23,300	3.65E+06	377,000
Lead	30,300 J	761,000	340,000
Manganese	1.00E+06	764,000	1.23E+06
Mercury	15	157	112
Nickel	13,300	162,000	50,400
Selenium	-	-	100 J
Silver	160	1,100	249
Zinc	119	3.76E+06	749,000
TPH			
TPH-Diesel	37,000	790,000	49,000
TPH-Motor Oil	370,000	4,500,00	380,000

Notes:
- Not Detected or Not Analyzed
J – Estimated concentration
A complete list of all analytical results is included in Appendix A, Table 1-d.

5.1.6 In-Water Sediment Sampling Results

The in-water sediment sampling effort was organized into six areas near the Moorings shore, (refer to Section 4.4, page 4-55, for a detailed description of the Willamette River sampling event). In general, the highest levels of COPCs were observed in surface sediments at the upstream (south) portion of the site, grading to lower concentrations in down gradient and deeper sediments. The major chemicals of concern observed throughout the site include PAHs, PCBs, cyanide (total), metals, organobutyltins, and TPHs. Table 5-11 (page 5-71) summarizes the in-water sediment detects. A complete list of all analytical results is included in Appendix A, Table 1-e.

Sample results collected from the Willamette River are presented first by chemical group then by sample area. The discussion begins with stations located along the upstream gradient and continues to stations located along the downstream gradient. The discussion is not subdivided into depth horizons as is the case in the discussion of the Upland Soil results because of the

inconsistency in the ranges of depths that the samples were collected. However, in some sample areas there is a correlation between sample depth and detected concentration and these cases are acknowledged throughout the discussion.

Similar to the previous discussions, the subsections discussing VOCs, non-PAH SVOCs, PCBs, pesticides, organobutyltins and TPHs identify the detected concentration ranges of the four most frequently detected analytes in each chemical group for each sampling area. Aside from the most frequently detected analytes, the remaining frequency of detections are identified and detected analytes and concentration ranges can be found in Table 5-11 (page 5-71).

Since metals and PAHs are so frequently detected on the site, the subsections are organized differently. The PAH sections identify the detected concentration ranges of LPAH, HPAH, TPAH and benzo(a)pyrene (for a detailed description of LPAH, HPAH and TPAH refer to Section 5.1.1.2, page 5-4). The metals sections identify the detected concentration ranges of the COPC analytes found in the Upland Area, arsenic, copper and lead. All figures can be found at the end of this section. In-water samples were not screened in any horizon.

5.1.6.1 VOCs

VOCs had detectable concentrations sporadically throughout the Under Dock and the Bulkhead samples and one VOC was detected in one sample in Dredge Area A. Of the 15 different VOC analytes with detectable concentrations in the in-water sediment samples, carbon disulfide was the most frequently, detected in 16 samples of the 30 samples taken from the Under Dock and Bulkhead sampling areas.

Under Dock Area. Fifteen of the 16 samples collected in this area had detectable concentrations of VOCs.

- Carbon disulfide was detected in 11 samples at concentrations ranging from 0.098 µg/kg to 1.7 µg/kg.
- 2-Butanone was detected in 11 samples at concentrations ranging from 6.7 µg/kg to 18 µg/kg.
- Toluene was detected in ten samples at concentrations ranging from 0.38 µg/kg to 930 µg/kg.
- m,p-Xylene were detected in five samples and o-xylene and chloroform were detected in three samples each.
- Sample SDUD-2-3 had nine detected VOCs (the maximum number of VOCs detected in a single sample in this area).
- Forty-eight of the 53 detectable concentrations were subsurface detections and 33 were in the 1 to 12 foot horizon.

Bulkhead Area. Five of the fourteen samples collected in the Bulkhead Area had detectable concentrations of VOCs.

- Carbon disulfide was detected in five samples at concentrations ranging from 0.18 µg/kg to 0.27 µg/kg.
- Toluene was detected in two samples at concentrations ranging from 0.52 µg/kg to 11 µg/kg.

- Eight other VOC analytes were each detected once in the Bulkhead Area samples.
- All VOC detections in this area were along the eastern bulkhead, samples SD-BH-8-1 through SD-BH-16-1 had no VOC detections.

5.1.6.2 PAHs

PAHs were distributed across all locations throughout the In-water sediment samples. All 56 samples had detectable concentrations of at least seven PAHs. Forty-nine samples had detectable concentrations of all 19 PAHs; 11 samples in the Under Dock Area, ten samples in Dredge Area A, all six samples in Dredge Area B and Dredge Area C, all 14 samples along the Bulkhead and both samples near the ODOT outfall. Seven PAHs (naphthalene, 2-methyl naphthalene, 1-methylnaphthalene, acenaphthene, fluoranthene, pyrene, and perylene) were detected in all 56 samples.

Benzo(a)pyrene was detected in all 56 samples at concentrations ranging from 0.54 µg/kg to 39,000 µg/kg. Detected concentrations of benzo(a)pyrene are illustrated on Figure 5-15 (page 5-77). Detected LPAH, HPAH and TPAH concentrations are illustrated on Figure 5-16 (page 5-79). See Section 5.1.1.2 (page 5-4) for a detailed description of LPAH and HPAH totals.

Under Dock Area. All 16 samples had detectable concentrations of PAHs in this area.

- Seven of the 19 PAHs were detected in all 16 samples.
- All PAHs were detected in 11 samples in this area.
- Detectable concentrations of PAHs decreased significantly with depth in this sample area.
    - TPAH concentrations ranged from 27,875 µg/kg to 212,000 µg/kg in the 0 to 1 foot horizon; 528 µg/kg to 281,410 µg/kg in the 1 to 6 foot horizon, 100 µg/kg to 7,708 µg/kg in the 6 to 12 foot horizon; and from 36 µg/kg to 53 µg/kg in the 12 to 20 foot horizon.
    - LPAHs were detected at concentrations ranging from 16 µg/kg to 26,200 µg/kg.
    - HPAHs were detected at concentrations ranging from 16 µg/kg to 185,800 µg/kg.
- Benzo(a)pyrene was detected in 14 samples at concentrations ranging from 2.2 µg/kg to 21,000 µg/kg.

Dredge Area A. All 12 samples had detectable concentrations of PAHs in this area.

- Seventeen of the 19 PAHs were detected in all 12 samples.
- All PAHs were detected in ten samples in this area.
- Detectable concentrations of PAHs were significantly elevated in the 1 to 11 foot horizon in this sample area.
    - TPAH concentrations ranged from 34,350 µg/kg to 152,610 µg/kg in the 0 to 1 foot horizon; 89,340 µg/kg to 319,210 µg/kg in the 1 to 11 foot horizon; and from 287 µg/kg to 17,954 µg/kg in the 11 to 16 foot horizon.
    - LPAHs were detected at concentrations ranging from 46 µg/kg to 100,900 µg/kg.
    - HPAHs were detected at concentrations ranging from 16 µg/kg to 212,500 µg/kg.

- Benzo(a)pyrene was detected in all 12 samples at concentrations ranging from 0.54 µg/kg to 19,000 µg/kg.

Dredge Area B. All six samples had detectable concentrations of PAHs in this area.

- All 19 PAHs were detected in all six samples.
- PAH concentrations were greater in the deeper soil horizon at two of the three sample locations, in this sample area.
- LPAHs were detected at concentrations ranging from 432 µg/kg to 14,400 µg/kg.
- HPAHs were detected at concentrations ranging from 2,662 µg/kg to 45,350 µg/kg.
- Benzo(a)pyrene was detected in all six samples at concentrations ranging from 350 µg/kg to 3,900 µg/kg.

Dredge Area C. All six samples had detectable concentrations of PAHs in this area.

- All 19 PAHs were detected in all six samples.
- In general, LPAH concentrations were greatest in the 12 to 15 foot horizon.
- HPAH concentrations were greatest in the 12 to 15 foot horizon at two of the three sample locations and greatest in the 10 to 12 foot horizon for the third sample location, in this area.
- LPAHs were detected at concentrations ranging from 18,550 µg/kg to 279,700 µg/kg.
- HPAHs were detected at concentrations ranging from 36,890 µg/kg to 509,700 µg/kg.
- Benzo(a)pyrene was detected in all six samples at concentrations ranging from 2,600 µg/kg to 36,000 µg/kg.

Bulkhead. All 14 samples along the bulkhead had detectable concentrations of PAHs.

- All 19 PAHs were detected in all 14 samples.
- Considerably higher PAH concentrations were found in samples SD-DC-25-1 and SD-BH-4-1.
- LPAHs were detected at concentrations ranging from 272 µg/kg to 11,190 µg/kg.
- HPAHs were detected at concentrations ranging from 1,615 µg/kg to 387,400 µg/kg.
- Benzo(a)pyrene was detected in all 14 samples at concentrations ranging from 190 µg/kg to 39,000 µg/kg.

ODOT Outfall. Both samples taken near the ODOT Outfall had detectable concentrations of PAHs.

- All 19 PAHs were detected in both samples.
- LPAHs were detected at concentrations ranging from 257 µg/kg to 266 µg/kg.
- HPAHs were detected at concentrations ranging from 1,640 µg/kg to 1,951 µg/kg.
- Benzo(a)pyrene was detected in both samples at concentrations 210 µg/kg and 250 µg/kg.

5.1.6.3 Non-PAH SVOCs

Twenty-one non-PAH SVOCs were detected inconsistently at all locations throughout the In-water samples. Carbazole was the most frequently detected non-PAH SVOC for the In-water sediment sampling (51 of 56 samples). The second most frequently detected non-PAH SVOC was bis(2-ethylhexyl)phthalate (36 of 56 samples), and the third most frequently detected non-PAH SVOC was diethyl phthalate (17 of 56 samples). Samples taken along the bulkhead had the most detections of non-PAH SVOCs in comparison with the other areas.

Under Dock Area. Fifteen of 16 samples had detectable concentrations of non-PAH SVOCs in this area.

- Carbazole was detected in 11 samples at concentrations ranging from 1.6 µg/kg to 750 µg/kg.
- bis(2-Ethlyhexyl)phthalate was detected in eight samples at concentrations ranging from 7.7 µg/kg to 1,400 µg/kg.
- Diethyl phthalate was detected in four samples at concentrations ranging from 1.3 µg/kg to 2.2 µg/kg
- Pentachlorophenol was detected in four samples at concentrations ranging from 8.6 µg/kg to 24 µg/kg.
- 2,3,5,6-tetrachlorophenol was detected in three samples at concentrations ranging from 1.8 µg/kg to 3.6 µg/kg.
- Four other non-PAH SVOCs were detected in one or two samples each, in this area.

Dredge Area A. All 12 samples had detectable concentrations of non-PAH SVOCs in this area.

- Carbazole was detected in all 12 samples at concentrations ranging from 2.6 µg/kg to 2,200 µg/kg.
- Pentachlorophenol was detected in all six samples at concentrations ranging from 1.8 µg/kg to 11 µg/kg.
- bis(2-Ethlyhexyl)phthalate was detected in five samples at concentrations ranging from 16 µg/kg to 110 µg/kg.
- 4-Methylphenol was detected in five samples at concentrations ranging from and 2.5 µg/kg to 94 µg/kg.
- Diethyl phthalate was detected in four samples at concentrations ranging from 1.5 µg/kg to 9.9 µg/kg.
- Benzyl alcohol was detected in four samples at concentrations ranging from and 2.8 µg/kg to 9.9 µg/kg.
- Four other non-PAH SVOCs were detected along the bulkhead in one, two or three samples, each.
- Non-PAH SVOC concentrations in the 1 to 11 foot horizon were greater than the concentrations detected in the 0 to 1 foot and 11 to 16 foot horizon.

Dredge Area B. All six samples had detectable concentrations of non-PAH SVOCs in this area.

- Carbazole was detected in all six samples at concentrations ranging from 23 µg/kg to 380 µg/kg.
- bis(2-Ethlyhexyl)phthalate was detected in five samples at concentrations ranging from 34 µg/kg to 180 µg/kg.
- Pentachlorophenol was detected in four samples at concentrations ranging from 4.3 µg/kg to 17 µg/kg.
- 2,4,6-Trichlorophenol was detected in four samples at concentrations ranging from 0.32 µg/kg to 0.5 µg/kg.
- Four other non-PAH SVOCs were detected in this area in one sample each.

Dredge Area C. All six samples had detectable concentrations of non-PAH SVOCs in this area.

- Carbazole was detected in all six samples at concentrations ranging from 180 µg/kg to 4,600 µg/kg.
- Pentachlorophenol was detected in all six samples at concentrations ranging from 8.4 µg/kg to 410 µg/kg.
- 2,3,5,6-Tetrachlorophenol was detected in five samples at concentrations ranging from 0.89 µg/kg to 66 µg/kg.
- 2,4,6-Trichlorophenol was detected in five samples at concentrations ranging from 1.5 µg/kg to 34 µg/kg.
- bis(2-Ethlyhexyl)phthalate was detected in three samples at concentrations ranging from 56 µg/kg to 500 µg/kg.
- Two other non-PAH SVOCs were detected in this area in one sample each.

Bulkhead. All 14 samples had detectable concentrations of non-PAH SVOCs in this area.

- Carbazole was detected in all 14 samples at concentrations ranging from 5.9 µg/kg to 2,900 µg/kg.
- bis(2-Ethlyhexyl)phthalate was detected in 13 samples at concentrations ranging from 35 µg/kg to 240 µg/kg.
- Pentachlorophenol was detected in eight samples at concentrations ranging from 1 µg/kg to 72 µg/kg.
- Di-n-butyl phthalate was detected in eight samples at concentrations ranging from 8.7 µg/kg to 29 µg/kg.
- Benzoic acid was detected in seven samples at concentrations ranging from 120 µg/kg to 150 µg/kg.
- Four other non-PAH SVOCs were detected in this area in one, two or three samples each.

ODOT Outfall. Both samples had detectable concentrations of non-PAH SVOCs in this area.

- Carbazole was detected in both samples at concentrations ranging from 8.4 µg/kg to 18 µg/kg.
- bis(2-Ethlyhexyl)phthalate was detected in both samples at concentrations ranging from 40 µg/kg to 61 µg/kg.
- Di-n-butyl phthalate was detected in both samples each at concentrations ranging from 11 µg/kg to 12 µg/kg.
- Butyl benzyl phthalate was detected in both samples at concentrations ranging from 5.4 µg/kg to 11 µg/kg.
- Three other non-PAH SVOCs were detected in this area in one sample each.

5.1.6.4 PCBs

Four PCBs were detected inconsistently at five of the six locations throughout the in-water samples. Aroclor® 1260 was the most frequently detected PCB in the in-water sampling in 26 of 56 samples. Aroclor® 1254 was the second most frequently detected PCB, (20 of 56 samples). Samples taken along the bulkhead had the most detections of PCBs in comparison with the other areas. No PCBs were detected in the Under Dock Area. The highest concentrations of total PCBs were found in the samples collected from Dredge Areas B and C. Locations and concentrations of total PCBs are illustrated on Figure 5-17 (page 5-81).

Under Dock Area. No PCBs were detected in this area.

Dredge Area A. Five of 12 samples had detectable concentrations of PCBs in this area.

- Aroclor® 1260 was detected in five samples at concentrations ranging from 4.3 µg/kg to 70 µg/kg.
- Aroclor® 1254 was detected in two samples at concentrations ranging from 9.9 µg/kg to 31 µg/kg.
- Aroclor® 1242 (12 µg/kg) was detected in one sample.
- Calculated total PCBs ranged from 6.3 µg/kg to 70 µg/kg, in this area.
- PCBs were only detected in the 0 to 1 foot and 1 to 11 foot horizon in this area and were greatest in the 1 to 11 foot horizon.

Dredge Area B. Four of six samples had detectable concentrations of PCBs in this area.

- Aroclor® 1260 was detected in four samples at concentrations ranging from 53 µg/kg to 74 µg/kg.
- Aroclor® 1254 was detected in four samples at concentrations ranging from 42 µg/kg to 110 µg/kg.
- Calculated total PCBs ranged from 95 µg/kg to 174 µg/kg, in this area.

Dredge Area C. Four of six samples had detectable concentrations of PCBs in this area.

- Aroclor® 1260 was detected in four samples at concentrations ranging from 25 µg/kg to 65 µg/kg.
- Aroclor® 1254 was detected in two samples at concentrations ranging from 56 µg/kg to 100 µg/kg.
- Calculated total PCBs ranged from 34 µg/kg to 134 µg/kg, in this area.

Bulkhead. All 14 samples had detectable concentrations of PCBs in this area.

- Aroclor® 1260 was detected in 21 samples at concentrations ranging from 2.9 µg/kg to 9 µg/kg.
- Aroclor® 1254 was detected in 18 samples at concentrations ranging from 4.3 µg/kg to 16 µg/kg.
- Aroclor® 1242 was detected in two samples at concentrations ranging from 3.8 µg/kg to 4.7 µg/kg.
- Aroclor® 1268 (6.3 µg/kg) was detected in one sample.
- Calculated total PCBs ranged from 4.3 µg/kg to 26.8 µg/kg, in this area.

ODOT Outfall. One sample had detectable concentrations of PCBs in this area.

- Aroclor® 1260 and Aroclor® 1254 were detected at concentrations of 3.3 µg/kg and 5.2 µg/kg, respectively.
- Calculated total PCBs were 8.5 µg/kg.

5.1.6.5 Pesticides

Thirty pesticides were detected inconsistently at all locations throughout the In-water samples. DDD isomers were the most frequently detected pesticide in the in-water sampling (in 45 of 56 samples). Chlordane isomers were the second most frequently detected pesticides, (in 35 of 56 samples). The next most frequently occurring detections were DDT and DDE isomers, detected in 31 and 30 samples, respectively.

Under Dock Area. Ten of 16 samples had detectable concentrations of pesticides in this area.

- Pesticides were detected in eight of the ten samples in the 0 to 6 foot horizon.
- DDD was detected in eight samples, the calculated total concentrations range from 0.087 µg/kg to 44 µg/kg.
- Chlordane was detected in seven samples, the calculated total concentrations range from 0.13 µg/kg to 2.4 µg/kg.
- DDT was detected in four samples, the calculated total concentrations range from 0.23 µg/kg to 50 µg/kg.
- DDE was detected in three samples, the calculated total concentrations range from 0.47 µg/kg to 4.41 µg/kg.

Dredge Area A. All 12 samples had detectable concentrations of pesticides in this area.

- Pesticide concentrations were greatest in the 1 to 11 foot horizon.
- DDD was detected in nine samples, the calculated total concentrations range from 0.1 µg/kg to 330 µg/kg.
- DDT was detected in seven samples, the calculated total concentrations range from 2.72 µg/kg to 54 µg/kg.
- Chlordane was detected in five samples, the calculated total concentrations range from 0.11 µg/kg to 10.3 µg/kg.
- DDE was detected in three samples, the calculated total concentrations range from 2.2 µg/kg to 15 µg/kg.

Dredge Area B. All six samples had detectable concentrations of pesticides in this area.

- DDD was detected in all six samples, the calculated total concentrations range from 15.7 µg/kg to 82 µg/kg.
- DDT was detected in all six samples, the calculated total concentrations range from 3.9 µg/kg to 62 µg/kg.
- DDE was detected in all six samples, the calculated total concentrations range from 5.7 µg/kg to 29 µg/kg.
- Chlordane was detected in four samples, the calculated total concentrations range from 0.72 µg/kg to 3.1 µg/kg.

Dredge Area C. All six samples had detectable concentrations of pesticides in this area.

- DDD was detected in all six samples, the calculated total concentrations range from 24.5 µg/kg to 353.9 µg/kg.
- DDE was detected in three samples, the calculated total concentrations range from 4.5 µg/kg to 30 µg/kg.
- Chlordane was detected in three samples, the calculated total concentrations range from 7.4 µg/kg to 220 µg/kg.
- DDT was detected in one sample, the calculated total was 180 µg/kg.

Bulkhead. All 14 samples had detectable concentrations of pesticides in this area.

- DDD was detected in all 14 samples, the calculated total concentrations range from 2.9 µg/kg to 499 µg/kg.
- DDE was detected in 13 samples, the calculated total concentrations range from 1.4 µg/kg to 2.8 µg/kg.
- Chlordane was detected in 13 samples, the calculated total concentrations range from 0.33 µg/kg to 19 µg/kg.
- DDT was detected in 12 samples, the calculated total concentrations range from 1.3 µg/kg to 220.7 µg/kg.

ODOT Outfall. Both samples had detectable concentrations of pesticides in this area.

- DDD was detected in both samples, the calculated total concentrations range from 2.52 µg/kg to 19.4 µg/kg.
- DDE was detected in both samples, the calculated total concentrations range from 1.4 µg/kg to 8.5 µg/kg.
- Chlordane was detected in both samples, the calculated total concentrations range from 0.53 µg/kg to 2.9 µg/kg.
- DDT was detected in both samples, the calculated total concentrations range from 1.47 µg/kg to 30.7 µg/kg.

5.1.6.6 Metals

Thirteen metals were detected at all locations throughout the In-water samples. Five samples had detectable concentrations of all 13 metals. Mercury, selenium and silver were the only metals that were not detected in all 56 samples. Copper was detected in all 56 samples at concentrations ranging from 18,700 µg/kg to 208,000 µg/kg. Locations and concentrations of copper are illustrated on Figure 5-19 (page 5-85). The results for arsenic, copper, and lead are detailed in the following discussion as they are the metals that pose the greatest concern on site.

Under Dock Area. All 16 samples had detectable concentrations of at least ten metals in this area.

- Largest concentrations of metals in this area are at the surface, and tend to decrease with depth.
- Arsenic was detected in all 16 samples at concentrations ranging from 1,880 µg/kg to 13,800 µg/kg.
- Copper was detected in all 16 samples at concentrations ranging from 21,300 µg/kg to 94,600 µg/kg.
- Lead was detected in all 16 samples at concentrations ranging from 3,100 µg/kg to 61,200 µg/kg.

Dredge Area A. All 12 samples had detectable concentrations of at least ten metals in this area.

- Detectable concentrations are significantly higher in the 0 to 7 foot horizon in comparison with the 7 to 12 foot horizon.
- Arsenic was detected in all 12 samples at concentrations ranging from 1,900 µg/kg to 7,270 µg/kg.
- Copper was detected in all 12 samples at concentrations ranging from 18,700 µg/kg to 90,400 µg/kg.
- Lead was detected in all 12 samples at concentrations ranging from 2,900 µg/kg to 171,000 µg/kg.

Dredge Area B. All six samples had detectable concentrations of at least 12 metals in this area.

- Arsenic was detected in all six samples at concentrations ranging from 4,170 µg/kg to 6,520 µg/kg.
- Copper was detected in all six samples at concentrations ranging from 50,800 µg/kg to 83,500 µg/kg.
- Lead was detected in all six samples at concentrations ranging from 15,400 µg/kg to 87,800 µg/kg.

Dredge Area C. All six samples had detectable concentrations of at least 12 metals in this area.

- Arsenic was detected in all six samples at concentrations ranging from 3,930 µg/kg to 11,600 µg/kg.
- Copper was detected in all six samples at concentrations ranging from 56,300 µg/kg to 183,000 µg/kg.
- Lead was detected in all six samples at concentrations ranging from 38,400 µg/kg to 363,000 µg/kg.

Bulkhead. All 14 samples had detectable concentrations of at least 12 metals in this area.

- Arsenic was detected in all 14 samples at concentrations ranging from 2,800 µg/kg to 18,300 µg/kg.
- Copper was detected in all 14 samples at concentrations ranging from 39,600 µg/kg to 208,000 µg/kg.
- Lead was detected in all 14 samples at concentrations ranging from 11,600 µg/kg to 385,000 µg/kg.

ODOT Outfall. Both samples had detectable concentrations of at least 12 metals in this area.

- Arsenic was detected in both samples at concentrations ranging from 2,660 µg/kg to 4,540 µg/kg.
- Copper was detected in both samples at concentrations ranging from 42,900 µg/kg to 54,100 µg/kg.
- Lead was detected in both samples at concentrations ranging from 11,500 µg/kg to 17,900 µg/kg.

5.1.6.7 Organobutyltins

Four organobutyltins were detected inconsistently in 38 locations throughout the In-water samples. DBT was the most frequently detected organobutyltins in the in-water sampling, (in 36 of 56 samples). TBT was the second most frequently detected, (in 34 of 56 samples). Locations and concentrations of TBT are illustrated on Figure 5-20 (page 5-87). In general, organobutyltins were not detected in soil horizons greater than 12 feet.

Under Dock Area. Five of 16 samples had detectable concentrations of organobutyltins in this area.

- TBT was detected in five samples at concentrations ranging from 5.6 µg/kg to 180 µg/kg.
- DBT was detected in five samples at concentrations ranging from 2 µg/kg to 36 µg/kg.
- MBT was detected in five samples at concentrations ranging from 0.35 µg/kg to 2.8 µg/kg.
- All the organobutyltins detected in this area were in the shallow horizons, less than six feet bgs.

Dredge Area A. Eight of 14 samples had detectable concentrations of organobutyltins in this area.

- DBT was detected in seven samples at concentrations ranging from 0.41 µg/kg to 5.3 µg/kg.
- TBT was detected in five samples at concentrations ranging from 1.2 µg/kg to 10 µg/kg.
- MBT was detected in four samples at concentrations ranging from 0.42 µg/kg to 1.1 µg/kg.

Dredge Area B. Five of six samples had detectable concentrations of organobutyltins in this area.

- TBT was detected in five samples at concentrations ranging from 1.8 µg/kg to 120 µg/kg.
- DBT was detected in five samples at concentrations ranging from 0.97 µg/kg to 42 µg/kg.
- MBT was detected in three samples at concentrations ranging from 1.1 µg/kg to 7.4 µg/kg.

Dredge Area C. Four of six samples had detectable concentrations of organobutyltins in this area.

- TBT was detected in three samples at concentrations ranging from 2.3 µg/kg to 390 µg/kg.
- DBT was detected in three samples at concentrations ranging from 0.64 µg/kg to 60 µg/kg.
- MBT was detected in two samples at concentrations ranging from 1.7 µg/kg to 6.3 µg/kg.
- Tetrabutyltin was detected in two samples at concentrations ranging from 0.65 µg/kg to 0.87 µg/kg.

Bulkhead. All 14 samples had detectable concentrations of organobutyltins in this area.

- TBT was detected in all 14 samples at concentrations ranging from 0.55 µg/kg to 830 µg/kg.
- DBT was detected in all 14 samples at concentrations ranging from 0.69 µg/kg to 71 µg/kg.

- MBT was detected in 11 samples at concentrations ranging from 0.42 µg/kg to 2.1 µg/kg.
- Tetrabutyltin was detected in two samples at concentrations ranging from 2.2 µg/kg to 4.2 µg/kg.

ODOT Outfall. Both samples had detectable concentrations of organobutyltins in this area.

- TBT was detected in both samples at concentrations ranging from 0.72 µg/kg to 25 µg/kg.
- DBT was detected in both samples at concentrations ranging from 0.29 µg/kg to 9.7 µg/kg.
- MBT (0.29 µg/kg) was detected in one sample.

5.1.6.8 Cyanide (total)

Cyanide (total) was detected in 51 of 56 samples throughout the in-water sampling areas. Cyanide (total) concentrations ranged from 100 µg/kg to 1,410,000 µg/kg. Locations and concentrations of cyanide (total) are illustrated on Figure 5-18 (page 5-83). Cyanide(total) concentrations were generally highest in the shallow horizons.

Under Dock Area. Cyanide (total) was detected in 15 of 16 samples in the Under Dock sampling. Cyanide (total) concentrations ranged from 110 µg/kg to 19,600 µg/kg.

Dredge Area A. Cyanide (total) was detected in 11 of 12 samples in the Dredge Area A sampling. Cyanide (total) concentrations ranged from 100 µg/kg to 16,100 µg/kg.

Dredge Area B. Cyanide (total) was detected in all six samples in the Dredge Area B sampling. Cyanide (total) concentrations ranged from 750 µg/kg to 52,700 µg/kg.

Dredge Area C. Cyanide (total) was detected in all six samples in the Dredge Area C sampling. Cyanide (total) concentrations ranged from 9,300 µg/kg to 1,410,000 µg/kg.

Bulkhead. Cyanide (total) was detected in 12 of 14 samples along the bulkhead. Cyanide (total) concentrations ranged from 100 µg/kg to 39.400 µg/kg.

ODOT Outfall. Cyanide (total) (1,310 µg/kg) was detected in one sample collected in the ODOT outfall.

5.1.6.9 Total Petroleum Hydrocarbons

TPHs were detected inconsistently throughout all six of the in-water sampling locations. Fifty of 56 samples had detectable concentrations of TPHs. TPH-Motor Oil was the most frequently detected TPH in the in-water sampling, in 50 of 56 samples. TPH-Diesel was detected in 47 of 56 samples.

Under Dock Area. Thirteen of 16 samples had detectable concentrations of TPHs in the Under Dock area.

- TPH-Diesel was detected in ten samples at concentrations ranging from 2,800 µg/L to 590,000 µg/L.

- TPH-Motor Oil was detected in 13 samples at concentrations ranging from 6,600 µg/L to 680,000 µg/L.
- TPH concentrations tend to decrease with depth but were generally highest in the 1 to 11 foot horizon, in this area.

Dredge Area A. Nine of 12 samples had detectable concentrations of TPHs in Dredge Area A.

- TPH-Diesel was detected in nine samples at concentrations ranging from 2,100 µg/L to 1,000,000 µg/L.
- TPH-Motor Oil was detected in nine samples at concentrations ranging from 27,000 µg/L to 990,000 µg/L.
- TPH concentrations were highest in the 1 to 11 foot horizon, in this area and lowest in the or not detected in the 11 to 14 foot horizon.

Dredge Area B. All six samples had detectable concentrations of TPHs in Dredge Area B.

- TPH-Diesel was detected in all six samples at concentrations ranging from 76,000 µg/L to 730,000 µg/L.
- TPH-Motor Oil was detected in all six samples at concentrations ranging from 230,000 µg/L to 940,000 µg/L.

Dredge Area C. All six samples had detectable concentrations of TPHs in Dredge Area C.

- TPH-Diesel was detected in all six samples at concentrations ranging from 530,000 µg/L to 2,400,000 µg/L.
- TPH-Motor Oil was detected in all six samples at concentrations ranging from 540,000 µg/L to 2,100,000 µg/L.

Bulkhead. All 14 samples had detectable concentrations of TPHs along the Bulkhead.

- TPH-Diesel was detected in all 14 samples at concentrations ranging from 32,000 µg/L to 450,000 µg/L.
- TPH-Motor Oil was detected in all 14 samples at concentrations ranging from 140,000 µg/L to 690,000 µg/L.

ODOT Outfall. Both samples collected near the ODOT Outfall had detectable concentrations of TPHs.

- TPH-Diesel was detected in both samples at concentrations ranging from 28,000 µg/L to 140,000 µg/L.
- TPH-Motor Oil was detected in both samples at concentrations ranging from 130,000 µg/L to 340,000 µg/L.

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Table 5-11 Summary of In-Water Sediment Detects (µg/kg)

(upstream to downstream gradients by sample area)

LOCATION	UNDER DOCK AREA																Dredge Area A											
Loocaion/Station	1				2				26				27				17				18				19			
Depth	0-1'	1-6'	6-12'	12-20'	0-1'	1-6'	6-12'	12-20'	0-1'	1-6'	6-12'	12-20'	0-1'	1-6'	6-12'	12-20'	0-1'	1-7'	7-9'	9-12'	0-1'	1-11'	11-13'	13-16'	0-1'	1-9'	9-11'	11-14'
ANALYTE																												
VOCs																												
Acetone	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbon Disulfide	-	0.69 J	-	0.16 J	-	0.26 J	0.38 J	0.29 J	0.34 J	0.23 J	0.098 J	0.14 J	-	1.7 J	-	0.48 J	-	-	-	-	-	-	-	-	-	-	-	-
Methyltert-butyl ether	-	-	-	-	-	-	-	-	0.42 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vinyl Acetate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2-Butanone (MEK)	-	12 J	18 J	7.4 J	-	9.6 J	7.8 J	13 J	-	10 J	8.1 J	6.7 J	-	-	11 J	7 J	-	-	-	-	-	-	-	-	-	-	-	-
Chloroform	-	0.31 J	-	-	-	-	-	-	-	-	-	0.49 J	-	-	-	0.27 J	-	-	-	-	-	-	-	-	-	-	-	-
1,1,1-Trichloroethane (TCA)	-	-	-	-	-	-	0.6 J	0.41 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzene	-	-	-	-	-	-	-	-	-	-	-	-	-	17 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trichloroethene (TCE)	-	-	-	-	-	-	1.5 J	0.5 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Toluene	4.3 J	0.64 J	0.46 J	1.1 J	-	0.38 J	9.6	2.7 J	14	-	-	-	930	4.2 J	-	-	1.4 J	-	-	-	-	-	-	-	-	-	-	-
Tetrachloroethene (PCE)	-	-	-	-	-	-	1.7 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ethylbenzene	-	-	-	-	-	-	1 J	-	-	-	-	-	-	460	-	-	-	-	-	-	-	-	-	-	-	-	-	-
m,p-Xylene	-	0.31 J	-	0.23 J	-	-	3.2 J	0.47 J	-	-	-	-	-	22 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-
o-Xylene	-	0.63 J	-	-	-	-	0.95 J	-	-	-	-	-	-	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Isopropylbenzene	-	1.4 J	-	-	-	-	-	-	-	-	-	-	-	54 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SVOCs																												
Phenols and Substituted Phenols																												
2,4,6-trichlorophenol	-	-	-	-	-	-	-	-	-	-	-	-	-	0.49 J	-	-	-	-	-	-	0.63 J	-	-	-	-	0.53 J	0.42 J	-
2,3,5,6-Tetrachlorophenol	3.6 J	-	-	-	1.8 J	-	-	-	-	-	-	-	2.8 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pentachlorophenol	24	-	-	-	8.6 J	-	-	-	-	13 J	-	-	22 J	-	-	-	7 J	3.7 J	-	-	11 J	1.8 J	-	-	-	4.5 J	2.4 J	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polycyclic Aromatic Hydrocarbons (PAHs)																												
Naphthalene	230	290	1.4 J	2.2 J	400	25	12	2.7	48	170	15	1.5 J	850	2,900	62	2 J	1,000	5,000	9.6	12	310	1,200	1.9 J	0.61 J	270	1,100	1,800	200
2-Methylnaphthalene	160	55	0.66 J	0.76 J	200	4.1	1.4 J	0.4 J	27	87	6.7	0.77 J	550	1,300	9.5	0.51 J	480	1,200	1.1 J	5.1	200	3,800	1.7 J	1.4 J	99	820	690	35
1-Methylnaphthalene	120 J	190	1.1 J	2.1 J	140 J	3.1	1.7 J	0.37 J	19	65	9.6	3	390	2,000	7.1	1.3 J	420	3,500	3.2	5.1	170	2,900	1.2 J	1.4 J	58	1,300	2,900	24
C2 -Naphthalenes	480	390	2.8	2.3 J	360	5.1	2.5	-	80	280	31	2.6	1,300	4,300	15	-	2,300	5,900	6.3	10	6,000 J	5,500	2.4 J	3	190	4,900	6,900	59
C3 -Naphthalenes	810	390	1.8 J	-	560	4	2.1 J	-	120	300	18	-	2,100	4,100	17	-	3,100	5,300	5.8	8	6,100 J	4,200	2 J	1.4 J	260	4,500	5,100	43
C4 -Naphthalenes	570	180	-	-	410	-	-	-	61	160	17	-	1,200	1,900	16	-	1,500	2,900	4.4	5.9	2,400 J	1,800	1.4 J	0.75 J	150	2,000	2,200	51
Acenaphthylene	670	56	-	-	340	0.82 J	0.6 J	-	130	49	5.7	0.26 J	800 J	410	20	-	430	1,300	2.2 J	0.92 J	170	320	0.51 J	-	110	360	470	59
Dibenzofuran	340	70	0.61 J	0.73 J	170	2.2 J	0.82 J	-	39	180	6.1	-	430 J	870	7.2	-	160	880	1.2 J	1.3 J	200	450	-	-	82	350	660	30
Acenaphthene	1,100	1,300	6.5	20	790	7.1	2.4 J	3.1	140	690	39	14	2,500	9,000	120	11	1,900	16,000	33	28	1,100	4,900	5.8	27	500	3,400	7,800	290
Fluorene	1,400	700	2.2	0.53 J	610	4.7	1.9 J	-	220	530	25	0.87 J	1,500	5,800	43	0.93 J	1,400	7,400	11	7.3	1,100	3,200	2.8	1.3 J	270	2,500	5,400	130
C1 -Fluorenes	720	200	0.86 J	-	320	1.7 J	-	-	120	70	6.8	-	830	780	5.8	-	1,100	940	2 J	1.7 J	1,300 J	1,300	1.3 J	0.69 J	110	1,300	1,900	44
C2 -Fluorenes	1,000	180	-	-	370	-	-	-	160	170	16	-	950	1,700	17	-	1,500	2,400	4.5	4	1,700 J	1,300	1.3 J	0.6 J	150	1,500	1,800	53
C3 -Fluorenes	1,200	160	-	-	450	-	-	-	220	210	25	-	1,600	1,600	24	-	2,000	2,200	-	-	1,800 J	1,600	0.8 J	-	210	1,900	2,000	81
Dibenzothiophene	700	630	1.2 J	0.72 J	450	3.6	1.1 J	-	100	200	14	-	1,500	6,100	51	-	2,000	8,100	15	7	1,300	2,800	4.3	1.2 J	200	2,500	5,900	150
C1 -Dibenzothiophenes	-	53	-	-	89 J	-	-	-	14	47	7.5	-	350	590	10	-	470	860	-	-	550	600	-	-	48	650	730	24
C2 -Dibenzothiophenes	850	150	-	-	430	-	-	-	130	170	8.7	-	1,400	2,000	11	-	1,900	2,300	-	-	1,500 J	1,200	0.88 J	-	180	1,600	1,500	37
C3 -Dibenzothiophenes	850	140	-	-	440	-	-	-	190	140	6.9	-	1,400	1,100	-	-	1,400	1,400	-	-	1,000	920	0.4 J	-	200	1,100	1,100	56
Phenanthrene	11,000	5,200	15	10	5,300	53	17	-	1,500	2,700	200	4.3	16,000	47,000	910	3.7	17,000	58,000	130	61	9,400	20,000	48	12	2,700	19,000	41,000	2,000
Anthracene	2,700	1,400	3.6	0.95 J	1,400	7.4	2.6	-	330	370	48	0.85 J	4,000	12,000	130	0.62 J	3,800	12,000	26	10	1,500	4,200	3.6	1 J	900	4,200	11,000	320
C1 -Phenanthrenes/Anthracenes	5,200	1100 J	3.9	-	2,000	26	9.2	-	760	950	83	2 J	7,100	11,000 J	93	1.1 J	9,500	12000 J	25	15	7,400 J	6,300	8.9	1.8 J	970	7,500	11,000	320
C2 -Phenanthrenes/Anthracenes	4,800	630	2	-	1,800	9	4.2	-	750	680	65	2.8	5,800	5,000	70	-	7,400	5,700	11	7.3	5,300 J	4,200	4.2	1.9 J	890	5,500	5,400	190
C3 -Phenanthrenes/Anthracenes	2,800	350	1.4 J	-	1,000	3.3	1.8 J	-	540	370	41	1.2 J	3,100	1,500	51	-	3,800	1,700	5.3	3.6	2,800 J	2,200	2.1 J	1.6 J	650	2,700	2,400	140
C4 -Phenanthrenes/Anthracenes	990	60	-	-	430	-	-	-	260	110	13	-	1,500	600	25	-	1,300	710	-	-	570	740	-	0.81 J	180	880	640	72
Fluoranthene	28,000	5,700	14	1.8 J	12,000	87	21	0.62 J	3,600	3,000	270	4.6	32,000	46,000	1,400	5.8	22,000	48,000	120	43	4,100	11,000	41	2.6	5,400	13,000	33,000	3,100
Pyrene	27,000	7,500	20	2.1 J	14,000	97	27	0.53 J	3,400	3,200	330	5.7	40,000	59,000	1,700	7.2	30,000	61,000	150	56	6,400	15,000	50	2.9	6,400	16,000	40,000	4,100
C1 -Fluoranthenes/Pyrenes	12,000	1,100 J	5.6	-	4,400 J	24	7.3	-	1,700	1,100 J	160	5.2	13,000	11,000 J	210	-	12,000	12000 J	27	11	3,300 J	4,300	8.6	1.9 J	1800 J	6,500	11,000	640
C2 -Fluoranthenes/Pyrenes	4,200	260	-	-	1,400	7.5	-	-	-	350	54	-	6,000	2,400	44	-	4,700	2,800	6.9	3.6	1,800 J	1,800	2.1 J	-	690	2,500	2,500	130
C3 -Fluoranthenes/Pyrenes	2,600	110	-	-	880	-	-	-	-	210	29	-	3,000	1,200	27	-	3,100	1,300	-	-	1,200 J	1,000	0.84 J	-	380	1,600	1,300	78
Benzo(a)anthracene	14,000	1,500	4.5	0.87 J	5,400	32	7.1	-	2300	980	120	2.7	15,000	13,000	310	1.8 J	10,000	13,000	29	11	1,700	3,400	7.8	0.9 J	2,500	5,000	11,000	700
Chrysene	16,000	1,800	5.6	0. 61 J	6,100	36	9	-	2,900	1,200	130	2.7	17,000	15,000	370	-	12,000	16,000	41	16	2,100	4,400	11	0.77 J	2,900	6,200	13,000	900
C1 -Chrysenes	8,100	400	2.6	-	2,700 J	12	3.8	-	1,600	480	68	-	8,900	4,100	69	-	7,900	4,500	9.8	4.7	1,700 J	2,100	3.2	0.52 J	1,100	3,300	3,900	220
C2 -Chrysenes	3,700	180	-	-	1,100	-	-	-	880	250	34	-	4,300	1,300	36	-	4,500	1,800	3.9	-	1,100	1,100	1.1 J	-	530	1,900	1,500	99
C3 -Chrysenes	1,800	65	-	-	680	-	-	-	430	140	23	-	1,900	520	28	-	2,300	910	-	-	600	590	-	-	270	900	510	64
C4 -Chrysenes	-	-	-	-	-	-	-	-	180	47	-	-	-	-	-	-	-	-	-	-	220	180	-	-	82	320	230	36
Benzo(b)fluoranthene	20,000	2,000	5.4	0.84 J	7,300	51	9.5	-	3,300	1,300	140	3	21,000	16,000	500	2.6	13,000	17,000	40	15	1,500	3,800	10	0.6 J	3,600	5,800	12,000	1,200
Benzo(k)fluoranthene	6,800	550	1.3 J	-	2,400	17	3	-	960	430	49	0.86 J	6,800	4,900	150	0.85 J	4,200	5,300	13	5.2	450	1,300	3.5	-	1,300	1,900	4,000	380
Benzo(e)pyrene	12,000	1,400	4.4	-	4,700	31	6.6	-	2,200	810	87	1.7 J	13,000	11,000	360	2.3 J	9,200	12,000	30	12	1,100	2,700	7.3	0.4 J	2,200	3,900	8,500	850
Benzo(a)pyrene	19,000	2,400	6.3	-	6,600	37	5.5	-	3,300	1,200	150	2.4 J	21,000	18,000	630	2.2 J	12,000	19,000	46	16	1,700	4,600	11	0.54 J	3,800	6,800	15,000	1,400
Perylene	4,600	560	100	14	1,600	120	83	100	780	370	120	10	5,000	4,700	270	3.9	2,800	4,600	11	6.1	330	1,000	5.2	51	950	1,500	3,400	480
Indeno(1,2,3-cd)pyrene	15,000	1,800	5.1	0.48 J	5,800	34	7.2	-	2,700	980	110	-	16,000	14,000	600	-	11,000	15,000	39	15	1,200	3,800	12	0.56 J	2,800	5,500	12,000	1,400
Dibenz(a,h)anthracene	2,000	240	0.59 J	-	750	4.2	0.87 J	-	420	150	14	-	2,000	2,100	43	-	1,400	2,200	3.7	1.7 J	220	520	1.4 J	-	450	770	1,300	140
Benzo(g,h,i)perylene	15,000	1,900	5.8	-	5,600	31	7.6	-	2,600	1,000	100	1.8 J	15,000	15,000	710	2.8	11,000	16,000	42	17	1,200	3,900	13	-	2,800	5,400	12,000	1600
LPAH	17,300	9,000	31	37	9,000	100	38	16	2,400	4,600	340	23	26,200	78,400	1,300	21	26,000	101,000	210	120	13,800	37,600	64	46	4,900	31,400	68,200	3,000
HPAH	163,000	25,400	69	16	66,000	430	98	20	25,500	13,400	1,400	29	186,000	203,000	6,400	31	127,000	213,000	520	200	20,600	51,700	160	16	32,000	66,400	153,000	15,000
Total PAH	180,000	34,400	100	53	75,000	530	140	36	28,000	18,000	1,750	52	212,000	281,000	7,700	52	153,000	313,000	740	320	34,400	89,300	230	62	36,800	97,800	220,000	18,000

Note: Not Detected or Not Analyzed; A complete list of all analytical results is included in Appendix A, Table 1-e.
J detected value and the reported concentration is an estimated value

Table 5-11 Summary of In-Water Sediment Detects (µg/kg)

(upstream to downstream gradients by sample area)

LOCATION	Dredge Area B						Dredge Area C						Bulkhead															ODOT Outfall	
Loocaion/Station	20		21		22		23		24		25		25	4	5	6	7	8	9	10	11	12	13	14	15	16		28	
Depth	6-8'	8-11'	4-6'	6-9'	6-8'	8-11'	12-14'	14-17'	10-12'	12-15'	10-12'	12-15'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'		0-1'	1-6'
ANALYTE																													
VOCs																													
Acetone	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,600	-	-	-	-	-	-	-	-	-	-	-		-	-
Carbon Disulfide	-	-	-	-	-	-	-	-	-	-	-	-	0.27 J	0.18 J	0.22 J	0.21 J	0.18 J	-	-	-	-	-	-	-	-	-		-	-
Methyltert-butyl ether	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
Vinyl Acetate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
2-Butanone (MEK)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.4 J	-	-	-	-	-	-	-	-	-	-	-		-	-
Chloroform	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
1,1,1-Trichloroethane (TCA)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.91 J	-	-	-	-	-	-	-	-	-	-		-	-
Benzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
Trichloroethene (TCE)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.3 J	-	-	-	-	-	-	-	-	-	-		-	-
Toluene	-	-	-	-	-	-	-	-	-	-	-	-	0.52 J	-	-	11	-	-	-	-	-	-	-	-	-	-		-	-
Tetrachloroethene (PCE)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.4 J	-	-	-	-	-	-	-	-	-	-		-	-
Ethylbenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.3 J	-	-	-	-	-	-	-	-	-	-		-	-
m,p-Xylene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.3 J	-	-	-	-	-	-	-	-	-	-		-	-
o-Xylene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.93 J	-	-	-	-	-	-	-	-	-	-		-	-
Isopropylbenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
SVOCs																													
Phenols and Substituted Phenols																													
2,4,6-trichlorophenol	0.32 J	-	-	0.34 J	0.5 J	0.39 J	-	1.5 J	34 J	13	3.7 J	9.8 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
2,3,5,6-Tetrachlorophenol	-	-	-	-	1.3 J	-	-	0.89 J	66 J	24 J	8.5 J	27 J	2.9 J	1.6 J	-	-	-	-	-	-	-	-	-	-	-	-		-	-
Pentachlorophenol	17 J	-	-	4.3 J	17	8.5 J	8.4 J	9 J	410 J	180 J	78 J	130 J	72	7.9 J	7.6 J	-	-	9.9 J	1 J	-	2. 2 J	-	-	-	1.7 J	5.4 J		-	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
Polycyclic Aromatic Hydrocarbons (PAHs)																													
Naphthalene	260	440	25	65	370	280	1,000	1,400	42,000	56,000	1,900	7,400	1,700	140	89	90	38	33	50	25	24	24	35	38	34	53		31 J	25
2-Methylnaphthalene	140	1,200	8.9	24	240	710	12,000	1,800	16,000	30,000	530	2,000	860	210	29	29	12	9.9	20	10	9.8	9.9	13	14	13	52		10	8.4
1-Methylnaphthalene	82	930	5.4	12	530	760	7,200	1,500	11,000	22,000	460	1,600	740	47	17	15	6.4	5.9	15	6.9	6.4	6.4	7.8	7.6	7.9	31		5.9	5.3
C2 -Naphthalenes	460	3,900	26	43	1,200	1,200	32,000	3,900 J	22,000 J	68,000 J	1,100	3,900	3,000	200	48	40	16	13	51	15	17	17	21	21	19	41		16J	24
C3 -Naphthalenes	440	4,000	17	36	1,300	1,000	35,000	4,200 J	18,000 J	55,000 J	1,300	3,700	4,100	240	50	45	18	15	39	13	17	18	20	21	17	24		15 J	19
C4 -Naphthalenes	230	1,800	15	35	640	500	15,000	2,300 J	7,800	21,000 J	740	1,900	2,600	130	47	45	16	14	33	12	14	18	19	22	16	17		14 J	15
Acenaphthylene	98	160	11	27	290	160	500	180	3,500	1,700	620	1,200	1,700	80	36	45	15	12	49	11	9	16	15	16	15	7.3		9.3	10
Dibenzofuran	180	190	13	20	240	210	1,400	210	1,700	3,700	290	660	910	240	23	12	5.2	9.3	28	46	11	3.8	4.6	6.5	6.4	36		3.5	6.8
Acenaphthene	600	1,100	64	100	970	860	5,600	2,300	6,500	28,000	1,100	2,600	5,500	360	94	46	22	34	160	110	35	26	26	30	24	100		19	35
Fluorene	430	1,200	38	64	860	650	8,300	1,500	11,000	22,000	1,200	2,600	4,300	1,000	76	42	16	21	89	66	21	16	16	20	18	80		11	20
C1 -Fluorenes	180	1,100	12	25	480	330	3,500	620	2,200	6,200	580	1,300	2,100	130	36	27	9.4	11	37	14	7.5	9.4	10	12	9.4	14		7.6	8.7
C2 -Fluorenes	220	1,200	15	32	590	410	13,000	1,900 J	6,100	12,000 J	720	1,200	2,300	170	51	44	16	14	39	14	12	15	16	17	16	13		11	13
C3 -Fluorenes	280	1,400	24	60	810	580	11,000	3,200 J	9,200	14,000 J	820	2,000	3,000	200	67	61	21	20	45	22	14	18	24	26	26	21		17 J	22
Dibenzothiophene	260	1,200	16	33	750	550	11,000	1,600	12,000	17,000	1,200	3,200	4,400	250	54	52	15	16	100	27	13	14	17	18	15	22		11	8.9
C1 -Dibenzothiophenes	96	540	6.8	19	260	200	3,000	520	1,700	4,100	310	690	770	48	21	21	11	6.5	13	6.1	6.2	6.5	8	9.5	8	7.3		6.6	8.1
C2 -Dibenzothiophenes	260	1,200	16	45	690	520	12,000	3,100 J	14,000 J	16,000 J	920	2,500	2,900	160	58	58	22	19	48	20	12	15	19	22	19	14		13 J	12
C3 -Dibenzothiophenes	220	880	16	55	550	430	6,000	1,200 J	5,900	4,400	670	1,800	2,500	170	65	58	19	18	64	19	10	14	18	18	18	13		14 J	13
Phenanthrene	3,200	8,500	240	420	6,600	4,800	64,000	12,000	100,000	120,000	11,000	27,000	48,000	4,600	620	530	160	210	1,200	500	130	140	170	180	150	260		130	140
Anthracene	590	1,800	45	97	1,500	1,000	13,000	2,200	18,000	22,000	2,200	4,100	9,500	4,800	190	140	67	69	260	110	43	53	55	70	55	47		47	28
C1 -Phenanthrenes/Anthracenes	1,300	5,600	89	180	3,000	2,100	58,000 J	5,900 J	46,000 J	51,000 J	4,800	12,000	15,000	980	290	240	85	92	330	140	52	70	81	91	68	76		61	57
C2 -Phenanthrenes/Anthracenes	1,100	4,400	81	170	2,400	1,700	39,000	7,700 J	56,000 J	48,000 J	3,600	8,900	11,000	690	260	230	99	81	230	100	53	71	89	96	74	70		61	62
C3 -Phenanthrenes/Anthracenes	640	2,400	49	140	1,100	920	15,000	2,300 J	15,000 J	13,000 J	1,800	4,700	5,400	430	170	160	76	43	150	52	28	39	45	54	45	41		32	43
C4 -Phenanthrenes/Anthracenes	370	710	23	59	440	290	3,300	480	4,100	2,800	770	2,000	1,400	190	54	57	28	20	64	21	14	16	23	24	23	19		17 J	23
Fluoranthene	3,900	4,400	380	680	8,400	5,700	14,000	9,500	110,000	61,000	16,000	35,000	82,000	6,100	1,800	1,400	420	520	2,300	950	250	320	350	420	330	310		290	220
Pyrene	4,400	5,600	390	750	9,700	6,500	22,000	11,000	140,000	76,000	19,000	40,000	94,000	5,700	2,000	2,000	580	650	2,800	1,100	320	450	520	600	450	340		370	260
C1 -Fluoranthenes/Pyrenes	1,700	3,200	210	390	3,200	2,400	15,000	4,000 J	28,000 J	22,000 J	6,100	13,000	26,000	1,900 J	720	540	210	270	850	450	120	170	190	220	170	150		140	130
C2 -Fluoranthenes/Pyrenes	770	1,800	86	170	1,300	870	7,600	1,100 J	8,100	6,800	2,200	4,400	7,200	510	230	200	100	99	280	150	50	60	76	87	80	58		53	64
C3 -Fluoranthenes/Pyrenes	490	1,100	58	120	910	620	4,600	610	4,200	4,100	1,400	2,900	3,700	280	120	110	59	58	180	87	31	37	48	57	47	41		33	43
Benzo(a)anthracene	1,600	1,800	230	400	3,200	2,300	4,400	2,400	34,000	18,000	7,100	15,000	30,000	2,200	710	590	210	300	1,200	640	120	170	200	230	170	130		150	130
Chrysene	2,000	2,300	230	510	4,200	2,900	5,300	3,200	46,000	24,000	9,500	19,000	34,000	3,000	910	760	280	350	1,400	680	150	200	230	290	210	130		170	130
C1 -Chrysenes	1,100	1,800	160	290	1,900	1,300	5,900	1000 J	13000 J	9,100	4,100	8,700	13,000	840	370	340	170	180	550	340	95	130	140	170	130	88		110	100
C2 -Chrysenes	650	1,300	81	170	1,100	680	4,000	540	5,600	4,600	2,000	4,400	5,400	360	170	170	81	87	270	160	37	57	72	84	71	52		51	62
C3 -Chrysenes	370	670	49	100	570	400	2,100	300	2,700	2,400	980	2,000	2,100	170	71	77	41	47	190	120	26	32	36	48	39	33		28	39
C4 -Chrysenes	130	220	15	43	200	130	-	110	1,000	630	340	730	-	57	22	-	-	-	76	-	-	-	-	-	-	-		-	15
Benzo(b)fluoranthene	2,200	1,900	350	560	4,700	3,300	2,900	2,700	44,000	22,000	10,000	21,000	38,000	2,600	1,000	890	330	460	1,900	1,000	190	240	290	340	270	190		240	210
Benzo(k)fluoranthene	750	590	120	190	1,700	1,100	910	870	20,000	6,800	3,400	6,900	13,000	750	350	290	110	160	610	340	66	80	98	110	84	61		76	70
Benzo(e)pyrene	1,400	1,300	210	370	3,200	2,100	2,300	1,900	32,000	17,000	6,900	15,000	24,000	1,500	630	620	230	280	1,200	560	130	180	210	230	190	120		160	140
Benzo(a)pyrene	2,100	2,000	350	590	3,900	2,900	3,100	2,600	36,000	18,000	8,600	19,000	39,000	2,200	910	900	330	430	1,800	900	200	290	330	370	290	190		250	210
Perylene	510	410	100	160	900	660	660	630	9,700	4,200	2,100	4,600	9,500	460	250	220	92	120	470	260	62	82	93	120	90	50		71	70
Indeno(1,2,3-cd)pyrene	1,900	1,600	290	510	4,400	2,900	2,100	2,100	36,000	18,000	9,400	20,000	28,000	1,700	740	760	270	340	1,400	700	150	220	270	300	230	140		190	190
Dibenz(a,h)anthracene	310	290	52	84	650	450	410	420	7,700	3,200	1,300	3,000	3,400	230	95	110	33	52	240	140	19	27	32	39	29	18		25	30
Benzo(g,h,i)perylene	1,900	1,700	270	480	4,500	2,900	2,300	2,100	36,000	19,000	9,400	20,000	26,000	1,600	730	780	270	330	1,200	600	150	230	280	300	240	140		190	190
LPAH	5,300	14,400	430	800	11,000	8,500	104,000	21,400	200,000	280,000	18,600	47,000	71,600	11,200	1,100	920	330	390	1,800	830	270	290	330	370	310	600		260	270
HPAH	21,000	22,200	2,700	4,800	45,400	31,000	57,400	37,000	510,000	266,000	93,700	200,000	387,000	26,000	9,200	8,500	2,800	3,600	15,000	7,100	1,600	2,200	2,600	3,000	2,300	1,700		2,000	1,600
Total PAH	26,400	36,600	3,100	5,600	56,200	39,400	162,000	58,300	707,000	546,000	112,000	246,000	460,000	37,200	10,400	9,400	3,200	4,000	16,700	7,900	1,900	2,500	2,900	3,400	2,600	2,300		2,200	1,900

Note: Not Detected or Not Analyzed; A complete list of all analytical results is included in Appendix A, Table 1-e.
J detected value and the reported concentration is an estimated value

Table 5-11 Summary of In-Water Sediment Detects (µg/kg)

(upstream to downstream gradients by sample area)

LOCATION	UNDER DOCK AREA																Dredge Area A											
Loocaion/Station	1				2				26				27				17				18				19			
Depth	0-1'	1-6'	6-12'	12-20'	0-1'	1-6'	6-12'	12-20'	0-1'	1-6'	6-12'	12-20'	0-1'	1-6'	6-12'	12-20'	0-1'	1-7'	7-9'	9-12'	0-1'	1-11'	11-13'	13-16'	0-1'	1-9'	9-11'	11-14'
ANALYTE																												
Organonitrogen Compounds, Halogenated Compounds, Phenols and Substituted Phenols, Oxygen-Containing Compounds																												
Phenol	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzyl Alcohol	-	-	-	11	-	-	-	14	-	-	-	-	-	-	-	-	-	-	3.5 J	2.8 J	-	-	9.9 J	-	6.5	-	-	-
4-Methylphenol (p-Cresol)	-	-	-	-	-	-	-	-	-	-	-	-	120 J	-	-	-	-	-	-	-	-	35 J	-	2.5 J	-	94	87 J	21 J
Benzoic Acid	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	170 J	-	-	-
4-Chloroaniline	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hexachlorocyclopentadiene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3-Nitroaniline	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2,4-Dinitrotoluene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diethyl Phthalate	-	-	-	1.5 J	-	2.2 J	-	1.4 J	-	-	-	1.3 J	-	-	-	-	-	-	2.1 J	1.5 J	-	-	9.9 J	1.9 J	-	-	-	-
4-Nitroaniline	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
N-Nitrosodiphenylamine	360 J	-	-	-	-	-	-	-	140 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hexachlorobenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbazole	750	190	-	-	270	5.7 J	-	-	350	93	1.6 J	3.2 J	710 J	690	1.9 J	-	580	2200	11	2.6 J	58 J	500	9.9 J	1.7 J	290	530	340	36 J
di-n-butyl Phthalate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8 J	8.1 J	-	-	-	-	57	-	-	-
Butyl Benzyl Phthalate	-	-	-	4.4 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.3 J	4.4 J	-	-	-	-	-	-	-	-
3,3'-Dichlorobenzidine	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
bis (2-Ethylhexyl) phthalate	-	-	-	-	180 J	13 J	7.7 J	9.1 J	1,400	-	-	13 J	330 J	-	-	160	-	-	-	-	86 J	-	20 J	16 J	74	110 J	-	-
di-n-octyl Phthalate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PCBs																												
Aroclor 1242	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	-	-	-	-	-
Aroclor 1254	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	31 J	-	-	-	9.9 J	-	-	-
Aroclor 1260	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.3	-	-	-	25	52 J	-	-	4.3	70	-	-
Aroclor 1268	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total PCBs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	68 J	52 J	-	-	14.2 J	70	-	-
Pesticides																												
α -BHC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.24	0.69 J	-	-	-	-	0.67 J	-
Hexachlorobenzene	1.3 J	-	-	-	-	-	-	-	0.29	0.29	-	-	1 J	-	-	-	1.1 J	1.1 J	-	-	1.1 J	-	-	-	0.18 J	-	-	-
γ -BHC (Lindane)	6 J	-	-	-	11	-	-	-	-	0.2 J	-	-	-	-	-	-	-	-	-	-	-	2.5 J	-	-	-	-	2.6	0.29
δ -BHC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.51 J	-	-	-	-	-	-
Heptachlor	-	-	-	-	1.6 NJ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aldrin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heptachlor epoxide	-	-	-	-	-	-	-	-	0.13 J	-	-	-	0.39 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
gamma-Chlordane	-	-	-	-	-	-	-	-	0.4	0.42	-	-	-	-	-	-	-	-	-	-	1 J	-	-	-	-	-	-	-
Endosulfan alpha-	-	-	-	-	-	-	0.12 J	-	-	0.62	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.53 J
alpha-Chlordane	-	0.57 J	-	-	-	-	-	-	-	-	-	-	-	-	0.13 J	-	-	8.1	-	-	-	-	-	-	-	-	-	-
Dieldrin	-	0.52	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.04 J	-	0.58 J	-	-	-	-	1.3 J	-	-
4,4'-DDE	-	0.3	-	-	-	-	-	-	4.1	4 J	-	-	-	-	-	-	7.1 J	-	-	-	15 J	-	-	-	2.2 J	-	-	-
Endrin	-	-	-	-	-	-	-	-	-	0.14 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Endosulfan beta-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4,4'-DDD	19	1.3 J	-	-	8.2 J	0.087 J	-	-	10	6.8	-	-	17	29	-	-	19	35 J	0.47 J	-	15	160	0.1 J	-	4.9	200	210	-
Endrin aldehyde	2 J	0.29 J	-	-	1.7 NJ	-	-	-	-	-	-	-	2 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Endosulfan sulfate	-	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4,4'-DDT	50	0.2	-	-	-	0.27	-	-	-	2.4	-	-	-	-	-	-	2.2	8	-	-	4.2	54	-	-	3.6	50	32	-
Endrin ketone	4.7 J	0.22	-	-	-	-	-	-	-	0.72 J	-	-	6.5 NJ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methoxychlor	-	0.35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.4 J	3.7	-	-	-	-	-	-	-	-	-	-
Toxaphene	-	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
oxy chlordane	1.2	0.19	-	-	-	-	-	-	-	-	-	-	-	2.4 J	-	-	-	2.2 J	-	-	-	-	-	0.7 J	-	-	-	-
2,4'-DDE	-	0.17	-	-		-	-	-	0.31 NJ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
cis -nonachlor	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2,4'-DDD	12 J	-	-	-	11 J	-	-	-	3.6 J	2.6 J	-	-	-	15	-	-	7.6 J	11 J	0.18 J	-	5.9	51	-	-	2.1	69	120	-
trans -nonachlor	0.77 J	-	-	-	0.6 J	0.047 J	-	-	-	0.78	-	-	-	-	-	-		-	0.26 J	0.11 J	-	-	-	-	-	-	-	-
2,4'-DDT	-	0.23 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.52 J	2.7	-	-	1.9 J	-	-	-	-	-	-	-
Mirex	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5 J	-
Hexachloroethane	-	-	-	-	-	-	-	-	-	0.18 J	-	-	-	-	-	-	-	-	-	-	0.18 J	-	-	-	-	-	-	-
Hexachlorobutadiene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DDE [1]	-	0.47	-	-	-	-	-	-	4.41 NJ	4 J	-	-	-	-	-	-	7.1 J	-	-	-	15 J	-	-	-	2.2 J	-	-	-
DDD [1]	31 J	1.3 J	-	-	19.2 J	0.087 J	-	-	13.6 J	9.4 J	-	-	17	44	-	-	26.6 J	46 J	0.65 J	-	20.9	211	0.1 J	-	7	269	330	-
DDT [1]	50	0.23 J	-	-	-	0.27	-	-	-	2.4	-	-	-	-	-	-	2.72 J	10.7	-	-	6.1 J	54	-	-	3.6	50	32	-
DDx-total [2]	81 J	2 J	-	-	19.2 J	0.357 J	-	-	18.01 NJ	15.8 J	-	-	17	ND	-	-	36.42 J	56.7 J	0.65 J	-	42 J	265	-	-	12.8 J	319	362	-
Chlordane -total [3]	1.97 J	0.57	-	-	0.6 J	ND	-	-	0.4	1.2	-	-	-	2.4 J	0.13 J	-	-	10.3 J	0.26 J	0.11 J	1 J	-	-	0.7 J	-	-	-	-
Endosulfan -total [4]	-	-	-	-	-		0.12 J	-	-	0.62	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.53 J

[1] This value represents the sum of the 2,4' and 4,4' isomers.

[2] This value represents the sum of DDE + DDD + DDT.

[3] This value represents the sum of alpha and gamma chlordane, oxy chlordane, and cis and trans nonachlor.

[4] This value represents the sum of alpha and beta endosulfan and endosulfan sulfate.

Note: Not Detected or Not Analyzed; A complete list of all analytical results is included in Appendix A, Table 1-e.
J detected value and the reported concentration is an estimated value

Table 5-11 Summary of In-Water Sediment Detects (µg/kg)

(upstream to downstream gradients by sample area)

LOCATION	Dredge Area B						Dredge Area C						Bulkhead															ODOT Outfall	
Loocaion/Station	20		21		22		23		24		25		25	4	5	6	7	8	9	10	11	12	13	14	15	16		28	
Depth	6-8'	8-11'	4-6'	6-9'	6-8'	8-11'	12-14'	14-17'	10-12'	12-15'	10-12'	12-15'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'		0-1'	1-6'
ANALYTE																													
Organonitrogen Compounds, Halogenated Compoun																													
Phenol	-	-	-	8.6 J	-	-	-	-	-	-	-	-	-	-	10 J	-	-	-	-	-	15 J	12 J	-			-		-	-
Benzyl Alcohol	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	-
4-Methylphenol (p-Cresol)	-	-	-	-	-	-	-	77	-	-	-	-	-	-	-	-	-	-	-	20	7.2 J	-	-	6.4 J		-		3.5 J	-
Benzoic Acid	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	130 J	-	120 J	120 J	150 J	-	120 J	140 J	120 J	-		-	-
4-Chloroaniline	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	12 R		-	-
Hexachlorocyclopentadiene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-		-	-
3-Nitroaniline	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-		-	-
2,4-Dinitrotoluene	-	-	-	-	-	-	700	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-		-	-
Diethyl Phthalate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.2 J	3 J	2.4 J	2 J	2.2 J	2.5 J	-	2.4 J	1.9 J	-	-		2 J	-
4-Nitroaniline	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
N-Nitrosodiphenylamine	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
Hexachlorobenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12 J	-	-		11 J	-
Carbazole	140	340	23	38	380	250	960	180	4,600	2,700	1100	1600	2,900	1,100	44	21	11 J	25	120	72	8.5 J	5.9 J	8.2 J	11 J	8.3 J	38		8.4 J	18
di-n-butyl Phthalate	-	-	-	8.3 J	-		-	-	-	-	-	-	-	-	8.7 J	9 J	13 J	16	29	11	-	-	-	11 J	16	-		11 J	12
Butyl Benzyl Phthalate	-	-	-	-	-		-	-	-	-	-	-	-	-	-	6.3 J	21	16	42	-	-	-	-	7.4 J	7.2 J	-		5.4 J	11
3,3'-Dichlorobenzidine	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
bis (2-Ethylhexyl) phthalate	53 J	-	34	85	180	80 J	-	56 J	-	-	380 J	500	-	240	89	66	120	120	170	100	87	41	78	85	79	35		61	40
di-n-octyl Phthalate	-	-	-	10	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
PCBs																													
Aroclor 1242	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.8 J	4.7	-	-	-	-	-	-		-	-
Aroclor 1254	100	100 J	-	-	42 J	110	-	-	-	-	56 J	100	-	-	16	11	7.8 J	10	7.7	9.3	-	5.9	4.3 J	6.6 J	7.8	8		5.2	-
Aroclor 1260	74	64 J	-	-	53	64	34	-	-	65	25 J	34	-	5.9	4.5 J	3	2.9 J	6.3 J	9	5.1	4.3 J	4	3.2	-	3.9	2.8 J		3.3	-
Aroclor 1268	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.3	-	-	-	-	-	-	-		-	-
Total PCBs	174	164 J	ND	ND	95	174	34	-	-	65	81 J	134	-	5.9	20.5 J	14	10.7J	16.3 J	26.8 J	19.1	4.3 J	9.9	7.5 J	6.6	11.7	10.8 J		8.5	-
Pesticides																													
α -BHC	-	0.7 J	-	-	-	-	1.9 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
Hexachlorobenzene	1.3	2.2	-	0.22	-	-	3.7 J	2.5 J	-	-	-	-	-	-	0.19 J	-	-	0.22 J	0.19 J	-	0.19 J	-	-	-	0.14 J	-		-	-
γ -BHC (Lindane)	4	-	0.26 J	0.71 NJ	6.2 J	12 J	-	-	-	-	-	-	-	8.1 NJ	0.51 J	-	-	-	-	-	-	-	-	0.35 J	0.35 J	0.36		-	-
δ -BHC	-	-	-	-	-	-	-	1.9 J	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-		-	-
Heptachlor	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-		-	-
Aldrin	-	-	0.11 J	-	-	-	-	-	-	-	-	-	-	-		0.15 J	-	0.38 J	-	0.22 J	0.17 J	0.48 NJ	-	-	0.15 J	-		-	-
Heptachlor epoxide	-	-	-	-	-	-	-	-	-	-	-	-	1.1 J	-		-	-		-				-	-	-	-		-	-
gamma-Chlordane	1.4 NJ	3.1 NJ	0.65	0.44 =,P	-	-	7.4 J	28	-	-	-	-	-	1.2 J	0.41	0.23	0.2 J	0.36	-	0.48 J	0.55	0.29	0.24	0.17 J	0.33 J	0.26		0.36 J	1.5
Endosulfan alpha-	-	-	0.32	-	-	-	-	11 J	-	26 J	5.7 J	-	-	1.5 J	0.42 J	-	-	-	0.62 J	-		0.16 J	-	0.1 J	-	0.081 J		-	-
alpha-Chlordane	-	-	-	-	-	-	-	-	-	-	-	-	19 J	-	-	-	-	-	-	-	0.38 J	0.12 J	0.18 J	0.18 J	0.097 J	0.079 J		-	-
Dieldrin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.062 J	0.057 J	-	-	-		0.097 J	-	-	0.13 J	0.083 J		0.1 J	-
4,4'-DDE	16	29 J	5.7	8.5 J	17 J	17 J	19 J	-	-	-	4.5 J	-	-	2.8 J	2.7 J	1.5 J	1.4	2 J	2.6 J	1.9 J	2	1.9	1.6	1.5	2	1.8 J		1.4	8.5
Endrin	-	-	-	-	-	1.7 J	-	-	-	-	-	-	-	-	-	-	-	0.14 J	-	-	-	-	0.074 J	0.075 J	-	-		-	-
Endosulfan beta-	-	-	-	-	-	-	3.2 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.063 J	-	-		-	-
4,4'-DDD	32	42	12	16	49	43	19	350	65 J	100	31 J	55	400	8.4 J	5.6	3.2	2	2.4	3.3 J	2.2 J	2.2 J	2.3	1.9	1.9 J	2.9 J	2.9		1.6	14
Endrin aldehyde	-	-	-	-	-	-	-	-	62 J	73 J	8.4 J	30	6.4 J	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
Endosulfan sulfate	-	0.62 J	-	-	-	-	0.77 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
4,4'-DDT	7.7	9.5	14	3.9 J	62	-	-	180	-	-	-	-	-	5.2	2.1	13	7	1.1	6.2	3.9	1.9	-	3 J	220	1.3	8.1		0.96	27
Endrin ketone	6.9 J	-	-	-	-	-	-	-	51 J	18	8.5 J	16 J	20 J	0.56 J	0.17 J	-	0.22 J	-	0.45 J	-	-	-	0.17 J	-	-	-		-	1 NJ
Methoxychlor	-	-	-	-	-	-	-	-	-	-	-	-	-	4.6 J	-	-	-	-	-	-	-	-	-	-	-	-		-	-
Toxaphene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
oxy chlordane	-	-	-	0.28 J	-	-	-	11 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
2,4'-DDE	-	-	-	-	-	-	-	30 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.16 J	-	-		-	-
cis -nonachlor	-	-	-	-	-	-	-	-	-	220 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
2,4'-DDD	15	16	3.7	4.7	33 J	21 J	5.5 J	3.9	140 J	120 J	50 J	-	99	6.3 J	2.3 J	1.6	1.1 J	1.5	1.8	1.4 J	1.3 J	1.2 J	1 J	1 J	1.5	1.2		0.92	5.4
trans -nonachlor	-	-	0.79 J	-	-	-	-	-	-	-	-	-	-	-	0.33 J	0.22 J	0.13 J	0.25	-	-	0.45 J	0.22 J	0.27 J	0.25 J	0.28 J	0.3 J		0.17 J	1.4 J
2,4'-DDT	-	-	1.2	-	-	7	-	-	-	-	-	-	-	-	1 J	-	0.42	0.63	3.2	0.7	0.52	-	0.43	0.69	-	-		0.51 J	3.7
Mirex	-	-	-	-	-	-	0.72 J	-	-	-	-	-	-	-	-	-	-	-	0.2 J	-	-	-	-	-	-	-		-	-
Hexachloroethane	1.6	1.1 J	0.21	0.35	1.2	1.6	-	-	-	-	-	-	-	-	0.39	0.11 J	-	0.17 J	-	-	-	-	-	-	-	0.12 J		0.11 J	-
Hexachlorobutadiene	0.43 J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.085 J		-	-
DDE [1]	16	29	5.7	8.5	17 J	17 J	19 J	30 J	-	-	4.5 J	-	-	2.8 J	2.7 J	1.5 J	1.4	2 J	2.6 J	1.9 J	2	1.9	1.6	1.66 J	2	1.8 J		1.4	8.5
DDD [1]	47	58	15.7	20.7	82 J	64 J	24.5 J	353.9	205 J	220 J	81 J	55	499	14.7 J	7.9 J	4.8	3.1 J	3.9	5.1 J	3.6 J	3.5 J	3.5 J	2.9 J	2.9 J	4.4 J	4.1		2.52	19.4
DDT [1]	7.7	9.5	15.2	3.9 J	62	7	-	180	-	-	-	-	-	5.2	3.1 J	13	7.42	1.73	9.4	4.6	2.42	-	3.43 J	220.70	1.3	-		1.47 J	30.7
DDx-total [2]	70.7	96.5	36.6	33.1 J	161 J	88 J	43.5 J	563.9 J	205 J	220 J	85.5 J	55	499	22.7 J	13.7 J	19.3 J	11.92 J	7.63 J	17.1 J	10.1 J	7.92 J	5.4 J	7.93 J	225.25 J	7.7 J	5.9 J		5.39 J	58.6
Chlordane -total [3]	1.4 NJ	3.1 NJ	1.44 J	0.72 J	-	-	7.4 J	39 J	-	220 J	-	-	19 J	1.2 J	0.74 J	0.66 J	0.33 J	0.61	-	0.48 J	1.38 J	0.63 J	0.69 J	0.6 J	0.707 J	0.639 J		0.53 J	2.9 J
Endosulfan -total [4]	-	0.62 J	-	-	-	-	3.97 J	11 J	-	26 J	5.7 J	-	-	1.5 J	0.42 J	-	-	-	0.62 J	-	-	0.16 J	-	0.2 J	-	0.081 J		-	-

[1] This value represents the sum of the 2,4' and 4,4' isomers.

[2] This value represents the sum of DDE + DDD + DDT.

[3] This value represents the sum of alpha and gamma chlordane, oxy chlordane, and cis and trans nonachlor.

[4] This value represents the sum of alpha and beta endosulfan and endosulfan sulfate.

Note: Not Detected or Not Analyzed; A complete list of all analytical results is included in Appendix A, Table 1-e.
J detected value and the reported concentration is an estimated value

Table 5-11 Summary of In-Water Sediment Detects (µg/kg)

(upstream to downstream gradients by sample area)

LOCATION	UNDER DOCK AREA																Dredge Area A											
Loocaion/Station	1				2				26				27				17				18				19			
Depth	0-1'	1-6'	6-12'	12-20'	0-1'	1-6'	6-12'	12-20'	0-1'	1-6'	6-12'	12-20'	0-1'	1-6'	6-12'	12-20'	0-1'	1-7'	7-9'	9-12'	0-1'	1-11'	11-13'	13-16'	0-1'	1-9'	9-11'	11-14'
ANALYTE																												
Cyanide																												
Cyanide (total)	12,300	1,040	230 J	-	16,200	370 J	1510 J	110 J	4,580	2,500	260 J	250 J	19600 J	6,400	270 J	220 J	16100 J	2,160	260 J	270 J	110 J	1,220	100 J	130 J	770 J	1,740	1,420	-
Metals																												
Aluminum (pH 6.5-9.0)	3.17E+07	2.32E+07	2.32E+07	2.10E+07	2.79E+07	2.96E+07	3.31E+07	2.31E+07	3.61E+07	3.42E+07	3.15E+07	2.64E+07	3.74E+07	3.40E+07	2.75E+07	1.80E+07	2.52E+07	2.79E+07	1.85E+07	2.20E+07	3.58E+07	2.93E+07	1.52E+07	1.78E+07	2.89E+07	2.66E+07	3.40E+07	2.45E+07
Antimony	290	140	70	60	420	90	80	90	820	810	90	60	970 J	420	110	60	740	710	70	70	280	330	100	100	150	270	280	140
Arsenic	4,520 J	2,390	2,030	1,880	3900 J	2,540	2,460	2,020	6,110 J	4,040	2,410	1,980	13,800 J	3,080	2,630	1,970	7,270	3,010	1,980	1,900	3,330	4,540	2,180	3,110	2,950	4,110	4,590	3,690
Cadmium	238	116	65	63	200	92	110	104	256	197	75	62	446	240	98	48	269	369	50	71	253	451	71	86	193	403	628	153
Chromium, total	43,700	33,800	32,700	28,300	44,300	33,700	37,800	33,900	61,200	65,400	42,100	29,900	87,000 J	45,900	34,800	23,100	85,300	85,900	24,500	21,500	43,200	37,400	23,000	22,700	38,200	37,700	41,100	31,900
Copper	62,300	28,600 J	28,400 J	24,000	55,000	34,200	35,000	31,400	74,700	55,300	32,300	24,100	94,600	48,400	32,800	21,300	90,400	52,300	20,400	25,200	53,000	49,400	18,700	23,100	45,300	49,700	64,600	37,400
Lead	30,000 J	19,000 J	4,140 J	3,320	51,300 J	5,130	4,990	4,500	26,700 J	58,800	7,990	3,360	61,200 J	13,000	3,580	3,100	25,000	75,400	5,440	2,900	24,100	29,400 J	3,560 J	3,420 J	15,000	34,200 J	171,000 J	23,400 J
Manganese	693,000	414,000	459,000	387,000	529,000	410,000	311,000	329,000	963,000	686,000 J	609,000 J	403,000 J	1.24E+06	647,000 J	555,000 J	345,000 J	806,000	557,000 J	449,000 J	289,000 J	878,000	679,000	309,000	455,000	826,000	569,000	621,000	604,000
Mercury	106	112	23	2,340	56	29	26	27	78	169	-	-	77	195	81	-	90	102	-	-	206	377	11 B	17 B	81	405	172	137
Nickel	35,600	29,400	27,500	26,400	31,900	38,200	43,300	31,500	44,600	41,000	33,300	29,500	43,700	34,800	29,400	24,200	43,800	58,400	24,000	20,500	31,800	34,100	25,100	23,500	29,000	33,000	32,800	27,000
Selenium	250	-	-	-	300	-	-	-	210	-	-	-	260	-	150	-		-	-	-	-	-	-	-	-	-	-	-
Silver	143	49 J	24 J	-	126	39	34	36	195	195	39	13 B	222	338	66	-	239	189	26	-	231	422	21	26	138	447	435	139
Zinc	154,000	96,300	71,200	65,400	137,000	88,100	89,100	73,700	169,000	151,000	82,800	69,700	307,000 J	154,000	80,000	61,800	218,000	228,000	63,100	58,600	175,000	160,000	59,400	60,600	121,000	194,000	149,000	89,400
B The result is an estimated concentration that is less than the MRL but greater than or equal to the MDL.																												-
Organobutyltins																												
Tetrabutyltin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tributyltin	180	-	-	-	7.3	-	-	-	7.3	33	-	-	5.6 J	-	-	-	6	2.2	-	-	1.2 J	-	-	-	3.9 J	-	-	10
Dibutyltin	13	-	-	-	2.9	-	-	-	3.4	36	-	-	2 J	-	-	-	1.9 J	0.49 J	-	-	0.41 J	0.45 J	-	-	1.9 J	-	0.52 J	5.3
Monobutyltin	1.6 J	-	-	-	1 J	-	-	-	2.8	2.8	-	-	0.35 J	-	-	-	0.42 J	-	-	-	-	-	-	0.44 J	0.54 J	-	-	1.1 J
TPHs																												
TPH-Deisel	1.90E+05	7.80E+04	-	-	1.70E+05	-	2,800 J	-	9.60E+04	1.10E+05	7,400 J	-	2.30E+05	5.90E+05	3.10E+04	-	3.80E+05	1.00E+06	-	-	4.30E+05	9.00E+05	-	2100 J	6.50E+04	9.30E+05	1.00E+06	8.50E+04
TPH-Motor Oil	3.20E+05	120,000 J	8,000 J	-	3.00E+05	7,300 J	9,300 J	6,600 J	2.30E+05	1.90E+05	14,000 J	-	4.60E+05	6.80E+05	56,000 J	-	6.60E+05	7.40E+05	-	-	4.80E+05	8.70E+05	-	27,000 J	180,000 J	9.90E+05	9.70E+05	1.70E+05

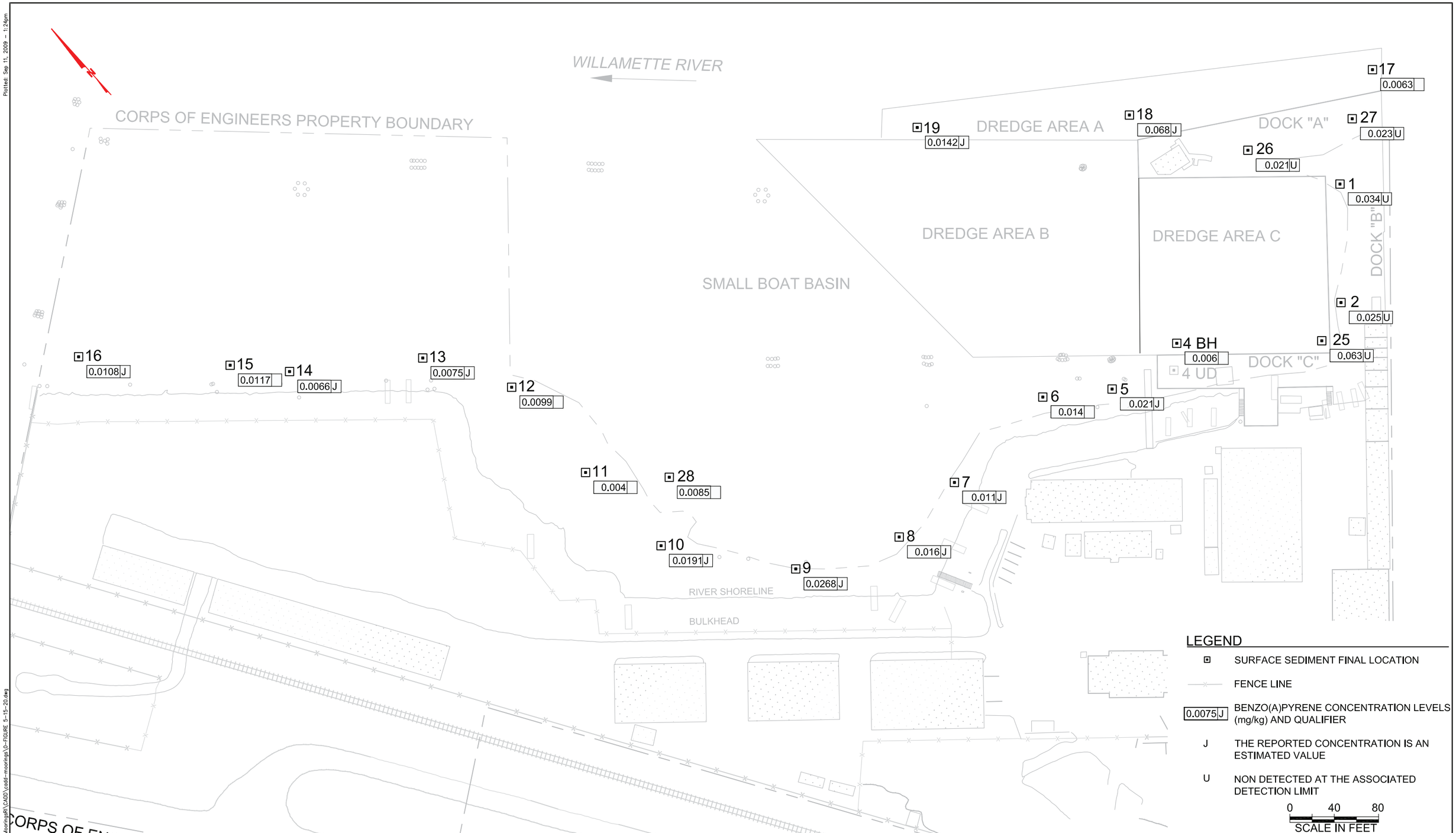
Note: Not Detected or Not Analyzed; A complete list of all analytical results is included in Appendix A, Table 1-e.
J detected value and the reported concentration is an estimated value

Table 5-11 Summary of In-Water Sediment Detects (µg/kg)

(upstream to downstream gradients by sample area)

LOCATION	Dredge Area B						Dredge Area C						Bulkhead															ODOT Outfall	
Loocaion/Station	20		21		22		23		24		25		25	4	5	6	7	8	9	10	11	12	13	14	15	16	28		
Depth	6-8'	8-11'	4-6'	6-9'	6-8'	8-11'	12-14'	14-17'	10-12'	12-15'	10-12'	12-15'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'	1-6'
ANALYTE																													
Cyanide																													
Cyanide (total)	2,630	2,540	1,200	750	52,700	15,200	15,600	9,300	1,410,000	271,000	129,000	423,000	39,400 J	1,880	-	-	100 J	820 J	4,400 J	430 J	190 J	390	340 J	310 J	280 J	370 J	-	1,310
Metals																													
Aluminum (pH 6.5-9.0)	3.11E+07	3.79E+07	3.33E+07	4.00E+07	4.02E+07	3.41E+07	4.47E+07	4.01E+07	2.29E+07	4.03E+07	3.36E+07	2.83E+07	2.03E+07	2.35E+07	2.73E+07	2.69E+07	2.92E+07	2.26E+07	2.23E+07	1.63E+07	2.79E+07	3.40E+07	3.18E+07	2.73E+07	3.12E+07	3.23E+07	2.36E+07	3.20E+07
Antimony	250	270	190	280	690	860	290	410	3,920	940	1,390	1,560	10,100	240	160	150	160	180	510	670	150	130	200	110	120	130	130	190
Arsenic	4,410	5,530	4,170	5,370	6,520	5,410	4,320	3,930	5,700	5,100	11,600	8,370	18,300	4,200	3,050	3,200	3,700	3,000	10,400	4,520	3,040	3,290	3,000	2,800	2,930	3,180	2,660	4,540
Cadmium	424	448	238	361	456	385	357	444	390	378	478	446	231	207	209	251	306	223	249	228	190	166	176	172	182	183	161	265
Chromium, total	41,500	43,800	38,900	48,500	55,000	45,600	48,200	44,200	72,300	55,300	97,500	125,000	332,000	38,800	36,800	33,300	37,200	41,600	141,000	84,800	38,600	42,800	41,100	36,500	37,900	39,300	33,900	39,300
Copper	58,300	56,500	50,800	65,300	83,500	65,500	60,000	56,300	141,000	107,000	183,000	124,000	208,000	110000 J	49,500	41,400	48,500	44,700	52,100	39,600	46,800 J	47,300 J	47,700 J	44,800 J	42,100 J	45,700 J	42,900	54,100
Lead	39,900 J	32,400 J	15,400 J	27,400 J	87,800 J	64,200 J	38,400	49,500	363,000	74,300	120,000 J	203 000 J	385,000	26000 J	24,600	27,800	21,200	19,400	62,300	41,800	13,800 J	13,000 J	11,600 J	12,400 J	12,400 J	14,200 J	11,500	17,900 J
Manganese	861,000	816,000	794,000	896,000	685,000	710,000	886,000J	843,000 J	477,000 J	432,000 J	601,000	451,000	614,000	586,000	606,000	560,000	556,000	534,000	675,000	614,000	897,000	817,000	759,000	657,000	635,000	642,000	661,000	886,000
Mercury	129	350	87	93	176	148	343	796	299	444	232	189	67	76	82	157	75	78	45	103	101	66	61	67	59	62	57	73
Nickel	31,500	37,000	28,700	35,500	47,200	36,200	39,100	41,800	60,600	60,900	59,900	74,600	82,000	29,000	32,700	27,100	29,200	31,400	62,700	46,600	30,600	30,100	29,400	27,900	28,000	29,900	26,300	29,700
Selenium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Silver	393	393	192	408	390	420	394	600	455	415	412	467	165	166 J	184	130	158	132	109	101	122 J	187 J	134 J	135 J	91 J	102 J	136	266
Zinc	191,000	195,000	118,000	175,000	223,000	202,000	180,000	165,000	265,000	205,000	298,000	239,000	402,000	131,000	121,000	135,000	124,000	122,000	166,000	131,000	114,000	117,000	120,000	112,000	110,000	118,000	99,300	125,000
B: The result is an estimated concentration that is less than the MRL but greater than or equal to the MDL.																													
Organobutyltins																													
Tetrabutyltin	-	-	-	-	-	-	-	-	-	-	0.87 J	0.65 J	4.2 J	-	-	-	-	-	-	-	-	-	-	2.2 J	-	-	-	-
Tributyltin	-	1.8 J	9.4	120	19 J	7.4 J	-	-	2.3	-	390	170 J	830	6.1	4.4 J	2.1 J	2.3 J	1.6 J	3.7	8.7	1.7 J	1.3 J	0.55 J	3.2	3.1	36	0.72 J	25
Dibutyltin	-	0.97 J	3.2	42	6.4	2.3	-	0.64 J	-	-	60 J	37 J	71	2.9	2.2 J	1.1 J	1.6 J	1.7 J	2.8	1.9 J	0.78 J	0.95 J	0.69 J	1.9 J	1.5 J	7.9	0.29 J	9.7
Monobutyltin	-	-	1.1 J	7.4	1.7 J	-	-	-	-	-	6.3	1.7 J	2.1 J	0.42 J	0.71 J	-	-	0.52 J	0.66 J	0.81 J	0.54 J	0.48 J	-	0.69 J	0.92 J	1.5 J	-	1.7 J
TPHs																													
TPH-Deisel	3.10E+05	7.30E+05	7.60E+04	2.90E+05	6.20E+05	4.80E+05	8.10E+05	5.30E+05	2.40E+06	2.10E+06	7.70E+05	1.10E+06	4.50E+05	8.70E+04	6.10E+04	2.70E+05	4.40E+04	4.60E+04	4.60E+04	4.50E+04	3.80E+04	3.80E+04	3.80E+04	3.20E+04	3.30E+04	4.50E+04	2.80E+04	1.40E+05
TPH-Motor Oil	5.10E+05	7.80E+05	2.30E+05	7.20E+05	9.40E+05	7.00E+05	5.40E+05	8.00E+05	2.10E+06	1.40E+06	1.20E+06	1.40E+06	6.90E+05	2.40E+05	200,000 J	210,000 J	190,000 J	220,000 J	2.20E+05	1.90E+05	160,000 J	150,000 J	160,000 J	140,000 J	140,000 J	160,000 J	130,000 J	3.40E+05

Note: Not Detected or Not Analyzed; A complete list of all analytical results is included in Appendix A, Table 1-e.
J detected value and the reported concentration is an estimated value



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REMEDIAL INVESTIGATION

WILLAMETTE RIVER SURFACE SEDIMENT BENZO(A)PYRENE CONCENTRATIONS

DRAWING NUMBER: FIGURE 5–15
CAD FILE NUMBER:
SHEET: OF
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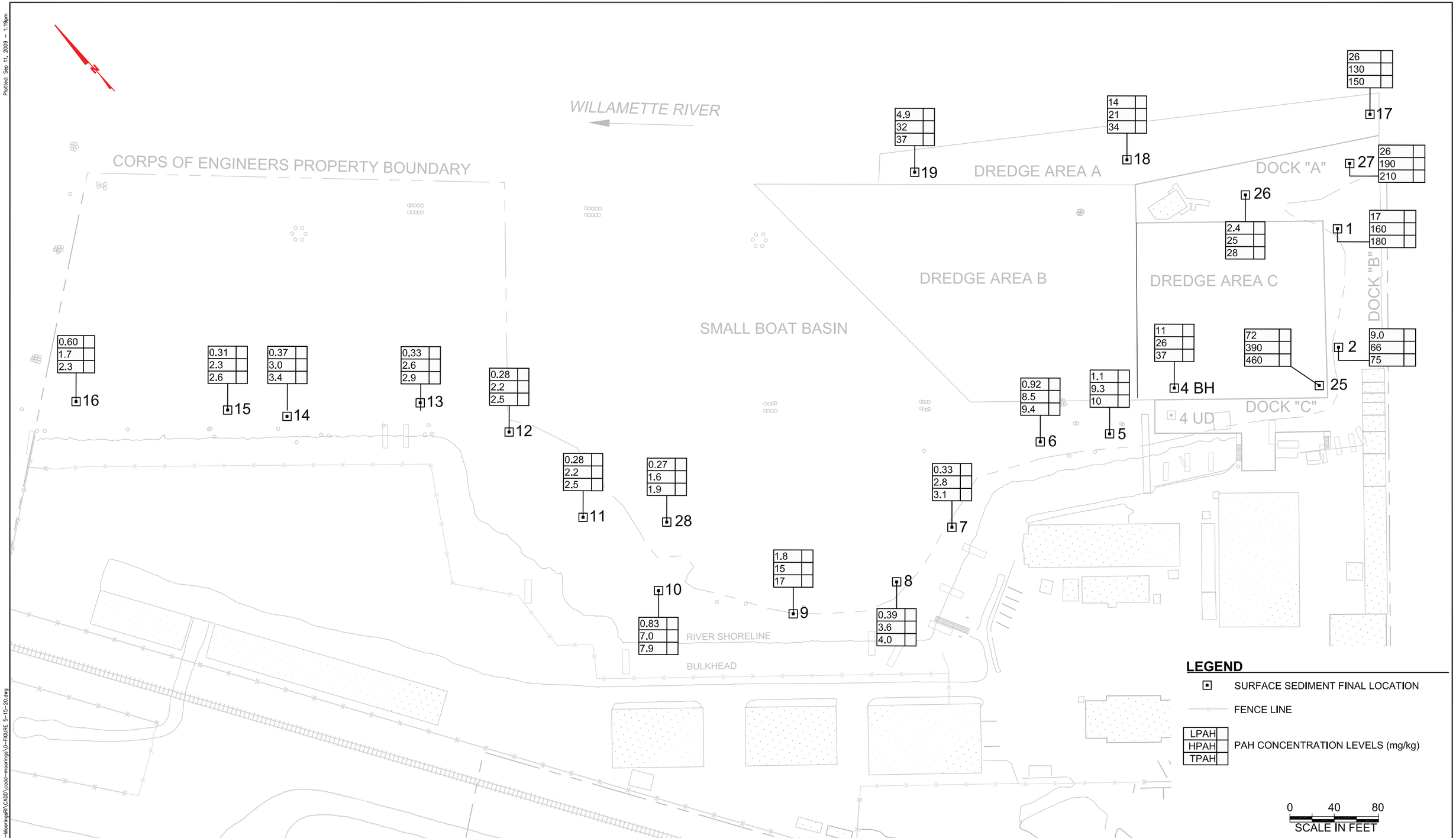

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REMEDIAL INVESTIGATION

WILLAMETTE RIVER SURFACE SEDIMENT PAH CONCENTRATIONS

DRAWING NUMBER: FIGURE 5–16

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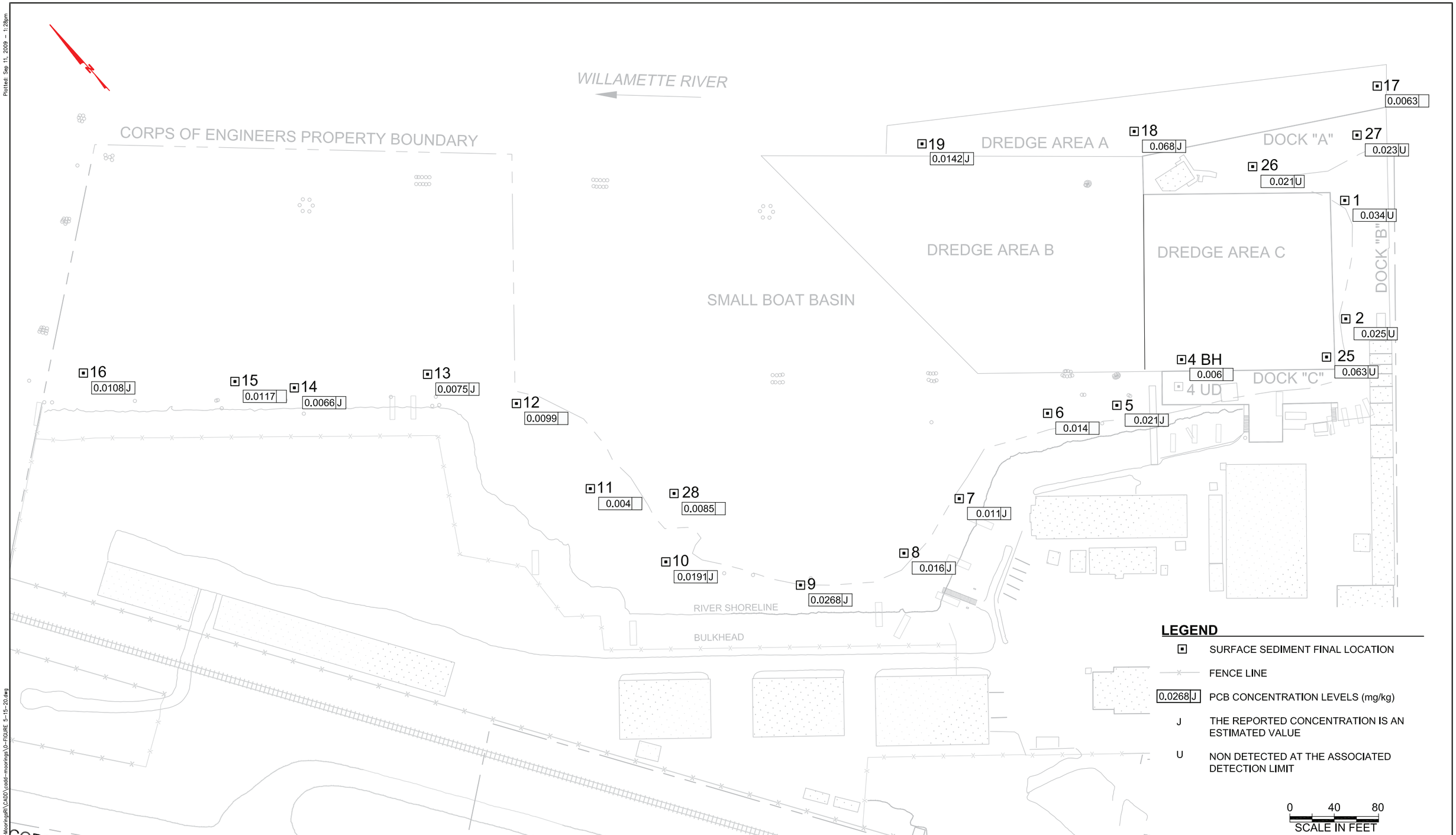

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WILLAMETTE RIVER SURFACE SEDIMENT PCB CONCENTRATIONS

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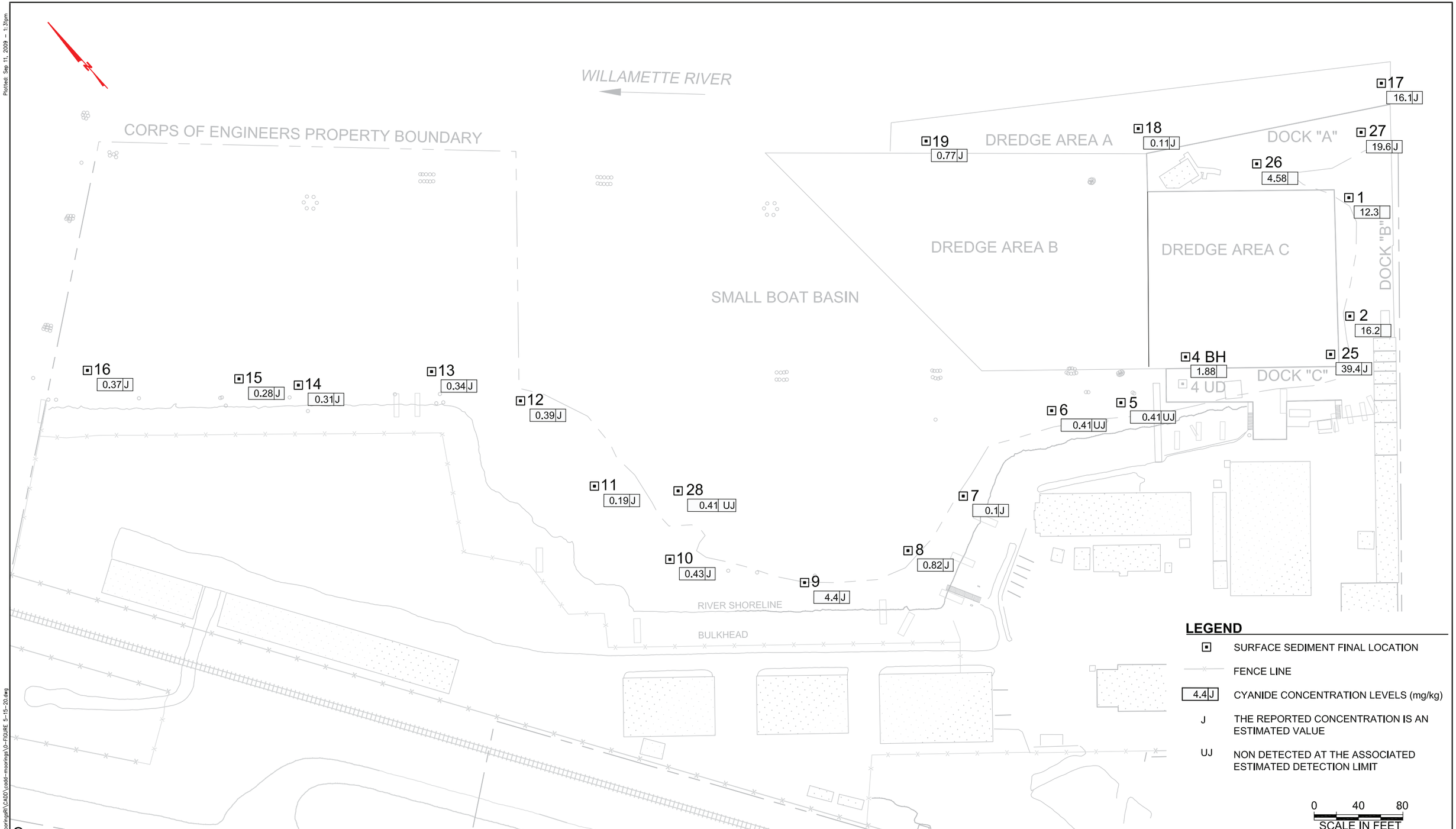

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WILLAMETTE RIVER SURFACE SEDIMENT CYANIDE (TOTAL) CONCENTRATIONS

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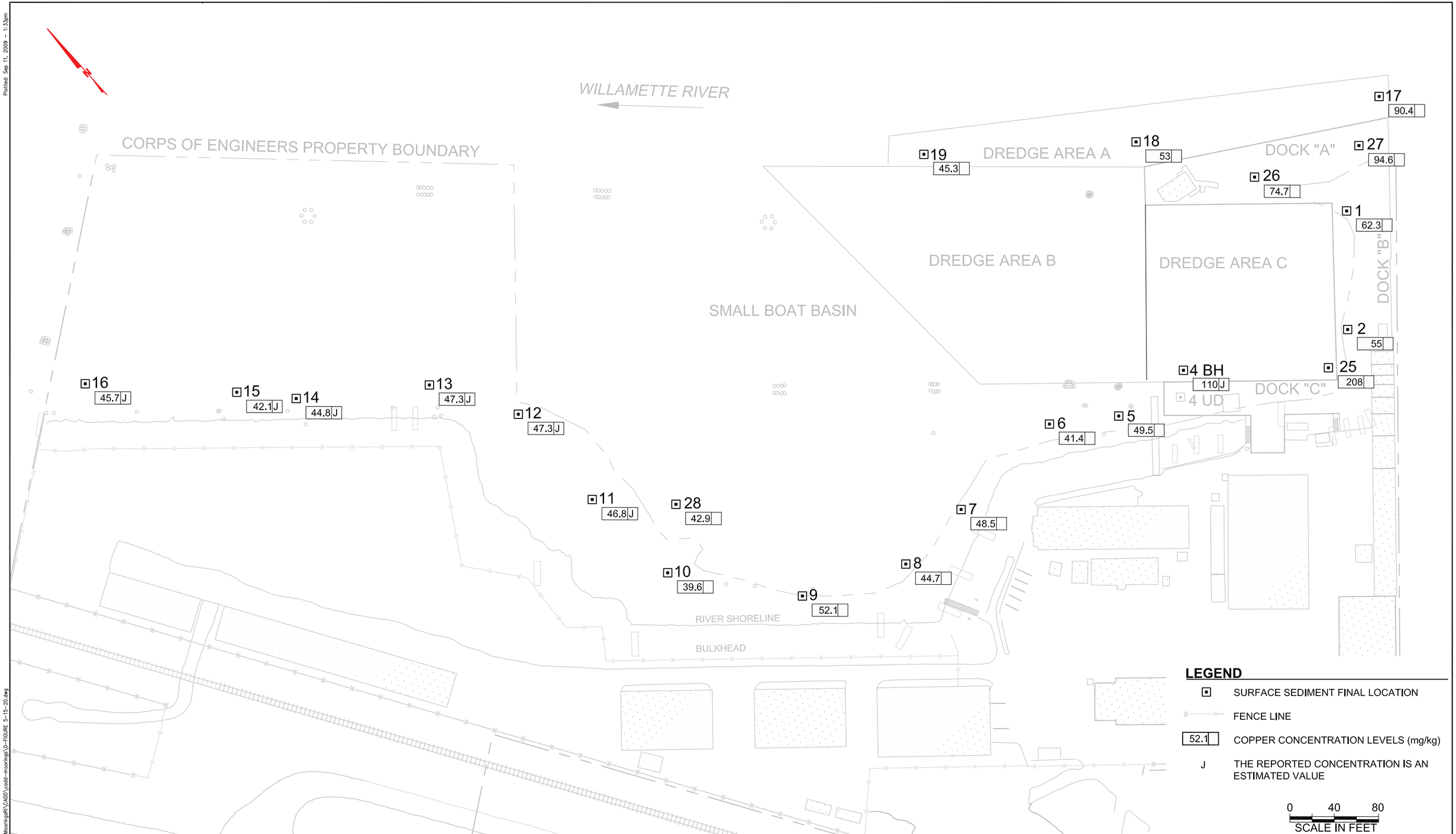

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WILLAMETTE RIVER SURFACE SEDIMENT COPPER CONCENTRATIONS

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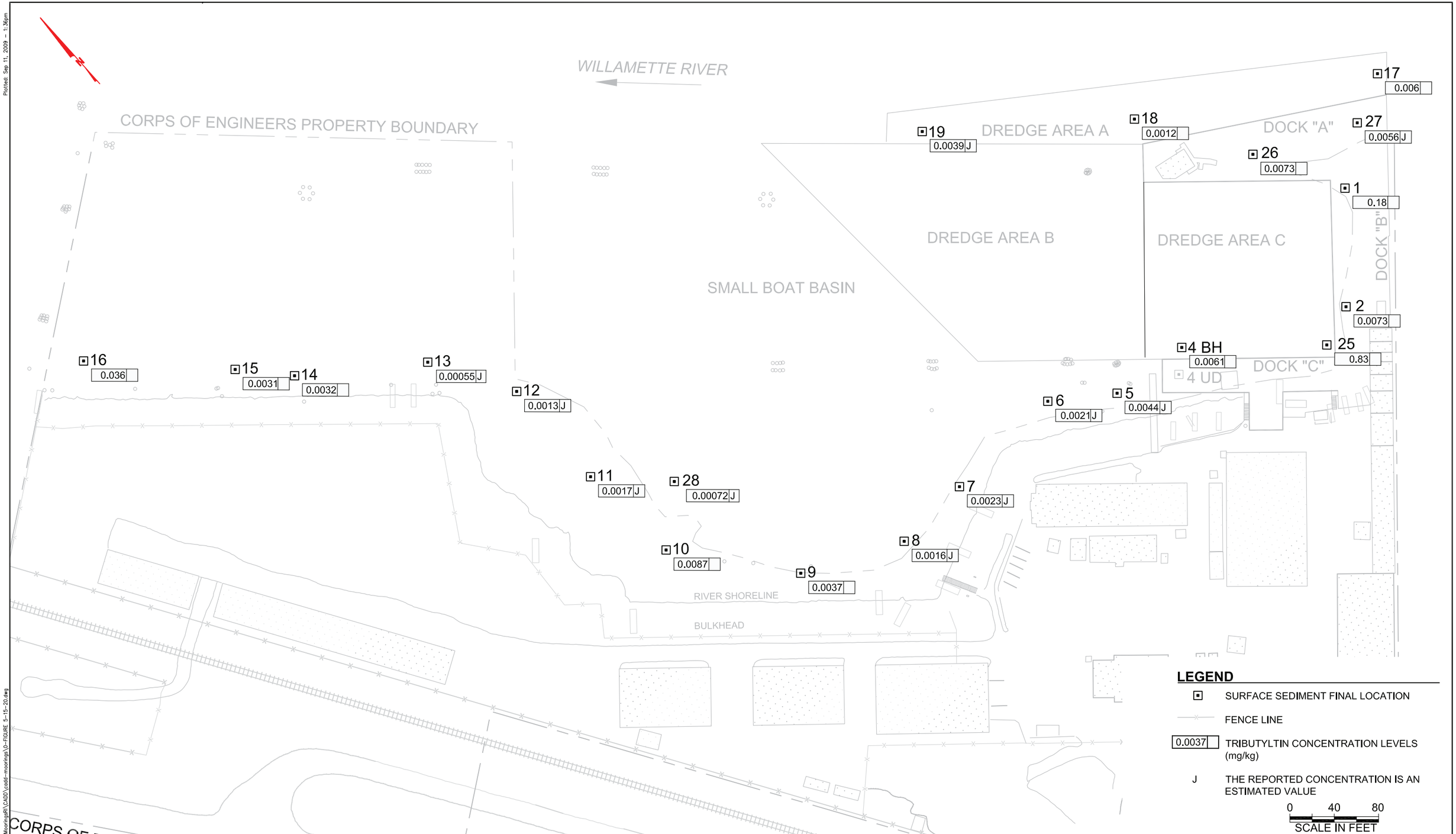

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US GOVERNMENT MOORINGS

REMEDIAL INVESTIGATION

WILLAMETTE RIVER SURFACE SEDIMENT TRIBUTYLTIN CONCENTRATIONS

DRAWING NUMBER: FIGURE 5–20

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5.2 SITE GEOLOGY/HYDROGEOLOGY

5.2.1 Geology

There have been three documented dredging periods at the Moorings during which river sediment from the basin directly in front of the site was used for upland fill (see Section 2.4 (page 2-5). Figure 5-21 (page 5-91) illustrates the current surface elevation contours at the site. In general, the site slopes from southwest to northeast with a local on-site relief of approximately 9 feet. The elevations range from approximately 38 feet at the flagpole in the southwest corner of the site to approximately 29 feet at the bulkhead on the northeast side of the site.

One objective of the RI was to locate the approximate interface between the native soils and the fill material. A series of direct push probe borings were advanced throughout the site to locate this interface and to collect environmental samples for physical/chemical analyses. Figure 5-21 (page 5-91) shows the locations of these borings and of 3 transects from which generalized cross-sections were developed to illustrate the subsurface characteristics of the site. Figure 5-22 (page 5-93) depicts the elevation contours for the native soil/fill interface, as interpreted from the soil boring logs. The interface between the native soil and fill was readily apparent beneath the majority of the site, as evidenced by clear changes in the nature of the subsurface materials. However, in the Laydown and North Logistics MUs near the north end of the site the subsurface materials were more homogenized such that the native soil/fill interface was not discernable.

Cross sections A - A', B - B' and C - C' are illustrated in Figures 5-23 (page 5-95) and 5-24 (page 5-97). These conceptual interpretations of subsurface lithology at the Moorings site are consistent with cross-sections developed as part of other studies in the area. It should be noted that cross section A – A' contains subsurface data from 5 locations (A, B, C, D, and F) that were part of a study conducted by MacKenzie/Sato and Associates for the USEPA (USEPA 1990).

5.2.2 Hydrogeology

Sixteen temporary wells installed in the Industrial Area to allow collection of groundwater samples and the better characterize the hydrogeology of the surficial fill in that portion of the site. The wells were installed in two phases. Phase 1 included wells at Locations 1 through 6, 11, 12, 16, and 20. Phase 2 included wells at Locations 21 through 28, 30, and 31. All of the wells were completed in the surficial water bearing zone, with screen depths ranging from 8 - 28 feet bgs.

Water table elevations were measured in the wells at two different times to assess possible seasonal differences in flow directions and gradients: March 2008 and August 2008. Figure 5-25 (page 5-99) illustrates the water table elevations measured in March of 2008, and Figure 5-26 (page 5-100) illustrates the measurements taken in August 2008. Groundwater flow in both cases is in a northwesterly direction under a hydraulic gradient of approximately 0.020. This value is consistent with the hydraulic gradient calculated during similar studies at GASCO (Hahn 2007).

Measurements of the Willamette River stage were not collected as part of the Moorings RI. However, it is reasonable to assume that the relationship between the shallow groundwater and river elevations at the Moorings would be similar to that of the upgradient GASCO and Siltronic sites (see Section 2.6.2, page 2-24).

5.3 SURFACE WATER

During the RI, a small depression was observed in the Laydown MU near the bulkhead wall on the north end that ponded water when it rained. There was also an unnamed intermittent stream located on the upgradient hillside that drained into the sampled ODOT catch basin. This catch basin was in turn drained by two pipes that run under the site to the Willamette River.

5.4 SEDIMENT LITHOLOGY

Cores were collected and logged for lithology for all under-dock, dredge areas, and for the ODOT outfall samples. The logs, and supporting photo documentation, are presented in Appendix E of the *Cruise Report*. Specific observations relevant to the interpretation of sediment chemical distribution are discussed herein.

In general, surface sediment samples throughout the site (including Bulkhead samples) consisted of a loose, unconsolidated, organic silts and clays, that become slightly consolidated with depth (>20 inches). At depths between 20 – 40 inches the sediments are soft, brownish olive-gray, moist silty/clays (30/70) with evidence of both thin (<1"), gray sand stringers, and black bands of PAH enriched sediments, some with mineralized PAH layers. Within Dredge Area A, below approximately 100 inches a soft, damp, well sorted, uniformly graded, gray fine sand with clasts of silty clay was encountered. For the remaining core samples, the sediments are characterized as silty-clays through the bottom of the core. At all stations, methane gas pockets were observed in organic silty clays in the upper 0 - 8 feet of the sediment column.

In all the under-dock cores (except SDUD-4), Dredge Areas A and C, and at SDDB-20 the subsurface sediments contained black laminar bands of PAH enriched sediment with diffuse sheen and strong PAH odor (Figure 5-27, page 5-101). These occurred throughout the samples, but were most evident between -23 to -29 CRD in Dredge Area A, and between -13 to -19.5 ft CRD in Dredge Areas B and C. These depths are within the bottom of the 1981 dredge prisms for areas A, B, and C. The dark PAH-bands were not observed in the cores at SDDB-21 and the ODOT outfall sampling station (SDOF-28).

The dark bands of PAH enriched sediments are representative of pulsed depositional events. Each band is well defined and laminar in orientation and these bands are frequently separated by 0.25->5-inch accumulations of brown silt/clays. Furthermore, some of the depositional bands have a parting plane of mineralized PAH, indicating a likely spill or NAPL event (e.g., SDDB-20) that has been covered by successive sedimentation. Stations in the southernmost portions of the sampling area, excluding the Under dock samples, exhibited the most pronounced and numerous of these bands.

In addition, bands and or layers of wood debris were evident with depth in some cores (e.g., SDDC-24, SDDC-23). This banding of woody material suggests episodic depositional events. The deposit of woody debris at SDDC-24 consists of mechanically fragmented wood chips intermixed with silts and clays. Sheening and strong PAH odor is also associated with this accumulation of mechanically fragmented woody debris.

It is important to note, based on the stratigraphy observed from the vibracores, that the areas sampled appear to be strongly depositional and a net sediment sink. Each of the vibracores collected in the river exhibits a near continuous depositional record with little evidence of erosional events other than scarce thin (<1”) stringers of fine sand. Furthermore, the preservation of fine-scaled laminae at depth indicates that the sediment column, at that depth has been stable since deposition.

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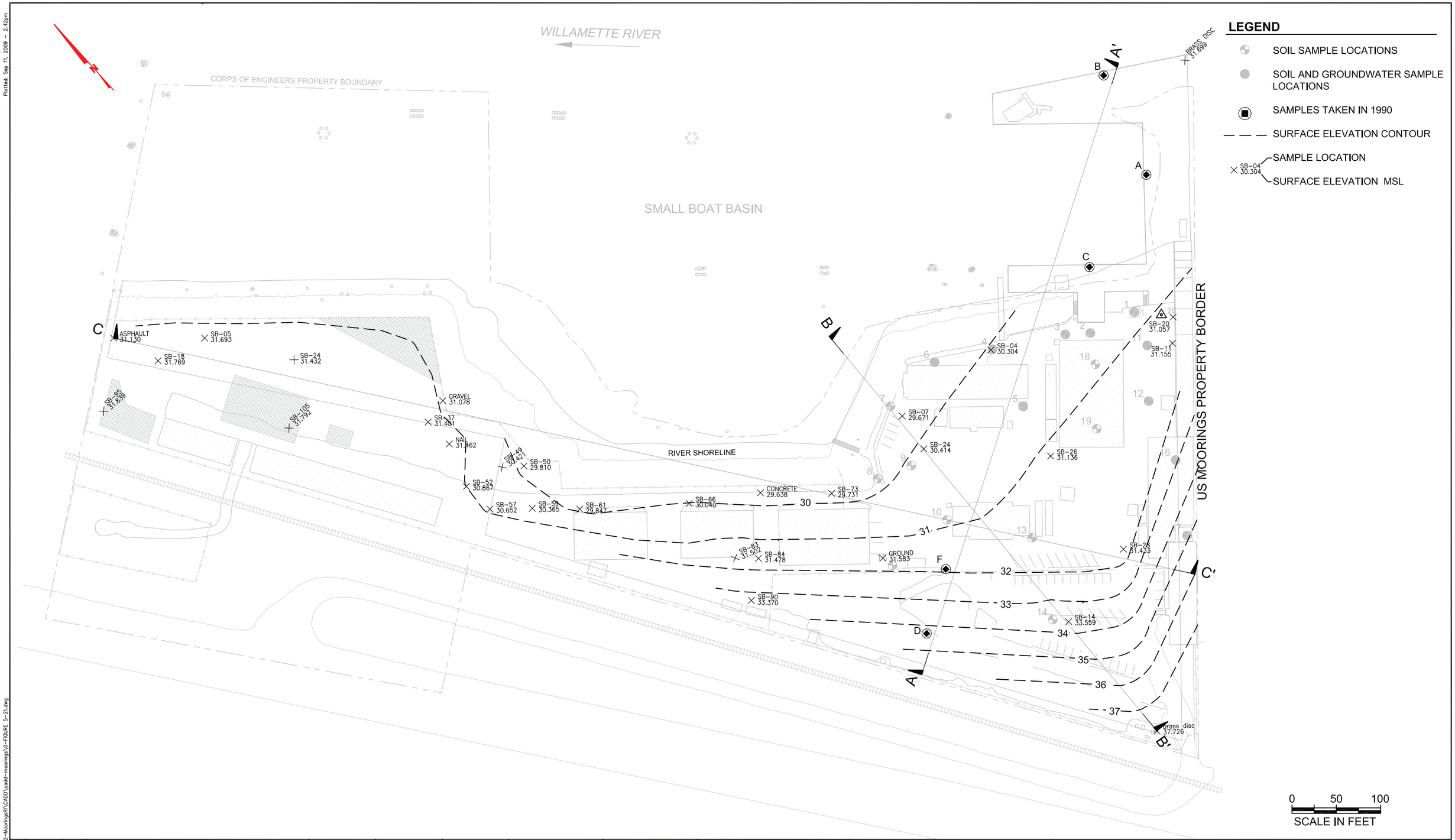

File: X:\Bellevue\office\Projects\6142-MooringsRI\CADD\cadd-moorings\D-FIGURE 5-21.dwg

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SURFACE ELEVATIONS (MSL) AND SECTION LINE LOCATIONS

DRAWING NUMBER: FIGURE 5-21

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REMEDIAL INVESTIGATION

NATIVE SOIL/FILL INTERFACE ELEVATION (MSL)

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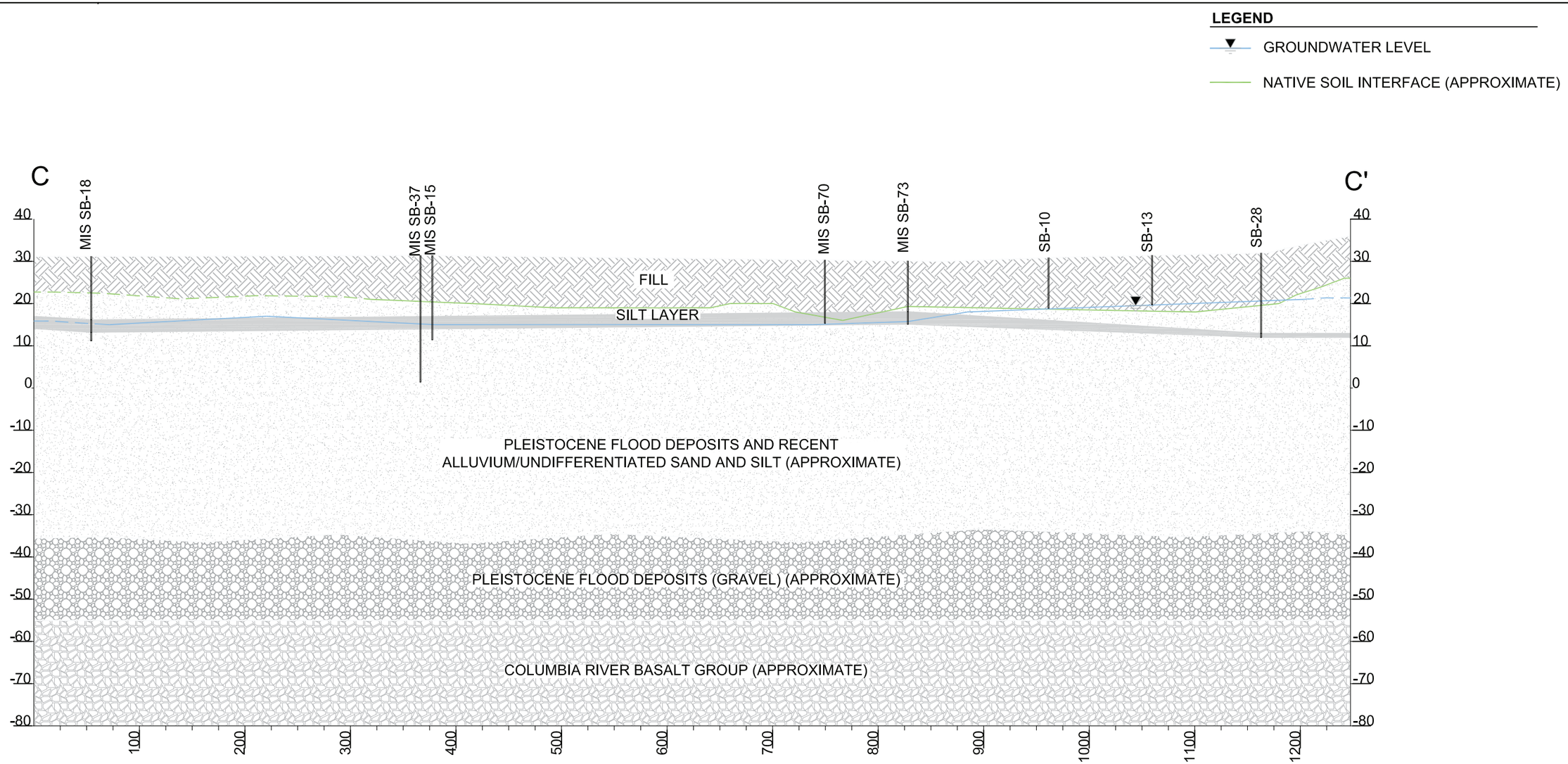

CONCEPTUAL SECTION C-C'

HORIZ: 1" = 100'
VERT: 1" = 25'

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A	XX/XX/XX	XXX	

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CONCEPTUAL CROSS SECTION
C-C'

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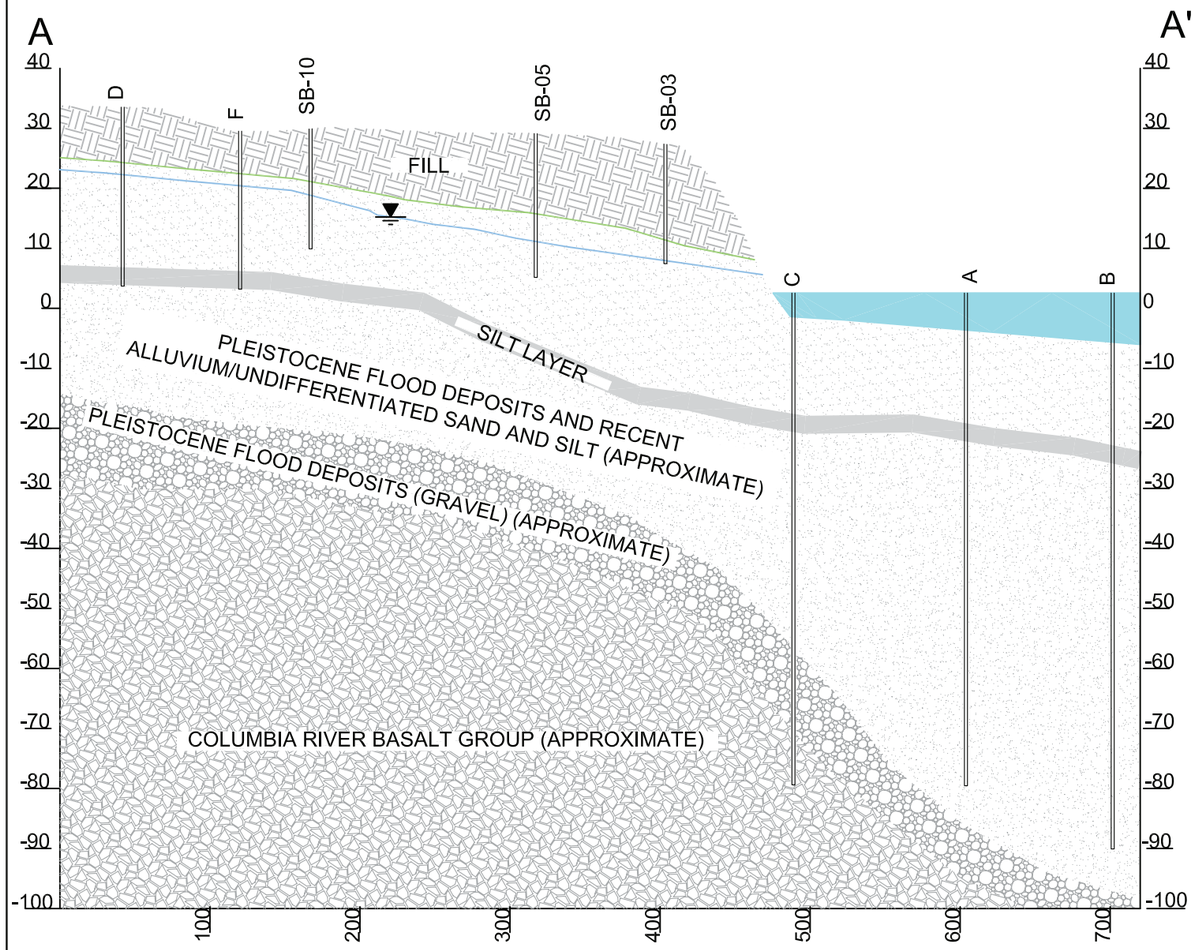
LEGEND

GROUNDWATER LEVEL

NATIVE SOIL INTERFACE (APPROXIMATE)



CONCEPTUAL SECTION A-A'

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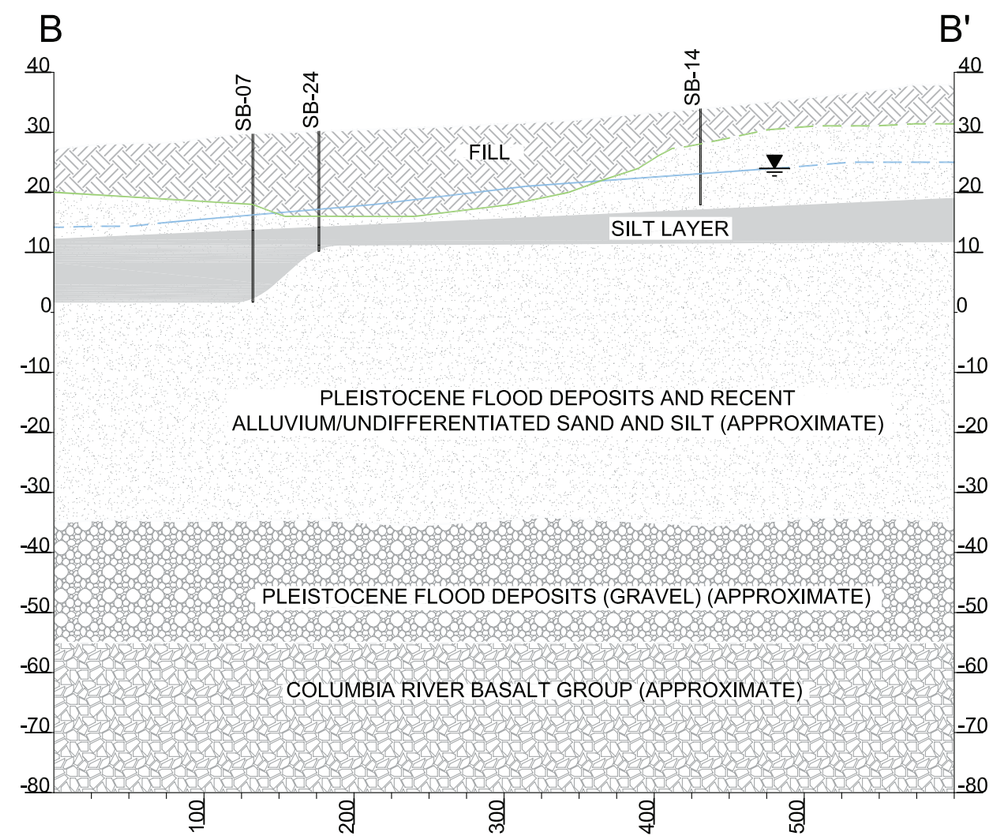
VERT: 1" = 25'



CONCEPTUAL SECTION B-B'

HORIZ: 1" = 100'
VERT: 1" = 25'

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REMEDIAL INVESTIGATION

CONCEPTUAL CROSS SECTION
A–A' AND B–B'

DRAWING NUMBER: FIGURE 5–24
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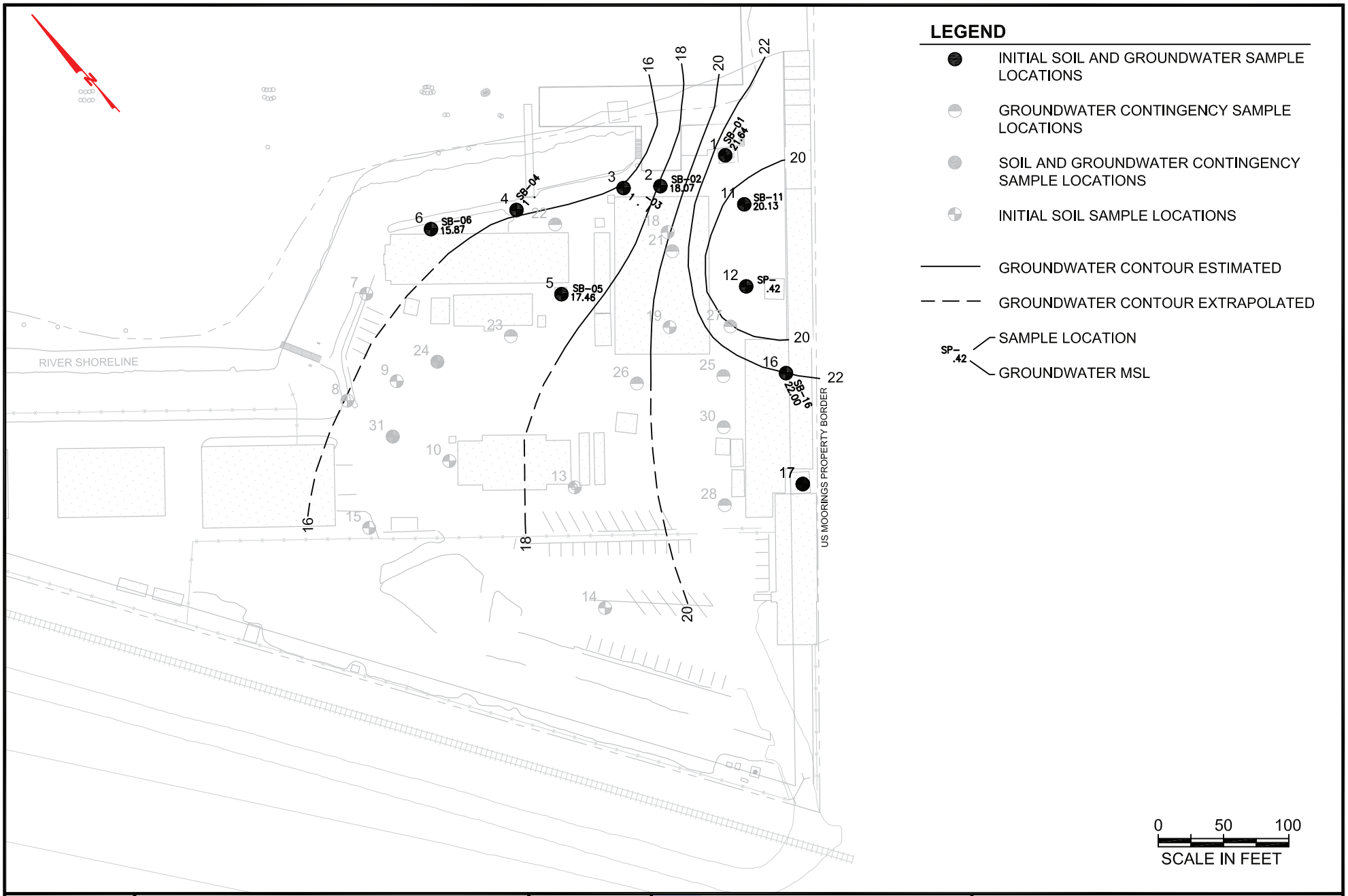
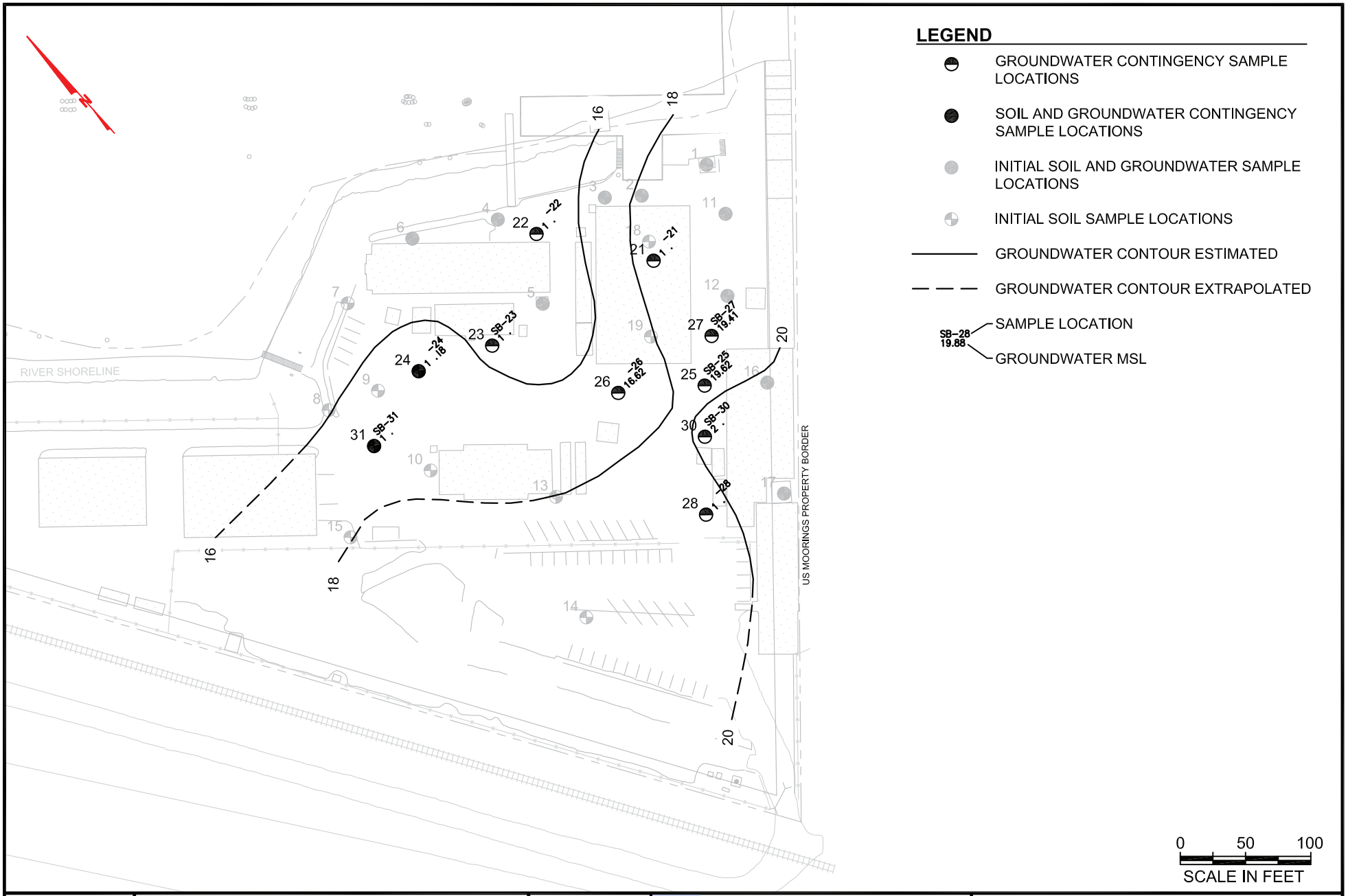


FI -	\DWATER INTERFACE ELEVATION CONTOURS (MARCH 2008 SAMPLING EVENT)	DAT : DRAWN: CHECKE):	TEC inc 1450 114th Ave llevue, Wa 98004 42	\ ENT MOORINGS REMEDIAL INVESTIGATION



FI -	\DWATER INTERFACE ELEVATION CONTOURS (AUGUST 2008 SAMPLING EVENT)	DAT : DRAWN: CHECKE):	TEC inc 1450 114th Ave llevue, Wa 98004 42	\ ENT MOORINGS REMEDIAL INVESTIGATION

Figure 5-27 below illustrates the evidence of episodic depositional events in Dredge Areas A, B and C. SDDA-19 core section collected between -24.9 to -29.5 CRD. SDDA-20 core section collected between -23.1 to -27.6 CRD. Note the mineralized PAH fracture planes (white arrow). SDDC-23 core section collected between -13.5 to -19.5 CRD. Note mineralized PAH fracture planes (white arrows) and deposited wood debris (black arrows). SDDC-24 core section collected between -12.6 to -18.7 CRD. Mineralized PAH fracture planes (white arrows) and deposited fragmented wood debris (black arrows).

Figure 5-27 Evidence of Episodic Depositional Events

5.5 DATA QUALITY SUMMARY

5.5.1 Data Validation and Quality Assessments

The purpose of data validation and data quality review is to eliminate suspect analytical data and to designate data qualifiers, as appropriate, for any data quality limitation discovered. All analytical data from the RI were review and validated prior to use in this report. Level IV (full) data validation was performed on the first sample delivery group (SDG) for each sample matrix (i.e., one for soil, groundwater, and sediment each). Included in the Level IV validation was a complete review of all data reporting forms to ensure that they complied with project requirements and quality objectives. All raw data, including records of sample preparation, instrument conditioning and calibrations and verifications, were reviewed against summarized forms for completeness and correctness. Chromatograms and ion spectrum were reviewed to verify target compound identification. A calculation check was performed to verify all reported values in the summarized forms, including initial calibrations, calibration verifications, spike recovery, duplicate relative differences, and target analyte quantitation.

A Data Quality Assessment Report (DQAR) was also completed. The DQAR presents an assessment of data quality against the DQOs set forth in the QAPP, Chapter 2 of the Management Plan for Remedial Investigation at U.S. Government Moorings, Portland Oregon, SAP, KTA/TEC, February 2008. The DQAR summarizes the data quality for each sample matrix in terms of precision accuracy, representativeness, sensitivity, comparability, and completeness.

Data Validation Reports (DVR) are included in Appendix A-5. Results of the data validation, in the form of data qualifiers, were incorporated into the data summary tables presented herein.

5.5.2 Analytical Data Overview

This section provides an overview of the overall data quality, major QC anomalies associated with sample analyses, and the general limitations to the data usability. Detailed discussions of data quality and usability and specific QC anomalies associated with individual data point are found in the DVRs and the DQARs included in Appendix A-5 and A-6, respectively.

In summary, ten groundwater (including two field duplicates) and three seepage water samples were collected in March 2008. All water samples collected in this phase were analyzed for VOCs, PAHs, chlorinated phenols, organochlorine pesticides (pesticides), PCB Aroclors, total and dissolved metals, and TPH-Diesel and TPH-Motor Oil. Only groundwater samples were analyzed for VOCs, cyanide (total), and TSS.

In August 2008, 11 additional groundwater samples (including one field duplicate) were collected for cyanide speciation in the groundwater. Samples were analyzed for cyanide (total), free cyanide, total available cyanide, WAD cyanide, and cyanide amenable to chlorination.

A total of 72 soil samples and seven field duplicates were collected from the Moorings upland soils as well as 11 MIS composite soils and two field triplicates were collected in March 2008. All soil samples were analyzed for SVOCs, PAHs, chlorinated phenols, pesticides, PCB Aroclors, metals, and TPH–diesel and motor oil. Only selected samples were analyzed for VOCs, organobutyltins, and cyanide (total).

A total of 61 sediment samples and three field duplicates were collected in April 2008. All sediment samples were analyzed for SVOCs, PAHs, chlorinated phenols, pesticides, PCB

Aroclors, organobutyltins, metals, TPH–diesel and motor oil, cyanide (total), total organic carbon (TOC), and grain size. Only selected samples were analyzed for VOCs.

5.5.3 Quality Control Outliers and Anomalies

QC outliers associated with the water, soil, and sediment data included the following:

- Low levels of common laboratory contaminants such as acetone, methylene chloride, toluene, o-xylene, selected phthalates, naphthalene and methylnaphthalenes, phenol, di-n-butyltin, selected metals (i.e., selenium, cadmium, silver, and zinc), and TPH-Diesel and TPH-Motor oil were detected in one or more method blanks. All these detections in method blanks were at levels below the practical quantitation limits (PQLs). The affected data were mostly at levels below the PQLs as well, or in few cases, slightly above the PQLs. These data were qualified as non-detects at or slightly above their PQLs. The final sample-specific PQLs had minimum, if any, deviations from the project goals for quantitation limits as a result of the laboratory artifact.

- Chemicals known to respond poorly to the analytical methods such as dichlorodi-fluoromethane, chloromethane, vinyl acetate, acrolein, aniline, N-nitrosodimethylamine, 2,4-dimethylphenol, 3,3'-dichlorobenzidine, benzoic acid, and hexachlorocyclo-pentadiene had low recovery in the calibration verifications and/or laboratory QC analyses. Results of these compounds were either qualified as estimated or, in few cases, rejected. In addition, 2-chloroethyl vinyl ether results for all groundwater samples were rejected because this chemical breaks down in acidic environments while all water samples were preserved with acid as required. For soil and sediment samples, 2-chloro-ethyl vinyl ether showed low recovery (less than 10%) in most of the MS/MSD analyses, and the associated results were rejected. All these target compounds were not detected at or above the method detection limits (MDLs) in field samples and were not expected as chemicals of potential concern at the site. The project goals were not compromised as a result of the potential low bias associated with these analytical data.

- Severe non-target chemical interferences were observed on organochlorine pesticides analyses (USEPA Method 8081A) for soil and sediment samples. The data review confirmed that all applicable sample and extract cleanup was performed prior to the instrumental analyses, and the interferences were primarily caused by the sample matrices. In particular, pesticides data were significantly (mostly false positively) affected in cases where PCB Aroclors were present in the samples. The analytical method is known to have limited ability in differentiating instrumental responses of chlorinated pesticides from other non-target chlorinated compounds such as PCBs. The ultimate effects on data quality by the interferences included: (1) raised chromatographic noise (sample-specific MDLs were therefore raised to the PQLs, and (2) elevated variability of values obtained from the two analytical columns (data were therefore qualified as estimated). In a few cases where severe interference was identified, as indicated by the elevated dual column relative percent difference (RPD) values (greater than 90%), the results were qualified (NJ) to alert data users that the presence of the compounds was presumptive and the reported concentrations might be highly biased.

Other QC outliers discretely occurred with various analyses including: biased recovery of surrogates, internal standards, laboratory control sample (LCS), and/or MS/MSD analyses, high variability of inductively coupled plasma (ICP) serial dilution analyses for selected metals, and high variability of laboratory duplicate analyses or field duplicate samples. In all cases,

appropriate data qualifiers were assigned to the affected data (primarily J or UJ as estimated) via the data review and data validation, and the usability of the data altered accordingly.

5.5.4 Summary

Data collected during the March and April 2008 investigation were sufficient in quality and completeness and achieved the project DQOs. However, data should only be used in conjunction with data qualifiers assigned via the data review and data validation, as presented in each of the data validation reports. Data qualified with (R) as rejected should not be used for any purposes or any levels of decision making. Data qualified with (NJ) should be used with caution that the reported results might be false positive and the presence of the compounds is presumptive.

5.5.5 Contingency Analytical Methods

At the request of the USEPA, the USACE agreed to conduct analysis of cyanide in groundwater in contingency samples similarly to current GASCO sampling and analysis activities. Accordingly, several different analytical methods were used to analyze groundwater contingency samples for cyanide. The purpose of analysis via multiple methods was to assist in the identification of what species of cyanide might be present in the groundwater. As described below, the different methods have different protocols and target different species of cyanide. Included in this section are laboratory control limits for the methods, as they were not part of the original QAPP developed for this project. Table 5-12 (page 5-105) summarize the analytical concentration goals, laboratory method detection limits (MDLs), MRLs, and QC control limits for the contingency sampling.

5.5.5.1 WAD Cyanide by Method SM4500 CN – I

The WAD methodology is similar to that of USEPA Method 335.4. However, samples are distilled in a slightly acidified solution (pH 4.5 to 6.0) instead of sulfuric acid as used in Method 335.4. HCN converted via this distillation procedure is, in general, from cyanide complexes that are less stable, such as free $cyanide^-$ ions, cadmium-cyanide, or zinc-cyanide complexes.

5.5.5.2 Available Cyanide by EPA Method OIA-1677

Ligand-exchange reagents are added at room temperature to the sample and form thermodynamically stable complexes with the transition metal ions including zinc, copper, cadmium, mercury, nickel, and silver, resulting in the release of cyanide ion from the metal-cyano complexes. Cyanide detection is accomplished using a flow-injection analysis (FIA) system.

The stability of the cyanide complexes that react to this methodology is in general similar to the WAD cyanide method. However, the types (species) of the cyanide complexes are selective to the exchange ligands rather than the weak-acid distillation process.

5.5.5.3 Free Cyanide by SW846 Method 9213

This method measures non-complexed cyanide (cyanide ions) and HCN. Samples are mixed with ion-strength adjusting solution, and measured by a cyanide ion selective electrode (ISE) for cyanide concentrations.

5.5.5.4 Cyanide (total) by USEPA Method 335.4

Cyanide as HCN is released from cyanide complexes by a manual reflux-distillation (with the addition of sulfuric acid into the sample) and absorbed in a scrubber containing sodium hydroxide solution. The cyanide ion in the absorbing solution is converted to cyanogen chloride by reactions with chloramine-T. The solution is then titrated with pyridine/barbituric acid reagent (give a red-colored complex) via manual titration or automated analyzer for cyanide quantitation.

This methodology intends to liberate cyanide from complexes with full range of stability, including the ones that are considered “tight” complexes such as iron-cyanide complexes.

5.5.5.5 Cyanide Amenable to Chlorination by Method SM4500 CN – G

The sample is divided into two portions – one treated with chlorine, a strong oxidant to destroy cyanide in various complexes and one is not treated. Both portions are then distilled separately in a strong acid solution (same as that for cyanide (total) by USEPA Method 335.4). The difference of cyanide concentration between the chlorine-treated and untreated sample is reported as Cyanide Amenable to Chlorination (CATC). The cyanide result obtained from this method represents the amount of high-stability cyano-complexes that sustain through the chlorination process in a sample.

Table 5-12 Contingency Sampling - Analytical Data Quality Control Guidelines

Analyte	Analytical Method	MRL	Surrogate Spike Accuracy (% Rec.)	LCS Accuracy (% Rec.)	Matrix Spike (% Rec.)	Precision (RPD)	Completeness (%)
Cyanides in Water (mg/L)							95%
Available Cyanide	EPA IOA-1677	0.01		90-110%	90-110%	20%	
Cyanide (total)	EPA 335.4	0.01		90-110%	90-110%	20%	
Cyanide Amendable to Chlorination	SM4500 CN-G	0.01		90-110%	90-110%	20%	
Free Cyanide	EPA 9213	0.1		90-110%	90-110%	20%	
WAD Cyanide	SM4500 CN-I	0.01		90-110%	90-110%	20%	
Total Petroleum Hydrocarbons in Soil		*(mg/kg)*					95%
TPH-Gasoline	NWTPH-Gx	5		81-111%	50-150%	40%	
4-Bromofluorobenzene (Surr.)	NWTPH-Gx		50-150%				
TPH-Diesel	NWTPH-Dx	25		63-120%	66-129%	40%	
o-Terphenyl (Surr.)	NWTPH-Dx		50-150%				
TPH-Motor Oil	NWTPH-Dx	100		60-131%	49-139%	40%	
n-Triacontane (Surr.)	NWTPH-Dx		50-150%				
Total Petroleum Hydrocarbons in Water		*(ug/L)*					95%
TPH-Gasoline	NWTPH-Gx	80		60-120%	76-138%	30%	
4-Bromofluorobenzene (Surr.)	NWTPH-Gx		50-150%				
TPH-Diesel	NWTPH-Dx	100		69-123%	45-161%	30%	
o-Terphenyl (Surr.)	NWTPH-Dx		50-150%				
TPH-Motor Oil	NWTPH-Dx	100		60-120%	60-140%	30%	
n-Triacontane (Surr.)	NWTPH-Dx		50-150%				

Notes:
1 Listed surrogate spike, precision, and accuracy control limits are based on laboratory in-house performance statistics and subject to change as updated by the laboratory.
2 EPA IOA-1677 = Available Cyanide by Flow Injection, Ligand Exchange, and Amperometry. U.S. EPA 821/R-99-013, August 1999.
3 EPA 335.4 = Methods for Chemical Analysis of Water and Wastes, U.S. EPA 600/4-79-020, Revised March 1983 and Updates.
4 SM4500 = Standard Methods for the Examination of Water and Wastewater, American Public Health Association, 21st Edition. 2005.
5 NWTPH Methods = Analytical Methods for Petroleum Hydrocarbons, ECY 97-602, Washington State Department of Ecology, June 1997.
LCS Laboratory control sample
%REC = Percent recovery
Surr. = Surrogate Spike

6.0 NATURE AND EXTENT OF CONTAMINATION

6.1 INTRODUCTION

This section describes the nature and extent of contamination at the Moorings based on the data presented in Section 5. For convenience, the findings are presented in terms of the potential on- and off-site contaminant sources identified in the CSM (Sections 6.2, page 6-2, and 6.3, page 6-9, respectively), and in relation to the in-water sediment investigation (Section 6.3, page 6-9). Also included is a discussion of the findings in relation to the Portland Harbor JSCS for evaluating potential impacts of upland contaminant sources on the Willamette River (Section 6.4, page 6-15). Potential human health and ecological risks associated with the detected contaminants are discussed in Section 7.

Reference is made to various COIs throughout this section. COIs were identified by comparing the sample analytical results to various media-specific SLVs as follows:

- Shallow Soils (i.e. generally less than 4 feet deep). Analytical results for shallow soil samples were screened against the USEPA Region 6 Industrial Soil PRG Regional Screening Levels (RSLs) for both cancer and non-cancer effects. For non-cancer effects, sample results were compared to one tenth of the screening level value to be conservative. Shallow soil sample results were not compared to ecological screening values because there are no terrestrial receptors on site (see Section 6.4, page 6-15). In addition, the Moorings shoreline is armored and the site surface is virtually completely paved or hard packed such that there is not a complete pathway for shallow soils to migrate toward the river.
- Deep Soils (i.e. below 4 feet). Deep soils were not screened against any human health or ecological screening criteria because there is not a complete pathway from deep soils to either receptor group (see Section 6.4, page 6-15).
- Groundwater. Groundwater sample results were screened against the USEPA Region 6 Tap Water PRGs for both cancer and non-cancer effects. For non-cancer effects, sample results were compared to one tenth of the screening level value to be conservative. Groundwater results were also compared to the Safe Drinking Water Act MCLs, the Chronic USEPA National Recommended Water Quality Criteria (NRWQC) (2004), the Chronic Oregon ODEQ Ambient Water Quality Criteria (AWQC) (2004) and the Oak Ridge National Laboratory Tier II Secondary Chronic Values (1999), In cases where multiple screening values were available, the most conservative value was used.
- Surface Water. Surface water sample results were screened as described above for groundwater.
- Upland Sediment. Upland sediment sample results (including results from the two representative samples of erodible soils, the Fence line and Run-off samples) were screened as described above for shallow soils. They were also screened against the MacDonald Probable Effects Concentrations (2000) for toxicity effects and the ODEQ Bioaccumulative Sediment SLVs (2001) for bioaccumulative effects. In cases where multiple screening values were available, the most conservative value was used

Appendix A1 lists all of the detections at the Moorings. Appendix A2 identifies detections that exceed one or more of the above noted SLVs.

6.2 NATURE AND EXTENT OF CONTAMINATION IN RELATION TO POTENTIAL ON-SITE SOURCES

6.2.1 Industrial Area

The primary goals of the Industrial Area soils investigation were to: 1) determine if the soils are acting as a source of contamination to the Willamette River; 2) determine if off-site sources are impacting the site; and 3) determine if the shallow horizon soils present unacceptable risks to human health or the environment. The remainder of this section discusses the RI findings in the Industrial Area relation to the first goal. Section 6.3 (page 6-9) discusses the findings in relation to the second goal, and Section 7 discusses the findings in relation to the third goal.

As noted in Section 3.3.1 (page 3-4) the Industrial Area includes four potential on-site sources (i.e. former USTs, electrical transformers, drywells, and routine vessel maintenance activities) and two other potential sources or features of concern (an area of localized TPH contamination detected in a 1993 geotechnical investigation, and a potential former creek channel). The nature and extent of contamination at each of these areas are discussed below.

6.2.1.1 Former Underground Storage Tanks

Two USTs were used at the Moorings: a 5,000 gallon single-walled steel tank located at the north side of Building 1, and a 1,000 gallon tank located on the southwest corner of Building 17 (Figure 4-2, page 4-13).

The 5,000 gallon UST was used for gasoline storage and was removed in October 1994 in accordance with ODEQ rules (USACE 2008). The removal effort involved collection and analysis (i.e., Oregon Hydrocarbon Identification) of two soil samples from either end of the excavation, neither of which showed evidence of contamination (USACE 2008). The excavation area was backfilled with excavated material as well as acquired, granular backfill, and then repaved.

The 1,000-gallon UST was also used for gasoline storage and anecdotal evidence suggests that it may have begun leaking in the late 1970s (USACE 2008). The tank was reportedly removed in approximately 1984, but there are no confirming records of the removal (USACE 2008). The 1,000 gallon tank was removed when the 5,000 gallon tank was installed.

To confirm whether or not the 5,000 gallon UST was a source of contamination at the Moorings site, soil samples were collected from four depth ranges (0 - 4, 4 - 8, 8 - 12, and 12 - 16 feet bgs) at location SB-10 (Figure 4-2, page 4-13). Similarly, to determine whether or not the 1,000 gallon UST was a source of contamination, samples were collected from four depth ranges at Location SB-15 (Figure 4-2, page 4-13). Additional soil samples were collected at Locations SB-08 and SB-09, both of which are hydraulically downgradient of the locations of the former USTs, to determine if there was evidence of contaminant migration related to the USTs. All samples were analyzed for a full suite of analytical parameters (e.g., VOCs, SVOCs, PCBs, pesticides, and metals), but the contaminants of concern with respect to both tanks include primarily BTEX compounds.

Table 5-1 (page 5-13) summarizes the results.

Soil sample SB-15-2 (4 - 8 feet bgs) at the location of the 1,000-gallon gasoline UST exhibited the highest concentrations of BTEX compounds at the Moorings. Specifically, m,p-xylene was detected at 310,000 µg/kg and ethylbenzene was detected at 97,000 µg/kg. These data suggest that there may have been a release of petroleum product from the 1,000 gallon storage

tank. However, the impact appears to be localized in that ethylbenzene and m,p-xylene compounds were not detected in comparable concentrations in the samples immediately above and below the 4 - 8 foot horizon, nor in the samples from downgradient Locations SB-08 or SB-09.

Samples from SB-10 at the location of the 5,000-gallon gasoline UST did not exhibit detectable concentrations of BTEX. This tank was successfully tested for tightness in 1993 and appeared sound upon its removal. The results from this investigation appear to confirm that the 5,000 gallon UST is not a source of contamination at the Moorings.

During the RI contingency sampling (Section 4.2.2, page 4-35), soil and groundwater samples were collected from Locations SB-24 and SB-31, both of which are downgradient from the former USTs (Figure 4-7, page 4-37) and analyzed for TPHs. TPHs were detected in both locations, but the concentrations were consistent with detections in the other soil and groundwater samples collected in the Industrial Area.

A second supplemental investigation (Appendix E) was performed to verify the elevated concentrations of VOCs and TPHs at SB-15. Soil samples from SB-32, collected immediately adjacent to SB-15 confirmed these concentrations. The contamination identified at both SB-15 and SB-32 appears to be isolated in a silty clay layer which extends from approximately 6 to 17 feet below ground surface. Exploratory soil borings SB-37 and SB-38, which were completed approximately 5 feet on either side (northwest and southwest) of SB-15/SB-32 showed little evidence of lateral contaminant migration based on screening with a PID. Based on the analytical and screening data collected, soil contamination near SB-15/SB-32 is localized both vertically and laterally.

In summary, RI soil data indicate that there is no apparent contamination related to the former 5,000 gallon UST. The presence of localized BTEX contamination in the vicinity of the former 1,000 gallon UST indicates that this UST might have leaked. There is no evidence that these contaminants have migrated any appreciable distance from the former UST location. Moreover, there is no substantive evidence of contaminant migration in groundwater toward the Willamette River related to the former USTs in this portion of the Moorings site.

6.2.1.2 Electrical Transformers

There are two above-ground transformers currently used at the Moorings; however, at one time there were three. Although it is believed that the three old units may have used PCB-containing dielectric fluids, there is no historical information suggesting that a release of PCB oil occurred. Figure 4-2, page 4-13, depicts the locations of the current and former transformers.

To confirm whether or not the transformers were a source of contamination at the Moorings, soil samples were collected at four depth ranges (1 - 4, 4 - 8, 8 - 12, and 12 - 16 feet bgs) at Locations SB-01, SB-02, SB-04, SB-05, SB-06, SB-07, SB-11, SB-14, and SB-17. No shallow zone soil sample was collected at location SB-02 due to recovery issues. All samples were analyzed for a full suite of analytical parameters (e.g., VOCs, SVOCs, PCBs, pesticides, and metals), but contaminants of concern with respect to the transformers include PCBs only.

Table 5-1 (page 5-13) summarizes the results. No PCBs were detected in any samples collected from the above locations. This evidence suggests that if PCB containing dielectric fluids were used in the old transformers, they were not released to the environment.

However, PCBs were detected in samples collected from other locations on site. Tables 6-1 through 6-3 (page 6-4) summarize the PCB detections in the Industrial Area, MIS Area, and

Upland Sediments, respectively. Aroclor® 1248 was the only PCB detected at levels above SLVs. In the North Logistics MU, Aroclor® 1248 was detected at two sample depths at concentrations that exceeded the ODEQ Bioaccumulative Sediment SLV (4 µg/kg). In the Run-off sediment sample, Aroclor® 1248 was detected at a concentration that exceeded the ODEQ Bioaccumulative Sediment SLV (4 ug/kg) and the MacDonald Probable Effects Concentration (PEC).

A soil removal was performed in the MIS Area in 1993 after a release of heavy oil that contained PCBs. The source of the release was believed to be leaking hydraulic equipment. PCBs are known to occur in hydraulic oils and it is reasonable to expect that the PCBs in the North Logistics MU are related to historic site activities involving hydraulic fluids. The source of the PCB SLV exceedance in the Run-off sediment sample is not readily apparent. The potential significance of this detection with respect to the Portland Harbor JSCS is discussed in Section 6.4, page 6-15.

Table 6-1 PCB Detections in the Industrial Area

Location	PCB	Concentration (µg/kg)			
		1 - 4 '	4 - 8 '	8 to 12 '	12 to 16 '
SB-15	Aroclor® 1254	2.4	-	-	NA
	Aroclor® 1260	5.5	4.5	-	NA
SB-16	Aroclor® 1260	20	-	-	-
SB-18	Aroclor® 1260	5.3	1.9	-	-
SB-19	Aroclor® 1260	81	-	2.6	4.7

Notes
'-' not detected
NA Not Analyzed

Table 6-2 PCB Detections in the MIS Area

MU	PCB	Concentration (µg/kg)		
		1 to 5 '	5 to 10 '	10 ' to NSI
North Logistics	Aroclor® 1248	68	8.2	NA
South Logistics	Aroclor® 1260	1.2	-	1.2
Sandblast	Aroclor® 1260	20	NA	NA
Fence Line	Aroclor® 1262	50	NA	NA

Notes
'-' not detected
NA Not Analyzed
Shaded cell indicates value exceeds SLV

Table 6-3 PCB Detections in the Upland Sediment

Location	PCB	Concentration (µg/kg)
ODOT	Aroclor® 1242	1.2
	Aroclor® 1254	3.8
	Aroclor® 1260	4.8
Drywell	Aroclor® 1254	130
	Aroclor® 1260	150
Runoff	Aroclor® 1248	1,600

Notes: Shaded cell indicates value exceeds SLV

6.2.1.3 Drywells

A drywell used for on-site containment of stormwater runoff is located near the southeast corner of Building 1. The drywell is constructed with square steel, with a welded grate on top, and a solid bottom plate with holes drilled for drainage. The drywell measures approximately one foot square by three feet deep. The square steel box effectively acts to collect sediment. At the time the drywell was opened, there were approximately 18 – 24 inches of sediment atop the bottom plate. While it is believed that only stormwater had been discharged to this well, it is recognized as a potential source of contamination in that stormwater runoff from paved surfaces (i.e., related to vehicular traffic and parking) could migrate to the catch basin via overland flow and then impact subsurface soil and groundwater.

Due to the proximity of the drywell to the foundation of Building 1, it was impossible to use the drill rig to collect soil samples directly below the drywell. Consequently, soil samples were collected from four depth ranges (1 - 4, 4 - 8, 8 - 12, and 12 – 16 feet bgs) at SB-13, which was located as close as possible to the drywell, approximately two feet to the west (Figure 4-2, page 4-13). These samples were collected to confirm whether or not the drywell is a source of contamination to subsurface soils or groundwater at the Moorings. For comparison, a sample of the sediment within the drywell was also collected (sample SD-DW-13, Figure 4-8 page 4-47). The soil samples were analyzed for a full suite of analytical parameters (i.e., VOCs, SVOCs, PCBs, pesticides, and metals), and the drywell sediment sample was analyzed for SVOCs, PCBs, pesticides, metals, and TPHs.

Sample results for the drywell (SB-DW-13) are summarized in Table 5-10 (page 5-55). Sample results for SB-13 are summarized in Table 5-1 (page 5-13). The sediment sample collected from the drywell (SB-DW-13) had generally elevated concentrations of PAHs (total 126,000 µg/kg), PCBs (total 280 µg/kg), TPH-Diesel (790,000 µg/kg), and TPH-Motor Oil (4,500,000 µg/kg) in comparison to soils collected in other locations in the Industrial Area. Twelve of the 19 individual PAHs were detected in concentrations above the MacDonald PEC SLVs (Appendix A2, Table 2dv). There were also seven metals (Hg, Cd, Ni, Cu, Zn, Pb, and Cr) detected in concentrations above the Macdonald PEC SLVs in this sample (Appendix A2, Table 2dv).

In contrast, the levels of PAHs, PCBs, TPH-Diesel, and TPH-Motor Oil detected in the samples from Location SB-13 were generally similar to concentrations detected in the other soil samples from the Industrial Area. No individual contaminants were detected at levels above SLVs in SB-13, except arsenic and lead which were detected at levels exceeding Region 6 PRGs (Appendix A2, Table 2a). These findings suggest that although the drywell itself contained contaminated sediment, the contaminants are not migrating from the drywell to surrounding subsurface soils in any appreciable manner. The most probable source of the PAH contamination in the drywell sediment is surface runoff from paved parking areas.

A second drywell, located west-southwest of Building 4, was discovered after the RI field activities were completed. No attempt was made to re-mobilize and sample this location because it drains a smaller area than the drywell near Building 1 and is primarily lawn that can be reasonably expected to contain sediment with characteristics that are similar or less contaminated to the sediment contained in the Building 1 Drywell sample.

6.2.1.4 Routine Vessel Maintenance Activities

Current and historic routine vehicle/vessel maintenance activities in the Industrial Area have largely been concentrated in and around Buildings 2 and 19 (Figure 2-2, page 2-3), the welding shop and machine shop respectively. Accordingly, both have been identified as potential

sources of contamination based on the nature of the activities conducted in them and their potential association with hazardous materials (e.g., paints, solvents, petroleum lubricants).

Although no information has been identified that indicates that a release occurred at these buildings, at one time both had dirt floors such that incidental spills of the materials stored and used there could result in contaminant releases to the environment. Professional experience with the types of maintenance activities conducted in the buildings suggests that if a release occurred, it would most likely be related to machine lubricants or paint-related wastes.

To confirm whether or not Buildings 2 and 19 were a source of contamination at the Moorings, soil samples were collected from four depth ranges (1 - 4, 4 - 8, 8 - 12, and 12 - 16 feet bgs) at locations SB-02, SB-03, SB-04, SB-11, SB-12, SB-18, and SB-19 (Figure 4-2, page 4-13). The samples were analyzed for the full suite of analytical parameters (i.e., VOCs, SVOCs, PCBs, pesticides, and metals), all of which represent potential contaminants of concern due to the nature of the current and historic routine maintenance activities.

Sample results are summarized in Table 5-1, page 5-13. In general, the data indicate that samples from the shallow zone (1 - 4 feet bgs) have elevated concentrations of several analytes in comparison to deeper zone samples, specifically TPAHs (Figure 5-6, page 5-23); copper and lead (Figure 5-9, page 5-26); TPH-Diesel; and TPH-Motor Oil. Only benzo(a)pyrene, antimony, lead, and arsenic were detected in concentrations above a SLV (i.e. USEPA Region 6 PRG (Appendix A2, Table 2a). Based on these results, routine maintenance activities conducted in Buildings 15 and 19 during the time that the buildings had dirt floors may have contributed to contamination of the shallow horizon soils in the area. The potential significance of these results with respect to the JSCS framework and the Willamette River is discussed in Section 6.4 (page 6-15).

6.2.1.5 Other Potential Sources or Features of Concern

6.2.1.5.1 Confirmation of 1993 Investigation

As part of a subsurface geotechnical investigation in 1992–1993 (Section 2.9.1.3, page 2-28), a sample was collected immediately beneath the paved parking lot at the west end of the Moorings (sample location CBR-6). This sample reportedly contained 2,400 mg/kg TPH. Visual observation indicated that the vertical extent of contamination was limited to a relatively thin horizon. No significant TPH concentrations were found at depth during other parts of this investigation. The depth to groundwater was measured during drilling; however, no groundwater samples were collected.

To confirm this earlier finding, soil samples were collected from depth ranges of 1 - 4 feet and 4 - 8 feet at location SB-14 (Figure 4-2, page 4-13). (There was insufficient recovery from the 8 to 12 and 12 to 16 foot ranges for a sample to be collected). The samples were analyzed for the full suite of analytical parameters, consistent with all other soil samples collected during the RI.

Table 5-1, page 5-13 summarizes the results. TPH-Motor Oil was detected at both sample depths in SB-14, but the concentrations are consistent with other samples within the Industrial Area. The only contaminant detected at a level that exceeded a SLV was arsenic (USEPA Region 6 PRG), and this finding is also consistent with other soil sample results in the Industrial Area. More telling, the PAH concentrations at SB-14 were the lowest of any Industrial Area samples collected from the same depths. Collectively, these results suggest that this location is not an area of concern for the RI.

6.2.1.5.2 Former Creek Channel

Historic documentation suggested that there may have been a creek channel that entered the Moorings between Buildings 2 and 14 and discharged to the river adjacent to Building 19. Such a channel, if it exists, could be considered a preferential subsurface contaminant transport pathway. Consequently, it was targeted for investigation during the RI. Boreholes were installed and samples were collected from locations SB-02, SB-03, SB-04, SB-12, SB-16, SB-17, SB-18, and SB-19 for this purpose (Figure 4-2, page 13).

Stream deposits are generally characterized by a distinct trend of increasingly finer grained materials occurring higher in the fluvial profile. In addition, a generally strong downstream decrease in particle size is also typically evident. However, fluvial deposits can be difficult to differentiate from glacial-outwash and other sedimentary deposits. Depositional features, such as deltas and sand bars, are also sometimes present.

The borehole logs from these locations did not reveal compelling lithologic evidence of a historic creek channel. However, fluvial deposits can be difficult to differentiate from glacial-outwash and other sedimentary deposits, and depositional features such as deltas and sand bars can further complicate the issue. Accordingly, the absence of direct lithological evidence in the borehole logs does not necessarily preclude the presence of the channel.

6.2.2 MIS Area

The primary goals of the MIS Area soils investigation were to: 1) determine if the shallow zone soils pose an unacceptable risk to construction workers involved in the excavation and repair of underground utility lines; 2) determine if deeper soils are a source of groundwater contamination; and 3) assess the adequacy and completeness of previous remedial activities. The remainder of this section uses the RI findings to describe the relative differences in the MIS MUs and assess the adequacy of prior cleanup actions. Section 6.4.3 (page 6-17) discusses the RI findings in relation to the second goal, and Section 7 discusses the findings in relation to the first goal.

For reference, the MUs in the MIS Area were initially designated to meet a size standard required for the MIS sampling technique (suggested maximum of one half acre). They were modified during the site investigation to better align each with observed subsurface soil conditions and known site activities (see Section 4.1.2.3, page 4-19).

6.2.2.1 South Logistics MU

The South Logistics MU (Figure 4-6A, page 4-26) was initially delineated largely based on historic elevation contours (Figure 2-5, page 2-9) that indicated it was a topographic depression and could have been the location of the former stream bed before fill events occurred.

Due to the relatively greater depth of fill in this area, samples were collected from three horizons and analyzed for SVOCs, PAHs, PCBs, pesticides, metals, organobutyltins, and TPHs as summarized in Table 4-6, page 4-25. Observations made during collection of the samples indicated that the fill was relatively homogenous, as might be expected if it were placed during a single fill event.

Sampling results are summarized in Tables 5-4 through 5-6 (pages 5-33 through 5-36) and compared to SLVs in Appendix A2, Table 2b. The concentrations of the detected analytes were generally the same as in adjacent MUs. The only contaminant detected at a level above a SLV was arsenic. As seen in Appendix A2 Table 2b, arsenic was detected in all MUs at levels that exceeded the USEPA Region 6 PRG.

6.2.2.2 North Logistics MU

The North Logistics MU (Figure 4-6B, page 4-27) bridged the gap between the Laydown MU and the South Logistics MU. This area was an access route and storage area for dredge and other large equipment storage. The original layout of this MU was significantly modified during the RI fieldwork on the basis of the subsurface conditions observed (see Section 4.1.2.3, page 4-19).

Samples were collected from two horizons and analyzed for SVOCs, PAHs, PCBs, pesticides, metals, organobutyltins, and TPHs. No surface sediment was present in this MU. Sampling results are summarized in Tables 5-4 and 5-5 (pages 5-33 and 5-35) and compared to SLVs in Appendix A2, Table 2b. While the types and numbers of analytes detected in the North Logistics MU were generally the same as those detected in the South Logistics and Laydown MUs, the detected concentrations were generally an order of magnitude higher for all chemical groups, especially TPHs.

6.2.2.3 Laydown MU

The Laydown MU (Figure 4-6C, page 4-28) is a compacted gravel and paved area that was primarily used for on-site storage of large parts and equipment required to support the USACE dredges.

Samples in this MU were collected from two horizons and analyzed for SVOCs, PAHs, PCBs, pesticides, metals, organobutyltins, and TPHs. No surface sediment was present in this MU.

Sampling results are summarized in Tables 5-4 and 5-5 (pages 5-33 and 5-35) and compared to SLVs in Appendix A2, Table 2b. The concentrations of the analytes detected were generally consistent with the South Logistics and North Logistics MUs. Only benzo(a)pyrene and arsenic were detected in concentrations that exceeded SLVs.

6.2.2.4 Fence Line MU

The Fence Line MU (Figure 4-6E, page 4-30) was created to help characterize erodible soils expected to be associated with the Laydown and North Logistics MUs. Specifically, erodible soils in the Laydown and North Logistics MUs were defined to be the 0” – 12” bgs soil horizon. Despite a superficial layer of fine soils on the surface, the Laydown and North Logistics MUs were compacted to the extent that there was no surface soil available to be sampled in the planned horizon (see Section 4.1.2.3.4, page 4-20). The area along the fence line was the only location along the northern perimeter of the site found to have erodible soils.

Sampling results are summarized in Table 5-4 (page 5-33) and compared to SLVs in Appendix A2, Table 2b. The numbers and types of analytes detected in the Fence Line MU sample were consistent with those detected in the adjacent MUs with the exception of PAH and metals which were generally elevated in comparison to the other MUs by an order of magnitude.

6.2.2.5 Slump MU

The Slump MU (Figure 4-6D, page 4-29) was created to sample a portion of the site that was backfilled after soils sloughed into the Willamette River during the flood of 1996. The area was backfilled with clean fill and was thus expected to have subsurface conditions that differed from the adjacent MUs (Section 4.1.2.3.5, page 4-20).

The Slump MU sample was analyzed for SVOCs, PAHs, PCBs, pesticides, metals, organo-butyltins, and TPHs. Sampling results are summarized in Table 5-4 (page 5-33) and compared to SLVs in Appendix A2, Table 2b. In general, and as expected, there were relatively fewer analytes detected in this sample in comparison to samples from the adjacent MUs. Moreover,

the detected concentrations were generally lower. Only arsenic was detected at a level above a SLV.

6.2.2.6 Prior Clean-Up MU

The Prior Clean-up MU (Figure 4-6F, page 4-31) was created to assess the success of a prior cleanup of a small (100 square feet) surface petroleum spill (Section 2.9.1.3.1, page 2-29). Approximately 18 inches of soil were removed during the cleanup and confirmation sampling showed residual TPH contamination at 40 mg/kg. No PCBs were detected after removal (USACE 2008).

To confirm these results, shallow zone soil (0 – 5 feet bgs) was sampled (SB-PC-01) in the Prior Cleanup MU and analyzed for PAHs, SVOCs, PCBs, pesticides, metals, organobutyltins, and TPHs. COIs for this MU include principally TPHs. Sample results are summarized in Table 5-4 (page 5-33) and compared to SLVs in Appendix A2, Table 2b. TPH-Diesel was detected at a concentration of 44 mg/kg and TPH-Motor Oil was detected at a concentration of 180 mg/kg.

These values are consistent with other TPH-Diesel/TPH-Motor Oil results for on-site soil samples collected in the MIS Area and are more than 500 times less than the TPH concentration detected prior to the clean-up of this area. Moreover, the diesel range concentration is nearly 100 times lower than the ODEQ risk-based screening criteria for diesel in residential soils of 3900 mg/kg. There are no JSCS SLVs for TPH-Diesel/TPH-Motor Oil.

6.2.2.7 Sandblast MU

The Sandblast MU (Figure 4-6F, page 4-31) was created to assess the success of a 1993 clean-up of historic sandblast activities (Section 2.9.1.3.1, page 2-29). Visible grit was removed to a depth of 2 to 8 inches bgs over an area measuring approximately 2,000 square feet.

The Sandblast MU was considered a potential source of metals and TBT contamination at the Moorings. TBT contamination is known to be associated with anti-fouling paint on ships. Sandblasting to remove paint may lead to TBT contamination and may also remove small bits of metal from the ship hull as well.

Sample results are summarized in Table 5-4 (page 5-33) and compared to SLVs in Appendix A2, Table 2b. TBT was not detected in the Sandblast MU sample (SB-SB-01) and the concentrations of metals in the sample were consistent with the concentrations detected in soil samples from other portions of the site. Only benzo(a)pyrene and arsenic were detected in concentrations that exceeded SLVs.

6.3 NATURE AND EXTENT OF CONTAMINATION WITH RESPECT TO POTENTIAL OFF-SITE SOURCES

This section discusses the nature and extent of environmental contamination at the Moorings in relation to potential off-sites sources, in particular the placement of dredge fill and potential impacts related to surrounding properties (see Section 3.3.2, page 3-4, and Table 3-3, page 3-10). It also provides a general discussion of the overall distribution of metals at the site. In general, the sample locations and analytical results presented in this section are the same as those used to discuss potential impacts associated with on-site sources in Section 6.2 (page 6-2). However, in this case the data are interpreted using a broader, site-wide perspective.

As a reminder, the various investigative approaches are summarized by media type in Sections 4.1 through 4.4 (page 4.1, page 4-35, page 4-41, page 4-55). Analytical results are presented by media in Section 5.

6.3.1 Dredge Fill Material

The Industrial Area was filled with dredge materials from the Willamette River to its present grade in 1913, before the general industrial character of the surrounding area really began to take shape. The surface was paved early on and has remained relatively unchanged over time. Accordingly, it was presumed that the fill placed in the Industrial Area was not grossly contaminated by off-site activities prior to its placement.

In comparison, the MIS Area was brought to its present-day grade as a result of three separate dredging activities that occurred over a longer period of time and after the industrial nature of the area was well established for several decades.

Accordingly, the RI was designed in part to determine whether or not the fill material placed in the MIS Area had substantially different chemical characteristics than the material placed in the Industrial Area. Differences, if any, could be a result of changing conditions in the river sediment over time, differing on-site activities, proximity to potential off-site sources, or a combination of all three factors.

To facilitate a comparison, analytical results for the soil samples collected at MUs other than the Fence Line MU (Tables 5-4 through 5-6, pages 5-33 through 5-36) were compared to results from samples collected in the Industrial Area (Table 5-1, page 5-13). All of the MIS and Industrial Area samples were analyzed for a full suite of analytical parameters (i.e., VOCs, SVOCs, PCBs, pesticides, and metals), but contaminants of concern with respect to the dredge fill are primarily VOCs, SVOCs, PCBs, TPHs, pesticides, and metals. Detections above SLVs are summarized in Appendix A2, Table 2b and highlighted in Section 6.2 where appropriate. They are not further discussed here.

In general, the SVOC (non-PAH), PCB, TPHs, pesticides, TBT, and metals concentrations found in the MIS MUs are comparable to the concentrations of these same groups of chemicals detected within the Industrial Area. However, the TPAH concentrations in the upper 10 feet of soils in the MIS MUs are generally 2 to 3 times greater than in the Industrial Area samples collected from similar depths. Additional discussion of PAH contamination in the MUs and the Industrial Area follows.

PAHs are one of the most pervasive contaminant groups detected on the site. There are nineteen different analytes in the PAH group. To simplify the presentation and discussion of PAH results, and to ensure that the results are comparable with the prior studies performed for the LWG in the area (LWG 2005), the nineteen analytes are divided into two subgroups in this report: LPAHs and HPAHs. The LPAH group includes naphthalene, 2-methylnaphthylene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene. The chemicals 1-methylnaphthylene and dibenzofuran are also considered LPAHs, but to be consistent with the LWG study, their concentrations were not used in the calculation of total LPAHs here. The HPAH chemicals include fluoranthene, pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)anthracene, chrysene, benzo(a)pyrene, indeno(1,2,3-cd)anthracene, dibenz(a,h)anthracene, and benzo(g,h,i)perylene.

Tables 6-4 and 6-5 (page 6-11) compare the ranges of LPAH, HPAH, and TPAH detected in the Industrial Area to three of the MIS Area samples, specifically the North Logistics, South Logistics, and Laydown MUs. Because this comparison is intended to evaluate potential differences in the dredged materials themselves, several samples in the Industrial Area are excluded from the comparison because they are not considered to be representative of the dredged materials. Specifically, results from the 1 - 4 foot sample at SB-16 are excluded from

Table 6-1 (page 6-4) because visual evidence during sampling indicated the presence of "tarball" in soil and the groundwater had a blue caste, both of which suggest that this location may be impacted by off-site, upland GASCO activities. Similarly, soil samples from the 4 - 8 foot range at locations SB-10 and SB-15 are also excluded from the comparison due to each location's proximity to a former UST (see Section 6.2.1.1, page 6-2).

Table 6-4 Low and High PAH Concentrations in the 1 to 5 Foot Depth

Analyte Group	Industrial Area (1-4')		MIS Area (1-5')		MIS High/IA High
	Low Conc.	High Conc.	Low Conc.	High Conc.	
LPAH (µg/kg)	9	520	60	1040	2.0
HPAH (µg/kg)	170	4620	890	8200	1.8
TPAH (µg/kg)	179	5140	950	9240	1.8

Table 6-5 Low and High PAH Concentrations in the Lower Depth Range

Analyte Group	Industrial Area (4-8')		MIS Area (5-10')		MIS High/IA High
	Low Conc.	High Conc.	Low Conc.	High Conc.	
LPAH (µg/kg)	0.9	180	30	2020	11
HPAH (µg/kg)	15	2800	460	8220	2.9
TPAH (µg/kg)	16	2980	490	10240	3.4

Note:
IA Industrial Area
Conc. concentration

Generally speaking, PAH concentrations in the MIS Area samples are two or more times greater than in the Industrial Area. Given that there are no obvious sources of PAH contamination in the MIS Area (except for possible runoff from paved areas), and several potential sources in the Industrial Area of the site, these data suggest that the sediment used as fill in the MIS area potentially was contaminated via alternate sources or pathways, or may itself be a source of the PAH contamination. Although there is no evidence to suggest that the dredge materials used to fill either location were grossly contaminated prior to placement on site, the MIS Area in particular was filled with dredged material in both 1925 and 1945 during which there was substantial industrial activity in the overall area. Additionally during this time the MIS area could have been subject to the atmospheric deposition of contaminants from nearby industrial processes, and windblown deposition of particulate matter from nearby waste storage piles.

6.3.2 Potential Impacts Related to Surrounding Properties

6.3.2.1 Contaminant Distribution Trends in Soil

An evaluation of soil distribution trends at the site was completed by comparing sample concentrations along three transects. As shown in Figure 6-1 (page 6-21), transect D – D' runs approximately parallel to the Moorings shoreline, transect E – E' roughly follows the assumed primary axis of groundwater flow (see Figures 5-25 and 5-26, pages 5-99 and 5-100) for water table contours), and transect F – F' runs approximately parallel to the Moorings/GASCO property boundary.

Figure 6-2 (page 6-22) shows the distribution of LPAHs along these 3 transects. Transects D – D' and E – E' indicate that LPAH concentrations are relatively higher near the Moorings/GASCO

site boundary and decrease with distance away from that boundary, particularly in the shallow zone soils. Transect F – F' shows that concentrations along the Moorings/GASCO boundary are relatively consistent with distance away from the shoreline, but increase substantially near SB-16 in the shallow zone. Figures 6-3, 6-4, 6-5, and 6-6 (pages 6-23 through 6-26) demonstrate similar trends for naphthalene, HPAHs, TPAHs, and benzo(a)pyrene. Specifically, the concentrations of these PAHs in the shallow zone are generally higher near the Moorings/GASCO boundary and lower in samples collected at locations away from the boundary. Additionally, concentrations are consistently elevated at SB-16, located approximately down gradient of a former GASCO waste pile (see Section 2.9.3, page 2-33). It should be noted that no locations on any of the three transects had naphthalene concentrations at levels that exceeded the USEPA Region 6 PRG RSL. However, several shallow soil locations on all three transects had benzo(a)pyrene concentrations that exceeded the same SLV (Appendix A2, Table 2a). Further discussion of the significance of these finding in relation to the JSCS is provided in Section 6.4 (page 6-15). Figure 6-7 (page 6-27) shows the distribution of total cyanide along the 3 transects. Like the PAHs, cyanide concentrations are generally higher near the Moorings/GASCO boundary and lower in samples collected at locations away from the boundary. Cyanide concentrations also spike near location SB-16. No soil samples had cyanide concentrations at levels that exceeded the USEPA Region 6 PRG RSL (Appendix A2, Table 2a).

These graphs suggest that potential off-site sources have contaminated subsurface soil in the Industrial Area of the Moorings.

6.3.2.2 Contaminant Distribution Trends in Groundwater

Using the three transects shown in Figure 6-1 (page 6-21), concentrations of cyanide, manganese, aluminum, cadmium, and lead in groundwater samples were plotted on line charts. Of the 13 metals analyzed, these 4 were detected in concentrations above SLVs most frequently (Appendix A2, Table 2ci-iv).

Figure 6-8 (page 6-28) shows the distribution of cyanide along the three transects. Transect E – E' along the presumed axis of groundwater flow, and F - F' perpendicular to the groundwater flow path show that cyanide concentrations are highest by an order of magnitude near the Moorings/GASCO border at location 16.

Figures 6-9, 6-10, and 6-11 (pages 6-29 through 6-31) show the concentrations of manganese, aluminum, and arsenic, cadmium, and lead along transects D – D'., E – E', and F – F', respectively. As can be seen, all five metals display similar distribution patterns along all three transects (i.e. relatively higher concentrations nearer the Moorings/GASCO boundary).

As with the soil distribution trends noted above, these graphs suggest that potential off-site sources have contaminated groundwater in the Industrial Area of the Moorings.

Only one groundwater sample was collected at depths below the shallow fill material at the Moorings. The sample was collected at location SB-20 from a depth of approximately 80-85 feet bgs (Figure 4-2, page 4-13, and Figure 4-7, page 4-37). Dissolved concentrations of zinc, aluminum, and nickel in sample GW-20 are 1-2 orders of magnitude less than in the shallow zone samples, while the concentration of dissolved manganese is 2 orders of magnitude greater. However, with only a single deep sample the nature of shallow/deep groundwater interaction at the Moorings cannot be characterized.

6.3.3 Other Considerations

6.3.3.1 Cyanide Contamination

Cyanide (total) is widely distributed throughout the Industrial Area as evidenced by results in both soil and groundwater samples. Cyanide was not analyzed in the MIS Area samples. Cyanide contamination is commonly associated with mining operations, metals plating, and gas manufacturing—none of which occurred on the Moorings. However, gas manufacturing activities were present at the NW Natural (GASCO) property.

Figure 5-7 (page 5-24) shows the concentrations of cyanide (total) for soil samples collected in the Industrial Area.

- In the 1 - 4 foot depth range, the highest concentrations of cyanide (total) are generally found on the southern border adjacent to the former MGP site at GASCO (see also Section 2). Concentrations in this area range from 1200 µg/kg (SB-12-1) to 61,000 µg/kg (SB-16-1). For comparison, the cyanide concentration at SB-06-1 in the northeast corner of the site was 870 µg/kg.

- In the 4 - 8 foot depth range, the highest concentrations of cyanide are also found on the southern border adjacent to the former MGP site. Concentrations in this area range from 4500 µg/kg (SB-12-2) to 12,600 µg/kg (SB-17-02). Again, for comparison, the concentration is 280 µg/kg at SB-06-2.

- In the 8 - 12 foot depth range, the highest concentrations of cyanide are again found on the southern border. Concentrations range from 3,660 µg/kg (SB-12-3) to 13,900 µg/kg (SB-16-3). In sample SB-06-3, the concentration was 280 µg/kg. This is also, generally speaking, the horizon where groundwater was encountered in the Industrial Area.

- In the 12 - 16 foot soil depth, the southern border locations continue to have significant cyanide concentrations ranging from 900 µg/kg (SB-11-4) to 10,100 µg/kg (SB-16-4). At this depth however, similarly high concentrations were detected in Locations 6 and 4 with concentrations of 10,500 µg/kg (SB-06-4) and 11,800 µg/kg (SB-04-4) respectively.

Figure 5-13 (page 5-48) shows the cyanide (total) concentrations in groundwater. (It is important to note that the contaminant isopleths identified in this figure combine data from samples collected in March 2008 [Table 4-9, page 4-36] with data collected from contingency samples [Table 4-10, page 4-36] collected in August 2008.) The highest concentrations of cyanide in groundwater were encountered in GW-16 (2,990 µg/L), GW-22 (2,320 µg/L), and GW-04 (1,110 µg/L). As Figure 5-13 (page 5-48) shows, GW-22 and GW-04 are almost due north of GW-16. The concentration contours for cyanide in groundwater coupled with the likely source along the Moorings southern border suggest that groundwater flow across the Moorings is primarily in a northeasterly direction towards the river as opposed to perpendicular to the Willamette River.

Measured concentrations of cyanide in both water and soils suggest that the source of the cyanide is south of the Moorings border. This is the precise location where the spent box waste pile for production activities at the GASCO site existed for decades.

Cyanide species have been observed in soil and groundwater at MGP sites throughout the United States. Groundwater impacts at these sites commonly occur as a result of leaching (dissolution) from spent oxide box residuals, which are sometimes used on-site as fill material. These oxides are of concern because “spent oxide material may also contain hydrocarbons that

passed through the upstream gas processing equipment, as well as cyanides that would be removed from the gas along with the sulfur. In addition to the preceding, spent oxide wastes have been found to contain varying amounts arsenic, chromium, copper, lead, nickel, and zinc" (Hahn 2007).

The predominant forms of cyanide compounds in these residuals are iron–cyanide solids, the most prominent among them being Prussian blue or ferric-ferrocyanide. In acidic soil, transport is probably dominated by equilibrium with Prussian blue, which is sparingly soluble under acidic conditions and limits dissolved cyanide concentrations and mobility. However, at pH levels higher than approximately 7, the solubility of this precipitate increases, which allows cyanide to be more mobile under such conditions. Nevertheless, according to field observations, Prussian blue appears to persist for decades in alkaline soils (Meeussen 1995). Presumptive evidence of iron cyanide compounds present on the Moorings includes the observations of fine blue particulate matter in the groundwater samples from location SB-16 (Section 4.6.1, page 4-71).

As stated earlier, there are no known activities on the Moorings that would have generated cyanide contamination. One likely scenario that the data above suggests is that the cyanide contamination is entering the Moorings Industrial Area through the shallow soils and groundwater from an upgradient source. Some may also be entering as airborne contaminants and in stormwater runoff. The cyanide is either slowly percolating through the soil to the groundwater or continuing to move through the groundwater either in a dissolved phase or as a particulate in the groundwater above the upper surface of the confining silt layer that is found throughout the Industrial Area.

There is a strong correlation between the concentrations of cyanide (total) in the 12 - 16 foot soil depth and in the groundwater. (The concentration contours for cyanide (total) in groundwater are included on Figure 5-7, page 5-24.) This correlation supports the hypothesis of transport of cyanide via groundwater either in solution, as a particulate, or both from the southern boundary almost due north to the northeast portion of the site and eventually into the Willamette River.

6.3.3.2 Metals Contamination

Elevated levels of metals were detected in soil and groundwater samples across the site, but not in any easily discernable patterns that are reflective of documented on-site activities. However, as discussed in Section 6.3.2.2 (page 6-12), the distribution of metals in soil and groundwater along the Moorings/GASCO boundary suggest that off-site sources are impacting the Moorings. In contrast, there were detections of TBT in locations that are consistent with site activities.

In general, the Fence Line MU (SB-FL-01) contained the highest concentrations of most metals and TBT. This is not unexpected, however, because this MU represents a strip of soil that acts as a catch basin or sediment trap for sheet stormwater runoff from other upland portions of the site, including the Sandblast MU, Laydown MU, Prior Clean-up MU, and a portion of the North Logistics MU. The drywell outside of Building 1 functions as designed by containing stormwater runoff (overland flow) from portions of the site. Trapped sediment within the drywell is a potential source of metals contamination but as discussed earlier, based on sampling near the dry well, contamination does not appear to migrate from the Drywell to surrounding soil or groundwater.

Arsenic is detected in high concentrations at the Moorings and presents a known human health risk. The ODEQ indicates that the background level for arsenic in the area of the site is approximately 7,000 µg/kg. Five soil samples from the site had arsenic concentrations above

background levels: Sample SB-SL-01 (8,200 µg/kg); Sample SB-FL-01 (62,900 µg/kg); and Samples SB-14-1 and SB-14-2 (8,800 and 10,000 µg/kg, respectively).

Antimony was detected in one discrete sample location in the Industrial Area at an abnormally elevated concentration. Sample SB-12-1 contained antimony in a concentration of 642,000 µg/kg. This value is 109 times greater than the next highest concentration detected the 0 to 4 foot sample from SB-16. The concentration detected in SB-12-1 is considered anomalous and is not representative of site conditions.

6.4 PORTLAND HARBOR JSCS CONSIDERATIONS

The Portland Harbor JSCS provides a framework for systematically and consistently identifying, evaluating, and controlling upland sources of contamination that may impact the Willamette River. The JSCS includes the use of various medium-specific SLVs to facilitate screening-level risk assessments and to help prioritize source control activities. As discussed in the introduction to Section 6, all sample detections at the Moorings were screened against SLVs consistent with the requirements of the JSCS.

The JSCS notes that exceedance of a SLV does not necessarily indicate that an upland source of contamination poses an unnecessary risk to human health or the environment, However, SLV exceedance require further consideration of the need for source control measures using a weight-of-evidence evaluation that addresses the extent to which an upland source impacts, or may impact, the river. The JSCS provides suggestions for conducting weight-of-evidence evaluations for the following potential upland contaminant migration pathways to the Willamette River:

- Direct discharges, including certain types of permitted discharges;
- Groundwater flow;
- Erosion of contaminated sediment/soil and/or leaching of contaminated sediment/soil to groundwater;
- Overwater activities; and
- Air pollution.

The remainder of this section provides weight-of-evidence evaluations of potential impacts to the Willamette River from potential direct discharge, groundwater flow, and erosion/leaching pathways at the Moorings. Consistent with the JSCS, the pathways of overwater activities and air pollution are not specifically addressed in that they are generally addressed as part of one of the other pathways. Human health and ecological risks associated with COPCs and complete transport pathways at the Moorings are discussed in detail in Section 7.

6.4.1 Direct Discharges

Direct discharge points at the Moorings are illustrated on Figure 2-13, page 2-37. Included are four tight lined ODOT storm drains that run beneath the property and a number of other stormwater conveyance systems and outfalls installed over the years in the Industrial Area.

As part of the RI, outfalls for the Moorings stormwater conveyance systems were identified and smoke/dye tested (Section 4.3.1.3 and 4.3.1.4, page 4-44). Results of the testing indicated that all but a few of the outfalls were inactive, and specific best management practices were provided for those that were active (Appendix B – Outfall Status Report). Samples were also

collected from three direct discharge locations (i.e. ODOT Outfall, French Drain, and Seep) to assess potential impacts to the River.

Analytical results for the three samples are summarized in Table 5-9, page 5-52. Detections above SLVs are summarized in Appendix A2, Table 2di-iv.

The French Drain sample represents stormwater collected from the southwest corner of the Laydown MU (Figure 4-5, page 4-21), in an area where a triangular section of land sloughed off into the Willamette River and was repaired using clean fill material. This sample contained three metals (aluminum, copper, and lead) at concentrations above either the USEPA 2004 NRWQC or the ODEQ 2004 AWQC, and one metal (aluminum) at a concentration above the drinking water MCL. The concentrations of copper and lead exceeded the SLVs by an order of magnitude, but other exceedances were by a factor of 2 or 3 only.

The ODOT outfall drains off-site stormwater from NW St. Helens road and is tight lined beneath the Moorings. The ODOT Catch Bain sample therefore represents off-site conditions. The sample had benzo(a)pyrene at a concentration that exceeded the Oak Ridge National Laboratory (ORNL) Tier II SCV, and two metals (aluminum, lead) at concentrations above either the USEPA 2004 NRWQC or the ODEQ 2004 AWQC, Both of these metals were an order of magnitude higher than their respective SLV. The only MCL exceeded in this sample was for aluminum.

The Seep sample is believed to be more representative of groundwater than surface water given the nature of the site surface (i.e. predominately paved, hard packed, and well maintained), river shoreline (i.e. completely armored and maintained), existing stormwater management systems (well maintained), and shallow zone hydrology. The Seep sample had benzo(a)pyrene, DDT, aluminum, copper, and lead at concentrations above either the USEPA 2004 National Recommended Water Quality Criteria (NRWQC) or the ODEQ 2004 AWQC, The only MCL exceeded in this sample was for aluminum. The benzo(a)pyrene, DDT, and copper SLVs were exceeded only by a factor of approximately 2, while the aluminum and lead SLVs were exceeded by an order of magnitude.

Although these sample results indicate that there may be some direct discharge impact to the Willamette River related to the Moorings, the findings are not inconsistent with the general industrial nature of the site and the surrounding area. Moreover, the well-maintained nature of the site in conjunction with the findings of the smoke/dye testing program suggest that the direct discharge impacts associated with the Moorings itself are well characterized and easily managed with appropriate best management practives.

6.4.2 Groundwater Flow

Permanent groundwater monitoring wells were not installed as part of the Moorings RI, Accordingly, groundwater flow characteristics can only be estimated from observations made during drilling activities and while installing/sampling temporary well points. Based on these observations, shallow groundwater In the Industrial Area is generally encountered at depths of 8 to 12 feet bgs within an upper water bearing zone that averages approximately 15 feet thick. Water level measurements collected in March and August of 2008 suggest that the groundwater generally flows in a northeasterly direction, from the vicinity of the GASCO property toward the Willamette River (see Figures 5-25 and 5-26, pages 5-99 and 5-100 respectively).

Darcy's Law can be used to estimate the groundwater flow rates beneath the Moorings:

$$Q_{gw} = K \times I \times A \times CF$$

Where:

Q = the volumetric flow rate (ft^3/sec);
K = Hydraulic Conductivity
I = Hydraulic gradient; and
A = Area of discharge, or the saturated thickness x the width of the aquifer.

Using the interpolated contours shown on Figures 5-25 and 5-26 (pages 5-99 and 5-100), the Hydraulic Gradient (I) along the primary flow axis across the site ranged from approximately 0.03 in March to 0.01 in August. Hydraulic Conductivity (K) was not measured at the Moorings during this RI, but it is reasonable to assume that the range calculated at the neighboring GASCO site (i.e. 9.7×10^{-5} cm/sec to 9.1×10^{-3} cm/sec) is also representative of the Moorings. The Area of Discharge (A) is estimated at 4,500 ft^2 based on a shoreline length of 1,455 feet and an average saturated thickness of 5 feet in the shallow zone.

With these estimated input parameters, the volumetric flow rate in the shallow zone beneath the Moorings is estimated to range from approximately 50 ft^3/day to approximately 3,500 ft^3/day, depending largely on the season and the assumed hydraulic conductivity of the soil profile.

Section 6.3.3.2 (page 6-14) discusses contaminant distribution trends in the shallow groundwater, and concludes that potential off-site sources are contributing to the groundwater contamination observed beneath the Moorings. Potential impacts to the Willamette River related to this contamination are best evaluated by looking at sample results for wells 1, 2, 3, 4, and 6 (Figure 6-1 [page 6-21] Transect D – D'). Samples from all five of these locations had metals concentrations that exceeded the USEPA 2004 NRWQCs, the ODEQ 2004 AWQCs, or the MCLs. The metals most commonly identified at levels above SLVs included aluminum, cadmium, lead, manganese, nickel, and zinc. The exceedances were commonly several orders of magnitude above the SLV (Appendix A2, Table 2ci-iv), Cyanide was detected in all 5 samples at levels above the USEPA 2004 NRWQCs or ODEQ 2004 AWQCs, but only in 3 samples at levels above the MCL. The only organic compounds found at concentrations above SLVs were naphthalene and flourene in two samples.

Comparison of the relative number and magnitude of the SLV exceedances in each sample indicate that locations SB-01 and SB-02 (i.e. those closest to the GASCO border) are measurably more contaminated than the other samples along the river edge. This data, as well as other information collected during the RI, suggest that source control measures for groundwater flow beneath the Moorings must consider off-site upland sources to be effective.

6.4.3 Erosion/Leaching

Virtually the entire Moorings surface is paved, hard packed, or covered by buildings. The hardpacked northern portions of the site exhibit a surficial layer of fine soils. These soils were source of the material sampled in the two locations identified as erodible soils – the Fence line MU and the Run-off sample location.

The Fence line MU is described in Section 4.1.2.3.4 (page 4-20). Sample results are summarized in Table 5-4, page 5-33, and Appendix A1, Table 1b. In general, PAH and metals levels were elevated in the Fenceline MU when compared to other MU soils. Benzo(a)pyrene, dibenz(a,h)anthracene, arsenic, chromium, and lead were detected at levels that exceeded the USEPA Region 6 Industrial Soil PRGs. The lead concentration exceeds the SLV by

approximately an order of magnitude, but the other exceedances were generally above SLVs by only a factor of 2 or 3.

The Runoff sample was collected in the North Logistics MU at a location where there was visual evidence of surface water ponding and sediment accumulation. This location had benzo(b)fluoranthene, benzo(a)pyrene, dibenz(a,h)anthracene, arsenic, and lead in concentrations that exceeded USEPA Region 6 Industrial Soil PRGs (Appendix A2, table 2B).

The Runoff sample and the Fence Line MU represent the accumulation and deposition of the fine surficial soils observed across the northern Moorings resulting from surface water flows. The rates of accumulation and erosion of these surficial soils is unknown. However, in combination, the surface area represented by the Runoff sample and the Fence Line (Section 4.1.2.3.4, page 4-20) and the area joining the two is approximately 0.12 acres. Observations suggest that the average depth of the fine soil in this area is less than one inch, which over the entire area represents less than 16 cubic yards of material.

The erodible soils at the fence line location lie in a slight depression in the ground surface and are surrounded by hard pack ground on the upland side of the MU and the rock armored shoreline downgradient such that the potential for movement of these soils into the River is limited. The Runoff sample location lies in a gentle topographic depression that may drain as much as 20% of the MIS Area. Relatively straightforward best management practices (e.g., regrading of portions of the surface) would redirect site runoff to existing stormwater management features and essentially eliminate this issue. Although results from both samples have constituents in concentrations that exceed SLVs, neither is believed to present a significant risk to the Willamette River.

To explore the potential for subsurface soil contamination to leach into groundwater, sample results along the southern Moorings/GASCO border were examined. Specifically, the soil PAH concentrations along the southern Moorings/GASCO border are among the lowest detected in the Industrial Area, whereas the groundwater PAH concentrations along the same border are among the highest. To determine if the soil PAH concentrations found along the southern border in the Industrial Area are high enough to produce the observed groundwater PAH concentrations, the LPAH, HPAH, and TPAH soil concentrations from the 8 to 12 foot horizon were used to predict the maximum potential groundwater concentration at each location using the following formula:

$C_w = C_o / K_d$,

where:

C_w is the projected PAH concentration in groundwater (µg/L);

C_o is the concentration of any particular PAH in soil (µg/kg); and

K_d is the chemical specific soil-water partition coefficient in L/kg.

The value of each chemical K_d was calculated using the equation:

$K_d = K_{oc} \times f_{oc}$,

where:

K_{oc} is the chemical specific soil organic carbon-water partition coefficient in L/kg; and

f_{oc} is the fraction of organic carbon in soil in g/g.

The f_{oc} value chosen for this evaluation was 0.006 g/g, which is the default value in the RAIS database soil saturation concentration PRG equation[5]. The K_{oc} for most of the PAH compounds was readily available at either the CLARC or RAIS databases, however, there were several that were not. These were calculated from the K_{ow} octanol-water partition coefficient values which were available using the equation:

$$\log K_{oc} = 0.00028 + (0.983 \times \log K_{ow})$$

Cw was calculated for each compound that was detected in the soil and the predicted values were then summed for the LPAH, HPAH, and TPAH groups.

Table 6-6 below provides an example of these calculations for location SB-1, a sample location close to both the Willamette River and the GASCO site.

Table 6-6 Example Calculations for SB-01

PAH Analyte	Koc[1] (L/kg)	Kd[2] (L/kg)	Location SB-01		
			Soil Concentration **(Co) (µg/kg)**	Measured Groundwater **Concentration (µg/L)**	Predicted Groundwater Concentration **(Cw) (µg/L)** [3]
Naphthalene	1.2E+03	7	6.4	0.15	
2-Methylnaphthalene	6.2E+03	37	0.59	0.0035	
Acenaphthylene	1.0E+04	60	1.9	ND	0.032
Acenaphthene	4.9E+03	29	ND	0.0074	NA
Fluorene	7.7E+03	46	ND	ND	NA
Phenanthrene	3.1E+04	186	5.2	0.0078	0.028
Anthracene	2.3E+04	138	1.4	0.017	0.010
Summed LPAH			16	0.19	1.00
Fluoranthene	4.9E+04	294	19	0.005	0.065
Pyrene	6.8E+04	408	34	0.01	0.083
Benzo(b)fluoranthene	1.2E+06	7200	84	0.004	0.012
Benzo(k)fluoranthene	1.2E+06	7200	23	0.0044	0.0032
Benzo(a)anthracene	3.6E+05	2160	18	0.011	0.0083
Chrysene	4.0E+05	2400	24	0.0029	0.0100
Benzo(a)pyrene	9.7E+05	5820	61	0.0085	0.011
Indeno(1,2,3-cd)pyrene	3.5E+06	21000	120	0.015	0.0057
Dibenz(a,h)anthracene	1.8E+06	10800	9.1	ND	0.0008
Benzo(g,h,i)perylene	3.8E+06	22800	140	0.019	0.0061
Summed HPAH			530	0.080	0.20
Summed TPAH			548	0.27	1.2

Notes:
[1] Values from CLARC database, RAIS database, and Log Koc = 0.00028 + (0.983 x Log K_{ow})
[2] Values calculated from Kd = Koc x f_{oc} (default foc value of 0.006 g/g from RAIS database)
[3] Values calculated from $C_w = C_o / K_d$

Using the above formulas, Table 6-7 (page 6-20) illustrates the predicted and measured groundwater PAH concentrations for Locations SB-11, SB-12, and SB-16 along the southern border of the site. Also shown are the ratios of the predicted to measured groundwater concentrations. A ratio of less than 1 indicates that the concentration of the summed PAH group measured in the soil samples was not sufficient to produce the observed concentration of the same PAH group in the corresponding groundwater sample. Only the summed HPAH concentration at Location SB-12 produced a ratio greater than 1. In other words, the measured

[5] http://rais.ornl.gov/prg/equations/csat.shtml

concentrations of PAHs in soil along the southern site border are generally not high enough to produce the measured concentrations of PAHs in groundwater. This suggests that PAH contamination of groundwater in the area may be related to off-site sources to the south, or upgradient, of the site.

Table 6-7 Predicted and Measured PAH Groundwater Concentrations along the Moorings Property Line

Analyte Group	Location 11			Location 12			Location 16		
	Meas. GW (µg/L)	Pred. GW (µg/L)	Ratio Pred. to Meas.	Meas. GW (µg/L)	Pred. GW (µg/L)	Ratio Pred. to Meas.	Meas. GW (µg/L)	Pred. GW (µg/L)	Ratio Pred. to Meas.
Summed LPAH	3.5	0.17	0.05	1.67	0.51	0.31	7.1	1.2	0.026
Summed HPAH	0.48	0.21	0.43	0.038	0.12	3.1	0.16	0.03	0.19
Summed TPAH	4.0	0.39	0.10	1.7	0.63	0.37	7.2	0.22	0.031

Notes
GW groundwater
Pred. predicted
Meas. measured

To further explore this hypothesis, all of the soil sample PAH results from the 8 to 12 foot depth range in the Industrial Area were examined to see if any could produce the observed groundwater PAH concentrations at Locations SB-11, SB-12, and SB-16 (the highest observed concentrations in the Industrial Area). Table 6-8 below shows the concentrations of the summed LPAH, HPAH, and TPAH groups from Locations SB-01 through SB-06, SB-11, SB-12, and SB-16 (Figures 5-4, 5-5, 5-6; pages 5-21 to 5-23) and the maximum predicted groundwater concentration values associated with each.

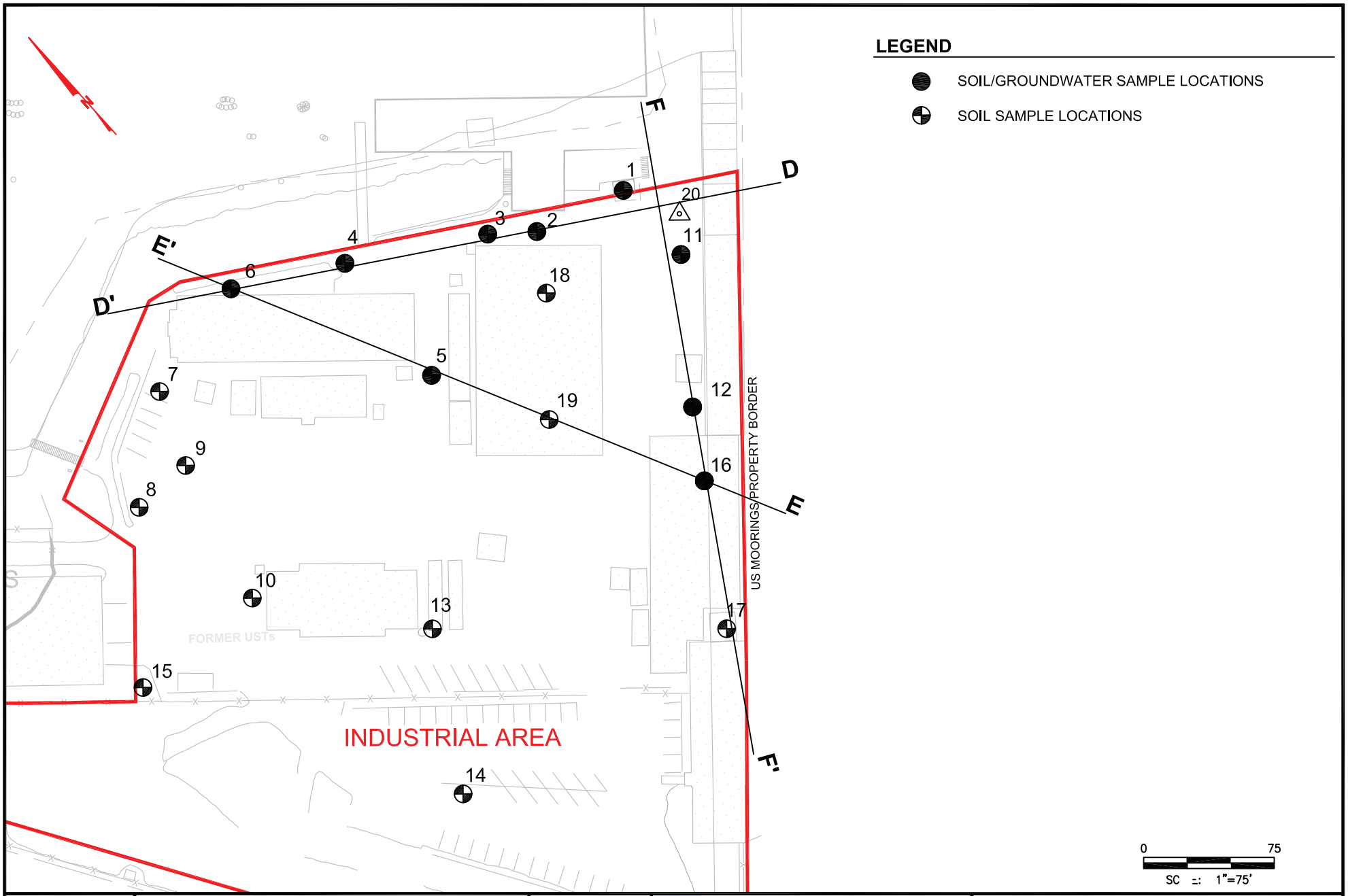
Table 6-8 Maximum Predicted Groundwater vs. Highest Measured Concentrations

Analyte Group	Maximum Pred. GW Concentration (µg/L) [1]	Location 11	Location 12	Location 16
		Meas. GW Concentration (µg/L)	Meas. GW Concentration (µg/L)	Meas. GW Concentration (µg/L)
Summed LPAH	0.60 (SB-05)	3.5	1.7	7.1
Summed HPAH	0.72 (SB-03)	0.48	0.038	0.16
Summed TPAH	1.1 (SB-03)	4.0	1.7	7.21

Notes
[1] Based on the values calculated from the maximum soil concentration in any IA location sampled for soil and groundwater at the 8 to 12' depth (location in parentheses).
GW groundwater
Pred. predicted
Meas. measured

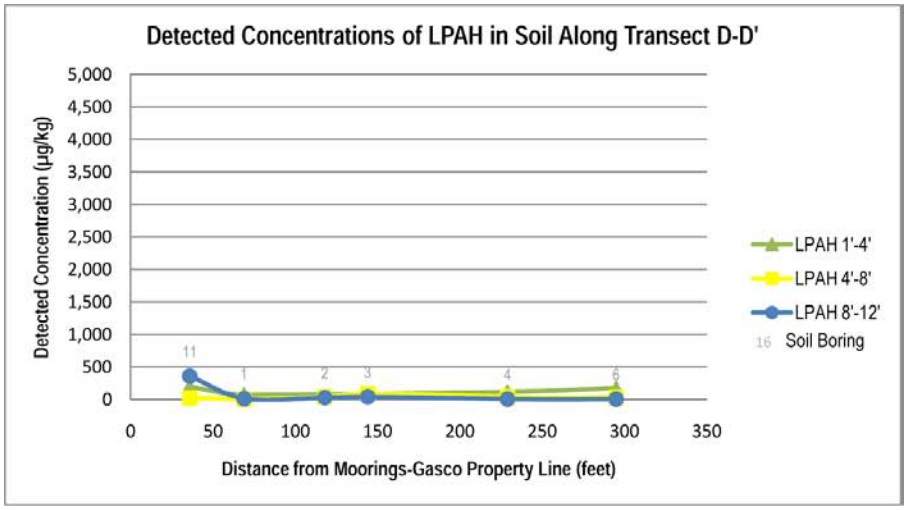
These results indicate that even when using the highest measured soil PAH concentrations in the 8 to 12 foot depth range at the site, the summed LPAH and summed HPAH ratios are still less than 1, and the summed TPAH ration is only slightly over 1. The observed PAH concentrations in the soil at the Moorings are unlikely to produce the concentrations of PAHs detected in the groundwater.

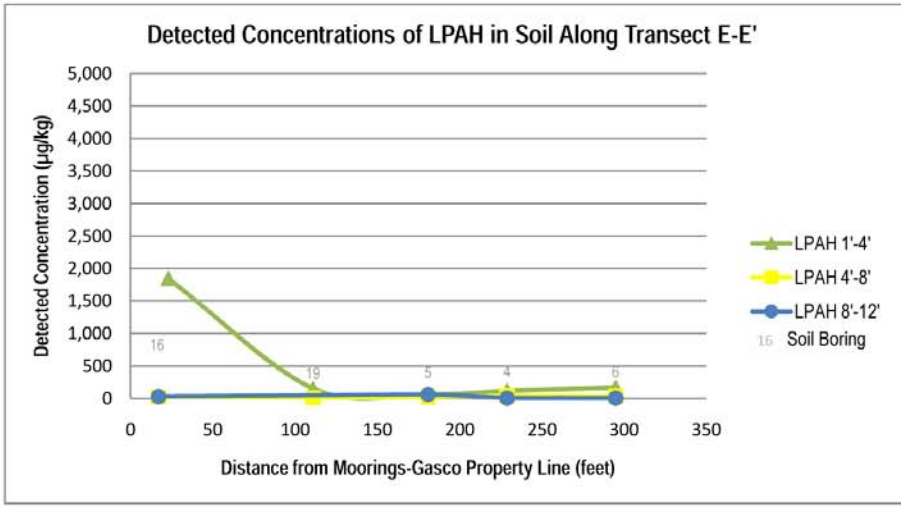
This analysis further suggests that the source of PAH contamination of soil and groundwater in the Industrial Area is off site, and that source control measures related to leaching should be focused in that direction.



FI -	INDUSTRIAL AREA SAMPLE TRANSECT LOCATIONS	DAT : DRAWN: CHECKE):	TEC inc 1450 114th Ave llevue, Wa 98004 42	ENT MOORINGS REMEDIAL INVESTIGATION

Figure 6-2 Distribution of LPAH along Industrial Area Soil Transects





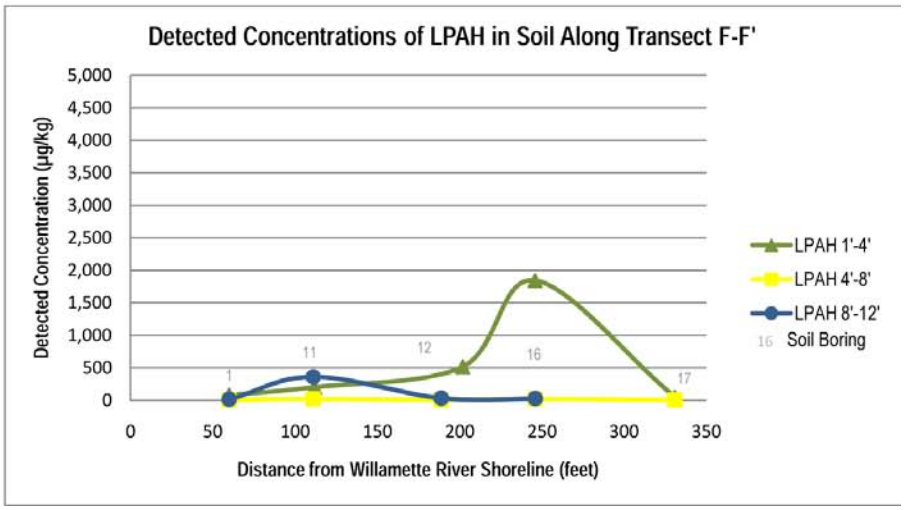
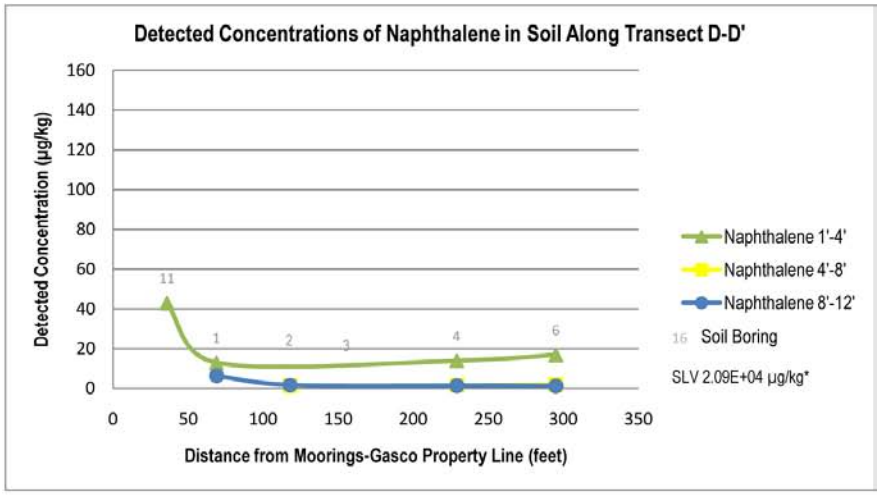
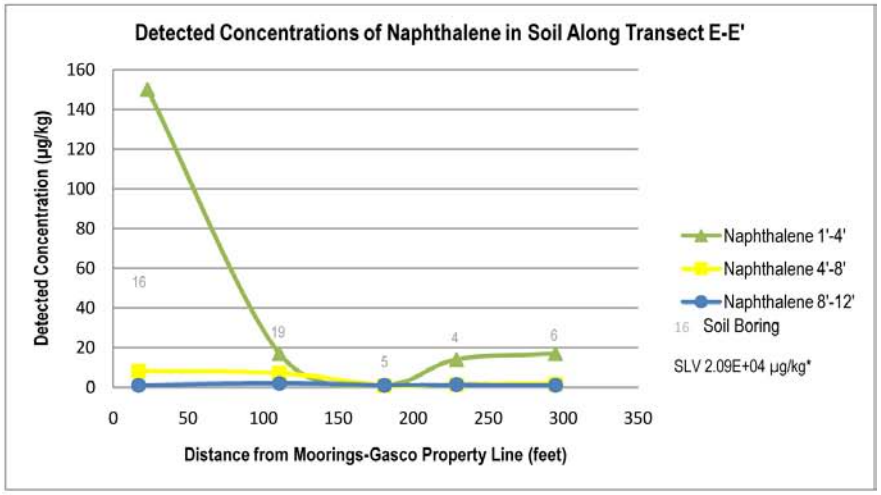
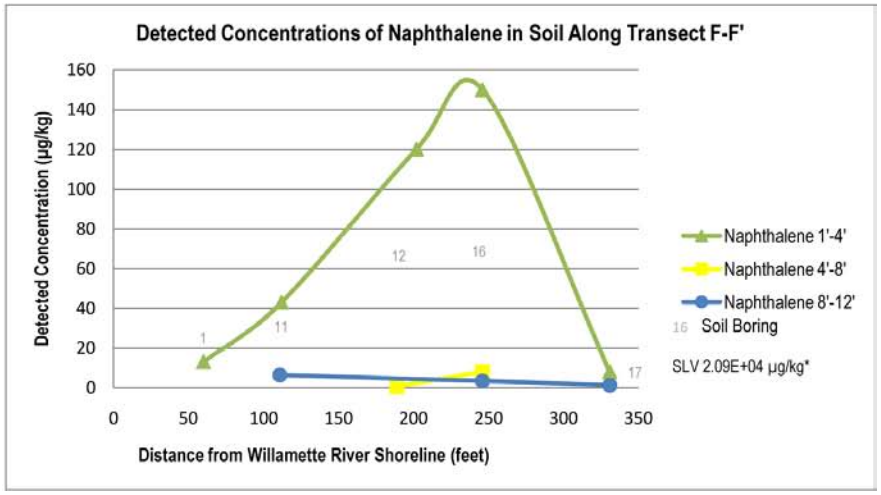


Figure 6-3 Distribution of Naphthalene along Industrial Area Soil Transects

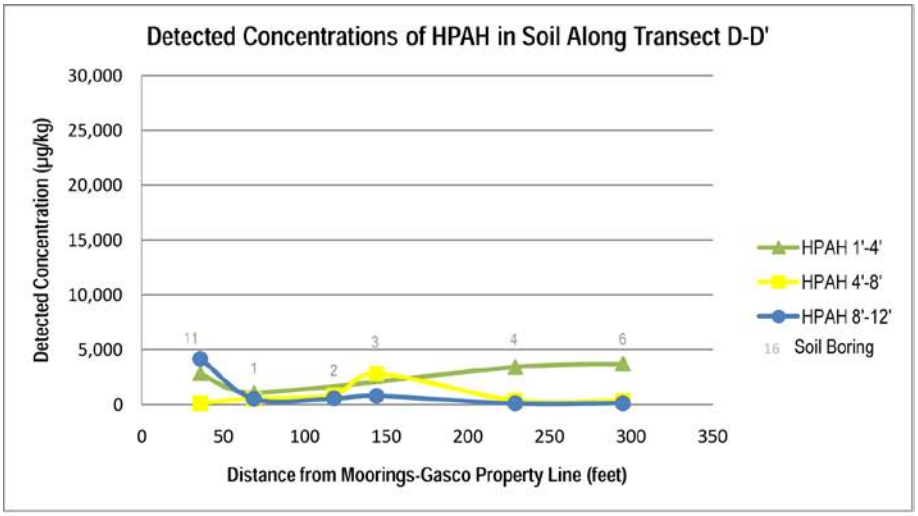


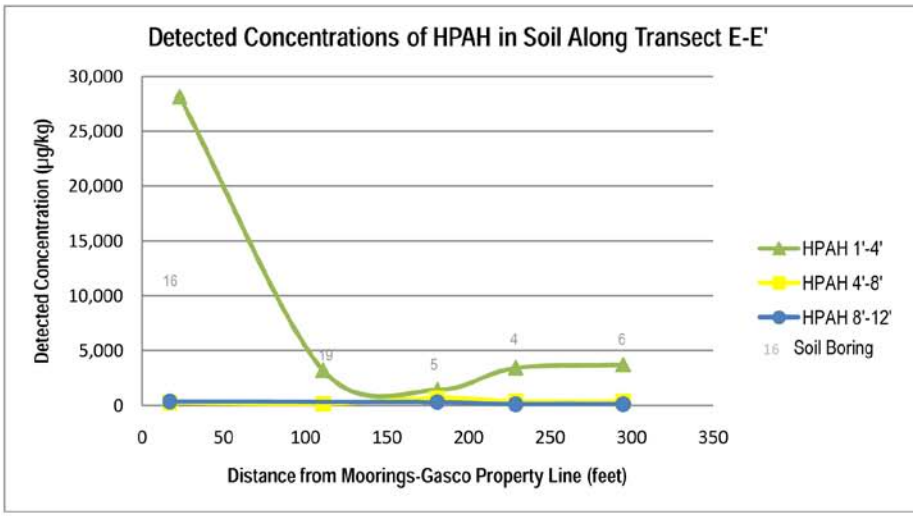




*USEPA Region 6 PRG Industrial Soil non-Cancer Risk 0.10 SLV (2008)

Figure 6-4 Distribution of HPAH along Industrial Area Soil Transects





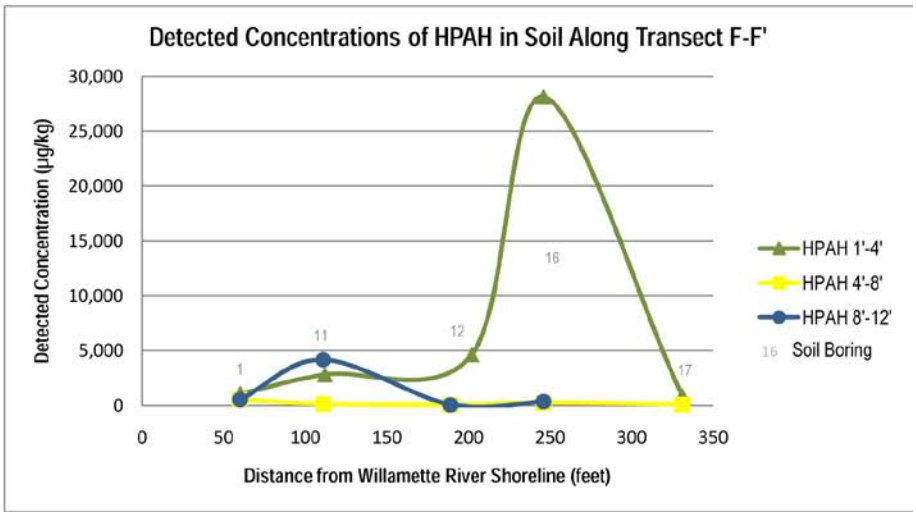
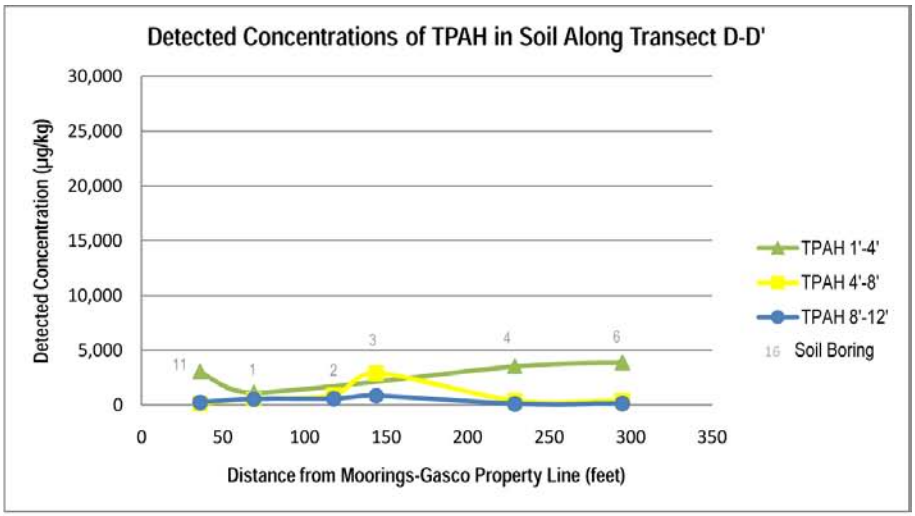
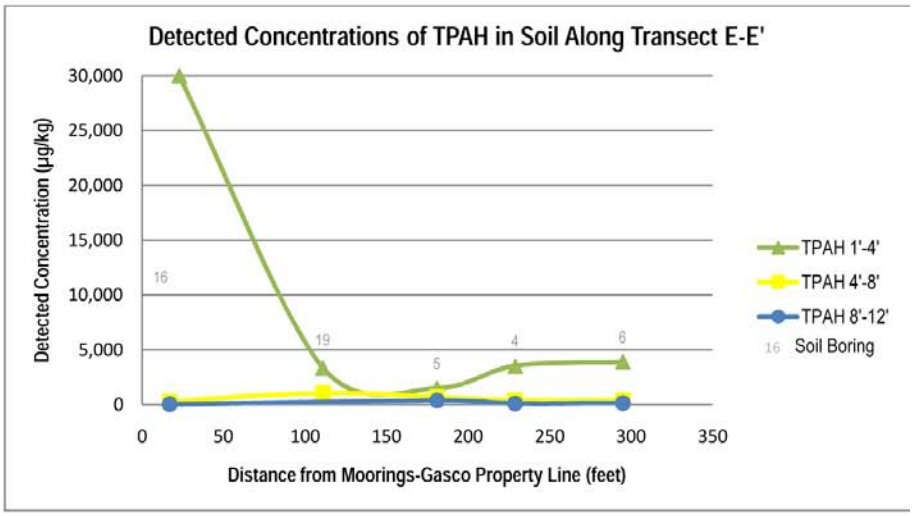


Figure 6-5 Distribution of TPAH along Industrial Area Soil Transects





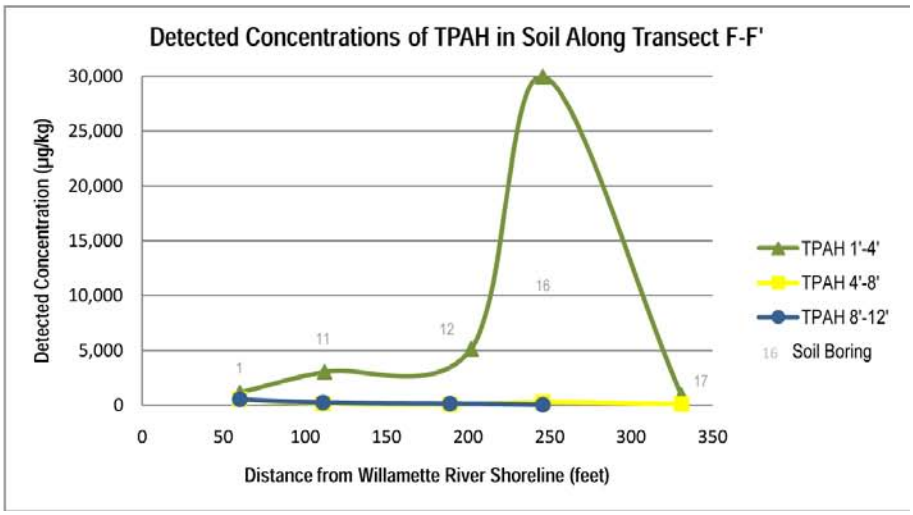
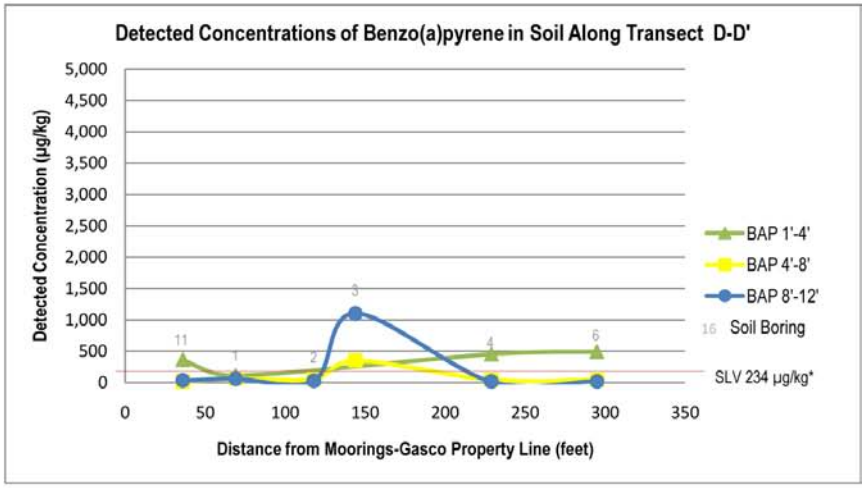
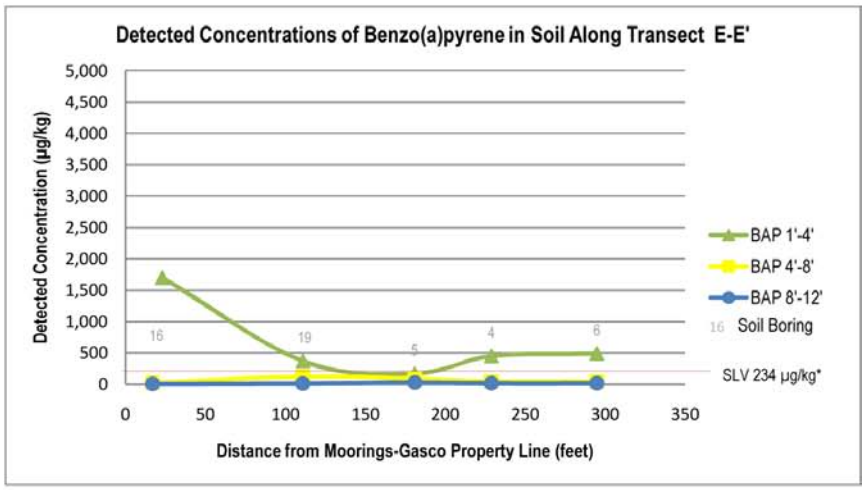
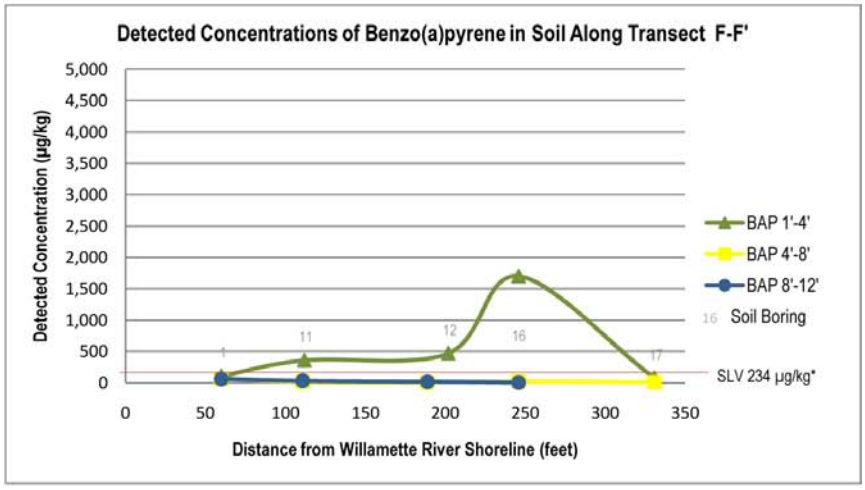


Figure 6-6 Distribution of Benzo(a)pyrene along Industrial Area Soil Transects

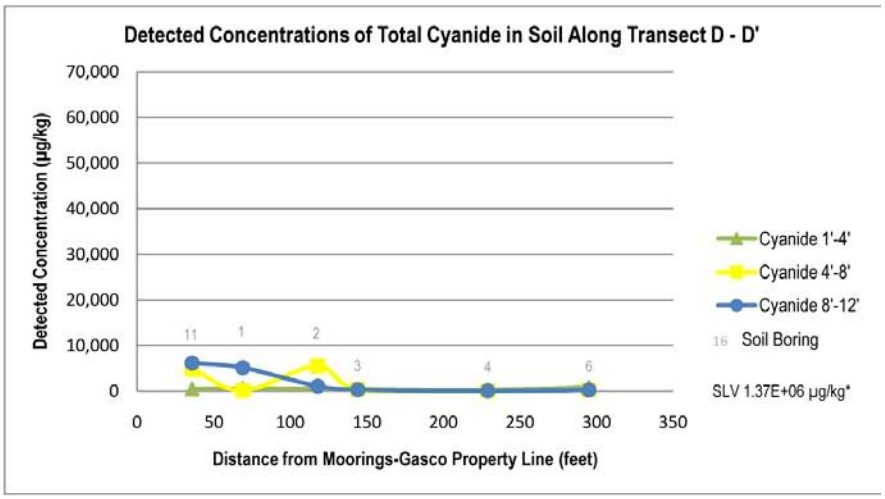


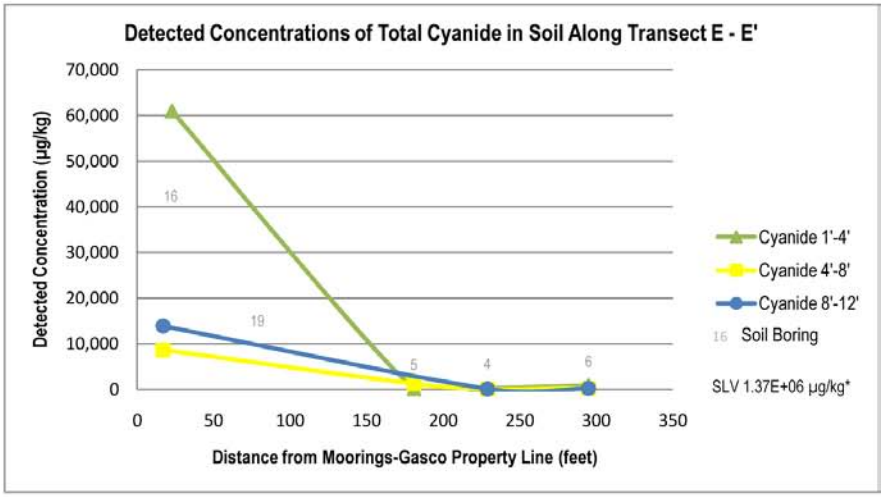


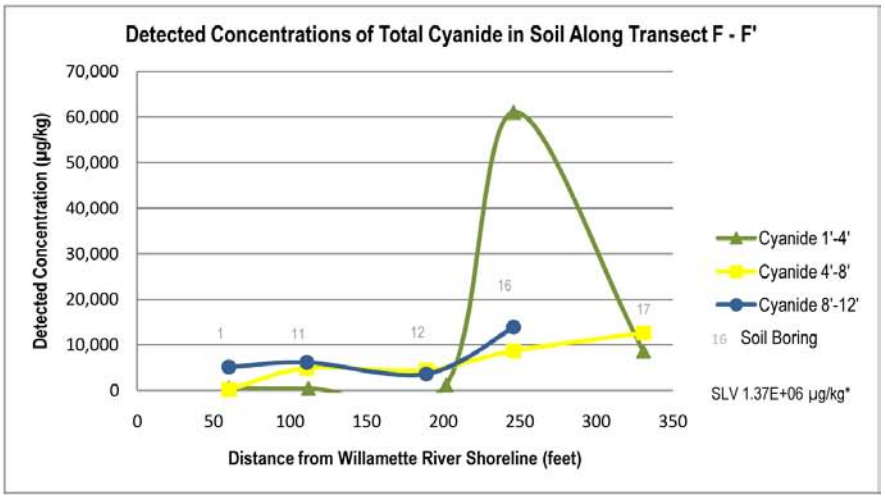


*USEPA Region 6 PRG Industrial Soil Cancer Risk SLV (2008)

Figure 6-7 Distribution of Total Cyanide along Industrial Area Soil Transects

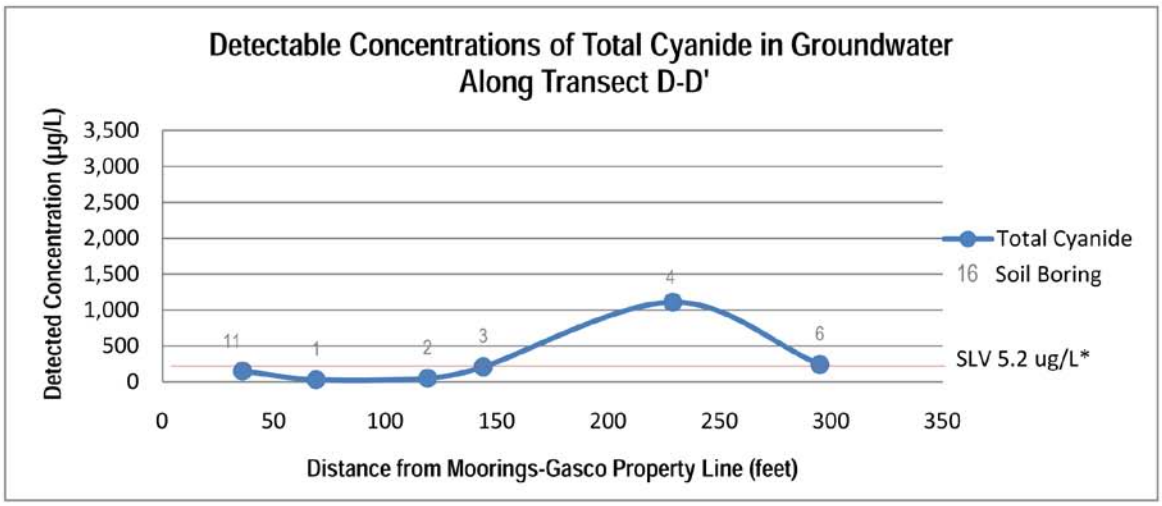


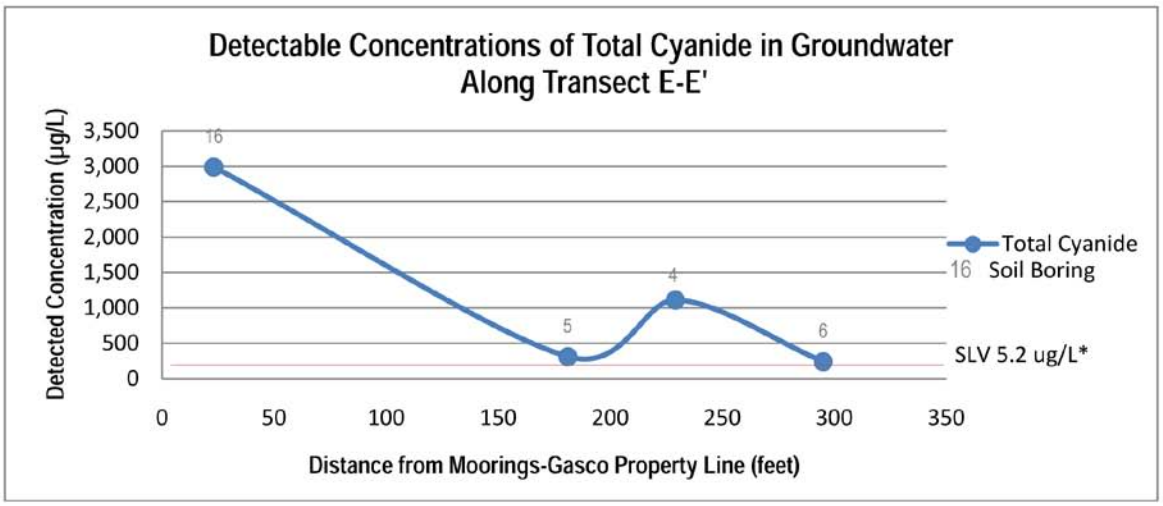


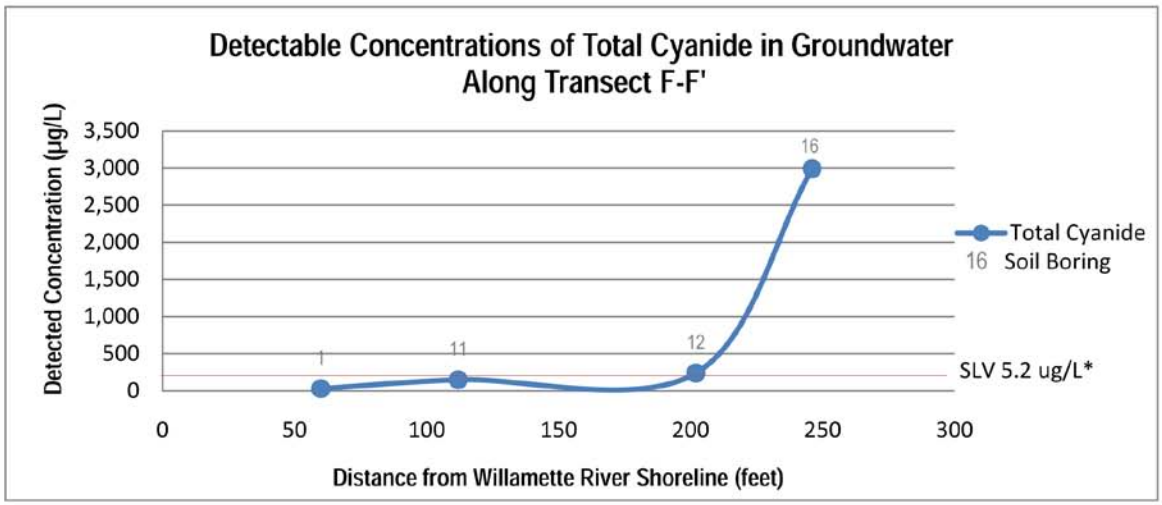


*USEPA Region 6 PRG Industrial Soil non-Cancer Risk 0.10 SLV

Figure 6-8 Distribution of Total Cyanide along Industrial Area Groundwater Transects

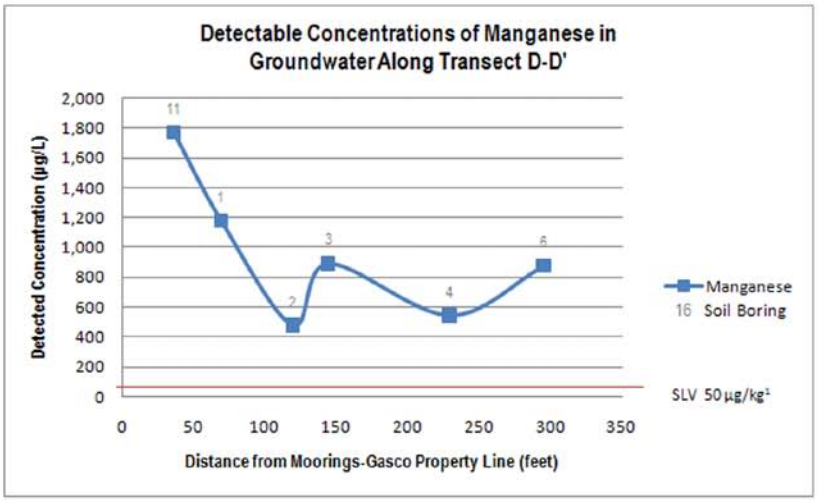


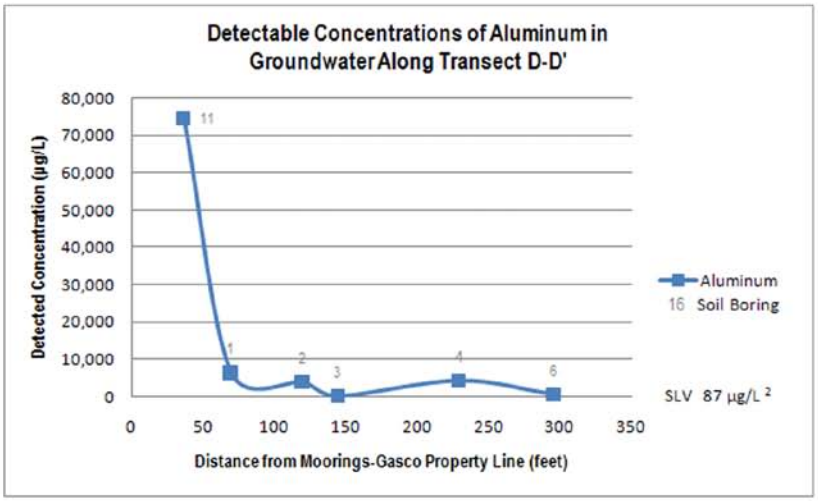


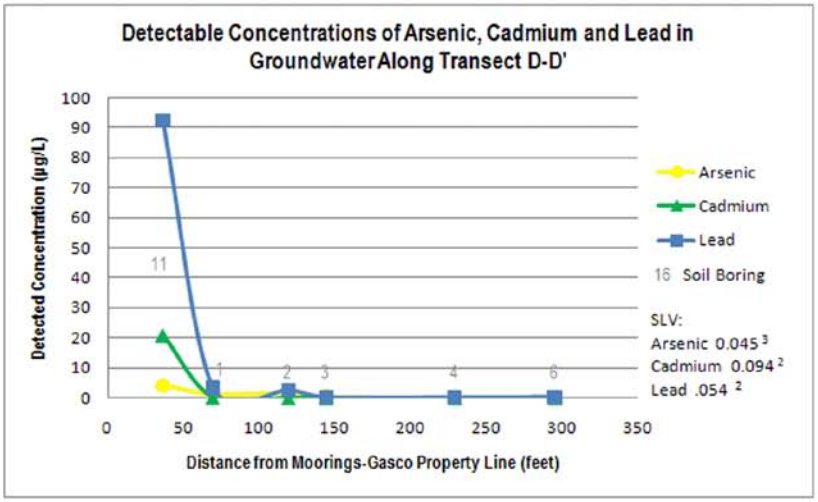


*USEPA 2004 NRWQC

Figure 6-9 Distribution of Select Metals in Groundwater along Transect D-D'

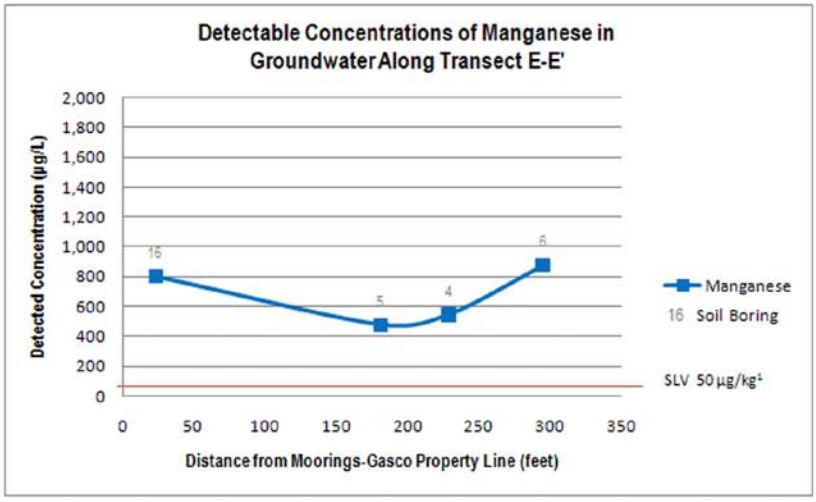


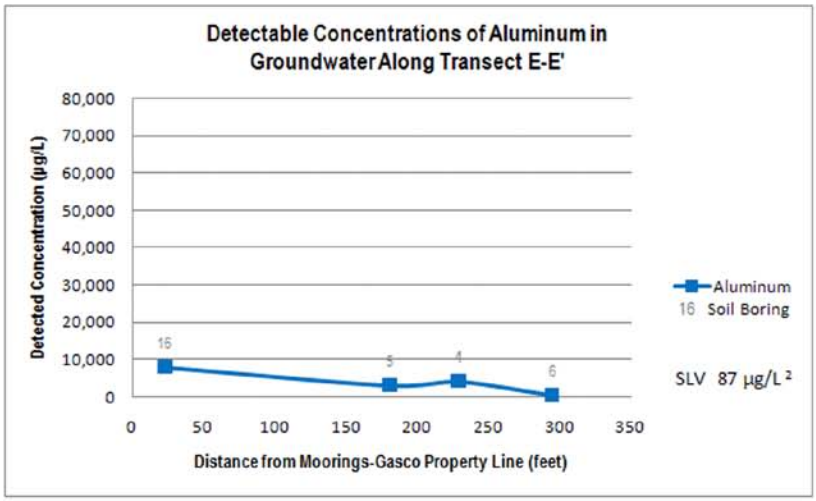


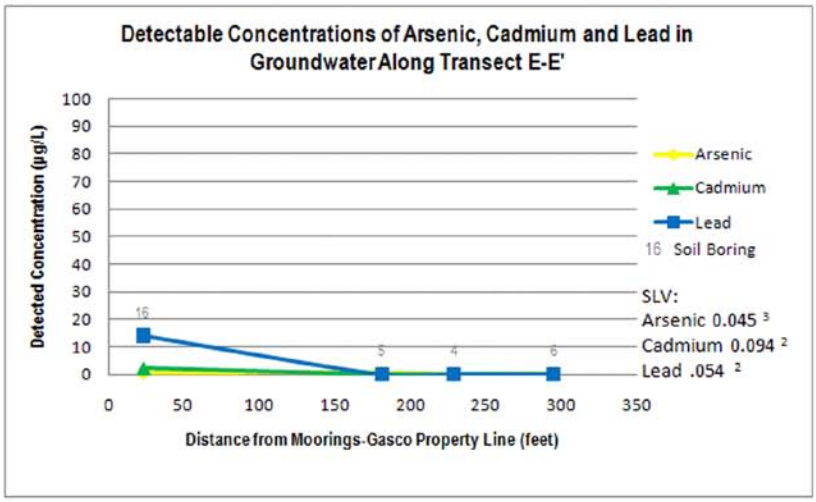


1 JCSC Safe Drinking Water Act MCLs
2 USEPA 2004 NRWQC (chronic) (from JSCS Table 3.1)
3 USEPA Region 6 PRG Industrial Soil Cancer Risk (2008)

Figure 6-10 Distribution of Select Metals in Groundwater along Transect E-E'

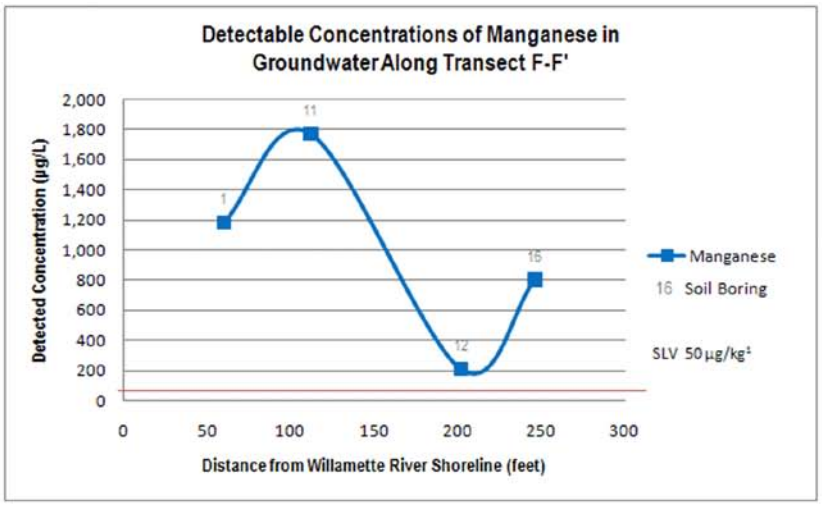


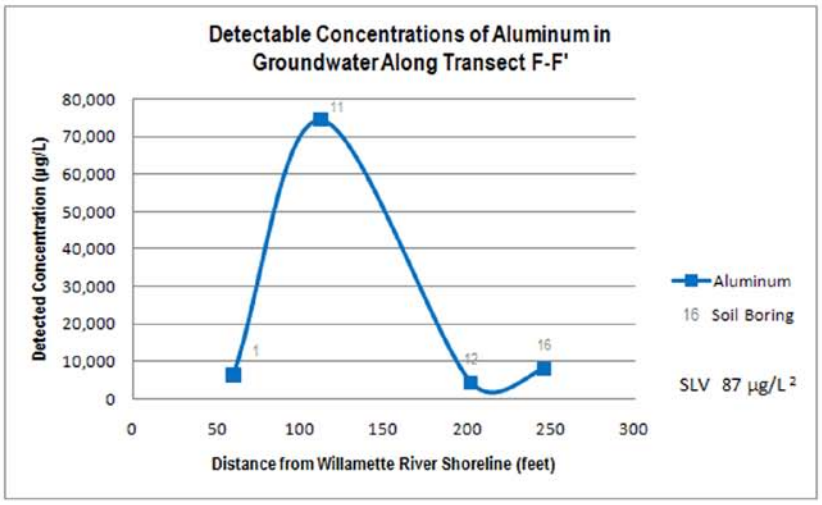


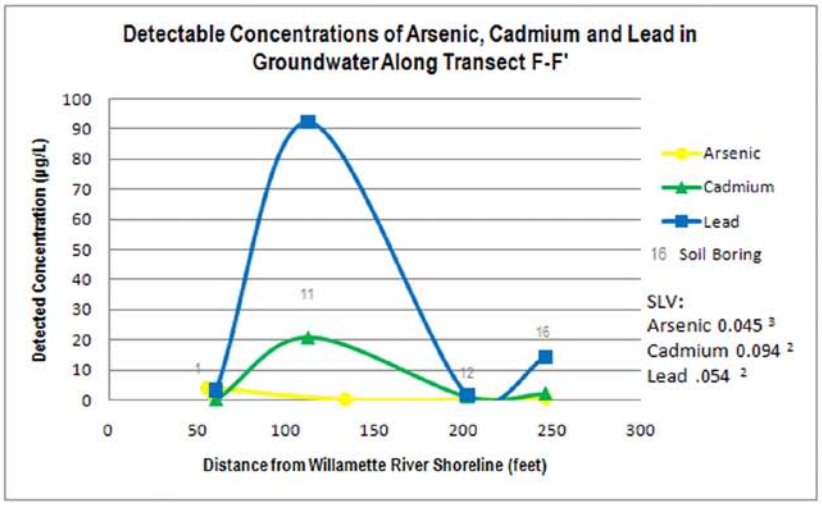


1 JCSC Safe Drinking Water Act MCLs
2 USEPA 2004 NRWQC (chronic) (from JSCS Table 3.1)
3 USEPA Region 6 PRG Industrial Soil Cancer Risk (2008)

Figure 6-11 Distribution of Select Metals in Groundwater along Transect F-F'







1 JCSC Safe Drinking Water Act MCLs
2 USEPA 2004 NRWQC (chronic) (from JSCS Table 3.1)
3 USEPA Region 6 PRG Industrial Soil Cancer Risk (2008)

6.5 IN-WATER SEDIMENT INVESTIGATION

The primary goals of the sediment investigation were to determine if the near-shore sediments are contaminated and to provide data to support on-going USACE sediment management activities and LWG studies. Evaluation of the sources of contaminants in sediment is implied, but is not a stated objective of this RI, as a separate detailed study to identify the source(s) of sediment contamination is planned. Additionally, the decision making process regarding potential remedial activities for the upland site will be separate from similar activities for the in water site, as the in-water sediments will be dealt with as part of the larger Portland Harbor Superfund project. This section includes a discussion of the distribution trends associated with COPCs detected in sediments, followed by a basic discussion of likely sources of sediment contamination. This evaluation however, is not as comprehensive as the upland discussion. This section is organized according to COPC grouping.

6.5.1 Distribution Trends

The highest levels of all COPCs were observed in upgradient sites in the Under Dock surface sediment samples and in the Dredge Area samples collected immediately adjacent to the docks. Surface sediments were not collected in Dredge Areas B and C.

6.5.1.1 PAHs

Individual PAH and TPAH concentrations are highest in surface sediment samples at Stations SDUD 1, 2, 17, 25, and 27 (Figure 5-16, page 5-79), approximately an order of magnitude higher than those measured downgradient. Benzo(a)pyrene concentrations are significantly elevated in samples SDDC 25-1 (39 mg/kg), SDUD 1-1 (19 mg/kg), SDUD 27-1 (21 mg/kg), and SDDA 17-1 (12 mg/kg) and are shown in Figure 5-15, page 5-77). The remaining Under Dock samples are approximately twice as high as the remaining Bulkhead samples downstream.

The HPAHs are significantly elevated over LPAH at all stations. Within 1 to 6 feet below mudline composite, PAHs remained elevated, although this depends upon the station location. For example, Station SDUD 27-2 had high levels of PAHs that were not inconsistent with those observed in the surface sediment composite, while Station SDUD 2-2 had levels that were orders of magnitude lower than those observed in the surface.

PAHs were also elevated at Stations SDDA 18 and 19 (Figure 5-16, page 5-79). Again, HPAHs dominated the PAH mixture, and were found distributed at elevated concentrations in the sediment column down to 14 feet at Station 19. The HPAH concentrations in subsurface composites were elevated above surface sediment concentrations in samples SDDA 17-2 (313 mg/kg), 18-2 (89 mg/kg), and 19-2 (98 mg/kg).

Along the bulkhead, TPAH concentrations similarly follow a trend of decreasing concentration towards the north, with the highest concentration at SDDC 25-1 (459 mg/kg), decreasing in concentration to 3 mg/kg at Station SDBH-7 (Figure 5-16, page 5-79). Slightly increased concentrations are observed at SDBH 9 and 10 (16.7 mg/kg and 7.9 mg/kg respectively), but are still multiple orders of magnitude below upstream concentrations.

6.5.1.2 Cyanide

Cyanide (total) concentrations, like PAHs, were highest at stations located on the southern end of the Moorings in the upstream areas (Figure 5-18, page 5-83). Surface sediment concentrations of cyanide (total) at SDUD Stations 1, 2, and 27, SDDA 17, and SDDC 25 were the highest on site with values ranging between 12 to 39 mg/kg. Surface concentrations dropped off downstream, with stations SDUD 26 and SDBH 4 having concentrations of 4.6 and

1.9 mg/kg, respectively. With the exception of Station SDDA 19 (Figure 5-18, page 5-83), all other measured values of cyanide (total) were less than 1 mg/kg. Subsurface concentrations of cyanide (total) mirrored the PAH results. Where concentrations in the 1 to 6 feet composite were elevated for PAHs, they were also elevated for cyanide (total). Also, like PAHs, cyanide (total) concentrations collected below 6 feet were generally low.

Cyanide (total) concentrations along the bulkhead show a similar pattern with highest levels at SDDC 25-1 and decreasing to less than 1 mg/kg at all stations, with the exception of SDBH 9 where a spike is again observed (Figure 5-18, page 5-83).

6.5.1.3 Metals

Surface sediments metals concentrations were also elevated at the upstream boundary of the Moorings, but measured metal concentrations were within a factor of approximately two relative to downgradient concentrations. The highest concentrations of metals were observed in the surface sediments. Metals concentrations were generally lower in the subsurface sediments at relatively consistent concentration at all lower depths. Distribution of copper, shown in Figure 5-19 (page 5-85), is indicative of the way all metals are distributed across the site. Concentrations are highest at Stations SDDC 25 and SDBH 4, 208 and 110 mg/kg, respectively. Copper concentrations are also elevated at SDUD Stations 1, 2, 26, and 27, as well as SDDA 17. Copper concentrations throughout the downgradient stations were generally 50 mg/kg or less.

Metal concentrations are relatively constant across all Bulkhead samples, but with spikes observed in chromium, lead, nickel and zinc at SDBH 9-1

Organobutyltins were detected in surface sediments at Stations SDUD 1-1, 2-1, 26-1, and 27-1. The highest measured concentration of TBT was 180 mg/kg at SDUD 1-1 (Figure 5-20, page 5-87). Organobutyltins were also measured in the 1 to 6 foot composite sample at Stations SDUD 26-1 and 27-1, but were otherwise undetected.

Dredge Area A organobutyltins were detected in surface sediments at all three stations at levels less than 10 mg/kg. At Stations 17 and 18, organobutyltins are detected in the first two elevation composites, but not detected at the deeper depth. Organobutyltins are detected down to 14 feet at Station SDDA 19.

6.5.2 Summary

Based upon the lithology discussed in Section 5.4 (page 5-90) and chemical distribution discussed above, the following conclusions may be drawn regarding In-water sediments at the Moorings.

- The nature and extent of PAHs, TPH-Diesel and cyanide (total) is highest at the upstream stations and progress to lower concentrations downstream. The highest concentrations are observed at the stations closest to the former MGP site, both in the surface and subsurface samples measured. PAH, TPH-Diesel, and cyanide (total) measurements are consistent with the lithological observations at those stations.
- Metals are also highest in the samples collected under and adjacent to the docks. The greatest concentrations of copper were observed in surface sediments from under the docks, and along the west (shore) side of Dredge Area C.

- An exception to the observation that concentrations decrease, is sample SDBH-9 which shows slightly elevated concentrations of PAHs and cyanide (total) when compared to adjacent samples in the basin.
- Organobutyltins are also highest in the samples collected under and adjacent to the docks. Additionally, higher organobutyltins concentrations were detected in sample SDBH-16, at the northernmost sediment sampling location, adjacent to the northern property boundary of the Moorings.
- PCB concentrations are uniformly low across all of the sampling stations at the Moorings.
- The ODOT outfall, while showing elevated PAHs and TPH-Diesel throughout the sediment column, does not appear to be contributing increased levels of metals, PCBs, or cyanide (total) to the Moorings sediment load.
- Dredge Areas A, B and C have been depositional zones for upriver sediments since the 1981 dredging event. This is evidenced principally by the increase in elevations from the approximate bottom of cut in 1981 of -20 CRD in Dredge Areas B and C, to mud line elevations between -7 to -15 ft. CRD presently. Likewise, Dredge Area A increased from approximately 30 feet CRD in 1981 to -18 to -20 CRD currently.
- Sediments under the docks and in the three Dredge Areas have been subject to periodic episodic depositional events. This is evidenced by the distinct dark bands of PAH enriched sediments that are representative of pulsed depositional events. Each band is well-defined, laminar in orientation, and is separated by accumulations of brown silt/clays.
- Further evidence of episodic depositional events is the bands and or layers of wood debris were evident with depth in some cores (e.g., SDDC-24, SDDC-23). This banding of woody material is likely indicative of depositional events upstream, discussed in Section 5.4 (page 5-90).

7.0 RISK ASSESSMENT

Potential human health risks associated with environmental contaminants detected at the Moorings were evaluated to assist decision makers in determining appropriate management options for the site. This section presents the results of the HHRA.

Background about the site, the surrounding area, and potential receptors is provided in Sections 2 and 3 of this RI report. The RI field program is described in Section 4 and the RI findings are documented in Sections 5 and 6.

Because the site is paved or covered in thick gravel, no ecological exposures exist for the upland portion of the Moorings; therefore, ecological risks are not assessed. However, a screening evaluation to qualify potential contribution of contaminants to the Willamette River from the Moorings is presented in Section 6.4 (page 6-15).

7.1 HUMAN HEALTH RISK ASSESSMENT

7.1.1 Introduction and Scope of Assessment

The Moorings has been in continuous use as a berthing facility since the early 1900s, and no change in land use activity is planned in the future. Consequently, site activities are unlikely to significantly change in the near term. Soil and groundwater on the upland portion of the Moorings is contaminated as a result of both on-site and off-site activity. Some of these contaminants occur at concentrations that exceed screening levels identified in the RI Management Plan and may pose a risk to human health upon exposure. Details on potential contaminant sources are outlined in Section 3.3, page 3-3.

Consistent with Superfund Human Health Risk Assessment Guidance (USEPA 2001), the Moorings HHRA includes the following items:

- Selection of Exposure Pathways and Receptors;
- Occurrence, Distribution, and Selection of COPCs;
- Exposure Point Selection and Concentration Summaries;
- Values Used for Daily Intake Calculations;
- Toxicity Values (a list of published toxicity values);
- Calculation of Chemical Cancer Risks and Non-Cancer Hazards;
- Summary of Receptor Risks for COPCs; and
- Uncertainty Analysis

The assessment estimates the cancer risks and non-cancer hazards associated with exposure to contaminant concentrations likely to occur in groundwater, surface soil (loose soil, 0 to 6 inches in depth), and shallow soils (0 feet to 5 feet in depth), as determined via samples collected on-site during the RI. Although the Moorings was split into two areas of investigation based on different conceptual models of how the areas may have been contaminated (i.e., the Industrial Area on the southern portion of the property and the MIS Area on the northern portion of the site; Figure 4-1, page 4-11), the HHRA encompasses the site as a whole.

The tables included in Section 7 follow a naming convention that references the USEPA Risk Assessment Guidance for Superfund (RAGS) D guidance (USEPA 2001) table number: for example, Table 7-2-1 (page 7-11) references RAGS D planning Table 2-1.

7.1.2 Selection of Exposure Pathways and Receptors

The Moorings CSM, as discussed in Section 3, provides the rationale for the sampling activities performed on site and acts as a basis for selecting exposure pathways that are evaluated in the HHRA. Figure 3-5 (page 3-21) visually depicts the potential exposure pathways at the Moorings, including contaminant sources, transport mechanisms, exposure media, routes, and receptors. The HHRA validates exposure pathways for the Moorings based on the need for risk and hazard quantification for reasonable on-site activities. The exposure pathways assessed in the HHRA are based on several pieces of information that identify when the exposure might take place, where the exposure might occur, who may be exposed, and what the exposure route may be. The exposure pathway is then identified as either applicable or not applicable to the Moorings. The exposure pathways are summarized in Table 7-1 (page 7-7) and the pathways further analyzed in the HHRA are highlighted.

7.1.2.1 Scenario Timeframe

The scenario timeframe establishes when the exposure might take place. Two timeframes apply to the Moorings HHRA.

- Current/Future timeframes (henceforth referred to as Current) indicate an exposure that is a current possibility the Moorings, and that may also occur in future use of the Moorings.
- Future timeframes indicate exposures that are not currently applicable to the Moorings, but may become applicable in the future.

7.1.2.2 Medium and Exposure Medium

For the purposes of the Mooring HHRA, three media are identified as applicable to the site based on the CSM and available samples:

- Surface Soil,
- Shallow Soil, and
- Groundwater.

The media is the substance (e.g., air, water, soil) that is a potential source of contamination of the exposure medium. The media are often what are targeted for remediation (USEPA 2001). Other media present on-site, but not discussed in the Moorings HHRA, include surface water and ambient air. Surface water is not included as a medium in the HHRA because any surface water that might be contacted is the direct result of a precipitation run-off event and is not necessarily indicative of upland contamination. Ambient air is not included as a medium because it is unlikely that the ambient air would be identified as a source to exposure medium. No air sampling was conducted as part of the RI.

The exposure media is the contaminated media to which an individual may be exposed by dermal contact, ingestion, or inhalation. The exposure media identified for the Moorings are air, surface soil, shallow soil, and groundwater.

- Air: Direct exposure to COPCs via the air exposure medium can occur at the site. COPCs that either existed in the fill material at placement, or were released to site soils or groundwater as a result of site activities, can be released to the air via volatilization or through particulate matter generation. COPCs in air were not sampled as part of the field investigation at the Moorings and will be estimated based on the concentration found in the soils and water media.

- Surface Soils and Shallow Soils: Direct exposure to COPCs via the surface soil and shallow soil pathways can occur at the site. Potential sources of surface soil and shallow soil contaminants include the fill material placed on-site, and the light industrial activities performed as a part of dredge berthing, and maintenance operations. COPCs that either existed in the fill material at placement, or were released to site soils as a result of site activities, could lead to exposure of certain receptor groups through inhalation, incidental ingestion, or dermal contact.

- Groundwater: Direct exposure to COPCs via the groundwater exposure medium could occur at the site in the future. Potential sources of groundwater contamination include leaching and infiltration of COPCs to groundwater from contaminated soil or from migration of off-site contaminated groundwater. COPCs in groundwater could result in exposure of certain receptor groups through dermal contact, ingestion, or inhalation in future scenario timeframes.

7.1.2.3 Exposure Point

The exposure point is the physical location that a worker on the Moorings could contact the various exposure medium. As previously described, approximately one-half of the upland area on the southern portion of the site is paved or covered by buildings. The remaining upland land surface, northwest of Building 17, is either covered by buildings or gravel and pavement. For soil sampling the Moorings site was split into two areas of investigation. In the southern Industrial Area, discrete soil samples were taken from 19 borings (SB-01 through SB-19) at 4-foot intervals starting at 1 - 4 feet bgs to a depth of 16 or 20 feet bgs. An additional sample from boring SB-20 at 80 to 85 feet bgs was also collected. Groundwater samples were also collected at depth (minimum of 8 feet bgs) from a subset of these borings. In the northern portion of the site, an MIS approach was used to collect samples from seven areas of this portion of the site. Multiple samples are taken to form composites in a MIS approach, so that each MIS sample represents an average of the contaminant concentrations within a given MIS MU. MIS samples were collected from 1 to 5 feet in six of the MIS MUs (South Logistics, North Logistics, Laydown, Slump, Prior Clean-up, and Sandblast) and from 0 to 6 inches in the Fence Line MIS MU. Samples were also collected at depth for three of the MIS MUS. Most of the borings and MIS samples started at 1-foot, as it was necessary to drill through concrete or pavement or to remove gravel to reach the soil. Additional surface soil, upland sediment, and surface water samples were collected on the site. For the Moorings site, the following samples were considered for use in the HHRA:

- Surface Soil – MIS Fence Line sample (0-6 inches) and Runoff sample, SD-NL-01, both from the northern portion of the site;

- Shallow Soil – The 1 - 4 foot samples from the borings in the southern Industrial Area of the site and the 1 to 5 foot MIS samples from the northern portion of the site, and;

- Groundwater – Groundwater samples taken from the borings in the southern Industrial Area of the site. There are no groundwater samples from the northern portion of the site where the MIS samples were taken.

Table 7.1 (page 7-7) presents these exposure points; a general description of their location (e.g., MIS MU [Fence Line] or Industrial Area); and whether the exposure point is the result of direct contact or inhalation of the volatilization or particulate matter generation into the air.

7.1.2.4 Receptor Population and Receptor Age

The Moorings is owned and operated by the USACE Portland District as a centralized maintenance and supply site supporting the District's fleet of dredges and other vessels, therefore, it is assumed that all personnel at the Moorings are adults between the ages of 18-70 years. The Moorings HHRA does not account for children or other receptor populations especially susceptible to risks.

The Moorings CSM identified three potential receptor groups, personnel that may be exposed to COPCs in the exposure media, which will be used during the Moorings HHRA (also defined in Section 3.5.1.3, page 3-18).

- Office Workers:
    - Full time on-site worker, 8 hours per day, 5 days per week, and working primarily inside in an office setting. Buildings 1, 5, and 17 contain office spaces.
    - Potential current exposure from inhalation of air contaminants from soil.
    - Potential future exposure from ingestion, dermal exposure, and inhalation of contaminants in groundwater used as a drinking water source.
    - Site pavement precludes contact (dermal and incidental ingestion) with surface, shallow, and subsurface soils.
- Maintenance Workers:
    - Full time on-site worker, 8 hours per day, 5 days per week, working either inside or outside, on all areas of the site, and engaged in general grounds/facilities maintenance that does not include intentional disturbance of the surface or shallow soils, except for the possibility of work along the MIS Fence Line MU and Run-Off area.
    - Potential current exposure from inhalation of air contaminants from soil and from direct exposure (dermal, inhalation and incidental ingestion) to surface soil;
    - Potential future exposure from ingestion, dermal exposure, and inhalation of contaminants in groundwater used as a drinking water source.
    - Site pavement precludes contact (dermal and incidental ingestion) with shallow and subsurface soils.
- Upland Excavation Workers:
    - Contractor working on site, engaged in specialized work, typically associated with buried utilities (e.g., water, electric, sewer, etc.) with a time on-site of approximately one nine-day period only once in a workers lifetime (ODEQ 2000).

- Potential exposure to shallow Industrial Area (1 - 4 feet bgs) and MIS Area (1 - 5 feet bgs) via incidental ingestion, dermal exposure, and inhalation.
- No reasonable expected contact with groundwater as sampled during the Mooring RI, because groundwater is estimated to have an upper elevation of 8 feet bgs.

7.1.2.5 Exposure Route

The exposure route is defined as the way a chemical comes in contact with a person (USEPA 2001). Four exposure routes were identified as applicable to the Moorings:

- Inhalation: Breathing of volatilized chemicals or particulate matter in the air that are generated by an exposure medium.
- Incidental ingestion: unintentional ingestion of the exposure medium (soil) during on-site activities.
- Dermal contact: Exposure of the skin to the exposure medium (soil and groundwater).
- Ingestion: Intentional ingestion of the exposure medium. Applicable to groundwater used as a drinking water source.

7.1.2.6 Rationale for Selection or Exclusion of Exposure Pathway and Type of Analysis

Potential exposure pathways are designated as complete, potentially complete, incomplete, or unlikely for each receptor. These designations are defined by the following criteria:

- Complete – All elements of the exposure pathway are present, and the presence of contamination throughout the exposure pathway has been documented. Complete pathways are further evaluated.
- Potentially Complete – The elements of the exposure pathway may be present, depending on how the land or water resources are used in the future. The fourth element will depend on the types of future receptors that may use the site, or be potentially exposed to the site contaminants. Potentially complete pathways are further evaluated.
- Incomplete – At least one of the elements of the exposure pathway isn't present. Incomplete pathways are not evaluated any further.
- Unlikely- Based on previous assessments of similar scenarios, or where circumstances clearly indicate so, the risk associated with this type of complete pathway is unlikely to occur and is less of a risk/hazard in comparison with the other pathways evaluated. Unlikely pathways are not evaluated any further.

If an exposure pathway for the Moorings is determined to be complete or potentially complete, it is selected to have a quantitative analysis of the risks present. If an exposure pathway is incomplete or unlikely, the pathway is excluded from analysis in the HHRA. Selection or exclusion of a pathway takes into consideration many assumptions.

Assumptions for surface soil:

- Direct exposure (dermal contact, incidental ingestion, and inhalation of volatiles and dust) to chemicals in surface soils is assumed for Maintenance Workers along the fence

line on the northwest portion of the Moorings and near the location of the North Logistics Runoff sample.

- Office Workers are not assumed to be spending time near those areas.

Assumptions for the shallow soil:

- Direct exposure (dermal contact, incidental ingestion, and inhalation of volatiles and dust) to chemicals in shallow soil is assumed for excavation workers. It is very unlikely that these workers would have access to deeper soils. For the purposes of the risk evaluation, shallow soils are considered to consist of soils under the site pavement, buildings, compacted gravel, or rock armor to a maximum depth of 5 feet below grade in the MIS area and 4 feet below grade in the Industrial Area.

- Upland Excavation Workers are generally present only for one instance of specialized construction work that lasts a few days at most. Upland Excavation Workers generally do not re-visit the site multiple times in any given year. Based on historical observations, the average construction worker is assumed to be on-site for a single three-day period once in a lifetime.

- Office Workers and Maintenance Workers that occupy the site on a regular basis are not expected to come into contact with shallow soils due to prevalence of pavement, compacted gravel, and rock armor on all surfaces not covered by buildings. However, volatilization of contaminants from shallow soil into office and other buildings is a potential exposure pathway. Although inhalation of particulates from shallow soil is very unlikely, this was also included as a potential route of exposure.

- Because the site is controlled and is in an industrial area, little risk of exposure to trespassers or area residents exists.

Assumptions for the groundwater exposure medium:

- Currently, site groundwater is not being used as a drinking water source. The current potable water source is the Portland Water Bureau and no on-site groundwater drinking water wells exist. However, office and maintenance workers could potentially be exposed to contaminants in groundwater through volatilization of contaminants into buildings (i.e., vapor intrusion).

- Office Workers and Maintenance Workers that occupy the site on a regular basis are not currently expected to contact groundwater or surface water during their daily activities, but could in the future if potable water wells are installed. Future use of groundwater as a drinking water source would result in exposures from dermal contact, ingestion, and inhalation of contaminants in groundwater.

7.1.2.7 Uncertainty Related to Selection of Exposure Pathways

Selection of exposure pathways is based on an assumed current and future physical setting at the Moorings. The likelihood of the activities described in the previous section is dependent on variables including workload, repair and replacement schedules of underground pipelines, and unknown events that could include more disturbance of the surface and subsurface soil than is anticipated in this HHRA.

TABLE 7-1 SELECTION OF EXPOSURE PATHWAYS
U.S. GOVERNMENT MOORINGS

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Current	Surface Soil [1]	Air	Volatilization of	Office Worker	Adult	Inhalation	None	Exposure to Exposure Point area unlikely.
			Fence Line (SB-FL-01)	Maintenance Worker [4]			Quant	Potentially complete pathway.
			and Run Off (SD-NL-01)	Upland Excavation Worker			None	Exposure to Exposure Point area unlikely.[3]
Current	Surface Soil	Air	Dust Generation	Office Worker	Adult	Inhalation	None	Exposure to Exposure Point area unlikely.
			Fence Line (SB-FL-01)	Maintenance Worker			Quant	Potentially complete pathway.
			and Run Off (SD-NL-01)	Upland Excavation Worker			None	Exposure to Exposure Point area unlikely.[3]
Current	Surface Soil	Surface Soil	Direct contact with surface soil at	Office Worker	Adult	Incidental Ingestion	None	Exposure to Exposure Point area unlikely.
			Fence Line (SB-FL-01)	Maintenance Worker			Quant	Potentially complete pathway.
			and Run Off (SD-NL-01)	Upland Excavation Worker			None	Exposure to Exposure Point area unlikely.[3]
Current	Surface Soil	Surface Soil	Direct contact with surface soil at	Office Worker	Adult	Dermal Contact	None	Exposure to Exposure Point area unlikely.
			Fence Line (SB-FL-01)	Maintenance Worker			Quant	Potentially complete pathway.
			and Run Off (SD-NL-01)	Upland Excavation Worker			None	Exposure to Exposure Point area unlikely.[3]
Current	Shallow Soil [2]	Air	Volatilization from Shallow Soils	Office Worker	Adult	Inhalation	Quant	Potentially complete pathway.
			into office buildings in	Maintenance Worker			Quant	Potentially complete pathway.
			Industrial Area	Upland Excavation Worker			None	Incomplete pathway.
Current	Shallow Soil	Air	Volatilization from Shallow Soils	Office Worker	Adult	Inhalation	Quant	Potentially complete pathway.
			into warehouse buildings in	Maintenance Worker			Quant	Potentially complete pathway.
			MIS Area	Upland Excavation Worker			None	Incomplete pathway.
Current	Shallow Soil	Air	Generation of Particulate Matter from Shallow Soils	Office Worker	Adult	Inhalation	None	Exposure to Exposure Point area unlikely.
			Industrial Area	Maintenance Worker			None	Exposure to Exposure Point area unlikely.
				Upland Excavation Worker			Quant	Complete pathway.
Current	Shallow Soil	Air	Generation of Particulate Matter	Office Worker	Adult	Inhalation	None	Exposure to Exposure Point area unlikely.
			from Shallow Soils	Maintenance Worker			None	Exposure to Exposure Point area unlikely.
			MIS Area	Upland Excavation Worker			Quant	Complete pathway.
Current	Shallow Soil	Shallow Soil	Direct contact with shallow soils.	Office Worker	Adult	Incidental Ingestion	None	Incomplete pathway.
			Industrial Area	Maintenance Worker			None	Incomplete pathway.
				Upland Excavation Worker			Quant	Complete pathway.
Current	Shallow Soil	Shallow Soil	Direct contact with shallow soils.	Office Worker	Adult	Incidental Ingestion	None	Incomplete pathway.
			MIS Area	Maintenance Worker			None	Incomplete pathway.
				Upland Excavation Worker			Quant	Complete pathway.
Current	Shallow Soil	Shallow Soil	Direct contact with shallow soils.	Office Worker	Adult	Dermal Contact	None	Incomplete pathway.
			Industrial Area	Maintenance Worker			None	Incomplete pathway.
				Upland Excavation Worker			Quant	Complete pathway.
Current	Shallow Soil	Shallow Soil	Direct contact with shallow soils.	Office Worker	Adult	Dermal Contact	None	Incomplete pathway.
			MIS Area	Maintenance Worker			None	Incomplete pathway.
				Upland Excavation Worker			Quant	Complete pathway.

TABLE 7-1 SELECTION OF EXPOSURE PATHWAYS
U.S. GOVERNMENT MOORINGS

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Current	Groundwater	Air	Volatilization of volatiles to office buildings from groundwater in Industrial Area	Office Worker	Adult	Inhalation	Quant	Potentially complete pathway.
				Maintenance Worker			Quant	Potentially complete pathway.
				Upland Excavation Worker			None	Incomplete pathway.
Current	Groundwater	Air	Volatilization of volatiles to warehouse buildings from groundwater in MIS Area	Office Worker	Adult	Inhalation	None	No sample data.
				Maintenance Worker			None	No sample data.
				Upland Excavation Worker			None	No sample data.
Future	Groundwater	Air	Volatilization of volatiles to indoor air in groundwater in Industrial Area as result of potable water use	Office Worker	Adult	Inhalation	Quant	Complete pathway.
				Maintenance Worker (5)			Quant	Complete pathway.
				Upland Excavation Worker			None	Incomplete pathway.
Future	Groundwater	Air	Volatilization of volatiles to indoor air in groundwater in MIS Area as result of potable water use	Office Worker	Adult	Inhalation	None	No sample data.
				Maintenance Worker (5)			None	No sample data.
				Upland Excavation Worker			None	No sample data.
Future	Groundwater	Groundwater	Drinking water wells potential in Industrial Area	Office Worker	Adult	Ingestion	Quant	Complete pathway.
				Maintenance Worker (5)			Quant	Complete pathway.
				Upland Excavation Worker			None	Incomplete pathway.
Future	Groundwater	Groundwater	Drinking water wells potential in MIS Area	Office Worker	Adult	Ingestion	None	No sample data.
				Maintenance Worker (5)			None	No sample data.
				Upland Excavation Worker			None	No sample data.
Future	Groundwater	Groundwater	Direct contact with drinking water wells from Industrial Area	Office Worker	Adult	Dermal Contact	Quant	Complete pathway.
				Maintenance Worker (5)			Quant	Complete pathway.
				Upland Excavation Worker			None	Incomplete pathway.
Future	Groundwater	Groundwater	Direct contact with drinking water wells from MIS Area	Office Worker	Adult	Dermal Contact	None	No sample data.
				Maintenance Worker (5)			None	No sample data.
				Upland Excavation Worker			None	No sample data.

(1) Surface Soils = Samples taken at the 0-6 inch depth.

(2) Shallow Soils = 1-4 foot bgs Industrial Area, 0-5 foot bgs MIS Area

(3) Human health risks from exposure of the maintenance worker are assumed to be greater that those of Upland Excavation Worker due to length of exposure. Therefore risks and hazards calculated for the Maintenance worker are considered greater that what would be quantified for excavation worker.

(4) The Maintenance worker in this scenario is working outdoors for 9 days a year along the sample areas.

(5) For purposes of evaluating human health risks and hazards from groundwater used as drinking water, the office worker and maintenance worker will be considered to be similar in exposure due to similar intake of drinking water.

7.1.3 Occurrence, Distribution, and Selection of Chemicals of Potential Concern

COPCs to human health are established by comparing the maximum detected concentration of a contaminant (or maximum non-detected value) within a medium sample to a health protective SLV. If the maximum detected concentration of the contaminant exceeds the SLV, the contaminant becomes a COPC. The three medium evaluated for the HHRA, surface soil, subsurface soil, and groundwater, were evaluated to select COPCs. These COPCs were then used in cancer risk and non-cancer hazard calculations in the HHRA. Contaminants that are not COPCs, are not evaluated further. The Moorings RI Management Plan specified that all upland site sample data are to be compared to appropriate media-specific SLVs, and that the SLVs are to be consistent with the Portland Harbor (JSCS).

A discussion of the SLVs used to compare to detected contaminant concentrations in each media is presented below:

- Surface Soil (Table 7-2-1, page 7-11) and shallow soil (Table 7-2-2, page 7-13)
    - Based on the CSM for the site, only soil samples from the shallow soil horizon were screened against SLVs. Samples at deeper depths were not included in the HHRA. For the Industrial Area, a total of 17 soil samples were collected from the 1 - 4 foot depth range and screened against SLVs. For the MIS Area, six samples were collected from the 1 to 5 foot horizon, and screened against SLVs.
    - The Fence Line sample and Runoff sample were collected to evaluate erodible or surface soils at the Moorings, a source of potential sediment transport to the Willamette River. They were screened against SLVs as surface soil.
    - The SLVs used to screen for COPCs are the Region 6 Industrial Soils PRG Regional Screening Levels (RSLs) as published in March 2008.
    - The Moorings Management Plan stated that to select COPCs for non-cancer effects, non-cancer SLVs for soils should be based on 10% of the PRG for non-cancer SLV value (i.e., a Hazard Quotient (HQ) of 0.1). The use of a HQ of 0.1 for screening is based on USEPA Region 10 guidance. Sample results that exceed 10% of the listed non-carcinogenic PRG were also designated as COPCs so that they can be evaluated for cumulative toxicity concerns.
    - USEPA has no consensus toxicity values for inorganic lead and instead uses the Adult Lead Model to estimate the SLV for industrial settings. This SLV is 800 ppm (800,000 µg/kg) and is intended to protect a fetus that may be carried by a pregnant female worker. It is assumed that a cleanup goal that is protective of a fetus will also afford protection for male or female adult workers.
- Groundwater (Table 7-2-3, page 7-17 and Table 7-2-4, page 7-19)
    - The SLVs used for groundwater are the Region 6 Tap Water PRGs from March 2008 (also listed in the JSCS Table 3.1, included as Attachment F). As with soils, the non-cancer SLVs for groundwater are based on 10% of the PRG for the non-cancer SLV value (i.e., a HQ of 0.1) (Table 7-2-3, page 7-17).
    - Safe Drinking Water Act's MCL as listed in the JSCS Table 3.1 (included as Attachment F) is used as additional SLVs for groundwater. MCLs are listed as potential applicable or relevant and appropriate requirements (ARAR) by the

USEPA under CERCLA authority. The final determination of whether MCLs are ARARs, and associated remedial targets, will be made in the Portland Harbor Record of Decision (ODEQ/USEPA 2005). (Table 7-2-4, page 7-19).

- COPCs for groundwater are a compiled list of the maximum detected concentrations that exceeded the SLV from both the Region 6 PRG RSL and the MCL tables.
- Groundwater samples collected under the contingency sampling program were analyzed for cyanide only. Total cyanide was designated as a COPC in water by comparing the sample results to one-tenth of the non-carcinogenic Region 6 PRGs and/or the MCL.

7.1.3.1 Uncertainty Related to COPC Selection and Concentration

The objectives, tasks, and methods for the Moorings RI sample collection program are detailed in Sections 4 and 5 of this report. In particular sample locations, media, and methods are described in Section 4.1 through Section 4.5 (pages 4-2, 4-35, 4-41, 4-55, 4-64) and analytical and data validation methods are discussed in Section 5.5 (page 5-102).

No background sampling was performed as part of the Moorings RI. Instead, default soil background concentrations, as developed by the ODEQ (ODEQ 2000), were used for background comparisons.

All definitive data not qualified as unusable during the data validation process were used in the human health risk assessment. As is always the case in environmental sampling programs, there are some uncertainties associated with the analytical results, including uncertainty associated with normal laboratory equipment variation and human error. Chemicals that were eliminated from further analysis in this HHRA may have unforeseen health effects that are not quantified because the concentration was below the SLV, or the detection limits limited the quantization of the concentration of the chemical.

TABLE 7-2-1 OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
U.S. GOVERNMENT MOORINGS

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (2)	Region 6 RSL Screening Value Industrial Soil (N/C) (3)	Region 6 RSL Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (4)
MIS Fence Line/North Logistics Run-off sample locations [9]														
SVOCs														
	Phenols and Substituted Phenols													
	935-95-5	2,3,5,6-Tetrachlorophenol	0.34 (J)	0.97 (J)	µg/kg	RUN-OFF	2/2	-	0.97	-	NA	NA	N	BSL
	87-86-5	Pentachlorophenol	21	21	µg/kg	RUN-OFF	2/2	-	21	1,285,461 N/ 9,998 C	NA	NA	N	BSL
	Polycyclic Aromatic Hydrocarbons (PAHs)													
	91-20-3	Naphthalene	20	26	µg/kg	RUN-OFF	2/2	-	26	20,898 N	NA	NA	N	BSL
	91-57-6	2-Methylnaphthalene	13	15	µg/kg	RUN-OFF	2/2	-	15	-	NA	NA	N	BSL
	90-12-0	1-Methylnaphthalene	10	12	µg/kg	FENCE LINE	2/2	-	12	-	NA	NA	N	BSL
	208-96-8	Acenaphthylene	13	17	µg/kg	FENCE LINE	2/2	-	17	-	NA	NA	N	BSL
	83-32-9	Acenaphthene	34	160	µg/kg	FENCE LINE	2/2	-	160	3,250,282 C	NA	NA	N	BSL
	86-73-7	Fluorene	100	110	µg/kg	RUN-OFF	2/2	-	110	2,622,198 N	NA	NA	N	BSL
	132-64-9	Dibenzofuran	55	79	µg/kg	FENCE LINE	2/2	-	79	173,789 N	NA	NA	N	BSL
	85-01-8	Phenanthrene	930	1,200	µg/kg	FENCE LINE	2/2	-	1,200	-	NA	NA	N	BSL
	120-12-7	Anthracene	120	150	µg/kg	RUN-OFF	2/2	-	150	26,494,973 N	NA	NA	N	BSL
	206-44-0	Fluoranthene	2,500	2,700	µg/kg	FENCE LINE	2/2	-	2,700	2,444,484 N	NA	NA	N	BSL
	129-00-0	Pyrene	2,400	2,600	µg/kg	RUN-OFF	2/2	-	2,600	3197938 N/ 32,000,000 C	NA	NA	N	BSL
	205-99-2	Benzo(b)fluoranthene	2,000	3,400	µg/kg	RUN-OFF	2/2	-	3,400	2,344 C	NA	NA	Y	ASL
	207-08-9	Benzo(k)fluoranthene	630	1,200	µg/kg	RUN-OFF	2/2	-	1,200	23,441 C	NA	NA	N	BSL
	56-55-3	Benzo(a)anthracene	1,100	1,700	µg/kg	RUN-OFF	2/2	-	1,700	2,344 C	NA	NA	N	BSL
	218-01-9	Chrysene	1,400	2,100	µg/kg	RUN-OFF	2/2	-	2,100	234,414 C	NA	NA	N	BSL
	50-32-8	Benzo(a)pyrene	1,500	2,700	µg/kg	RUN-OFF	2/2	-	2,700	234 C	NA	NA	Y	ASL
	193-39-5	Indeno(1,2,3-cd)pyrene	1,200	2,200	µg/kg	RUN-OFF	2/2	-	2,200	2,300 C	NA	NA	N	BSL
	53-70-3	Dibenz(a,h)anthracene	250	550	µg/kg	RUN-OFF	2/2	-	550	234 C	NA	NA	Y	ASL
	191-24-2	Benzo(g,h,i)perylene	970	2,000	µg/kg	RUN-OFF	2/2	-	2,000	-	NA	NA	N	BSL
	Organonitrogen Compounds, Halogenated Compounds, Phenols and Substituted Phenols, Oxygen-Containing Compounds													
	86-30-6	N-Nitrosodiphenylamine	ND	41 (J)	µg/kg	RUN-OFF	1/2	58-58	41	390,861 C	NA	NA	N	BSL
	86-74-8	Carbazole	150	270	µg/kg	FENCE LINE	2/2	-	270	95,761 C	NA	NA	N	BSL
	84-74-2	di-n-butyl Phthalate	ND	100	µg/kg	FENCE LINE	1/2	79-79	100	6,840,070 N	NA	NA	N	BSL
	85-68-7	Butyl Benzyl Phthalate	38 (J)	41 (J)	µg/kg	RUN-OFF	2/2	-	41	13,680,140 N	NA	NA	N	BSL
	117-81-7	bis (2-Ethylhexyl) phthalate	140	210	µg/kg	RUN-OFF	2/2	-	210	1,368,014 N/ 136,801 C	NA	NA	N	BSL
PCBs														
	12672-29-6	Aroclor 1248	ND	1,600	µg/kg	RUN-OFF	1/2	-	1,600	830 C	NA	NA	Y	ASL
	11096-82-5	Aroclor 1260	ND	14	µg/kg	FENCE LINE	1/2	-	14	830 C	NA	NA	N	BSL

TABLE 7-2-1 OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
U.S. GOVERNMENT MOORINGS

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (2)	Region 6 RSL Screening Value Industrial Soil (N/C) (3)	Region 6 RSL Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (4)
MIS Fence Line/North Logistics Run-off sample locations [9]														
Pesticides														
	58-89-9	γ-BHC (Lindane)	ND	2.4	µg/kg	RUN-OFF	1/2	2.6-2.6	2.4	26,948 N / 1,935 C	NA	NA	N	BSL
	72-55-9	4,4'-DDE	ND	4.2 (J)	µg/kg	FENCE LINE	1/2	0.99-0.99	4.2	-	NA	NA	N	BSL
	72-54-8	4,4'-DDD	ND	0.44 (J)	µg/kg	FENCE LINE	1/2	0.68-0.68	0.44	-	NA	NA	N	BSL
	1031-07-8	Endosulfan sulfate	ND	1.4 (J)	µg/kg	RUN-OFF	1/2	0.12-0.12	1.4	-	NA	NA	N	BSL
	50-29-3	4,4'-DDT	8.7 (J)	23	µg/kg	RUN-OFF	2/2	-	23	-	NA	NA	N	BSL
	53494-70-5	Endrin ketone	0.66 (J)	1.1 (J)	µg/kg	RUN-OFF	2/2	-	1.1	-	NA	NA	N	BSL
	39765-80-5	trans-nonachlor	ND	0.21	µg/kg	FENCE LINE	1/2	6.9-6.9	0.21	-	NA	NA	N	BSL
	789-02-6	2,4'-DDT	ND	3.3 (J)	µg/kg	FENCE LINE	1/2	14-14	3.3	-	NA	NA	N	BSL
	72-55-9	DDE [5]	ND	4.2 (J)	µg/kg	FENCE LINE	1/2	-	4.2	7,800 C	NA	NA	N	BSL
	72-54-8	DDD [5]	ND	0.44 (J)	µg/kg	FENCE LINE	1/2	-	0.44	11,000 C	NA	NA	N	BSL
	50-29-3	DDT [5]	12 (J)	23 (J)	µg/kg	RUN-OFF	1/2	-	23	47,388 N/ 7,800 C	NA	NA	N	BSL
	50-29-3	DDx-total [6]	16.64 (J)	23 (J)	µg/kg	RUN-OFF	2/2	-	23	-	NA	NA	N	BSL
		Chlordane-total [7]	ND	0.21	µg/kg	FENCE LINE	1/2	-	0.21	44,906N/ 7,186C	NA	NA	N	BSL
		Endosulfan-total [8]	ND	1.4 (J)	µg/kg	RUN-OFF	1/2	-	1.4	410,404 N	NA	NA	N	BSL
Metals														
	7429-90-5	Aluminum (pH 6.5 - 9.0)	11,200,000	13,800,000	µg/kg	RUN-OFF	2/2	-	13,800,000	102,636,259 N	NA	NA	N	BSL
	7440-36-0	Antimony	1,050	6,800	µg/kg	FENCE LINE	2/2	-	6,800	45,422 N	NA	NA	N	BSL
	7440-38-2	Arsenic	5,270	62,900	µg/kg	FENCE LINE	2/2	-	62,900	28,436 N/ 2 C	NA	NA	Y	ASL
	7440-43-9	Cadmium	1,500	2,190	µg/kg	RUN-OFF	2/2	-	2,190	56,406N/ 500,000C	NA	NA	N	BSL
	7440-47-3	Chromium, total	76,600	508,000	µg/kg	FENCE LINE	2/2	-	508,000	500,000C	NA	NA	Y	ASL
	7440-50-8	Copper	226,000	377,000	µg/kg	RUN-OFF	2/2	-	377,000	4,217,778 N	NA	NA	N	BSL
	7439-92-1	Lead	340,000	585,000 (J)	µg/kg	FENCE LINE	2/2	-	585,000	800,000 N	NA	NA	N	BSL
	7439-96-5	Manganese	896,000	1,230,000	µg/kg	RUN-OFF	2/2	-	1,230,000	3,517,063 N	NA	NA	N	BSL
	7439-97-6	Mercury	52	112	µg/kg	RUN-OFF	2/2	-	112	34,067 N	NA	NA	N	BSL
	7440-02-0	Nickel	50,400	213,000	µg/kg	FENCE LINE	2/2	-	213,000	2,271,111 N	NA	NA	N	BSL
	7782-49-2	Selenium	ND	100 (J)	µg/kg	RUN-OFF	1/2	100-100	100	567,788 N	NA	NA	N	BSL
	7440-22-4	Silver	249	270	µg/kg	FENCE LINE	2/2	-	270	567,778 N	NA	NA	N	BSL
	7440-66-6	Zinc	749,000	1,120,000	µg/kg	FENCE LINE	2/2	-	1,120,000	34,066,667 N	NA	NA	N	BSL
Organobutylins														
	56573-85-4	Tributyltin	14	14	µg/kg	FENCE LINE	1/1		14	-	NA	NA	N	BSL
	1002-53-5	Dibutyltin	32	32	µg/kg	FENCE LINE	1/1		32	-	NA	NA	N	BSL
	78763-54-9	Monobutyltin	25	25	µg/kg	FENCE LINE	1/1		25	-	NA	NA	N	BSL
TPHs														
		TPH-Deisel	22,000	49,000	µg/kg	RUN-OFF	1/1		49,000	-	NA	NA	N	BSL
		TPH-Motor Oil	130,000	380,000	µg/kg	RUN-OFF	1/1		380,000	-	NA	NA	N	BSL

Notes:
(1) (J) = The analyte was detected above the reported quantitation limit, and the reported concentration was an extimated value.
(2) Maximum value detected in samples used as Concentration Used For Screening.
(3) Screening Values updated from Region 6 Human Health Medium-Specific Screening Levels 2008; March 2008, Industrial Soils, Outdoor Worker, Integrated.
(4) Rationale Codes:
Selection Reason: Above Screening Level (ASL)
Deletion Reason: Below Screening Level (BSL)
(5) This value represents the sum of the 2,4' and 4,4' isomers.
(6) This value represents the sum of DDE + DDD + DDT.
(7) This value represents the sum of alpha and gamma chlordane, oxy chlordane, and cis and trans nonachlor.
(8) This value represents the sum of alpha and beta endosulfan and endosulfan sulfate.
(9) Exposure point includes volatilzation, dust generation and direct contact with surface soils.

TABLE 7-2-2 OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
U.S. GOVERNMENT MOORINGS

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (2)	Region 6 RSL Screening Value Industrial Soil (N/C) -3	Region 6 RSL Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion -4
Industrial Area [9]														
VOCs														
	75-71-8	Dichlorodifluoromethane	0.25 (J)	1.6 (J)	µg/kg	SB-14-1	5/17	5.2-7.8	1.6	34,302 N	NA	NA	N	BSL
	75-69-4	Trichlorofluoromethane	0.18 (J)	0.26 (J)	µg/kg	SB-13-1	2/17	4.4-7.8	0.26	142,087 N	NA	NA	N	BSL
	75-15-0	Carbon Disulfide	ND	1.9 (J)	µg/kg	SB-19-1	1/17	4.4-7.8	1.9	133,806 N	NA	NA	N	BSL
	78-93-3	2-Butanone (MEK)	4.3 (J)	5.6 (J)	µg/kg	SB-07-1	2/17	18-32	5.6	12,816,822 N	NA	NA	N	BSL
	71-43-2	Benzene	1.2 (J)	2.7 (J)	µg/kg	SB-07-1	5/17	4.4-7.8	2.7	13,186 N/ 1,598 C	NA	NA	N	BSL
	108-88-3	Toluene	0.14 (J)	1 (J)	µg/kg	SB-13-1	8/17	4.4-7.8	1	2,191,388 N	NA	NA	N	BSL
	127-18-4	Tetrachloroethene (PCE)	0.82 (J)	4.7 (J)	µg/kg	SB-19-1	5/17	5.5-7.8	4.7	242,594 N/ 1,735 C	NA	NA	N	BSL
	100-41-4	Ethylbenzene	ND	0.3 (J)	µg/kg	SB-04-1	1/17	4.4-7.8	0.3	646,145 N	NA	NA	N	BSL
	1330-20-7	m,p-Xylene	0.22 (J)	1.1 (J)	µg/kg	SB-04-1	6/17	4.4-7.8	1.1	70,996 N	NA	NA	N	BSL
	95-47-6	o-Xylene	ND	0.33 (J)	µg/kg	SB-04-1	1/17	4.4-7.8	0.33	227,111,112 N	NA	NA	N	BSL
	106-46-7	1,4-Dichlorobenzene	ND	0.21 (J)	µg/kg	SB-10-1	1/17	4.4-7.8	0.21	1,127,833 N	NA	NA	N	BSL
	110-57-6	trans-1,4-Dichloro-2-butene	ND	ND	µg/kg	SB-16-1	0/17	18-32	32	20 C	NA	NA	N	RDL ASL
	107-02-8	Acrolein	ND	ND	µg/kg	SB-16-1	0/17	88-160	160	37 N	NA	NA	N	RDL ASL
SVOCs														
	Phenols and Substituted Phenols													
	88-06-2	2,4,6-trichlorophenol	ND	0.42 (J)	µg/kg	SB-16-1	1/17	5.4-6.7	0.42	68,407 N	NA	NA	N	BSL
	95-95-4	2,4,5-Trichlorophenol	3.4 (J)	5 (J)	µg/kg	SB-10-1	3/17	5.4-6.7	5	6,840,070 N	NA	NA	N	BSL
	87-86-5	Pentachlorophenol	0.21 (J)	5.2 (J)	µg/kg	SB-16-1	8/17	5.4-6.7	5.2	1,285,461 N/ 9,998 C	NA	NA	N	BSL
	Polycyclic Aromatic Hydrocarbons (PAHs)													
	91-20-3	Naphthalene	0.92 (J)	150	µg/kg	SB-16-1	14/17	2.5-3.9	150	20,989 N	NA	NA	N	BSL
	91-57-6	2-Methylnaphthalene	0.59 (J)	53	µg/kg	SB-16-1	14/17	1.6-2.4	53	-	NA	NA	N	BSL
	90-12-0	1-Methylnaphthalene	0.59 (J)	26	µg/kg	SB-16-1	14/17	1.6-2.4	26	-	NA	NA	N	BSL
	208-96-8	Acenaphthylene	0.8 (J)	110	µg/kg	SB-16-1	17/17	NA	110	-	NA	NA	N	BSL
	83-32-9	Acenaphthene	0.66 (J)	11	µg/kg	SB-16-1	15/17	2.4-2.5	11	3,250,282 N	NA	NA	N	BSL
	86-73-7	Fluorene	0.65 (J)	26	µg/kg	SB-16-1	16/17	2.4	26	2,622,198 N	NA	NA	N	BSL
	132-64-9	Dibenzofuran	0.61 (J)	9.9	µg/kg	SB-16-1	13/17	1.6 - 2.5	9.9	173,789 N	NA	NA	N	BSL
	85-01-8	Phenanthrene	4.3	1,400	µg/kg	SB-16-1	17/17	NA	1,400	-	NA	NA	N	BSL
	120-12-7	Anthracene	0.84 (J)	94	µg/kg	SB-16-1	17/17	NA	94	26,494,973 N	NA	NA	N	BSL
	206-44-0	Fluoranthene	15	3,500	µg/kg	SB-16-1	17/17	NA	3,500	2,444,484 N	NA	NA	N	BSL
	129-00-0	Pyrene	25	4,200	µg/kg	SB-16-1	17/17	NA	4,200	3,197,938 N/ 32,000,000 C	NA	NA	N	BSL
	205-99-2	Benzo(b)fluoranthene	23	4,500	µg/kg	SB-16-1	17/17	NA	4,500	2,344 C	NA	NA	Y	ASL
	207-08-9	Benzo(k)fluoranthene	6.3	1,500	µg/kg	SB-16-1	17/17	NA	1,500	23,441 C	NA	NA	N	BSL
	56-55-3	Benzo(a)anthracene	8.5	1,500	µg/kg	SB-16-1	17/17	NA	1,500	2,344 C	NA	NA	N	BSL
	218-01-9	Chrysene	11	2,200	µg/kg	SB-16-1	17/17	NA	2,200	234,414 C	NA	NA	N	BSL
	50-32-8	Benzo(a)pyrene	21	1,700	µg/kg	SB-16-1	17/17	NA	1,700	234 C	NA	NA	Y	ASL
	193-39-5	Indeno(1,2,3-cd)pyrene	26	4,500	µg/kg	SB-16-1	17/17	NA	4,500	2,300 C	NA	NA	Y	ASL
	53-70-3	Dibenz(a,h)anthracene	2 (J)	520	µg/kg	SB-16-1	17/17	NA	520	234 C	NA	NA	Y	ASL
	191-24-2	Benzo(g,h,i)perylene	28	4,000	µg/kg	SB-16-1	17/17	NA	4,000	-	NA	NA	N	BSL
	Organonitrogen Compounds, Halogenated Compounds, Phenols and Substituted Phenols, Oxygen-Containing Compounds													
	108-95-2	Phenol	72	73	µg/kg	SB-05-1	2/17	20-300	73	20,522,088 N	NA	NA	N	BSL
	100-51-6	Benzyl Alcohol	2.8	6.6	µg/kg	SB-13-1	6/17	7.4-99	6.6	20,520,210 N	NA	NA	N	BSL
	65-85-0	Benzoic Acid	ND	210	µg/kg	SB-05-1	1/17	130-2000	210	273,602,795 N	NA	NA	N	BSL
	106-47-8	4-Chloroaniline	ND	2.2 (J)	µg/kg	SB-14-1	1/17	6.4-99	2.2	273,602 N	NA	NA	N	BSL
	84-66-2	Diethyl Phthalate	1.3 (J)	3.7 (J)	µg/kg	SB-01-1	9/17	8.5-99	3.7	684,006,990 N	NA	NA	N	BSL
	86-74-8	Carbazole	2.9 (J)	110	µg/kg	SB-16-1	13/17	6.4-10	110	95,761 C	NA	NA	N	BSL
	84-74-2	di-n-butyl Phthalate	ND	11	µg/kg	SB-10-1	1/17	7.9-99	11	6,840,070 N	NA	NA	N	BSL
	85-68-7	Butyl Benzyl Phthalate	ND	12 (J)	µg/kg	SB-19-1	1/17	6.4-99	12	13,680,140 N	NA	NA	N	BSL
	117-81-7	bis (2-Ethylhexyl) phthalate	7.5 (J)	120	µg/kg	SB-01-1	11/17	18-200	120	1,368,014 N/ 136,801 C	NA	NA	N	BSL

TABLE 7-2-2 OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
U.S. GOVERNMENT MOORINGS

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (2)	Region 6 RSL Screening Value Industrial Soil (N/C) -3	Region 6 RSL Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion -4
Industrial Area continued [9]														
PCBs														
	11097-69-1	Aroclor 1254	ND	2.4 (J)	µg/kg	SB-15-1	1/17	1.6-11	2.4	1,180 N/ 8 30C	NA	NA	N	BSL
	11096-82-5	Aroclor 1260	5.3	81	µg/kg	SB-19-1	4/17	1.6-2.5	81	830 C	NA	NA	N	BSL
		Total PCBs	5.3	81	µg/kg	SB-19-1	4/17	NA	81	-	NA	NA	N	BSL
Pesticides														
	118-74-1	Hexachlorobenzene	ND	0.18 (J)	µg/kg	SB-04-1	1/17	0.13-0.99	0.18	57,721 N/ 1,197 C	NA	NA	N	BSL
	58-89-9	γ -BHC (Lindane)	0.11 (J)	5	µg/kg	SB-16-1	2/17	0.13-0.2	5	26,948 N/ 1,935 C	NA	NA	N	BSL
	319-86-8	δ -BHC	0.21 (J)	0.99 (J)	µg/kg	SB-16-1	2/17	0.13-0.2	0.99	1,397 C	NA	NA	N	BSL
	76-44-8	Heptachlor	0.61	0.88	µg/kg	SB-11-1	2/17	0.13-0.2	0.88	34,200 N/ 426 C	NA	NA	N	BSL
	5103-74-2	gamma-Chlordane	0.053 (J)	0.31	µg/kg	SB-19-1	3/17	0.13-0.99	0.31	-	NA	NA	N	BSL
	959-98-8	Endosulfan alpha-	0.03 (J)	0.06 (J)	µg/kg	SB-19-1	3/17	0.13-0.99	0.06	-	NA	NA	N	BSL
	5103-74-2	alpha-Chlordane	0.06 (J)	0.14 (J)	µg/kg	SB-19-1	2/17	0.13-0.99	0.14	-	NA	NA	N	BSL
	72-55-9	4,4'-DDE	0.07 (J)	3.5	µg/kg	SB-15-1	11/17	0.17-0.2	3.5	-	NA	NA	N	BSL
	33213-65-9	Endosulfan beta-	0.091 (J)	0.28 (J)	µg/kg	SB-16-1	3/17	0.13-0.21	0.28	-	NA	NA	N	BSL
	72-54-8	4,4'-DDD	0.057 (J)	0.29	µg/kg	SB-15-1	2/17	0.13-2.2	0.29	-	NA	NA	N	BSL
	50-29-3	4,4'-DDT	0.65	43	µg/kg	SB-16-1	12/17	0.17-0.2	43	-	NA	NA	N	BSL
	53494-70-5	Endrin ketone	ND	0.11 (J)	µg/kg	SB-01-1	1/17	0.13-1.9	0.11	-	NA	NA	N	BSL
	72-43-5	Methoxychlor	ND	0.16 (J)	µg/kg	SB-15-1	1/17	0.13-0.99	0.16	342,033 N	NA	NA	N	BSL
	NA	oxy chlordane	0.074 (J)	2.5	µg/kg	SB-16-1	2/17	0.13-0.2	2.5	-	NA	NA	N	BSL
	3424-82-6	2,4'-DDE	ND	0.2 (J)	µg/kg	SB-11-1	1/17	0.13-22	0.2	-	NA	NA	N	BSL
	5103-73-1	cis -nonachlor	ND	1.8 (J)	µg/kg	SB-16-1	1/17	0.13-2.9	1.8	-	NA	NA	N	BSL
	53-19-0	2,4'-DDD	0.048 (J)	2 (J)	µg/kg	SB-19-1	8/17	0.13-2.3	2	-	NA	NA	N	BSL
	39765-80-5	trans -nonachlor	0.043 (J)	0.071 (J)	µg/kg	SB-15-1	2/17	0.13-0.99	0.071	-	NA	NA	N	BSL
	789-02-6	2,4'-DDT	0.22	12	µg/kg	SB-16-1	9/17	0.13-0.78	12	-	NA	NA	N	BSL
	72-55-9	DDE [5]	0.07 (J)	3.5	µg/kg	SB-15-1	11/17	NA	3.5	7,800 C	NA	NA	N	BSL
	72-54-8	DDD [5]	0.048 (J)	2 (J)	µg/kg	SB-19-1	9/17	NA	2	11,000 C	NA	NA	N	BSL
	50-29-3	DDT [5]	0.31	55	µg/kg	SB-16-1	12/17	NA	55	47,388 N/ 7,800C	NA	NA	N	BSL
	50-29-3	DDx-total [6]	0.38 (J)	58.3	µg/kg	SB-16-1	12/17	NA	58.3	-	NA	NA	N	BSL
		Chlordane-total [7]	0.061 (J)	4.3 (J)	µg/kg	SB-16-1	5/17	NA	4.3	44,906 N/ 7,186 C	NA	NA	N	BSL
		Endosulfan-total [8]	0.03	0.28	µg/kg	SB-16-1	5/17	NA	0.28	410,404 N	NA	NA	N	BSL
Cyanide														
	57-12-5	Cyanide	190 (J)	61,000	µg/kg	SB-16-1	9/13	290	61000	1,368,139 N	NA	NA	N	BSL
Metals														
	7429-90-5	Aluminum (pH 6.5 - 9.0)	8,180,000	27,700,000	µg/kg	SB-14-1	17/17	NA	27,700,000	102,636,259 N	NA	NA	N	BSL
	7440-36-0	Antimony	90	642,000 (J)	µg/kg	SB-12-1	17/17	NA	642,000	45,422 N	NA	NA	Y	ASL
	7440-38-2	Arsenic	1,870 (J)	14,900	µg/kg	SB-01-1	17/17	NA	14,900	28,436 N/ 1,767 C	NA	NA	Y	ASL
	7440-43-9	Cadmium	71	872	µg/kg	SB-12-1	16/17	47	872	56,406 N/ 500,000 C	NA	NA	N	BSL
	7440-47-3	Chromium, total	16,900	35,100	µg/kg	SB-16-1	17/17	NA	35,100	500,000 C	NA	NA	N	BSL
	7440-50-8	Copper	16,700	528,000 (J)	µg/kg	SB-12-1	17/17	NA	528,000	4,217,778 N	NA	NA	N	BSL
	7439-92-1	Lead	6,680	1,550,000 (J)	µg/kg	SB-12-1	17/17	NA	1,550,000	800,000 N	NA	NA	Y	ASL
	7439-96-5	Manganese	207,000	623,000	µg/kg	SB-15-1	17/17	NA	623,000	3,517,064 N	NA	NA	N	BSL
	7439-97-6	Mercury	18 B	2,790	µg/kg	SB-06-1	17/17	NA	2,790	34,067 N	NA	NA	N	BSL
	7440-02-0	Nickel	16,300	46,900	µg/kg	SB-12-1	17/17	NA	46,900	2,271,112 N	NA	NA	N	BSL
	7782-49-2	Selenium	20 B	180	µg/kg	SB-14-1	4/17	0.11-130	180	567,778 N	NA	NA	N	BSL
	7440-22-4	Silver	24	4,620	µg/kg	SB-12-1	15/17	45-71	4,620	567,778 N	NA	NA	N	BSL
	7440-66-6	Zinc	57700	399,000	µg/kg	SB-12-1	17/17	NA	399,000	34,066,667 N	NA	NA	N	BSL
Organobutylins														
	1002-53-5	Dibutyltin	0.22 (J)	3.8	µg/kg	SB-07-1	5/9	1.1-1.2	3.8	NA	NA	NA	N	BSL
	78763-54-9	Monobutyltin	ND	2.3 (J)	µg/kg	SB-08-1	1/9	1.1-1.3	2.3	NA	NA	NA	N	BSL
TPHs														
		TPH-Diesel	1,800 (J)	57,000	µg/kg	SB-04-1	16/17	12,000	57,000	NA	NA	NA	N	BSL
		TPH-Motor Oil	6,000	280,000	µg/kg	SB-17-1	16/17	120,000	280,000	NA	NA	NA	N	BSL

TABLE 7-2-2 OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
U.S. GOVERNMENT MOORINGS

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (2)	Region 6 RSL Screening Value Industrial Soil (N/C) -3	Region 6 RSL Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion -4
MIS Area Management Units [10]														
SVOCs														
	Phenols and Substituted Phenols													
	87-86-5	Pentachlorophenol	ND	1.9 (J)	µg/kg	NL	1/6	5-6.2	1.9	1,285,461 N/ 9,998 C	NA	NA	N	BSL
	Polycyclic Aromatic Hydrocarbons (PAHs)													
	91-20-3	Naphthalene	1 (J)	96	µg/kg	NL	6/6		96	20,989 N	NA	NA	N	BSL
	91-57-6	2-Methylnaphthalene	0.6 (J)	61	µg/kg	NL	6/6		61	-	NA	NA	N	BSL
	90-12-0	1-Methylnaphthalene	0.62 (J)	58	µg/kg	NL	5/6	1.7-1.7	58	-	NA	NA	N	BSL
	208-96-8	Acenaphthylene	0.3 (J)	55	µg/kg	NL	6/6		55	-	NA	NA	N	BSL
	83-32-9	Acenaphthene	0.33 (J)	65	µg/kg	PC	6/6		65	3,250,282 N	NA	NA	N	BSL
	86-73-7	Fluorene	1.8 (J)	77	µg/kg	PC	5/6	1.7-1.7	77	2,622,198 N	NA	NA	N	BSL
	132-64-9	Dibenzofuran	4.5	41	µg/kg	NL	4/6	1.7-2.5	41	173,789 N	NA	NA	N	BSL
	85-01-8	Phenanthrene	2.8	600	µg/kg	NL	6/6		600	-	NA	NA	N	BSL
	120-12-7	Anthracene	8.2	210	µg/kg	PC	5/6	1.7-1.7	210	26,494,973 N	NA	NA	N	BSL
	206-44-0	Fluoranthene	5.8	1000	µg/kg	NL	6/6		1,000	2,444,484 N	NA	NA	N	BSL
	129-00-0	Pyrene	6.5	1500	µg/kg	NL	6/6		1,500	3,197,938 N/ 32,000,000 C	NA	NA	N	BSL
	205-99-2	Benzo(b)fluoranthene	3.7	980	µg/kg	NL	6/6		980	2,344 C	NA	NA	N	BSL
	207-08-9	Benzo(k)fluoranthene	1.2 (J)	280	µg/kg	NL	6/6		280	23,441 C	NA	NA	N	BSL
	56-55-3	Benzo(a)anthracene	2.5	530	µg/kg	NL	6/6		530	2,344 C	NA	NA	N	BSL
	218-01-9	Chrysene	2.5	740	µg/kg	NL	6/6		740	234,414 C	NA	NA	N	BSL
	50-32-8	Benzo(a)pyrene	3.5	960	µg/kg	NL	6/6		960	234 C	NA	NA	Y	ASL
	193-39-5	Indeno(1,2,3-cd)pyrene	3.1	980	µg/kg	NL	6/6		980	2,300 C	NA	NA	N	BSL
	53-70-3	Dibenz(a,h)anthracene	0.44 (J)	120	µg/kg	NL	6/6		120	234 C	NA	NA	N	BSL
	191-24-2	Benzo(g,h,i)perylene	3.1	1100	µg/kg	NL	6/6		1,100	-	NA	NA	N	BSL
	Organonitrogen Compounds, Halogenated Compounds, Phenols and Substituted Phenols, Oxygen-Containing Compounds													
	108-95-2	Phenol	2.6 (J)	5.2 (J)	µg/kg	PC	2/6	20-97	5.2	20,522,088 N	NA	NA	N	BSL
	100-51-6	Benzyl Alcohol	ND	3.2 (J)	µg/kg	PC	1/6	6.3-33	3.2	20,520,210 N	NA	NA	N	BSL
	106-44-5	4-Methylphenol (p-Cresol)	1.7 (J)	5.6 (J)	µg/kg	PC	3/6	6.7-33	5.6	342,003 N	NA	NA	N	BSL
	84-66-2	Diethyl Phthalate	2.4 (J)	7.3 (J)	µg/kg	SB	5/6	9.7-9.7	7.3	54,720,559 N	NA	NA	N	BSL
	86-30-6	N-Nitrosodiphenylamine	ND	18	µg/kg	NL	1/6	6.7-33	18	390,861 C	NA	NA	N	BSL
	86-74-8	Carbazole	6.5 (J)	71	µg/kg	PC	5/6	6.7-6.7	71	95,761 C	NA	NA	N	BSL
	84-74-2	di-n-butyl Phthalate	ND	10	µg/kg	PC	1/6	7.9-40	10	6,840,070 N	NA	NA	N	BSL
	117-81-7	bis (2-Ethylhexyl) phthalate	18	9500	µg/kg	SL	6/6	-	9,500	1,368,014 N/ 136,801 C	NA	NA	N	BSL
PCBs														
	12672-29-6	Aroclor 1248	ND	68	µg/kg	NL	1/6	1.7-2.5	68	830 C	NA	NA	N	BSL
	11096-82-5	Aroclor 1260	ND	1.2 (J)	µg/kg	SL	1/6	1.7-2.4	1.2	830 C	NA	NA	N	BSL
	37324-23-5	Aroclor 1262	ND	50	µg/kg	SB	1/6	1.7-2.5	50	-	NA	NA	N	BSL
		Total PCBs	ND	68	µg/kg	NL	3/6	-	68	-	NA	NA	N	BSL
Pesticides														
	58-89-9	γ-BHC (Lindane)	0.17 (J)	0.47 (J)	µg/kg	NL	2/6	0.14-0.22	0.47	26,948 N/ 1,935 C	NA	NA	N	BSL
	5103-74-2	gamma-Chlordane	ND	0.08 (J)	µg/kg	SB	1/6	0.14-0.2	0.08	-	NA	NA	N	BSL
	5103-74-2	alpha-Chlordane	ND	0.12 (J)	µg/kg	SB	1/6	0.14-0.2	0.12	-	NA	NA	N	BSL
	72-55-9	4,4'-DDE	0.18	2.7 (J)	µg/kg	NL	4/6	0.14-0.19	2.7	-	NA	NA	N	BSL
	72-20-8	Endrin	ND	0.08 (J)	µg/kg	NL	1/6	0.14-0.2	0.08	20,520 N	NA	NA	N	BSL
	72-54-8	4,4'-DDD	0.71	4.5	µg/kg	NL	2/6	0.14-0.2	4.5	-	NA	NA	N	BSL
	50-29-3	4,4'-DDT	0.52 (J)	7.7 (J)	µg/kg	NL	4/6	0.14-0.34	7.7	-	NA	NA	N	BSL
	3424-82-6	2,4'-DDE	ND	0.094 (J)	µg/kg	PC	1/6	0.14-0.2	0.094	-	NA	NA	N	BSL
	5103-73-1	cis-nonachlor	0.097 (J)	0.87 (J)	µg/kg	SB	2/6	0.14-1.3	0.87	-	NA	NA	N	BSL
	53-19-0	2,4'-DDD	0.3	2.7 (J)	µg/kg	NL	2/6	0.14-0.2	2.7	-	NA	NA	N	BSL
	39765-80-5	trans-nonachlor	0.056 (J)	0.064 (J)	µg/kg	NL	2/6	0.14-0.2	0.064	-	NA	NA	N	BSL
	789-02-6	2,4'-DDT	0.24	2.9 (J)	µg/kg	NL	2/6	0.14-0.23	2.9	-	NA	NA	N	BSL
	2385-85-5	Mirex	ND	0.065 (J)	µg/kg	LD	1/6	0.13-0.2	0.065	13,680 N/ 1,064 C	NA	NA	N	BSL
	72-55-9	DDE [5]	0.094 (J)	2.7 (J)	µg/kg	NL	5/6	-	2.7	7,800 C	NA	NA	N	BSL
	72-54-8	DDD [5]	1.01	7.2 (J)	µg/kg	NL	2/6	-	7.2	11,000 C	NA	NA	N	BSL
	50-29-3	DDT [5]	0.52 (J)	10.6 (J)	µg/kg	NL	4/6	-	10.6	47,388 N/ 7,800C	NA	NA	N	BSL
	50-29-3	DDx-total [6]	0.614 (J)	20.5 (J)	µg/kg	NL	5/6	-	20.5	-	NA	NA	N	BSL
		Chlordane-total [7]	0.064 (J)	1.126 (J)	µg/kg	SB	3/6	-	1.126	44,906 N/ 7,186 C	NA	NA	N	BSL

TABLE 7-2-2 OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
U.S. GOVERNMENT MOORINGS

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (2)	Region 6 RSL Screening Value Industrial Soil (N/C) -3	Region 6 RSL Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion -4
MIS Area Management Units continued (10)														
Metals														
	7429-90-5	Aluminum (pH 6.5 - 9.0)	1280000	23500000	µg/kg	PC	6/6	-	23,500,000	102,636,259 N	NA	NA	N	BSL
	7440-36-0	Antimony	70	710	µg/kg	NL	6/6	-	710	45,422 N	NA	NA	N	BSL
	7440-38-2	Arsenic	1060	8200	µg/kg	SB	6/6	-	8,200	28,436 N/ 1,767 C	NA	NA	Y	ASL
	7440-43-9	Cadmium	43	358	µg/kg	NL	6/6	-	358	56,406 N/ 500,000 C	NA	NA	N	BSL
	7440-47-3	Chromium, total	17,400 (J)	48800	µg/kg	SB	6/6	-	48,800	500,000 C	NA	NA	N	BSL
	7440-50-8	Copper	3000	239,000 (J)	µg/kg	PC	6/6	-	239,000	4,217,778 N	NA	NA	N	BSL
	7439-92-1	Lead	5,080 (J)	203,000 (J)	µg/kg	NL	6/6	-	203,000	800,000 N	NA	NA	N	BSL
	7439-96-5	Manganese	92900	772000	µg/kg	PC	6/6	-	772,000	3,517,064 N	NA	NA	N	BSL
	7439-97-6	Mercury	4 B	104	µg/kg	NL	6/6	-	104	34,067 N	NA	NA	N	BSL
	7440-02-0	Nickel	7000	79600	µg/kg	NL	6/6	-	79,600	2,271,112 N	NA	NA	N	BSL
	7782-49-2	Selenium	100 B	120	µg/kg	SB	2/6	100-100	120	567,778 N	NA	NA	N	BSL
	7440-22-4	Silver	12 B	333 (J)	µg/kg	PC	6/6	-	333	567,778 N	NA	NA	N	BSL
	7440-66-6	Zinc	10800	182000	µg/kg	NL	6/6	-	182,000	34,066,667 N	NA	NA	N	BSL
Organobutylins														
	1002-53-5	Dibutyltin	0.19 (J)	0.38 (J)	µg/kg	LD	3/5	1.2-1.3	0.38	NA	NA	NA	N	BSL
	78763-54-9	Monobutyltin	ND	0.64 (J)	µg/kg	NL	1/5	1.1-1.3	0.64	NA	NA	NA	N	BSL
TPHs														
		TPH-Deisel	3000 (J)	140000	µg/kg	NL	6/6	-	140,000	NA	NA	NA	N	BSL
		TPH-Motor Oil	60000	180000	µg/kg	PC	5/6	100,000	180,000	NA	NA	NA	N	BSL

Notes:

(1) (J) = The analyte was detected above the reported quantitation limit, and the reported concentration was an extimated value.

(2) Maximum value detected in samples used as Concentration Used For Screening.

(3) Screening Values updated from Region 6 Human Health Medium-Specific Screening Levels 2008; March 2008, Industrial Soils, Outdoor Worker, Integrated. Is 10% of the listed PRG to take into account non-cancer affects for all chemicals except lead. This is in accordance with the Work Plan.

(4) Rationale Codes:
Selection Reason: Above Screening Level (ASL)
Deletion Reason: Below Screening Level (BSL)
Reported Detection Limit Above Screening Level (RDL ASL)

(5) This value represents the sum of the 2,4' and 4,4' isomers.

(6) This value represents the sum of DDE + DDD + DDT.

(7) This value represents the sum of alpha and gamma chlordane, oxy chlordane, and cis and trans nonachlor.

(8) This value represents the sum of alpha and beta endosulfan and endosulfan sulfate.

(9) Includes volatilization, generation of particulate matter and direct contact with shallow soil in the Industrial Area.

(10) Includes volatilization, generation of particulate matter and direct contact with shallow soil in the MIS Management Unit areas. Abbreviations are:
LD = Laydown
NL = North Logistics
PC = Prior Clean Up
SB = Sand Blast
SL = South Logistics

Definitions:
NA = Not Applicable
ND = Not Detected
"-" = No Value Listed

TABLE 7-2-3 OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
U.S. GOVERNMENT MOORINGS

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (2)	Region 6 RSL Screening Value (N/C) (3)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (4)
Industrial Area														
Volatile Organic Compounds (VOCs)														
	156-59-2	cis-1,2-Dichloroethlyene	ND	0.31 (J)	µg/L	GW-2	1/10	0.5-0.5	0.31	6.1 N	NA	NA	N	BSL
	75-15-0	Carbon Disulfide	0.4 (J)	2.3	µg/L	GW-11	2/10	0.5-0.5	2.3	104 N	NA	NA	N	BSL
	67-66-3	Chloroform	ND	0.3 (J)	µg/L	GW-2	1/10	0.5-0.5	0.3	7.5 N/ 0.167 C	NA	NA	Y	ASL
	71-43-2	Benzene	0.19 (J)	0.94	µg/L	GW-11	7/10	0.5-0.5	0.94	4.4 N/ 0.354 C	NA	NA	Y	ASL
	79-01-6	Trichloroethene (TCE)	ND	0.67	µg/L	GW-2	1/10	0.5-0.5	0.67	0.97 N/0.028 C	NA	NA	Y	ASL
	108-88-3	Toluene	0.21 (J)	0.33 (J)	µg/L	GW-16	2/10	0.5-0.5	0.33	228 N	NA	NA	N	BSL
	127-18-4	Tetrachloroethene (PCE)	0.14 (J)	0.22 (J)	µg/L	GW-2	2/10	0.5-0.5	0.5	28.2 N/ 0.105C	NA	NA	Y	ASL
	100-41-4	Ethylbenzene	0.14 (J)	0.14 (J)	µg/L	GW-16, GW-11	2/10	0.5-0.5	0.5	134 N	NA	NA	N	ASL
	91-20-3	Naphthalene	0.8 (J)	5.9	µg/L	GW-16	5/10	2-2	5.9	0.620 N	NA	NA	Y	ASL
	75-01-4	Vinyl Chloride	ND	ND	µg/L	NA	0/10	0.5-0.5	0.5	7.2N / 0.015C	NA	NA	N	RDL ASL
	107-13-1	Acrylonitrile	ND	ND	µg/L	NA	0/10	5-5	5	0.374 N/ 0.039 C	NA	NA	N	RDL ASL
	10061-01-5	cis-1,3-Dichloropropene	ND	ND	µg/L	NA	0/10	0.5-0.5	0.5	4.02 N/ 0.395 C	NA	NA	N	RDL ASL
	10061-02-6	trans-1,3-Dichloropropene	ND	ND	µg/L	NA	0/10	0.5-0.5	0.5	4.02 N/ 0.395 C	NA	NA	N	RDL ASL
	79-00-5	1,1,2-Trichloroethane	ND	ND	µg/L	NA	0/10	0.5-0.5	0.5	2.4 N/ 0.200 C	NA	NA	N	RDL ASL
	124-48-1	Dibromochloromethane	ND	ND	µg/L	NA	0/10	0.5-0.5	0.5	12.2 N/ 0.113 C	NA	NA	N	RDL ASL
	106-93-4	1,2-Dibromoethane (EDB)	ND	ND	µg/L	NA	0/10	2-2	2	1.8 N/ 0.006 C	NA	NA	N	RDL ASL
	79-34-5	1,1,2,2-Tetrachloroethane	ND	ND	µg/L	NA	0/10	0.5-0.5	0.5	36.5 N/ 0.55 C	NA	NA	N	RDL ASL
	110-57-6	trans-1,4-Dichloro-2-butene	ND	ND	µg/L	NA	0/10	10-10	10	0.001 C	NA	NA	N	RDL ASL
	96-18-4	1,2,3-Trichloropropane	ND	ND	µg/L	NA	0/10	0.5-0.5	0.5	0.995 N/ 0.034 C	NA	NA	N	RDL ASL
	106-46-7	1,4-Dichlorobenzene	ND	ND	µg/L	NA	0/10	0.5-0.5	0.5	66.2 N/ 0.467 C	NA	NA	N	RDL ASL
SVOCs														
	Polycyclic Aromatic Hydrocarbons (PAHs)													
	91-20-3	Naphthalene	0.008	6	µg/L	GW-16	9/10	0.012-0.012	6	0.620 N	NA	NA	Y	ASL
	91-57-6	2-Methylnaphthalene	0.0035 (J)	0.19	µg/L	GW-16	8/10	0.0077-0.008	0.19	-	NA	NA	N	BSL
	90-12-0	1-Methylnaphthalene	0.0043	0.29	µg/L	GW-16	8/10	0.0077-0.0079	0.29	-	NA	NA	N	BSL
	208-96-8	Acenaphthylene	0.0074 (J)	0.014	µg/L	GW-16	4/10	0.0077-0.008	0.014	-	NA	NA	N	BSL
	83-32-9	Acenaphthene	0.0064 (J)	0.11	µg/L	GW-16	8/10	0.0077-0.0079	0.11	36.5 N	NA	NA	N	BSL
	86-73-7	Fluorene	0.009	0.39	µg/L	GW-16	7/10	0.0077-0.0079	0.39	24.3 N	NA	NA	N	BSL
	132-64-9	Dibenzofuran	0.0067 (J)	0.022	µg/L	GW-4	4/10	0.0077-0.008	0.022	1.217 N	NA	NA	N	BSL
	85-01-8	Phenanthrene	0.0059 (J)	0.17	µg/L	GW-16	8/10	0.0077-0.0079	0.17	-	NA	NA	N	BSL
	120-12-7	Anthracene	0.0043 (J)	0.18	µg/L	GW-16	9/10	0.0079-0.0079	0.18	183 N	NA	NA	N	BSL
	206-44-0	Fluoranthene	0.005 (J)	0.079	µg/L	GW-11	7/10	0.0077-0.0079	0.079	146 N	NA	NA	N	BSL
	129-00-0	Pyrene	0.01	0.098	µg/L	GW-11	8/10	0.0078-0.0079	0.098	18.3 N	NA	NA	N	BSL
	56-55-3	Benzo(a)anthracene	0.003 (J)	0.056	µg/L	GW-11	6/10	0.0077-0.0079	0.056	0.029 C	NA	NA	Y	ASL
	218-01-9	Chrysene	0.0034 (J)	0.018	µg/L	GW-11	4/10	0.0077-0.008	0.018	2.950 C	NA	NA	N	BSL
	205-99-2	Benzo(b)fluoranthene	0.0077 (J)	0.034	µg/L	GW-11	5/10	0.0077-0.008	0.034	0.029 C	NA	NA	Y	ASL
	207-08-9	Benzo(k)fluoranthene	0.0029 (J)	0.041	µg/L	GW-11	4/10	0.0077-0.008	0.041	0.295 C	NA	NA	N	BSL
	50-32-8	Benzo(a)pyrene	0.009	0.051	µg/L	GW-11	3/10	0.0077-0.008	0.051	0.003 C	NA	NA	Y	ASL
	193-39-5	Indeno(1,2,3-cd)pyrene	0.0032 (J)	0.047	µg/L	GW-11	5/10	0.0078-0.0079	0.047	0.029 C	NA	NA	Y	ASL
	53-70-3	Dibenz(a,h)anthracene	0.0037 (J)	0.0052 (J)	µg/L	GW-11	2/10	0.0078-0.0079	0.0052	0.003 C	NA	NA	Y	ASL
	191-24-2	Benzo(g,h)perylene	0.0034 (J)	0.055	µg/L	GW-11	5/10	0.0077-0.0079	0.055	-	NA	NA	N	BSL
	Organonitrogen Compounds, Halogenated Compounds, Phenols and Substituted Phenols, Oxygen-Containing Compounds													
	62-75-9	n-Nitrosodimethylamine	ND	ND	µg/L	NA	0/10	2-2	2	0.0292 N/ 0.0004C	NA	NA	N	RDL ASL
	111-44-4	bis (2-Chloroethyl) ether	ND	ND	µg/L	NA	0/10	0.2-0.2	0.2	0 N/ 0.0098C	NA	NA	N	RDL ASL
	541-73-1	1,3-Dichlorobenzene	0.039 (J)	0.053 (J)	µg/L	GW-2	7/10	0.2-0.2	0.053	1.4 N	NA	NA	N	BSL
	106-46-7	1,4-Dichlorobenzene	ND	0.053 (J)	µg/L	GW-3	9/10	0.2-0.2	0.053	66.1 N/ 0.4669C	NA	NA	N	BSL
	100-51-6	Benzyl Alcohol	ND	0.089 (J)	µg/L	GW-1	9/10	4.9-5	0.089	1,095 N	NA	NA	N	BSL
	621-64-7	n-Nitroso-di-n-propylamine	ND	ND	µg/L	NA	0/10	0.2-0.2	0.2	0.0096 C	NA	NA	N	RDL ASL
	65-85-0	Benzoic Acid	1.1 (J)	1.2 (J)	µg/L	GW-2, GW-3, GW-4, GW-5	5/10	4.8-4.9	1.2	14,600 N	NA	NA	N	BSL
	86-74-8	Carbazole	0.025 (J)	0.036 (J)	µg/L	GW-4	2/10	0.2-0.2	0.036	3.36 C	NA	NA	N	BSL
	85-68-7	Butyl Benzyl Phthalate	ND	0.05 (J)	µg/L	GW-1	1/10	0.2-0.2	0.05	73 N	NA	NA	N	BSL
PCBs														
	11104-28-2	Aroclor 1221	ND	ND	µg/L	NA	0/10	0.0097-0.059	0.059	0.034 C	NA	NA	N	RDL ASL

TABLE 7-2-3 OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
U.S. GOVERNMENT MOORINGS

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (2)	Region 6 RSL Screening Value (N/C) (3)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (4)
Industrial Area														
Pesticides														
	118-74-1	Hexachlorobenzene	0.0006	0.0007 (J)	µg/L	GW-2	2/10	0.00049-0.00081	0.0007	2.92 N/ 0.042 C	NA	NA	N	BSL
	319-85-7	β -BHC	ND	0.0013 (J)	µg/L	GW-5	1/10	0.00049-0.00081	0.0013	0.0374 C	NA	NA	N	BSL
	58-89-9	γ -BHC (Lindane)	0.0005 (J)	0.0007	µg/L	GW-12	2/10	0.0005-0.00054	0.0007	1.095 N/ 0.0517 C	NA	NA	N	BSL
	309-00-2	Aldrin	ND	0.00027 (J)	µg/L	GW-12	1/10	0.00049-0.00099	0.00027	0.1095 N/ 0.004 C	NA	NA	N	BSL
	959-98-8	Endosulfan alpha-	0.0006	0.0013 (J)	µg/L	GW-3	3/10	0.00049-0.00099	0.0013	21.9 N	NA	NA	N	BSL
	7421-93-4	Endrin aldehyde	ND	0.00032 (J)	µg/L	GW-11	1/10	0.00049-0.0015	0.00032	-	NA	NA	N	BSL
	1031-07-8	Endosulfan sulfate	ND	0.00046 (J)	µg/L	GW-3	1/10	0.00049-0.0015	0.00046	-	NA	NA	N	BSL
	8001-35-2	Toxaphene	ND	ND	µg/L	NA	0/10	0.025-0.092	0.092	0.0611 C	NA	NA	N	BSL
		oxy chlordane	0.0049 (J)	0.0054 (J)	µg/L	GW-5	2/10	0.00097-0.0013	0.0054	1.825 N/ 0.1921 C	NA	NA	N	BSL
	3424-82-6	2,4'-DDE	ND	0.0011	µg/L	GW-12	1/10	0.00049-0.0014	0.0011	0.1977 C	NA	NA	N	BSL
	5103-73-1	cis -nonachlor	ND	0.0018 (J)	µg/L	GW-6	1/10	0.00046-0.0044	0.0018	-	NA	NA	N	BSL
	39765-80-5	trans -nonachlor	0.00035 (J)	0.0024 (J)	µg/L	GW-1	3/10	0.00049-0.0013	0.0024	-	NA	NA	N	BSL
	67-72-1	Hexachloroethane	0.00029 (J)	0.00038 (J)	µg/L	GW-5	2/10	0.00049-0.0005	0.00038	3.65 N/ 4.8023 C	NA	NA	N	BSL
	87-68-3	Hexachlorobutadiene	ND	0.0008	µg/L	GW-11	1/10	0.00049-0.0005	0.0008	3.65 N/ 0.8619 C	NA	NA	N	BSL
	72-55-9	DDE (5)	ND	0.0011	µg/L	GW-12	1/10	NA	0.0011	0.1977 C	NA	NA	N	BSL
	50-29-3	DDx-total (6)	ND	0.0011	µg/L	GW-12	1/10	NA	0.0011	1.825 N/ 0.1977 C	NA	NA	N	BSL
		Chlordane-total (7)	0.00035 (J)	0.0085 (J)	µg/L	GW-06	4/10	NA	0.0085	1.825 N/ 0.1921 C	NA	NA	N	BSL
		Endosulfan-total (8)	0.00082 (NJ)	0.0013 (J)	µg/L	GW-06	3/10	NA	0.0013	21.9 N	NA	NA	N	BSL
Cyanide														
	57-12-5	Cyanide	30.4	2900	µg/L	GW-16	18/21	10-10	2900	73 N	NA	NA	Y	ASL
Total Suspended Solids														
		Total Suspended Solids	117	1180000	µg/L	GW-11	6/10	5000-5000	1180000	-	NA	NA	N	BSL
Metals														
	7429-90-5	Aluminum (pH 6.5 - 9.0)	35.7	74600	µg/L	GW-11	10/10	-	74600	3650 N	NA	NA	Y	ASL
	7440-36-0	Antimony	0.12	0.03 B	µg/L	GW-2	4/10	0.05-0.05	0.03	1.46 N	NA	NA	N	BSL
	7440-38-2	Arsenic	0.058	4.68	µg/L	GW-20	10/10	-	4.68	1.095 N/0.0448 C	NA	NA	Y	ASL
	7440-43-9	Cadmium	0.023	20.9	µg/L	GW-11	8/10	0.02-0.02	20.9	1.825 N	NA	NA	Y	ASL
	7440-47-3	Chromium, total	0.24	100	µg/L	GW-11	9/10	0.46-0.46	100	-	NA	NA	N	BSL
	7440-50-8	Copper	0.2	108	µg/L	GW-11	10/10	-	108	135.5714 N	NA	NA	N	BSL
	7439-92-1	Lead	0.04	92.3	µg/L	GW-11	10/10	-	92.3	-	NA	NA	N	BSL
	7439-96-5	Manganese	210	12000	µg/L	GW-20	10/10	-	12,000	170.3 N	NA	NA	Y	ASL
	7439-97-6	Mercury	ND	0.07 B	µg/L	GW-11	1/10	0.2-0.2	0.07	0.0626 N	NA	NA	Y	ASL
	7440-02-0	Nickel	2.12	212	µg/L	GW-11	10/10	-	212	73 N	NA	NA	Y	ASL
	7782-49-2	Selenium	0.3 B	1.1 B	µg/L	GW-16	3/10	0.1-1	1.1	18.25 N	NA	NA	N	BSL
	7440-22-4	Silver	ND	0.269	µg/L	GW-11	1/10	0.003-0.03	0.269	18.25 N	NA	NA	N	BSL
	7440-66-6	Zinc	10.3	5510	µg/L	GW-11	10/10	-	5510	1095 N	NA	NA	Y	ASL
		Aluminum, Dissolved	2.6	10500	µg/L	GW-11	10/10	-	10500	3650 N	NA	NA	Y	ASL
		Antimony, Dissolved	0.05	0.18	µg/L	GW-12	9/10	0.05-0.05	0.18	1.46 N	NA	NA	N	BSL
		Arsenic, Dissolved	0.155	4.71	µg/L	GW-5	10/10	-	4.71	1.095 N/0.0448 C	NA	NA	Y	ASL
		Cadmium, Dissolved	0.02	2	µg/L	GW-16	8/10	0.02-0.02	2	1.825 N	NA	NA	N	BSL
		Chromium, Dissolved	0.34	7.17	µg/L	GW-16	9/10	0.28-0.28	7.17	0 N	NA	NA	N	BSL
		Copper, Dissolved	0.18	1.77	µg/L	GW-4	10/10	-	1.77	135.5714 N	NA	NA	N	BSL
		Lead, Dissolved	0.022	11.5	µg/L	GW-16	10/10	-	11.5	-	NA	NA	N	BSL
		Manganese, Dissolved	221	12000	µg/L	GW-20	10/10	-	12000	170.309 N	NA	NA	Y	ASL
		Mercury, Dissolved	ND	ND	µg/L	NA	0/10	0.2-0.2	0.2	0.0626 N	NA	NA	N	RDL ASL
		Nickel, Dissolved	2.12	145	µg/L	GW-1	10/10	-	145	73 N	NA	NA	Y	ASL
		Selenium, Dissolved	0.3 B	0.027	µg/L	GW-16	8/10	1-1	0.027	18.25 N	NA	NA	N	BSL
		Silver, Dissolved	0.003 B	0.027	µg/L	GW-1	4/10	0.02-0.02	0.027	18.25 N	NA	NA	N	BSL
		Zinc, Dissolved	10.6	3550	µg/L	GW-1	10/10	-	3550	1095 N	NA	NA	Y	ASL
TPHs														
		TPH-Deisel	13 (J)	13 (J)	µg/kg	GW-16, GW-11	2/10	250-270	13	NA	NA	NA	N	BSL
		TPH-Motor Oil	60000	180000	µg/kg	PC	5/6	490-530	180000	NA	NA	NA	N	BSL

Notes:
(1) (J) = The analyte was detected above the reported quantitation limit, and the reported concentration was an extimated value.
(NJ) = The analyte was not identified and the reported concentration was an estimated value.
(B) = The result is an estimated concentration that is less than the MRL bu greater than or equal to the MDL.
(2) Maximum value detected in samples used as Concentration Used For Screening.
(3) USEPA Region 6 Tap Water PRGs as provided from Table 3.1 of the Final Portland Harbor JSCS Document, updated July 2007.

(4) Rationale Codes:
Selection Reason: Above Screening Level (ASL)
Deletion Reason: Below Screening Level (BSL)
(5) This value represents the sum of the 2,4' and 4,4' isomers.
(6) This value represents the sum of DDE + DDD + DDT.
(7) This value represents the sum of alpha and gamma chlordane, oxy chlordane, and cis and trans nonachlor.
(8) This value represents the sum of alpha and beta endosulfan and endosulfan sulfate.

Definitions: NA = Not Applicable ND = Not Detected "-" = No Value Listed

TABLE 7-2-4 OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
U.S. GOVERNMENT MOORINGS

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (2)	Screening Toxicity Value MCL (3)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (4)
Industrial Area														
Volatile Organic Compounds (VOCs)														
	156-59-2	cis-1,2-Dichloroethlyene	ND	0.31 (J)	µg/L	GW-2	1/10	0.5-0.5	0.31	70	70	MCL	N	BSL
	75-15-0	Carbon Disulfide	0.4 (J)	2.3	µg/L	GW-11	2/10	0.5-0.5	2.3	-	NA	NA	N	BSL
	67-66-3	Chloroform	ND	0.3 (J)	µg/L	GW-2	1/10	0.5-0.5	0.3	-	NA	NA	N	BSL
	71-43-2	Benzene	0.19 (J)	0.94	µg/L	GW-11	7/10	0.5-0.5	0.94	5	5	MCL	N	BSL
	79-01-6	Trichloroethene (TCE)	ND	0.67	µg/L	GW-2	1/10	0.5-0.5	0.67	5	5	MCL	N	BSL
	108-88-3	Toluene	0.21 (J)	0.33 (J)	µg/L	GW-16	2/10	0.5-0.5	0.33	1000	1000	MCL	N	BSL
	127-18-4	Tetrachloroethene (PCE)	0.14 (J)	0.22 (J)	µg/L	GW-2	2/10	0.5-0.5	0.5	5	5	MCL	N	BSL
	100-41-4	Ethylbenzene	0.14 (J)	0.14 (J)	µg/L	GW-16, GW-11	2/10	0.5-0.5	0.5	700	700	MCL	N	BSL
	91-20-3	Naphthalene	0.8 (J)	5.9	µg/L	GW-16	5/10	2-2	5.9	-	NA	NA	N	BSL
	75-01-4	Vinyl Chloride	ND	ND	µg/L	NA	0/10	0.5-0.5	0.5	2	2	MCL	N	BSL
	107-13-1	Acrylonitrile	ND	ND	µg/L	NA	0/10	5-5	5.0	-	NA	NA	N	BSL
	10061-01-5	cis-1,3-Dichloropropene	ND	ND	µg/L	NA	0/10	0.5-0.5	0.5	-	NA	NA	N	BSL
	10061-02-6	trans-1,3-Dichloropropene	ND	ND	µg/L	NA	0/10	0.5-0.5	0.5	-	NA	NA	N	BSL
	79-00-5	1,1,2-Trichloroethane	ND	ND	µg/L	NA	0/10	0.5-0.5	0.5	5	5	MCL	N	BSL
	124-48-1	Dibromochloromethane	ND	ND	µg/L	NA	0/10	0.5-0.5	0.5	-	NA	NA	N	BSL
	106-93-4	1,2-Dibromoethane (EDB)	ND	ND	µg/L	NA	0/10	2-2	2.0	-	NA	NA	N	BSL
	79-34-5	1,1,2,2-Tetrachloroethane	ND	ND	µg/L	NA	0/10	0.5-0.5	0.5	-	NA	NA	N	BSL
	110-57-6	trans-1,4-Dichloro-2-butene	ND	ND	µg/L	NA	0/10	10-10	10.0	-	NA	NA	N	BSL
	96-18-4	1,2,3-Trichloropropane	ND	ND	µg/L	NA	0/10	0.5-0.5	0.5	-	NA	NA	N	BSL
	106-46-7	1,4-Dichlorobenzene	ND	ND	µg/L	NA	0/10	0.5-0.5	0.5	-	NA	NA	N	BSL
SVOCs														
	Polycyclic Aromatic Hydrocarbons (PAHs)													
	91-20-3	Naphthalene	0.008	6	µg/L	GW-16	9/10	0.012-0.012	6	0.2 (10)	0.2	MCL	Y	ASL
	91-57-6	2-Methylnaphthalene	0.0035 (J)	0.19	µg/L	GW-16	8/10	0.0077-0.008	0.19	0.2 (10)	0.2	MCL	N	BSL
	90-12-0	1-Methylnaphthalene	0.0043	0.29	µg/L	GW-16	8/10	0.0077-0.0079	0.29	-	NA	NA	N	BSL
	208-96-8	Acenaphthylene	0.0074 (J)	0.014	µg/L	GW-16	4/10	0.0077-0.008	0.014	0.2 (10)	0.2	MCL	N	BSL
	83-32-9	Acenaphthene	0.0064 (J)	0.110	µg/L	GW-16	8/10	0.0077-0.0079	0.110	0.2 (10)	0.2	MCL	N	BSL
	86-73-7	Fluorene	0.009	0.390	µg/L	GW-16	7/10	0.0077-0.0079	0.390	0.2 (10)	0.2	MCL	Y	ASL
	132-64-9	Dibenzofuran	0.0067 (J)	0.022	µg/L	GW-4	4/10	0.0077-0.008	0.022	-	NA	NA	N	BSL
	85-01-8	Phenanthrene	0.0059 (J)	0.170	µg/L	GW-16	8/10	0.0077-0.0079	0.170	0.2 (10)	0.2	MCL	N	BSL
	120-12-7	Anthracene	0.0043 (J)	0.180	µg/L	GW-16	9/10	0.0079-0.0079	0.180	0.2 (10)	0.2	MCL	N	BSL
	206-44-0	Fluoranthene	0.005 (J)	0.079	µg/L	GW-11	7/10	0.0077-0.0079	0.079	0.2 (10)	0.2	MCL	N	BSL
	129-00-0	Pyrene	0.010	0.098	µg/L	GW-11	8/10	0.0078-0.0079	0.098	0.2 (10)	0.2	MCL	N	BSL
	56-55-3	Benzo(a)anthracene	0.003 (J)	0.056	µg/L	GW-11	6/10	0.0077-0.0079	0.056	0.2 (10)	0.2	MCL	N	BSL
	218-01-9	Chrysene	0.0034 (J)	0.018	µg/L	GW-11	4/10	0.0077-0.008	0.018	0.2 (10)	0.2	MCL	N	BSL
	205-99-2	Benzo(b)fluoranthene	0.0077 (J)	0.034	µg/L	GW-11	5/10	0.0077-0.008	0.034	0.2 (10)	0.2	MCL	N	BSL
	207-08-9	Benzo(k)fluoranthene	0.0029 (J)	0.041	µg/L	GW-11	4/10	0.0077-0.008	0.041	0.2 (10)	0.2	MCL	N	BSL
	50-32-8	Benzo(a)pyrene	0.009	0.051	µg/L	GW-11	3/10	0.0077-0.008	0.051	0.2	0.2	MCL	N	BSL
	193-39-5	Indeno(1,2,3-cd)pyrene	0.0032 (J)	0.047	µg/L	GW-11	5/10	0.0078-0.0079	0.047	0.2 (10)	0.2	MCL	N	BSL
	53-70-3	Dibenz(a,h)anthracene	0.0037 (J)	0.0052 (J)	µg/L	GW-11	2/10	0.0078-0.0079	0.0052	0.2 (10)	0.2	MCL	N	BSL
	191-24-2	Benzo(g,h)perylene	0.0034 (J)	0.055	µg/L	GW-11	5/10	0.0077-0.0079	0.055	0.2 (10)	0.2	MCL	N	BSL
	Organonitrogen Compounds, Halogenated Compounds, Phenols and Substituted Phenols, Oxygen-Containing Compounds													
	62-75-9	n-Nitrosodimethylamine	ND	ND	µg/L	NA	0/10	2-2	2.0	-	NA	NA	N	BSL
	111-44-4	bis (2-Chloroethyl) ether	ND	ND	µg/L	NA	0/10	0.2-0.2	0.2	-	NA	NA	N	BSL
	541-73-1	1,3-Dichlorobenzene	0.039 (J)	0.053 (J)	µg/L	GW-2	7/10	0.2-0.2	0.053	-	NA	NA	N	BSL
	106-46-7	1,4-Dichlorobenzene	ND	0.053 (J)	µg/L	GW-3	9/10	0.2-0.2	0.053	75	75	MCL	N	BSL
	100-51-6	Benzyl Alcohol	ND	0.089 (J)	µg/L	GW-1	9/10	4.9-5	0.089	-	NA	NA	N	BSL
	621-64-7	n-Nitroso-di-n-propylamine	ND	ND	µg/L	NA	0/10	0.2-0.2	0.2	-	NA	NA	N	BSL
	65-85-0	Benzoic Acid	1.1 (J)	1.2 (J)	µg/L	GW-5	5/10	4.8-4.9	1.2	-	NA	NA	N	BSL
	86-74-8	Carbazole	0.025 (J)	0.036 (J)	µg/L	GW-4	2/10	0.2-0.2	0.036	-	NA	NA	N	BSL
	85-68-7	Butyl Benzyl Phthalate	ND	0.05 (J)	µg/L	GW-1	1/10	0.2-0.2	0.05	-	NA	NA	N	BSL
PCBs														
	11104-28-2	Aroclor 1221	ND	ND	µg/L	NA	0/10	0.0097-0.059	0.059	-	NA	NA	N	BSL

TABLE 7-2-4 OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
U.S. GOVERNMENT MOORINGS

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (2)	Screening Toxicity Value MCL (3)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (4)
Industrial Area														
	118-74-1	Hexachlorobenzene	0.0006	0.0007 (J)	µg/L	GW-2	2/10	0.00049-0.00081	0.00070	1	1	MCL	N	BSL
	319-85-7	β -BHC	ND	0.0013 (J)	µg/L	GW-5	1/10	0.00049-0.00081	0.00130	-	NA	NA	N	BSL
	58-89-9	γ -BHC (Lindane)	0.0005 (J)	0.0007	µg/L	GW-12	2/10	0.0005-0.00054	0.00070	0.2	0.2	MCL	N	BSL
	309-00-2	Aldrin	ND	0.00027 (J)	µg/L	GW-12	1/10	0.00049-0.00099	0.00027	-	NA	NA	N	BSL
	959-98-8	Endosulfan alpha-	0.0006	0.0013 (J)	µg/L	GW-3	3/10	0.00049-0.00099	0.00130	-	NA	NA	N	BSL
	7421-93-4	Endrin aldehyde	ND	0.00032 (J)	µg/L	GW-11	1/10	0.00049-0.0015	0.00032	-	NA	NA	N	BSL
	1031-07-8	Endosulfan sulfate	ND	0.00046 (J)	µg/L	GW-3	1/10	0.00049-0.0015	0.00046	-	NA	NA	N	BSL
		oxy chlordane	0.0049 (J)	0.0054 (J)	µg/L	GW-5	2/10	0.00097-0.0013	0.0054	-	NA	NA	N	BSL
	3424-82-6	2,4'-DDE	ND	0.0011	µg/L	GW-12	1/10	0.00049-0.0014	0.0011	-	NA	NA	N	BSL
	5103-73-1	cis -nonachlor	ND	0.0018 (J)	µg/L	GW-6	1/10	0.00046-0.0044	0.0018	-	NA	NA	N	BSL
	39765-80-5	trans -nonachlor	0.00035 (J)	0.0024 (J)	µg/L	GW-1	3/10	0.00049-0.0013	0.0024	-	NA	NA	N	BSL
	67-72-1	Hexachloroethane	0.00029 (J)	0.00038 (J)	µg/L	GW-5	2/10	0.00049-0.0005	0.00038	-	NA	NA	N	BSL
	87-68-3	Hexachlorobutadiene	ND	0.0008	µg/L	GW-11	1/10	0.00049-0.0005	0.0008	-	NA	NA	N	BSL
	72-55-9	DDE (5)	ND	0.0011	µg/L	GW-12	1/10	NA	0.0011	-	NA	NA	N	BSL
	50-29-3	DDx-total (6)	ND	0.0011	µg/L	GW-12	1/10	NA	0.0011	-	NA	NA	N	BSL
		Chlordane-total (7)	0.00035 (J)	0.0085 (J)	µg/L	GW-06	4/10	NA	0.0085	2	2	MCL	N	BSL
		Endosulfan-total (8)	0.00082 (NJ)	0.0013 (J)	µg/L	GW-06	3/10	NA	0.0013	*	NA	NA	N	BSL
Cyanide														
	57-12-5	Cyanide (12)	30.4	2,900	µg/L	GW-16	18/21	10-10	2,900	200	200	MCL	Y	ASL
Total Suspended Solids														
		Total Suspended Solids	117	1,180,000	µg/L	GW-11	6/10	5000-5000	1,180,000	-	NA	NA	N	BSL
Metals														
	7429-90-5	Aluminum (pH 6.5 - 9.0)	35.7	74,600	µg/L	GW-11	10/10	-	74,600	(50-200)	(50-200)	MCL	Y	ASL
	7440-36-0	Antimony	0.12	0.03 B	µg/L	GW-2	4/10	0.05-0.05	0.03	6	6	MCL	N	BSL
	7440-38-2	Arsenic	0.058	4.68	µg/L	GW-20	10/10	-	4.68	10	10	MCL	N	BSL
	7440-43-9	Cadmium	0.023	20.9	µg/L	GW-11	8/10	0.02-0.02	20.9	5	5	MCL	Y	ASL
	7440-47-3	Chromium, total	0.24	100	µg/L	GW-11	9/10	0.46-0.46	100	100	100	MCL	Y	ASL
	7440-50-8	Copper	0.2	108	µg/L	GW-11	10/10	-	108	1,300	1,300	MCL	N	BSL
	7439-92-1	Lead	0.04	92.3	µg/L	GW-11	10/10	-	92.3	15	15	MCL	Y	ASL
	7439-96-5	Manganese	210	12000	µg/L	GW-20	10/10	-	12,000	(50)	(50)	MCL	Y	ASL
	7439-97-6	Mercury	ND	0.07 B	µg/L	GW-11	1/10	0.2-0.2	0.07	2	2	MCL	N	BSL
	7440-02-0	Nickel	2.12	212	µg/L	GW-11	10/10	-	212	-	NA	NA	N	BSL
	7782-49-2	Selenium	0.3 B	1.1 B	µg/L	GW-16	3/10	0.1-1	1.10	50	50	MCL	N	BSL
	7440-22-4	Silver	ND	0.269	µg/L	GW-11	1/10	0.003-0.03	0.269	100	100	MCL	N	BSL
	7440-66-6	Zinc	10.3	5510	µg/L	GW-11	10/10	-	5,510	5,000	5,000	MCL	Y	ASL
		Aluminum, Dissolved	2.6	10500	µg/L	GW-11	10/10	-	10,500	(50-200)	(50-200)	MCL	Y	ASL
		Antimony, Dissolved	0.05	0.18	µg/L	GW-12	9/10	0.05-0.05	0.18	6	6	MCL	N	BSL
		Arsenic, Dissolved	0.155	4.71	µg/L	GW-5	10/10	-	4.71	10	10	MCL	N	BSL
		Cadmium, Dissolved	0.02	2.00	µg/L	GW-16	8/10	0.02-0.02	2.00	5	5	MCL	N	BSL
		Chromium, Dissolved	0.34	7.17	µg/L	GW-16	9/10	0.28-0.28	7.17	100	100	MCL	N	BSL
		Copper, Dissolved	0.18	1.77	µg/L	GW-4	10/10	-	1.77	1,300	1,300	MCL	N	BSL
		Lead, Dissolved	0.022	11.50	µg/L	GW-16	10/10	-	11.50	15	15	MCL	N	BSL
		Manganese, Dissolved	221	12000	µg/L	GW-20	10/10	-	12,000	50	50	MCL	Y	ASL
		Mercury, Dissolved	ND	ND	µg/L	NA	0/10	0.2-0.2	0.20	2	2	MCL	N	BSL
		Nickel, Dissolved	2.12	145	µg/L	GW-1	10/10	-	145	-	NA	NA	N	BSL
		Selenium, Dissolved	0.3 B	0.03	µg/L	GW-16	8/10	1-1	0.03	50	50	MCL	N	BSL
		Silver, Dissolved	0.003 B	0.03	µg/L	GW-1	4/10	0.02-0.02	0.03	100	100	MCL	N	BSL
		Zinc, Dissolved	10.6	3550	µg/L	GW-1	10/10	-	3,550	5,000	5,000	MCL	N	BSL
TPHs														
		TPH-Diesel	13 (J)	13 (J)	µg/kg	GW-16, GW-11	2/10	250-270	13	-	NA	NA	N	BSL
		TPH-Motor Oil	60,000	180,000	µg/kg	PC	5/6	490-530	180,000	-	NA	NA	N	BSL

Notes:
(1) (J) = The analyte was detected above the reported quantization limit, and the reported concentration was an estimated value.
(NJ) = The analyte was not identified and the reported concentration was an estimated value.
(B) = The result is an estimated concentration that is less than the MRL but greater than or equal to the MDL.
(2) Maximum value detected in samples used as Concentration Used For Screening.
(3) MCL as SLV from Table 3.1 of the Final Portland Harbor JSCS Document, updated July 2007
(4) Rationale Codes:
Selection Reason: Above Screening Level (ASL)
Deletion Reason: Below Screening Level (BSL)
Reported Detection Limit Above Screening Level (RDL ASL)

(5) This value represents the sum of the 2,4' and 4,4' isomers.
(6) This value represents the sum of DDE + DDD + DDT.
(7) This value represents the sum of alpha and gamma chlordane, oxy chlordane, and cis and trans nonachlor.
(8) This value represents the sum of alpha and beta endosulfan and endosulfan sulfate.
(10) MCL is based on benzo(a)pyrene

Definitions: NA = Not Applicable
ND = Not Detected
"-" = No Value Listed

7.1.4 Exposure Point Selection and Concentration Summaries

As recommended in USEPA's Superfund Guidance (Risk Assessment Guidance for Superfund Volume I, Human Health Evaluation Manual (Part A) USEPA/540/1-89/002, December 1989), actions at Superfund sites should be based on an estimate of the reasonable maximum exposure (RME) expected to occur under both current and future land-use conditions. The reasonable maximum exposure is defined as the highest exposure that is reasonably expected to occur at a site. RMEs are estimated for individual pathways. Intake variables for a given exposure pathway should be selected so that the combination of all of the intake variables results in an estimate of the RME. If a population is exposed via more than one pathway, the combination of exposures across pathways also must represent an RME. USEPA guidance (Guidance For Risk Characterization U.S. Environmental Protection Agency Science Policy Council February, 1995) also recommends that a central tendency estimate of risk be calculated. Sample locations selected as RME locations are shown in Figure 7-1, page 7-25.

USEPA's Superfund Guidance recommends that the exposure point concentration (EPC) (that point in contaminated media where human contact may take place) used for the HHRA be calculated using the upper confidence limit (i.e., the 95 percent upper confidence limit) of the arithmetic mean of the concentrations of the exposure area. For the Moorings HHRA, this was not done; instead the EPCs used were individual soil samples (shallow MIS or shallow industrial core samples) or individual well samples. It should be noted that the MIS Area soil samples were collected using a systematic random technique (Section 4.1.2, page 4-17) that results in an averaged concentration for each COPC. The rationale for the use of individual samples is provided below for each medium and receptor population.

<u>Surface Soil Exposure Point Concentrations</u> (Table 7-3-1, page 7-27)

- Contact with surface soil and air contaminated by the surface soil is possible at two exposure points: the Runoff and the Fence Line locations at the northeast portion of the site as shown on Figure 7.1 (page 7-25). Moorings Maintenance Workers are assumed to be exposed to these two surface samples through dermal absorption, incidental ingestion, and inhalation.

- The COPCs identified as a result of comparing detected contaminant concentrations to SLVs as described in Section 7.1.3 (page 7-9) are the only contaminants evaluated. These COPCs are three carcinogenic PAHs, arsenic, chromium and Aroclor® 1248. The Run-off exposure point is the only location with a detected value of Aroclor® 1248, and the Fence Line exposure point has higher metal concentrations.

- No direct sampling of the air around either exposure point was performed during the field sampling, but the surface soil concentration will be used to calculate an estimated air concentration for volatized and particulate matter contaminants.

- These two samples were collected as part of the "erodible" soil samples, and physically reside at the base of the chain link fence bordering the Moorings upland site. It is assumed that a Maintenance Worker could be exposed to the surface soil during fence maintenance.

<u>Shallow Soils Exposure Point Concentrations</u> (Table 7-3-2, page 7-28)

- Moorings Maintenance Workers and Office Workers are assumed to be exposed to contaminants in shallow subsurface soils in the Industrial Area and in the South Logistics

MU via air inhalation. Incidental soil ingestion and dermal exposure to soils are not possible because the soils are covered (e.g., with asphalt). The South Logistics MU is the area closest to the buildings used by the Moorings workers in the northern part of the site.

- Upland Excavation Workers are assumed to be present only for one instance of specialized construction work that lasts a few days, at most, and to be in contact with only a small area of the site. Therefore, individual soil samples (shallow cores or MIS MUs) were used for the EPCs. These workers could be exposed through incidental ingestion, dermal absorption, or inhalation of contaminants in soil.
- The COPCs identified for the industrial area were four carcinogenic COPCs: one PAH, antimony, arsenic, and lead. For the MIS MUs, the COPCs identified are arsenic and lead.
- SB-01, SB-12, and SB-16 are the RME exposure points selected for shallow soil in the Industrial Area because they contained the highest concentrations of individual and multiple COPCs. This approach results in conservative estimates of risks. Exposures at locations that are not an RME exposure point in the industrial area are assumed to result in lower risks than those calculated for the RME exposure points.
    - SB-01 has the maximum arsenic concentration and high concentrations of antimony.
    - SB-12 has the maximum antimony concentration and high concentrations of arsenic and lead.
    - SB-16 has the highest levels of PAH concentrations.
- Each MIS Area soil sample was used as an EPC. These were collected using a systematic random technique (Section 4.1.2.2.1, page 4-19) that results in an averaged concentration for each COPC.

Groundwater Exposure Point Concentrations (Table 7-3-3, page 7-29).

- Groundwater at the Moorings site is not currently being used as a drinking water source; however, it was assumed that in the future, Moorings Maintenance Workers and Office Workers could potentially be exposed to contaminants in groundwater through ingestion, dermal exposure, and inhalation of contaminants in groundwater.
- For future groundwater use, it was assumed that a well could be placed into any area of the site, therefore data from individual groundwater wells were used as the EPC.
- COPCs in groundwater differed depending on the well location. These COPCs included, volatiles, carcinogenic PAH, cyanide, and metals.
- Groundwater exposure points are selected to represent the highest COPC concentrations locations (Figure 7-1, page 7-25).
    - GW-02 has the only detect of chloroform, and has the highest concentration of tetracholoethene and trichloroethene.
    - GW-11 has the highest PAH and aluminum concentrations.

- GW-16 has the highest cyanide and naphthalene concentrations.
- GW-20 is the deepest groundwater well drilled during the RI sampling activities and represents groundwater down to bedrock. GW-20 also has the highest concentration of manganese.

The use of the industrial soil samples and groundwater well samples with the highest contaminant levels is a very health protective assumption. Lower risks would be expected if additional samples with lower contaminant levels had been used for the risk calculations.

7.1.4.1 Uncertainty Related to Exposure Point Selection and Concentration Summaries

Exposure points and exposure point concentrations were chosen specifically where highest concentrations of COPCs for the Moorings site occur. It is assumed that these represent a reasonable maximum for the current Moorings site condition and future Moorings site condition. The HHRA does not take into account any increase in concentration of COPCs due to chemical movement throughout the site. This assumption may underestimate future risk related to groundwater consumption and subsurface soils if concentration of the COPC at the exposure point increases. Underestimation of human health risks and hazards resulting from this assumption could occur.

High levels of manganese are most likely a result of the reducing environment and not direct site contamination, so the rate of reduction may be variable. Also, because background concentration in groundwater were not collected, and are not available in close proximity to the Moorings site due to surrounding known contamination, it is not possible to compare concentrations of arsenic to background concentrations. Potentially the arsenic is naturally occurring and is not entirely resultant of contamination.

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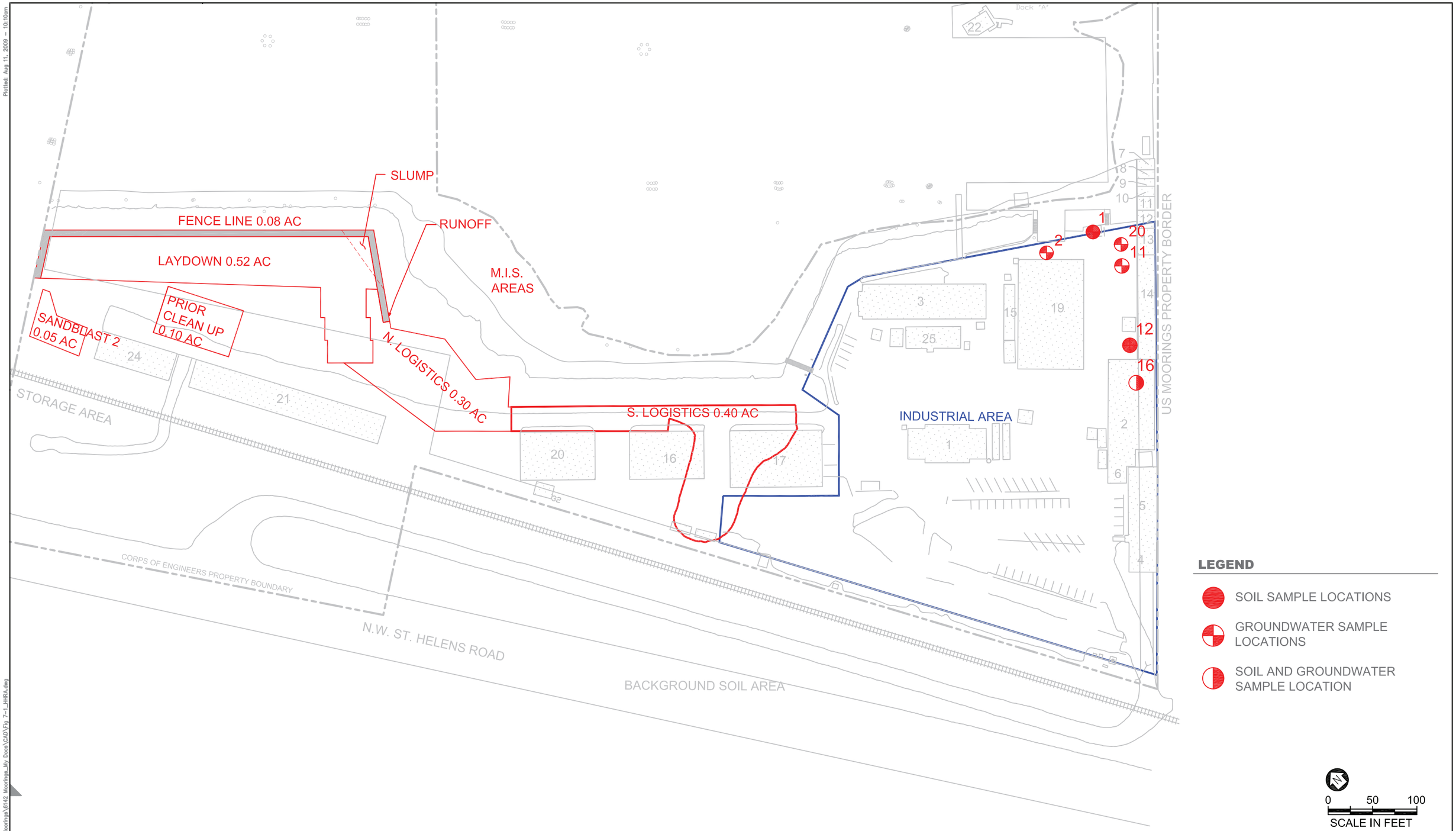

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JOB No.
SCALE:
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DRAWN BY:
CHECKED BY:
PROJ. ENGINEER:
APPROVED BY:
DATE:

WARNING
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US GOVERNMENT MOORINGS

REMEDIAL INVESTIGATION

SOIL AND GROUNDWATER SAMPLE LOCATIONS FOR HHRA

DRAWING NUMBER: FIGURE 7–1
CAD FILE NUMBER:
SHEET: OF
REV.

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TABLE 7-3-1 EXPOSURE POINT CONCENTRATION SUMMARY REASONABLE MAXIMUM EXPOSURE
U.S. GOVERNMENT MOORINGS

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)	Maximum Concentration (Qualifier)	Exposure Point Concentration			
						Value	Units (2)	Statistic (3)	Rationale
RUN-OFF	Benzo(b)fluoranthene	µg/kg	-	-	3400	3.4	mg/kg	Maximum of samples	Higher PAH and only detect of Aroclor 1248
	Benzo(a)pyrene	µg/kg	-	-	2700	2.7	mg/kg	Maximum of samples	
	Dibenz(a,h)anthracene	µg/kg	-	-	550	0.55	mg/kg	Maximum of samples	
	Aroclor® 1248	µg/kg	-	-	1600	1.6	mg/kg	Maximum of samples	
	Arsenic	µg/kg	-	-	5270	5.27	mg/kg	Sample concentration	
	Chromium, total	µg/kg	-	-	76600	76.6	mg/kg	Sample concentration	
FENCELINE	Benzo(b)fluoranthene	µg/kg	-	-	2000	2	mg/kg	Sample concentration	Highest metal detects
	Benzo(a)pyrene	µg/kg	-	-	1500	1.5	mg/kg	Sample concentration	
	Dibenz(a,h)anthracene	µg/kg	-	-	250	0.25	mg/kg	Sample concentration	
	Aroclor® 1248	µg/kg	-	-	ND	-	-	Sample concentration	
	Arsenic	µg/kg	-	-	62900	62.9	mg/kg	Maximum of samples	
	Chromium, total	µg/kg	-	-	508000	508	mg/kg	Maximum of samples	

Notes:

(1) No direct samples of air were taken for measurement of volatilized of particulate matter, therefore the concentrations measured in the surface soil samples will be used as a basis for the estimated concentration in air.

(2) Note that the units are mg/kg, not µg/kg as mg/kg are required in the risk calculations to correspond to the RfD

(3) The codes have the following meanings:

Sample concentration = the concentration determined in the lab for that COPC, indicates it is not the highest concentration found between the two samples, FENCELINE and RUN-OFF.

Maximum of samples = the maximum concentration found between the two samples that will determine the higher risk.

TABLE 7-3-2 EXPOSURE POINT CONCENTRATION SUMMARY REASONABLE MAXIMUM EXPOSURE
U.S. GOVERNMENT MOORINGS

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution) (1)	Reported Concentration (Qualifier) (2)	Exposure Point Concentration			
						Value	Units (3)	Statistic (1)	Rationale
Industrial Area									
SB-01	Benzo(b)fluoranthene	µg/kg	-	-	150	0.15	mg/kg	-	Highest arsenic concentration sample.
	Benzo(a)pyrene	µg/kg	-	-	110	0.11	mg/kg	-	
	Indeno(1,2,3-cd)pyrene	µg/kg	-	-	180	0.18	mg/kg	-	
	Dibenz(a,h)anthracene	µg/kg	-	-	20	0.02	mg/kg	-	
	Antimony	µg/kg	-	-	210	0.21	mg/kg	-	
	Arsenic	µg/kg	-	-	14,900	14.9	mg/kg	-	
	Lead	µg/kg	-	-	79,900	79.9	mg/kg	-	
SB-12	Benzo(b)fluoranthene	µg/kg	-	-	540	0.54	mg/kg	-	Highest antimony concentration.
	Benzo(a)pyrene	µg/kg	-	-	470	0.47	mg/kg	-	
	Indeno(1,2,3-cd)pyrene	µg/kg	-	-	820	0.82	mg/kg	-	
	Dibenz(a,h)anthracene	µg/kg	-	-	72	0.072	mg/kg	-	
	Antimony	µg/kg	-	-	642,000	642	mg/kg	-	
	Arsenic	µg/kg	-	-	3,700	3.7	mg/kg	-	
	Lead	µg/kg	-	-	1,550,000	1550	mg/kg	-	
SB-16	Benzo(b)fluoranthene	µg/kg	-	-	4,500	4.5	mg/kg	-	Highest PAH concentrations.
	Benzo(a)pyrene	µg/kg	-	-	1,700	1.7	mg/kg	-	
	Indeno(1,2,3-cd)pyrene	µg/kg	-	-	4,500	4.5	mg/kg	-	
	Dibenz(a,h)anthracene	µg/kg	-	-	520	0.52	mg/kg	-	
	Antimony	µg/kg	-	-	5,860	5.86	mg/kg	-	
	Arsenic	µg/kg	-	-	4,560	4.56	mg/kg	-	
	Lead	µg/kg	-	-	429,000	429	mg/kg	-	
MIS Area									
South Logistics	Benzo(a)pyrene	µg/kg	-	-	98	0.098	mg/kg	-	
	Arsenic	µg/kg	-	-	3,110	3.11	mg/kg	-	
North Logistics	Benzo(a)pyrene	µg/kg	-	-	960	0.96	mg/kg	-	
	Arsenic	µg/kg	-	-	6,160	6.16	mg/kg	-	
Laydown	Benzo(a)pyrene	µg/kg	-	-	360	0.36	mg/kg	-	
	Arsenic	µg/kg	-	-	4,140	4.14	mg/kg	-	
Slump	Benzo(a)pyrene	µg/kg	-	-	3.5	0.0035	mg/kg	-	
	Arsenic	µg/kg	-	-	1,060	1.06	mg/kg	-	
Prior Cleanup	Benzo(a)pyrene	µg/kg	-	-	630	0.63	mg/kg	-	
	Arsenic	µg/kg	-	-	7,180	7.18	mg/kg	-	
Sandblast	Benzo(a)pyrene	µg/kg	-	-	380	0.38	mg/kg	-	
	Arsenic	µg/kg	-	-	8,200	8.2	mg/kg	-	

Notes"
(1) No statistics were utilized.
(2) Exposure locations were chosen to reflect the places where certain COPCs are highest, only 3 industrial soil samples were chosen because in combination show the highest reasonable
(3) Conversion from µg/kg to mg/kg:1000 µg/kg = 1 mg/kg

TABLE 7-3-3 EXPOSURE POINT CONCENTRATION SUMMARY REASONABLE MAXIMUM EXPOSURE
U.S. GOVERNMENT MOORINGS

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution) (1)	Maximum Concentration (Qualifier)	Exposure Point Concentration			
						Value	Units	Statistic (2)	Rationale
GW-2	Aluminum (pH 6.5 - 9.0)	µg/L	-	-	3,820	3,820	µg/L	Max	Only detect of chlorform, has highest TCE, PCE
	Arsenic	µg/L	-	-	1.43	1.43	µg/L	Max	
	Benz(a)anthracene	µg/L	-	-	0.0077 (U)	None	µg/L	Non-Detect	
	Benzene	µg/L	-	-	0.5 (U)	None	µg/L	Non-Detect	
	Benzo(a)pyrene	µg/L	-	-	0.0077 (U)	None	µg/L	Non-Detect	
	Benzo(b)fluoranthene	µg/L	-	-	0.0077 (U)	None	µg/L	Non-Detect	
	Cadmium	µg/L	-	-	0.02	0.02	µg/L	Max	
	Chloroform	µg/L	-	-	0.3 (J)	0.3 (J)	µg/L	Max	
	Chromium, total	µg/L	-	-	3.6	3.6	µg/L	Max	
	Cyanide	µg/L	-	-	50	50	µg/L	Max	
	Dibenz(a,h)anthracene	µg/L	-	-	0.0077 (U)	None	µg/L	Non-Detect	
	Fluorene	µg/L	-	-	0.0077 (U)	None	µg/L	Non-Detect	
	Indeno(1,2,3-cd)pyrene	µg/L	-	-	0.0077 (U)	None	µg/L	Non-Detect	
	Manganese	µg/L	-	-	478	478	µg/L	Max	
	Mercury	µg/L	-	-	0.2 (U)	None	µg/L	Non-Detect	
	Naphthalene	µg/L	-	-	0.008	0.008	µg/L	Max	
	Nickel	µg/L	-	-	25	25	µg/L	Max	
	Tetrachloroethene (PCE)	µg/L	-	-	0.22 (J)	0.22 (J)	µg/L	Max	
	Trichloroethene (TCE)	µg/L	-	-	0.67	0.67	µg/L	Max	
	Zinc	µg/L	-	-	281	281	µg/L	Max	
GW-11	Aluminum (pH 6.5 - 9.0)	µg/L	-	-	74,600	74,600	µg/L	Max	Well with highest PAH Levels, highest aluminum
	Arsenic	µg/L	-	-	4.02	4.02	µg/L	Max	
	Benz(a)anthracene	µg/L	-	-	0.06	0.06	µg/L	Max	
	Benzene	µg/L	-	-	0.22 (J)	0.22 (J)	µg/L	Max	
	Benzo(a)pyrene	µg/L	-	-	0.051	0.051	µg/L	Max	
	Benzo(b)fluoranthene	µg/L	-	-	0.03	0.03	µg/L	Max	
	Cadmium	µg/L	-	-	20.90	20.90	µg/L	Max	
	Chloroform	µg/L	-	-	0.5 (U)	None	µg/L	Non-Detect	
	Chromium, total	µg/L	-	-	100.0	100.0	µg/L	Max	
	Cyanide	µg/L	-	-	150	150	µg/L	Max	
	Dibenz(a,h)anthracene	µg/L	-	-	0.0052 (J)	0.0052 (J)	µg/L	Max	
	Fluorene	µg/L	-	-	0.06	0.06	µg/L	Max	
	Indeno(1,2,3-cd)pyrene	µg/L	-	-	0.047	0.047	µg/L	Max	
	Lead	µg/L	-	-	92	92	µg/L	Max	
	Manganese	µg/L	-	-	1,770	1,770	µg/L	Max	
	Mercury	µg/L	-	-	0.07 B	0.07 B	µg/L	Max	
	Naphthalene	µg/L	-	-	3.3	3.3	µg/L	Max	
	Nickel	µg/L	-	-	212	212	µg/L	Max	
	Tetrachloroethene (PCE)	µg/L	-	-	0.5 (U)	None	µg/L	Non-Detect	
	Trichloroethene (TCE)	µg/L	-	-	0.5 (U)	None	µg/L	Non-Detect	
	Zinc	µg/L	-	-	5,510	5,510	µg/L	Max	

TABLE 7-3-3 EXPOSURE POINT CONCENTRATION SUMMARY REASONABLE MAXIMUM EXPOSURE
U.S. GOVERNMENT MOORINGS

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution) (1)	Maximum Concentration (Qualifier)	Exposure Point Concentration			
						Value	Units	Statistic (2)	Rationale
GW-16	Aluminum (pH 6.5 - 9.0)	µg/L	-	-	8,040	8,040	µg/L	Max	Well with highest cyanide, napthalene
	Arsenic	µg/L	-	-	0.55	0.55	µg/L	Max	
	Benz(a)anthracene	µg/L	-	-	0.01	0.01	µg/L	Max	
	Benzene	µg/L	-	-	0.56	0.56	µg/L	Max	
	Benzo(a)pyrene	µg/L	-	-	0.0078 (U)	None	µg/L	Non-Detect	
	Benzo(b)fluoranthene	µg/L	-	-	0.02	0.02	µg/L	Max	
	Cadmium	µg/L	-	-	2.17	2.17	µg/L	Max	
	Chloroform	µg/L	-	-	0.5 (U)	0.5 (U)	µg/L	Max	
	Chromium, total	µg/L	-	-	7.1	7.1	µg/L	Max	
	Cyanide	µg/L	-	-	2,990	2,990	µg/L	Max	
	Dibenz(a,h)anthracene	µg/L	-	-	0.0078 (U)	None	µg/L	Non-Detect	
	Fluorene	µg/L	-	-	0.39	0.39	µg/L	Max	
	Indeno(1,2,3-cd)pyrene	µg/L	-	-	0.005 (J)	0.005 (J)	µg/L	Max	
	Lead	µg/L	-	-	14	14	µg/L	Max	
	Manganese	µg/L	-	-	804	804	µg/L	Max	
	Mercury	µg/L	-	-	0.2 (U)	None	µg/L	Non-Detect	
	Naphthalene	µg/L	-	-	6.0	6.0	µg/L	Max	
	Nickel	µg/L	-	-	72	72	µg/L	Max	
	Tetrachloroethene (PCE)	µg/L	-	-	0.5 (U)	None	µg/L	Non-Detect	
	Trichloroethene (TCE)	µg/L	-	-	0.5 (U)	None	µg/L	Non-Detect	
	Zinc	µg/L	-	-	1,250	1,250	µg/L		
GW-20	Aluminum (pH 6.5 - 9.0)	µg/L	-	-	102	102	µg/L	Max	Deepest well, highest manganese
	Arsenic	µg/L	-	-	4.68	4.68	µg/L	Max	
	Benz(a)anthracene	µg/L	-	-	0.0079 (U)	0.0079 (U)	µg/L	Max	
	Benzene	µg/L	-	-	0.5 (U)	None	µg/L	Non-Detect	
	Benzo(a)pyrene	µg/L	-	-	0.0079 (U)	None	µg/L	Non-Detect	
	Benzo(b)fluoranthene	µg/L	-	-	0.0079 (U)	None	µg/L	Non-Detect	
	Cadmium	µg/L	-	-	0.02 (U)	None	µg/L	Non-Detect	
	Chloroform	µg/L	-	-	0.5 (U)	None	µg/L	Non-Detect	
	Chromium, total	µg/L	-	-	0.46 (U)	None	µg/L	Non-Detect	
	Cyanide	µg/L	-	-	200	200	µg/L	Max	
	Dibenz(a,h)anthracene	µg/L	-	-	0.0079 (U)	None	µg/L	Non-Detect	
	Fluorene	µg/L	-	-	0.0079 (U)	None	µg/L	Non-Detect	
	Indeno(1,2,3-cd)pyrene	µg/L	-	-	0.0079 (U)	None	µg/L	Non-Detect	
	Lead	µg/L	-	-	0.146	0.1	µg/L	Max	
	Manganese	µg/L	-	-	12,000	12,000	µg/L	Max	
	Mercury	µg/L	-	-	0.2 (U)	None	µg/L	Non-Detect	
	Naphthalene	µg/L	-	-	0.12 (U)	None	µg/L	Non-Detect	
	Nickel	µg/L	-	-	2.12	2	µg/L	Max	
	Tetrachloroethene (PCE)	µg/L	-	-	0.5 (U)	None	µg/L	Non-Detect	
	Trichloroethene (TCE)	µg/L	-	-	0.5 (U)	None	µg/L	Non-Detect	
	Zinc	µg/L	-	-	33.4	33	µg/L	Max	

Notes:
(1) No statistics were utilized.
(2) Exposure locations were chosen to reflect the places where certain COPCs are highest to present a conservative cancer risk and non-cancer hazard. The abbreviations are as follows:
Max = Detected concentration in sample.
Non-Detect = concentration below detectable limits. No EPC is available.

7.1.5 Daily Intake Equations

Each receptor has different levels of contact with exposure media via exposure routes that result in the intake of COPCs. The estimated daily intake of a COPC is calculated based on the EPC (Section 7.1.4, page 7-21), receptor, and exposure route.

Soil COPC exposure can occur through dermal contact, incidental ingestion, and inhalation of airborne contaminant. Exposure to surface soil is applicable to the Maintenance Worker for all exposure routes. It is assumed that the Maintenance Worker is exposed for only part of their work year to the Fence Line and Runoff samples. Shallow soil exposure is applicable to the Upland Excavation Worker for all exposure routes, and for Office Workers and Maintenance Workers through the inhalation route due to volatilization and particulate matter generation that affects the interior air quality in the buildings. Exposure parameters used to calculate the daily intake of COPCs for surface and shallow soils are considered the RME that the receptor could experience, which equates to daily doses higher than would be experienced on average.

Groundwater exposure may be possible in the future. Groundwater might be used for potable water at the Moorings. Exposure to groundwater COPCs may be through dermal contact with the water, ingestion of the water as drinking water, and volatilization of COPCs into the air. Daily intakes are calculated for both the RME and the less conservative central tendency intake parameters. The RME parameters assume a longer exposure period and higher daily ingestion of water while the central tendency exposures parameters assume a shorter exposure and less daily ingestion of water.

The volatilization of COPCs from groundwater to the indoor air (i.e., vapor intrusion) is only applicable to a sub-set of the COPCs including benzene, chloroform, mercury, naphthalene, and PCE. This list was compiled by comparing the list of COPCs in groundwater with a list of available screening levels from Region 6 Regional Screening Level Table for tap water inhalation screening level values (USEPA 2009a). Only a subset of COPCs that are present in groundwater have a sufficient volatilization potential to have a screening level value developed by the USEPA for inhalation. If the COPC did not have an USEPA listed screening level value or inhalation toxicity information it was not considered in the Moorings human health risk assessment.

For the Moorings HHRA, daily intake calculations were performed using the Risk Assessment Information System (RAIS) online chemical risk calculator tool (DOE 2006). RAIS allows the user to input all parameters utilized in the daily intake equations into the tool and calculate the daily intake of each COPC in the exposure medium.

RAIS uses the following equations to calculate daily intake values and parameters for the equations are found in Tables 7-4-1 (page 7-35) through 7-4-4 (page 41).

7.1.5.1 Uncertainty Related to Daily Intake Equations

Uncertainty related to the daily intake equation is present in every assumption made about intake. For example, the average body weight utilized is 70 kilograms, but not every person exposed will be the average body weight; therefore, the average daily intake of a COPC could vary be greater or less. Other examples of uncertainty exist when the consumption rate of water is estimated at 2.3 liters/day which could vary by a liter or more based on personnel preference. Less water consumption would result in lower risk and hazards, but greater water consumption could result in higher risks and hazards. A specific water consumption amount by future personnel is unknown. Some chemical based parameters are also more uncertain than

others. For example, no dermal absorption rate is available for chromium or antimony, so it is assumed that the absorption rate of the gastrointestinal track is equivalent to the dermal absorption rate for those two chemicals. Due to variation in protective equipment and skin absorption rates, absorption from soil may be underestimated.

<u>Surface Soil</u> Table 7-4-1 (page 7-35) shows the exposure parameters used for the Maintenance Worker exposed to Surface Soil (dermal, incidental ingestion and inhalation) Csoil= The EPCs for Surface Soil are shown in Table 7-3-1 (page 7-27) <u>Shallow Soil</u> Table 7-4-2 (page 7-37) shows the exposure parameters used for the Upland Excavation Worker exposed to Shallow Soil (dermal, incidental ingestion, and inhalation) and the Office Worker and Maintenance Worker exposed to Shallow Soil (inhalation only) Csoil = The EPCs for Shallow Soil are shown in Table 7-3-2 (page 7-28)	Dermal Contact Intake ($CDI_{ca\text{-}der}$) - Cancer	$CDI_{ca\text{-}der}\left(\frac{mg}{kg\text{-}day}\right)=\frac{C_{soil}\left(\frac{mg}{kg}\right)\times EF\times ED\times SA\times AF\times ABS_d\times CF}{AT_C\times BW}$
	Dermal Contact Intake ($CDI_{nc\text{-}der}$) – Non-Cancer	$CDI_{nc\text{-}der}\left(\frac{mg}{kg\text{-}day}\right)=\frac{C_{soil}\left(\frac{mg}{kg}\right)\times EF\times ED\times SA\times AF\times ABS_d\times CF}{AT_n\times BW}$
	Incidental Ingestion Intake ($CDI_{ca\text{-}ing}$) Cancer	$CDI_{ca\text{-}ing}\left(\frac{mg}{kg\text{-}day}\right)=\frac{C_{soil}\left(\frac{mg}{kg}\right)\times EF\times ED\times IR\times CF}{AT_C\times BW}$
	Incidental Ingestion Intake ($CDI_{nc\text{-}ing}$) Non-Cancer	$CDI_{nc\text{-}ing}\left(\frac{mg}{kg\text{-}day}\right)=\frac{C_{soil}\left(\frac{mg}{kg}\right)\times EF\times ED\times IR\times CF}{AT_n\times BW}$
	Inhalation Intake ($CDI_{ca\text{-}inh}$) Cancer	$CDI_{ca\text{-}inh}\left(\frac{\mu g}{m^3}\right)=\frac{C_{soil}\left(\frac{mg}{kg}\right)\times EF\times ED\times ET\times\left(\frac{1}{VF_s\left(\frac{m^3}{kg}\right)}+\frac{1}{PEF_W\left(\frac{m^3}{kg}\right)}\right)}{AT_C\times\left(\frac{1\ mg}{1000\ \mu g}\right)}$
	Inhalation Intake ($CDI_{nc\text{-}inh}$) Non-Cancer	$CDI_{nc\text{-}inh}\left(\frac{mg}{m^3}\right)=\frac{C_{soil}\left(\frac{mg}{kg}\right)\times EF\times ED\times ET\times\left(\frac{1}{VF_s\left(\frac{m^3}{kg}\right)}+\frac{1}{PEF_W\left(\frac{m^3}{kg}\right)}\right)}{AT_n}$

<u>Groundwater</u> Table 7-4-3 (page 7-40) (RME) and Table 7-4-4 (page 7-41) (Central Tendency [CT]) show the exposure parameters used for the Maintenance Worker and Office Worker exposed to groundwater (dermal, inhalation and ingestion) Cg-water= The EPC for groundwater are shown in Table 7-3-3 (page 7-29).	Dermal Contact Intake ($CDI_{ca\text{-}der}$) - Cancer	$CDI_{ca\text{-}der}\left(\frac{mg}{kg\text{-}day}\right)=\frac{C_{g\text{-}water}\left(\frac{\mu g}{L}\right)\times EF\times ED\times SA\times EV\times ET\times K_p}{AT_n\times BW}$
	Dermal Contact Intake ($CDI_{nc\text{-}der}$) – Non-Cancer	$CDI_{nc\text{-}der}\left(\frac{mg}{kg\text{-}day}\right)=\frac{C_{g\text{-}water}\left(\frac{\mu g}{L}\right)\times EF\times ED\times SA\times EV\times ET\times K_p}{AT_n\times BW}$
	Ingestion Intake ($CDI_{ca\text{-}ing}$) Cancer	$CDI_{ca\text{-}ing}\left(\frac{mg}{kg\text{-}day}\right)=\frac{C_{g\text{-}water}\left(\frac{\mu g}{L}\right)\times EF\times ED\times IRW}{AT_n\times BW}$
	Ingestion Intake ($CDI_{nc\text{-}ing}$) Non-Cancer	$CDI_{nc\text{-}ing}\left(\frac{mg}{kg\text{-}day}\right)=\frac{C_{g\text{-}water}\left(\frac{\mu g}{L}\right)\times EF\times ED\times IRW}{AT_n\times BW}$
	Inhalation Intake[(1)] ($CDI_{ca\text{-}inh}$) Cancer	$CDI_{ca\text{-}inh}\left(\frac{\mu g}{m^3}\right)=\frac{C_{g\text{-}water}\left(\frac{\mu g}{L}\right)\times EF\times ED\times ET\times K\left(\frac{0.5L}{m^3}\right)}{AT_C}$
	Inhalation Intake[(1)] ($CDI_{nc\text{-}inh}$) Non-Cancer	$CDI_{nc\text{-}inh}\left(\frac{mg}{m^3}\right)=\frac{C_{g\text{-}water}\left(\frac{\mu g}{L}\right)\times EF\times ED\times ET\times K\left(\frac{0.5L}{m^3}\right)}{AT_n}$

TABLE 7-4-1 VALUES USED FOR DAILY INTAKE CALCULATIONS REASONABLE MAXIMUM EXPOSURE
U.S. GOVERNMENT MOORINGS

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name (1)
Dermal contact	Maintenance Worker (Outdoor Worker)	18-70	FENCELINE	CF	Conversion Factor	0.000001	kg/mg	ODEQ	Dermal Exposure
			RUN-OFF	SA	Skin Surface Area	4100	cm^2/event	ODEQ	
	(Occupational Adult)			AF	Adherance Factor	0.08	mg/cm^3	ODEQ	
				EF	Exposure Frequency(2)	9	day/year	ODEQ	
				ED	Exposure Duration	25	years	ODEQ	
				BW	Body Weight	70	kg	ODEQ	
				ATc	Averaging Time - Cancer	25550	days	=70 years x 365 day/year: ODEQ	
				ATn	Averaging Time - Non-cancer	9125	days	=ED x 365 day/year	
				ABSd	Dermal Absorption Fraction from Soil (chemical-specific)		unitless	RAGS E, Exhibit 3-4	
					Arsenic	0.03	unitless	"	
					Chromium (3)	0.001	unitless	RAGS E	
					Benzo(a)pyrene and other PAHs	0.13	unitless	RAGS E, Exhibit 3-4	
					Aroclors 1254/1242 and other PCBs	0.14	unitless	"	
Incidental Ingestion	Maintenance Worker (Outdoor Worker)	18-70	FENCELINE	IR	Soil Ingestion Rate	300	mg/day	ODEQ	Incidental Ingestion
			RUN-OFF	EF	Exposure Frequency	9	day/year	ODEQ	
	(Occupational Adult)			ED	Exposure Duration	25	years	ODEQ	
				BW	Body Weight	70	kg	ODEQ	
				ATc	Averaging Time - Cancer	25550	days	=70 years x 365 day/year: ODEQ	
				ATn	Averaging Time - Non-cancer	9125	days	=ED x 365 day/year	
Inhalation of volatiles	Maintenance Worker (Outdoor Worker)	18-70	FENCELINE	EDw	Exposure Duration	25	years	ODEQ	Inhalation Exposure
Inhalation of Particulates			RUN-OFF	ETw	Exposure Time	8	hours	RAIS Default	
Combined Risk	(Occupational Adult)			LT	Lifetime	70	years	RAIS Default	
				EFw	Exposure Frequency	9	day/year	ODEQ	
				ATn	Averaging Time - Cancer	25550	days	=70 years x 365 day/year: ODEQ	
				ATc	Averaging Time - Non-cancer	9125	days	=ED x 365 day/year	
				VFs	Volatilization Factor (4)		m^3/kg	RAIS Calculated (see calculation below)	
				PEFw	Particulate Emisssion Factor (4)		m^3/kg	RAIS Calculated (see calculation below)	

(1) Model as presented in RAIS Contaminated Media (Risk) Calculator

(2) ODEQ standard number of days that an excavation worker would be exposed to one certain site. Field personnel at the Moorings concur with the estimate of 9 days exposure potential per worker.

(3) There are no default dermal absorption values presented for volatile organic compounds nor inorganic classes of compounds. The rationale for this is that in the considered soil exposure scenarios, volatile organic compounds would tend to be volatilized from the soil on skin and should be accounted for via inhalation routes in the combined exposure pathway analysis. For inorganics, the speciation of the compound is critical to the dermal absorption and there are too little data to extrapolate a reasonable default value.

However, as an interim method, dermal exposure to other compounds should be treated qualitatively in the uncertainty section or quantitatively using default values after presenting the relevant studies to the regional risk assessors so that absorption factors can be agreed upon on a site-specific basis before the start of the risk assessment.

A value of 0.001 for chromium total was chosen as the Dermal Absorption Fraction because that is the listed value for cadmium and since the permeability coefficient of chromium is equavalent to cadmium, an assumption is that the dermal absorption fraction is similar.

(4) Calculated by RAIS calculator using the below equations and climate data.

Particulate Emission Factor

$$PEF_w = \frac{Q}{C_w} \times \frac{3{,}600}{0.036 \times (1-V) \times (U_m/U_t)^3 \times F(X)}$$

where

$$\frac{Q}{C_w} = A \times \exp\left[\frac{(\ln A_s - B)^2}{C}\right]$$

Salem, OR (1)	City (Climatic Zone) - Selection based on most likely climatic conditions for the site
0.5	A_s (acres)
72.7856	Q/C_{wind} / inverse of the ratio of the geometric mean
0.5	V / fraction of vegetative cover (unitless)
4.69	U_m / mean annual wind speed (m/s)
11.32	U_t / equivalent threshold value
0.194	F(x) / function dependant on U_m/U_t derived using Cowherd et al. (1985) (unitless)

Volatilization Factor

$$VF = \frac{\frac{Q}{C_w} \times (3.14 \times D_A \times T)^{\frac{1}{2}} \times 10^{-4} \left(m^2/cm^2\right)}{2 \times \rho_b \times D_A}$$

where

$$\frac{Q}{C_w} = A \times \exp\left[\frac{(\ln A_s - B)^2}{C}\right] \text{ and}$$

$$D_A = \frac{\left[\left(\theta_a^{10/3} \times D_{ia} \times H' + \theta_w^{10/3} \times D_{iw}\right) / n^2\right]}{\rho_b \times K_d + \theta_w + \theta_a \times H'}$$

Salem, OR (1)	City (Climatic Zone)
0.5	A_s (acres)
72.7856	Q/C_{vol} / inverse of the ratio of the geometric mean
0.006	foc / (fraction organic carbon in soil) g/g
1.5	ρ_b (dry soil bulk density) g/cm^3
0.15	θ_w (water-filled soil porosity) L_{water}/L_{soil}
2.65	ρ_s (soil particle density) g/cm^3
9.5e8	T (exposure interval) s

NOTES:

1. θ_a(air-filled soil porosity) $L_{air}/L_{soil} = n - \theta_w$
2. H' (dimensionless Henry's law constant) - chemical-specific
3. n (total soil porosity) $L_{pore}/L_{soil} = 1-(\rho_b/\rho_s)$
4. K_d (soil-water partition coefficient) L/kg = K_{oc} x f_{oc} (organics) - chemical-specific
5. K_{oc} (soil organic carbon/water partition coefficient) L/kg - chemical specific

TABLE 7-4-2 VALUES USED FOR DAILY INTAKE CALCULATIONS REASONABLE MAXIMUM EXPOSURE
U.S. GOVERNMENT MOORINGS

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name (1)
Dermal contact	Upland Excavation Worker	18-70	SB-1	CF	Conversion Factor	0.000001	kg/mg	ODEQ	Dermal Exposure
			SB-12	SA	Skin Surface Area	4100	cm^2/event	ODEQ	
			SB-16	AF	Adherance Factor	1	mg/cm^3	ODEQ	
				EF	Exposure Frequency	9	day/year	ODEQ	
				ED	Exposure Duration	1	years	ODEQ	
				BW	Body Weight	70	kg	ODEQ	
				ATn	Averaging Time - Cancer	25550	days	=70 years x 365 day/year: ODEQ	
				ATc	Averaging Time - Non-cancer	365	days	=ED x 365 day/year	
				ABSd	Dermal Absorption Fraction from Soil (chemical-specific)		unitless	RAGS E, Exhibit 3-4	
					Arsenic	0.03	unitless	"	
					Antimony (2)	0.001	unitless	"	
					Benzo(a)pyrene and other PAHs	0.13	unitless	"	
					Aroclors 1254/1242 and other PCBs	0.14	unitless	"	
Incidental Ingestion	Upland Excavation Worker	18-70	SB-1	IR	Soil Ingestion Rate	480	mg/day	ODEQ	Incidental Ingestion
			SB-12	EF	Exposure Frequency	9	day/year	ODEQ	
			SB-16	ED	Exposure Duration	1	years	ODEQ	
				BW	Body Weight	70	kg	ODEQ	
				ATn	Averaging Time - Cancer	25550	days	=70 years x 365 day/year: ODEQ	
				ATc	Averaging Time - Non-cancer	365	days	=ED x 365 day/year	
Inhalation of volatiles Inhalation of Particulates Combined Risk	Upland Excavation Worker	18-70	SB-1	EDw	Exposure Duration	1	years	ODEQ	Inhalation Exposure
			SB-12	ETw	Exposure Time	8	hours	ODEQ	
			SB-16	LT	Lifetime	70	years	ODEQ	
				EFw	Exposure Frequency	9	day/year	ODEQ	
				ATn	Averaging Time - Cancer	25550	days	=70 years x 365 day/year: ODEQ	
				ATc	Averaging Time - Non-cancer	365	days	=ED x 365 day/year	
				VFs	Volatilization Factor		m^3/kg	RAIS Calculated	
				PEFw	Particulate Emisssion Factor		m^3/kg	RAIS Calculated	

TABLE 7-4-2 VALUES USED FOR DAILY INTAKE CALCULATIONS REASONABLE MAXIMUM EXPOSURE
U.S. GOVERNMENT MOORINGS

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name (1)
Inhalation of volatiles	Maintenance Worker	18-70	SB-1	EDw	Exposure Duration	25	years	ODEQ	Inhalation Exposure
Inhalation of Particulates	(Outdoor Worker)		SB-12	ETw	Exposure Time	8	hours	RAIS Default	
Combined Risk	(Occupational Adult)		SB-16	LT	Lifetime	70	years	RAIS Default	
				EFw	Exposure Frequency	250	day/year	ODEQ	
				ATn	Averaging Time - Cancer	25,550	days	RAIS Default	
				ATc	Averaging Time - Non-cancer	9,125	days	=ED x 365 day/year	
				VFs	Volatilization Factor	-	m^3/kg	RAIS Calculated	
				PEFw	Particulate Emisssion Factor	-	m^3/kg	RAIS Calculated	
Inhalation of volatiles	Office Worker	18-70	SB-1	EDw	Exposure Duration	25	years	ODEQ	Inhalation Exposure
Inhalation of Particulates	(Indoor Worker)		SB-12	ETw	Exposure Time	8	hours	RAIS Default	
Combined Risk			SB-16	LT	Lifetime	70	years	RAIS Default	
				EFw	Exposure Frequency	250	day/year	ODEQ	
				ATn	Averaging Time - Cancer	25,550	days	RAIS Default	
				ATc	Averaging Time - Non-cancer	9,125	days	=ED x 365 day/year	
				VFs	Volatilization Factor(3)	-	m^3/kg	RAIS Calculated	
				PEFw	Particulate Emisssion Factor(3)	-	m^3/kg	RAIS Calculated	

Notes
(1) Model as presented in RAIS Contaminated Media (Risk) Calculator
(2) Antimony is assumed to have a ABSd similar to cadmium.
(3) Calculated by RAIS calculator using the below equations and climate data.

Particulate Emission Factor

$$PEF_W = \frac{Q}{C_W} \times \frac{3{,}600}{0.036 \times (1-V) \times (U_m/U_t)^3 \times F(x)}$$

where

$$\frac{Q}{C_W} = A \times \exp\left[\frac{(\ln A_S - B)^2}{C}\right]$$

Salem, OR (1)	City (Climatic Zone) - Selection based on most likely climatic conditions for the site
0.5	A_s (acres)
72.7856	Q/C_{wind} / inverse of the ratio of the geometric mean
0.5	V / fraction of vegetative cover (unitless)
4.69	U_m / mean annual wind speed (m/s)
11.32	U_t / equivalent threshold value
0.194	F(x) / function dependant on U_m/U_t derived using Cowherd et al. (1985) (unitless)

Volatilization Factor

$$VF = \frac{\frac{Q}{C_W} \times (3.14 \times D_A \times T)^{\frac{1}{2}} \times 10^{-4} \left(m^2/cm^2\right)}{2 \times \rho_b \times D_A}$$

where

$$\frac{Q}{C_W} = A \times \exp\left[\frac{(\ln A_S - B)^2}{C}\right] \text{ and}$$

$$D_A = \frac{\left[\left(\theta_a^{10/3} \times D_{ia} \times H' + \theta_w^{10/3} \times D_{iw}\right) / n^2\right]}{\rho_b \times K_d + \theta_w + \theta_a \times H'}$$

Salem, OR (1)	City (Climatic Zone)
0.5	A_s (acres)
72.7856	Q/C_{vol} / inverse of the ratio of the geometric mean
0.006	foc / (fraction organic carbon in soil) g/g
1.5	ρ_b (dry soil bulk density) g/cm^3
0.15	θ_w (water-filled soil porosity) L_{water}/L_{soil}
2.65	ρ_s (soil particle density) g/cm^3
9.5e8	T (exposure interval) s

NOTES:

1. θ_a(air-filled soil porosity) $L_{air}/L_{soil} = n - \theta_w$
2. H' (dimensionless Henry's law constant) - chemical-specific
3. n (total soil porosity) $L_{pore}/L_{soil} = 1-(\rho_b/\rho_s)$
4. K_d (soil-water partition coefficient) L/kg = K_{oc} x f_{oc} (organics) - chemical-specific
5. K_{oc} (soil organic carbon/water partition coefficient) L/kg - chemical specific

TABLE 7-4-3 VALUES USED FOR DAILY INTAKE CALCULATIONS REASONABLE MAXIMUM EXPOSURE

U.S. GOVERNMENT MOORINGS

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Office Worker	18-70	Volatilization of groundwater as a result of potable water use.	EDw	Exposure Duration	25	years	ODEQ	Inhalation Exposure
	Maintenance Worker			ETw	Exposure Time	8	hours	ODEQ	
				LT	Lifetime	70	years	ODEQ	
				EFw	Exposure Frequency	250	day/year	ODEQ	
				ATn	Averaging Time - Cancer	25,550	days	=70 years x 365 day/year: ODEQ	
				ATc	Averaging Time - Non-cancer	9,125	days	=ED x 365 day/year	
				VFs	Volatilization Factor		m^3/kg	RAIS Calculated	
				PEFw	Particulate Emisssion Factor		m^3/kg	RAIS Calculated	
Ingestion	Office Worker	18-70	Ingestion of water used as drinking water	IRW	Drinking water ingestion rate	2.3	liter/day	ODEQ	Resident Exposure to Tap Water Ingestion
	Maintenance Worker			EF	Exposure Frequency	250	day/year	ODEQ	
				ED	Exposure Duration	25	years	ODEQ	
				BW	Body Weight	70	kg	ODEQ	
				ATn	Averaging Time - Cancer	25,550	days	=70 years x 365 day/year: ODEQ	
				ATc	Averaging Time - Non-cancer	9,125	days	=ED x 365 day/year	
Dermal contact	Office Worker	18-70	Dermal contact	CF	Conversion Factor	0.000001	kg/mg	ODEQ	Dermal Exposure
	Maintenance Worker		GW-2	SA	Skin Surface Area	4,100	cm^2/event	ODEQ	
			GW-11	AF	Adherance Factor	0.08	mg/cm^3	ODEQ	
			GW-16	EF	Exposure Frequency	250	day/year	ODEQ	
			GW-20	ED	Exposure Duration	25	years	ODEQ	
				BW	Body Weight	70	kg	ODEQ	
				ATn	Averaging Time - Cancer	25,550	days	=70 years x 365 day/year: ODEQ	
				ATc	Averaging Time - Non-cancer	9,125	days	=ED x 365 day/year	
				ETa	Exposure time per event	0.25	hr/event	ODEQ	
				Kd	Permeability Coefficient		cm/hr	EPA 1992 (Dermal Exposure Assessment U.S. EPA /600/18-9-91)	
					Inorganics				
					Aluminum	1.00E-03			
					Arsenic (T and D)	1.00E-03			
					Cadmium	1.00E-03			
					Chromium	1.00E-03			
					Cyanide	1.00E-03			
					Manganese	1.00E-03			
					Mercury	1.00E-03			
					Nickel (T and D)	2.00E-04			
					Zinc	6.00E-04			
					VOCs				
					Benzene	1.50E-02			
					Chloroform	6.80E-03			
					PCE	3.30E-02			
					TCE	1.20E-02			
					PAHs				
					Benzo(a)anthracene	4.70E-01			
					Benzo(a)pyrene	7.00E-01			
					Benzo(b)fluoranthene	7.00E-01			
					Dibenz(a,h)anthracene	1.50E+00			
					Fluorene	7.00E-01			
					Indeno(1,2,3-cd)pyrene	1.00E+00			
					Naphthalene	4.70E-02			

TABLE 7-4-4 VALUES USED FOR DAILY INTAKE CALCULATIONS CENTRAL TENDANCY EXPOSURE
U.S. GOVERNMENT MOORINGS

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Office Worker	18-70	Volatilization of groundwater as a result of potable water use.	EDw	Exposure Duration	6	years	ODEQ	Inhalation Exposure
	Maintenance Worker			ETw	Exposure Time	8	hours	ODEQ	
				LT	Lifetime	70	years	ODEQ	
				EFw	Exposure Frequency	250	day/year	ODEQ	
				ATn	Averaging Time - Cancer	25,550	days	=70 years x 365 day/year: ODEQ	
				ATc	Averaging Time - Non-cancer	2,190	days	=ED x 365 day/year	
				VFs	Volatilization Factor		m^3/kg	RAIS Calculated	
				PEFw	Particulate Emisssion Factor		m^3/kg	RAIS Calculated	
Ingestion	Office Worker	18-70	Ingestion of water used as drinking water	IRW	Drinking water ingestion rate	1.4	liter/day	ODEQ	Resident Exposure to Tap Water Ingestion
	Maintenance Worker			EF	Exposure Frequency	250	day/year	ODEQ	
				ED	Exposure Duration	6	years	ODEQ	
				BW	Body Weight	70	kg	ODEQ	
				ATn	Averaging Time - Cancer	25,550	days	=70 years x 365 day/year: ODEQ	
				ATc	Averaging Time - Non-cancer	2,190	days	=ED x 365 day/year	
Dermal contact	Office Worker	18-70	Dermal contact	CF	Conversion Factor	0.000001	kg/mg	ODEQ	Dermal Exposure
	Maintenance Worker		GW-2	SA	Skin Surface Area	3,200	cm2/event	ODEQ	
			GW-11	AF	Adherance Factor	0.08	mg/cm3	ODEQ	
			GW-16	EF	Exposure Frequency	250	day/year	ODEQ	
			GW-20	ED	Exposure Duration	6	years	ODEQ	
				BW	Body Weight	70	kg	ODEQ	
				ATn	Averaging Time - Cancer	25,550	days	=70 years x 365 day/year: ODEQ	
				ATc	Averaging Time - Non-cancer	2,190	days	=ED x 365 day/year	
				ETa	Exposure time per event	0.25	hr/event	ODEQ	
				Kd	Permeability Coefficient		cm/hr		
					Inorganics				
					Aluminum	1.00E-03			
					Arsenic (T and D)	1.00E-03			
					Cadmium	1.00E-03			
					Chromium	1.00E-03			
					Cyanide	1.00E-03			
					Manganese	1.00E-03			
					Mercury	1.00E-03			
					Nickel (T and D)	2.00E-04			
					Zinc	6.00E-04			
					VOCs				
					Benzene	1.50E-02			
					Chloroform	6.80E-03			
					PCE	3.30E-02			
					TCE	1.20E-02			
					PAHs				
					Benzo(a)anthracene	4.70E-01			
					Benzo(a)pyrene	7.00E-01			
					Benzo(b)fluoranthene	7.00E-01			
					Dibenz(a,h)anthracene	1.50E+00			
					Fluorene	7.00E-01			
					Indeno(1,2,3-cd)pyrene	1.00E+00			
					Naphthalene	4.70E-02			

7.1.6 Toxicity Values

Toxicity information necessary to calculate the cancer risks and non-cancer hazards was compiled based on the USEPA approved hierarchy of human health toxicity values (USEPA 2003):

- Tier 1 – USEPA's Integrated Risk Information System (IRIS)
- Tier 2 – USEPA's Provisional Peer Reviewed Toxicity Values (PPRVTs)
- Tier 3 – Other Toxicity Values – possible sources include:
    - The California Environmental Protection Agency (Cal USEPA)
    - The Agency for Toxic Substances and Disease Registry (ATSDR)
    - Region 10 toxicity information for trichloroethylene.

The toxicity information used in the HHRA is listed by COPC and include source, primary target organs for the non-cancer values, and weight of evidence factors for cancer values. The toxicity values presented are:

- Reference dose for chronic oral exposure (RfD) (Table 7-5-1, page 7-44).The efficiency of dermal absorption needed to convert the oral RfD to a dermal RfD is also presented.
- Reference concentration for chronic inhalation exposure (RfC) (Table 7-5-2, page 7-45).
- Cancer slope factor for chronic oral exposure (CSF) (Table 7-6-1, page 7-46). The efficiency of dermal absorption needed to convert the oral CSF to a dermal CSF is also presented.
    - CSFs for PAHs are based on a relative potency to benzo(a)pyrene in accordance with USEPA 600/R93/089 "Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons" (USEPA 1993).
- Cancer inhalation unit risks for chronic inhalation exposure (IUR) (Table 7-6-2, page 7-47).

RfDs and RfCs are estimates (with uncertainty spanning perhaps an order of magnitude or greater) of the daily exposure that is likely to be without appreciable risk of deleterious effects in a person's lifetime. CSFs and IUR are considered to be plausible upper bound estimates of the cancer potency of a chemical.

For any toxicity value not available, an "NA" is used as a placeholder. An "NA" does not indicate the chemical carries no human health risk or hazard. Human health risks from COPCs without related cancer or toxicity information cannot be quantified at this time.

7.1.6.1 Uncertainty Related to Toxicity Information

For the Moorings risk assessment, CSF and IUR values were used to estimate cancer risk; RfDs and RfCs were used to estimate non-cancer health impacts. These toxicity values are health protective values that are unlikely to underestimate the potential for cancer risks and adverse non-cancer health impacts. The oral cancer slope factors and inhalation unit risk values are developed assuming daily exposure over a lifetime. The RfDs and RfC are developed assuming daily exposure from 7 years to a lifetime. For the Moorings' maintenance

Worker exposed to surface soil and the Upland Excavation Worker exposed to subsurface soil, exposures frequencies are 9 days per year rather than every day; and, for the Upland Excavation Worker, exposure duration is only 1 year. Therefore, the use of chronic toxicity values in the Moorings risk assessment may overestimate the potential for non-cancer health impacts, especially for the Upland Excavation Worker. Subchronic RfDs and RfCs, which are intended to be used for exposures of 2 weeks to 7 years, would be more appropriate for the Upland Excavation Worker, but subchronic values were largely unavailable for the COPCs identified at the Moorings.

Also, no RfD was available for Aroclor® 1248, so the value for Aroclor® 1254 was used as a reference dose in quantifying risks to human health. This introduces uncertainty into the results as the value is not specific to the chemical kinetics of Aroclor® 1248.

TABLE 7-5-1 NON-CANCER TOXICITY DATA -- ORAL/DERMAL
U.S. GOVERNMENT MOORINGS

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD (1)		Oral Absorption Efficiency for Dermal (2)	Absorbed RfD for Dermal (3)		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfD:Target Organ(s)	
		Value	Units		Value	Units			Source(s)	Date(s) (MM/DD/YYYY)
Inorganics										
Aluminum	Chronic	1.00E+00	mg/kg-day	1	1.00E+00	mg/kg-day	Central Nervous System	100	PPRTV	07/02/2009
Antimony	Chronic	4.00E-04	mg/kg-day	0.15	6.00E-05	mg/kg-day	Gastrointestinal	1000	IRIS	07/02/2009
Arsenic	Chronic	3.00E-04	mg/kg-day	1	3.00E-04	mg/kg-day	Skin/Central Nervous System/Cardiovascular	3	IRIS	07/02/2009
Cadmium -Water	Chronic	5.00E-04	mg/kg-day	0.05	2.50E-05	mg/kg-day	Urinary Tract	10	IRIS	07/02/2009
Cadmium -Diet	Chronic	1.00E-03	mg/kg-day	0.05	5.00E-05	mg/kg-day	Urinary Tract	10	IRIS	07/20/2009
Chromium (4)	Chronic	1.50E+00	mg/kg-day	0.013	1.95E-02	mg/kg-day	No observed effects	1000	IRIS	07/02/2009
Cyanide	Chronic	2.00E-02	mg/kg-day	1	2.00E-02	mg/kg-day	No observed effects	5000	IRIS	07/02/2009
Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese - Water	Chronic	2.40E-02	mg/kg-day	1	2.40E-02	mg/kg-day	Central Nervous System	1	IRIS	07/20/2009
Manganese - Diet	Chronic	1.40E-01	mg/kg-day	0.04	5.60E-03	mg/kg-day	Central Nervous System	1	IRIS	07/02/2009
Mercury (6)	Chronic	3.00E-04	mg/kg-day	1	3.00E-04	mg/kg-day	Central Nervous System	1000	IRIS	07/20/2009
Nickel (5)	Chronic	2.00E-02	mg/kg-day	0.04	8.00E-04	mg/kg-day	Body/Organ Weights	300	IRIS	07/02/2009
Zinc	Chronic	3.00E-01	mg/kg-day	1	3.00E-01	mg/kg-day	Blood	3	IRIS	07/02/2009
VOCs										
Benzene	Chronic	4.00E-03	mg/kg-day	1	4.00E-03	mg/kg-day	Blood	300	IRIS	07/02/2009
Chloroform	Chronic	1.00E-02	mg/kg-day	1	1.00E-02	mg/kg-day	Liver	100	IRIS	07/02/2009
Tetrachloroethylene (PCE)	Chronic	1.00E-02	mg/kg-day	1	1.00E-02	mg/kg-day	Liver	1000	IRIS	07/02/2009
Trichloroethylene(TCE)	NA	NA	NA	1	NA	NA	NA	NA	NA	NA
PCBs										
Aroclor 1248 (7)	Chronic	2.00E-05	mg/kg-day	1	1.00E-02	mg/kg-day	NA	300	IRIS	08/02/2009
PAHs										
Naphthalene	Chronic	2.00E-02	mg/kg-day	1	2.00E-02	mg/kg-day	Blood	3000	IRIS	07/02/2009
Fluorene	Chronic	4.00E-02	mg/kg-day	1	4.00E-02	mg/kg-day	Blood	3000	IRIS	07/02/2009
Benzo(a)anthracene	NA	NA	NA	1	NA	NA	NA	NA	NA	NA
Benzo(b)fluoranthene	NA	NA	NA	1	NA	NA	NA	NA	NA	NA
Benzo(a)pyrene	NA	NA	NA	1	NA	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	NA	NA	NA	1	NA	NA	NA	NA	NA	NA
Dibenz(a,h)anthracene	NA	NA	NA	1	NA	NA	NA	NA	NA	NA

Notes:
(1) Oral RfD taken from Region 6 Regional Screening tables available at http://www.epa.gov/Region6/6pd/rcra_c/pd-n/screen.htm Accessed 2 July 2009
(2) Source: Risk Assessment Guidance for Superfund. Volume 1: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim. Section 4.2 and Exhibit 4-1.
(3) Absorbed RfD = Oral RfD * Oral Absorption Efficiency
(4) Oral RfD value for Chromium III, Oral Absorption Efficiency from chromium (III)
(5) Nickel as nickel soluble salts
(6) Based on mercuric sulfide
(7) Toxicity values are Aroclor 1254 values.
Definitions:
PPRTV = Provisional Peer Reviewed Toxicity Values
IRIS = Integrated Risk Information Systems
NA = Toxicity value not available

TABLE 7-5-2 NON-CANCER TOXICITY DATA -- INHALATION
U.S. GOVERNMENT MOORINGS

Chemical of Potential Concern	Chronic/ Subchronic	Inhalation RfC (1)		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfC : Target Organ(s)	
		Value	Units			Source(s)	Date(s) (MM/DD/YYYY)
Inorganics							
Aluminum	Chronic	5.00E-03	mg/m^3	Central Nervous System	300	PPRTV	07/20/2009
Antimony	NA	NA	NA	NA	NA	NA	NA
Arsenic	Chronic	1.50E-05	mg/m^3	Skin		CAL EPA: IRIS	07/20/2009
Cadmium - Diet	Chronic	1.00E-05	mg/m^3	Urinary Tract	10	ATDSR: IRIS	07/20/2009
Cadmium - Water	Chronic	1.00E-05	mg/m^3	Urinary Tract	10	ATDSR: IRIS	07/20/2009
Chromium (4)	Chronic	1.00E-04	mg/m^3	NA	300	IRIS	08/03/2009
Cyanide	NA	NA	NA	NA	NA	NA	NA
Lead	NA	NA	NA	NA	NA	NA	NA
Manganese	Chronic	5.00E-05	mg/m^3	Central Nervous System	1000	IRIS	07/20/2009
Mercury	Chronic	3.00E-04	mg/m^3	Central Nervous System	30	IRIS	07/20/2009
Nickel (3)	Chronic	9.00E-05	mg/m^3	Body/Organ Weights	NA	ATDSR	07/20/2009
Zinc	NA	NA	NA	NA	NA	NA	NA
VOCs							
Benzene	Chronic	3.00E-02	mg/m^3	Blood	300	IRIS	07/20/2009
Chloroform	Chronic	9.80E-02	mg/m^3	Liver	100	ATDSR	07/20/2009
Tetrachloroethylene (PCE)	Chronic	2.70E-01	mg/m^3	Liver	NA	CAL EPA: IRIS	07/20/2009
Trichloroethylene(TCE)	NA	NA	NA	NA	NA	NA	NA
PCBs							
Aroclor 1248	NA	NA	NA	NA	NA	NA	NA
PAHs							
Naphthalene	Chronic	3.00E-03	mg/m^3	Nasal Effects	3000	IRIS	07/20/2009
Fluorene	NA	NA	NA	NA	NA	NA	NA
Benzo(a)anthracene	NA	NA	NA	NA	NA	NA	NA
Benzo(b)fluoranthene	NA	NA	NA	NA	NA	NA	NA
Benzo(a)pyrene	NA	NA	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	NA	NA	NA	NA	NA	NA	NA
Dibenz(a,h)anthracene	NA	NA	NA	NA	NA	NA	NA

Notes:
(1) RfC taken from Region 6 Regional Screening tables available at http://www.epa.gov/Region6/6pd/rcra_c/pd-n/screen.htm Accessed 2 July 2009
(4) RfC value for Chromium III
(3) Nickel as nickel soluble salts
(4) Based on chromium (IV) values
Definitions:
PPRTV = Provisional Peer Reviewed Toxicity Values
IRIS = Integrated Risk Information Systems
NA = Toxicity value not available
CAL EPA = California Environmental Protection Agency
ATDSR = Agency for Toxic Substance and Disease Registry

TABLE 7-6-1 CANCER TOXICITY DATA -- ORAL/DERMAL
U.S. GOVERNMENT MOORINGS

Chemical of Potential Concern	Oral Cancer Slope Factor (1)		Oral Absorption Efficiency for Dermal (2)	Absorbed Cancer Slope Factor for Dermal		Weight of Evidence/ Cancer Guideline Description (3)	Oral CSF	
	Value	Units		Value	Units		Source(s)	Date(s)
Inorganics								
Aluminum	NA	NA	1	NA	NA	D	NA	NA
Antimony	NA	NA	0.15	NA	NA	NA	NA	NA
Arsenic	1.50E+00	$(mg\text{-}kg/day)^{-1}$	1	1.50E+00	$(mg\text{-}kg/day)^{-1}$	A	IRIS	05/27/2009
Cadmium	NA	NA	0.05	NA	NA	B1	IRIS	05/27/2009
Chromium	NA	NA	0.25	NA	NA	D	IRIS	05/27/2009
Cyanide	NA	NA	1	NA	NA	D	IRIS	05/27/2009
Lead	NA	NA	NA	NA	NA	D	IRIS	05/27/2009
Manganese	NA	NA	0.04	NA	NA	D	IRIS	05/27/2009
Mercury	NA	NA	1	NA	NA	D	IRIS	05/27/2009
Nickel	NA	NA	0.04	NA	NA	NA	NA	NA
Zinc	NA	NA	1	NA	NA	D	IRIS	05/27/2009
VOCs								
Benzene	5.50E-02	$(mg\text{-}kg/day)^{-1}$	1	5.50E-02	$(mg\text{-}kg/day)^{-1}$	A	IRIS	05/28/2009
Chloroform	6.10E-02	$(mg\text{-}kg/day)^{-1}$	1	6.10E-02	$(mg\text{-}kg/day)^{-1}$	A	IRIS	02/20/2009
Tetrachloroethylene (PCE)	5.40E-01	$(mg\text{-}kg/day)^{-1}$	1	5.40E-01	$(mg\text{-}kg/day)^{-1}$	NA	CAL EPA	02/20/2009
Trichlorethylene(TCE)	8.90E-02	$(mg\text{-}kg/day)^{-1}$	1	8.90E-02	$(mg\text{-}kg/day)^{-1}$	NA	Region 10 (4)	02/20/2009
PCBs								
Aroclor 1248	2.00E+00	$(mg\text{-}kg/day)^{-1}$	1	2.00E+00	$(mg\text{-}kg/day)^{-1}$	NA	Listed in Region 6 Table as IRIS (5)	07/02/2009
PAHs								
Napthalene	NA	NA	1	NA	NA	C	IRIS	05/28/2009
Fluorene	NA	NA	1	NA	NA	D	IRIS	05/28/2009
Benzo(a)anthracene (6)	7.30E-01	$(mg\text{-}kg/day)^{-1}$	1	7.30E-01	$(mg\text{-}kg/day)^{-1}$	B2	Other	05/28/2009
Benzo(b)fluoranthene (7)	7.30E-01	$(mg\text{-}kg/day)^{-1}$	1	7.30E-01	$(mg\text{-}kg/day)^{-1}$	B2	Other	05/28/2009
Benzo(a)pyrene	7.30E+00	$(mg\text{-}kg/day)^{-1}$	1	7.30E+00	$(mg\text{-}kg/day)^{-1}$	B2	IRIS	05/28/2009
Indeno(1,2,3-cd)pyrene (8)	7.30E-01	$(mg\text{-}kg/day)^{-1}$	1	7.30E-01	$(mg\text{-}kg/day)^{-1}$	B2	Other	05/28/2009
Dibenz(a,h)anthracene (9)	7.30E+00	$(mg\text{-}kg/day)^{-1}$	1	7.30E+00	$(mg\text{-}kg/day)^{-1}$	B2	Other	05/28/2009

Notes:
(1) Oral Cancer Slope Factor taken from Region 6 Regional Screening tables available at http://www.epa.gov/Region6/6pd/rcra_c/pd-n/screen.htm, accessed 2 July 2009
Exhibit 4-1.
(3) From IRIS with the following definitions:
A = Human carcinogen (sufficient evidence of carcinogenicity in humans)
B1 = Probable human carcinogen, limited evidence of carcinogenicity in humans.
B2 = Probable human carcinogen, sufficient evidence of carconogenicity in animals with inadequate or lack of evidence in humans
D = Not classifiable as a human carcinogen (inadequate or no evidence)
trichloroethylene in human health risk assessments.
(5) Region 6 Regional Screening Tables lists the source for the cancer slope factor for Aroclor 1248 to be IRIS, however the IRIS website does not list assessments for Aroclor 1248.
(6) Benzo(a)anthracene Relative Potency = 0.1 Source USEPA 1993.
(7) Benzo(b)fluoranthene Relative Potency = 0.1 Source USEPA 1993.
(8) Indeno(1,2,3-c,d)pyrene Relative Potency = 0.1 Source USEPA 1993.
(9) Dibenz(a,h)anthracene Relative Potency = 1.0 Source USEPA 1993.
Definitions:
PPRTV = Provisional Peer Reviewed Toxicity Values
IRIS = Integrated Risk Information Systems
NA = Toxicity value not available
Other = Toxicity calculated based on relative potency to benzo(a)pyrene and information listed in IRIS.
CAL EPA = California Environmental Protection Agency (Tier 3 source)

TABLE 7-6-2 CANCER TOXICITY DATA -- INHALATION
U.S. GOVERNMENT MOORINGS

Chemical of Potential Concern	Unit Risk (1)		Weight of Evidence/ Cancer Guideline Description (2)	Unit Risk : Inhalation CSF	
	Value	Units		Source(s)	Date(s) (MM/DD/YYYY)
Inorganics					
Aluminum	NA	NA	D	IRIS	07/20/2009
Antimony	NA	NA	NA	NA	NA
Arsenic	4.30E-03	$(\mu g/m3)^{-1}$	A	IRIS	07/20/2009
Cadmium	1.80E-03	$(\mu g/m3)^{-1}$	B1	IRIS	07/20/2009
Chromium (10)	1.20E-02	$(\mu g/m3)^{-1}$	D	IRIS	07/20/2009
Cyanide	NA	NA	D	IRIS	07/20/2009
Lead	NA	NA	NA	NA	NA
Manganese	NA	NA	D	IRIS	07/20/2009
Mercury	NA	NA	NA	NA	NA
Nickel (6)	2.60E-04	$(\mu g/m3)^{-1}$	NA	CAL EPA	07/20/2009
Zinc	NA	NA	D	IRIS	07/20/2009
VOCs					
Benzene	7.80E-06	$(\mu g/m3)^{-1}$	A	IRIS	07/20/2009
Chloroform	2.30E-05	$(\mu g/m3)^{-1}$	B2	IRIS	07/20/2009
Tetrachloroethylene (PCE)	5.90E-06	$(\mu g/m3)^{-1}$	NA	CAL EPA	07/20/2009
Trichloroethylene(TCE)	2.00E-05	$(\mu g/m3)^{-1}$	NA	Region 10 (4)	07/20/2009
PCBs					
Aroclor 1248	5.70E-04	$(\mu g/m3)^{-1}$	NA	Listed in Region 6 Table as IRIS (5)	07/20/2009
PAHs					
Naphthalene	3.40E-05	$(\mu g/m3)^{-1}$	C	CAL EPA	07/20/2009
Fluorine	NA	NA	D	IRIS	07/20/2009
Benzo(a)anthracene (6)	1.10E-04	$(\mu g/m3)^{-1}$	B2	Other	07/20/2009
Benzo(b)fluoranthene (7)	1.10E-04	$(\mu g/m3)^{-1}$	B2	Other	07/20/2009
Benzo(a)pyrene	1.10E-03	$(\mu g/m3)^{-1}$	B2	IRIS	07/20/2009
Indeno(1,2,3-cd)pyrene (8)	1.10E-04	$(\mu g/m3)^{-1}$	B2	Other	07/20/2009
Dibenz(a,h)anthracene (9)	1.10E-03	$(\mu g/m3)^{-1}$	B2	Other	07/20/2009

Notes:
(1) Unit Risk taken from Region 6 Regional Screening tables available at http://www.epa.gov/Region6/6pd/rcra_c/pd-n/screen.htm, accessed 2 July 2009
(2) From IRIS with the following definitions:
A = Human carcinogen (sufficient evidence of carcinogenicity in humans)
B1 = Probable human carcinogen, limited evidence of carcinogenicity in humans.
B2 = Probable human carcinogen, sufficient evidence of carconogenicity in animals with inadequate or lack of evidence in humans
D = Not classifiable as a human carcinogen (inadequate or no evidence)
(3) Nickel as nickel soluble salts
(4) EPA 2008. Letter to Jeff Christensen, Cleanup and emergency Response Manager. 22 October 2008. Concerning Office of Environmental Assessment recommendations for evaluating trichloroethylene in human health risk assessments.
(5) Region 6 Regional Screening Tables lists the source for the cancer slope factor for Aroclor 1248 to be IRIS, however the IRIS website does not list assessments for Aroclor 1248.
(6) Benzo(a)anthracene Relative Potency = 0.1 Source USEPA 1993.
(7) Benzo(b)fluoranthene Relative Potency = 0.1 Source USEPA 1993.
(8) Indeno(1,2,3-c,d)pyrene Relative Potency = 0.1 Source USEPA 1993.
(9) Dibenz(a,h)anthracene Relative Potency = 1.0 Source USEPA 1993.
(10) IUR from chromium (VI)

Definitions:
PPRTV = Provisional Peer Reviewed Toxicity Values
IRIS = Integrated Risk Information Systems
NA = Not Applicable
Other = Toxicity calculated based on relative potency to benzo(a)pyrene and information listed in IRIS.
CAL EPA = California Environmental Protection Agency (Tier 3 source)

7.1.7 Calculation of Chemical Cancer Risks and Non-Cancer Hazards

The calculation of cancer risks and non-cancer hazards allows for quantification of the level of concern for human health. Cancer risks and non-cancer hazards are calculated using the daily intake of the COPC and the toxicity information. After cancer risks and non-cancer hazards are calculated, they are summed to create the cumulative cancer risk and non-cancer hazard indices for each exposure route and exposure point.

For non-cancer health effects, it is assumed that there is an exposure threshold below which adverse effects are unlikely to occur. The evaluation of non-cancer health impacts involves a comparison of the average daily intake of contaminants from soil or groundwater with the RfDs and RfCs discussed in Section 7.1.6 (page 7-42). Potential non-cancer health impacts for a specific chemical are expressed as a HQ, which is the ratio of the calculated exposure or intake (in mg/kg/day or mg/cm^3) (Section 7.1.4, page 7-21) to the RfD or RfC, respectively, for that chemical (see equations below). If the exposure level (intake) exceeds this threshold (i.e., if intake/RfD exceeds unity), there may be concern for potential non-cancer effects. As a rule, the greater the value of the HQ above unity, the greater the level of concern. However, it is important to emphasize that the level of concern does not increase linearly as the RfD is approached or exceeded because RfDs do not have equal accuracy or precision and are not based on the same severity of toxic effects.

For carcinogenic effects, USEPA assumes that a threshold dose for effects does not exist unless data are available to show otherwise. For chemicals for which a threshold has not been shown to exist, including those evaluated in the Moorings' HHRA, it is assumed that any dose can contribute to cancer risks; that is, the risk of cancer increases proportionally to exposure. For non-threshold carcinogens, risks are estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to the potential carcinogen (i.e., incremental or excess individual lifetime cancer risk). These risks are calculated by multiplying the estimated intake, in µg/kg/day or µg/cm^3, by the cancer slope factor or the inhalation unit risk factor, respectively (see equations below). The cancer risk calculated for a chemical using this method represents the upper-bound incremental cancer risk that an individual has of developing cancer in their lifetime due to exposure to that chemical.

Non-cancer hazard, dermal contact and ingestion (incidental or intentional)	$HQ = \frac{Intake}{R_fD}$	Where: Intake = Exposure expressed as mass of a substance contacted per unit body weight per unit time RfD = chronic reference dose from Table 7-5-1 (page 7-44) (either absorbed or ingested depending on the units of the Intake) RfC = chronic inhalation exposure from Table 7-5-2 (page 7-45).
Non-cancer hazard, inhalation	$HQ = \frac{Intake}{R_fC}$	
Cancer risk, dermal contact and ingestion (incidental or intentional	$Risk = (Intake) \times (CSF)$	Intake = Exposure expressed as mass of a substance contacted per unit body weight per unit time CSF= slope factor from Table 7-6-1 (page 7-46) (either absorbed or ingested depending on the units of the intake) IUR = inhalation unit risk from Table 7-6-2 (page 7-47).
Cancer risk, inhalation	$Risk = (Intake) x (IUR)$	

Cancer risks and non-cancer hazards are calculated for every COPC in each exposure route (dermal contact, incidental ingestion, and inhalation) for each exposure point. Estimating risk or hazard potential by considering one chemical at a time might significantly underestimate the risks associated with simultaneous exposures to several substances. Therefore, USEPA has developed guidance that can be used to assess the overall potential for cancer and non-cancer effects posed by multiple chemicals, as well the effects from simultaneous exposures to several chemicals from a variety of sources by more than one exposure pathway.

For carcinogens, cancer risks are summed by exposure route to calculate the cumulative cancer risk for that exposure route. This summing approach for carcinogens assumes independence of action by the carcinogens in the mixture, that is, assumes that there are no synergistic or antagonistic interactions among the carcinogens.

For non-cancer effects, USEPA recommends that a Hazard Index (HI) be calculated by summing the HQs for each chemical in a given exposure route. If the HI is greater than unity as a consequence of summing several hazard quotients, the HQ values for chemicals with similar target organs or mechanisms of action (health end[points) should be summed to calculate a HI specific for each endpoint. As with HQs, as a rule, the greater the value of the HI above unity, the greater the level of concern. This summing approach assumes that simultaneous sub-threshold exposures to several chemicals could result in an adverse health effect. It also assumes that the magnitude of the adverse effect will be proportional to the sum of the ratios of the sub-threshold exposures to acceptable exposures.

Cancer risks and HIs are also calculated for multiple exposure routes for a given exposure point and receptor (e.g., dermal exposure, water consumption and inhalation of volatiles from groundwater for workers) and across exposure media (e.g., exposure to groundwater and soil) if such concurrent exposures are likely to occur.

The USEPA National Contingency Plan (40 CFR 300) states that “for known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6} using information on the relationship between dose and response. The 10^{-6} risk level shall be used as the point of departure for determining remediation goals for alternatives when ARARs are not available or are not sufficiently protective because of the presence of multiple contaminants at a site or multiple pathways of exposure...” and for non-cancer impacts, “acceptable exposure levels shall represent concentration levels to which the human population, including sensitive subgroups, may be exposed without adverse effect during a lifetime or part of a lifetime, incorporating an adequate margin of safety” (i.e., below a HI of 1). The USEPA OSWER DIRECTIVE 9355.0-30, Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions states that action generally is not warranted based on reasonable maximum exposure for both current and future land use if the cumulative cancer risk is less than 10-4 and the non-carcinogenic hazard quotient is less than 1 unless there are adverse environmental impacts. However, if MCLs or non-zero MCL goals are exceeded, action generally is warranted (USEPA 2002).

Oregon Hazardous Substance Remedial Action Rules (OAR 340-122-0040), which is a potential ARAR for the Moorings’ facility, sets standards for degree of cleanup required, including for oil and other petroleum products/wastes. This rule establishes an acceptable cancer risk level for human health at $1x10^{-6}$ for individual chemicals, $1x10^{-5}$ for multiple chemicals, and a HQ and HI of 1 for non-cancer health impacts for individual and multiple chemicals, respectively.

The results of the Moorings' risk characterization are discussed in relation to these regulations and guidance.

7.1.7.1 Characterization of Risk and Hazards from Exposure to Surface Soils

At the Moorings, the Maintenance Worker could be exposed to surface soils and COPCs contaminating that soil may pose health risks to the worker. Table 7-7-1 (page 7-55) shows the calculated RME cancer risk and non-cancer hazard calculated for both the Runoff exposure point and the Fence Line exposure points (Figure 7-1, page 7-25). The estimation of risks and hazards for the Maintenance Worker exposed to surface soil is health protective for the reason discussed below:

- Intake is calculated by assuming the Maintenance Worker in this scenario working outside along the fence line doing repairs or exposed to Run-off soils for nine (9) days every year, which based on interviews is much more than the actual work practices currently in use at the Moorings. Additional parameters used for calculating the intake are listed in Table 7.4.1 (page 7-35).

- The EPC used for the calculation of the intake in RAIS is shown in Table 7-3-1 (page 7-27). The same EPC is used for each exposure route at each exposure point, including inhalation. RAIS calculates the intake of COPCs in air as a function of the concentration in the soil.

Based on the results shown in Table 7-7-1 (page 7-55) no HQs or HIs were identified above 1. The estimated non-cancer HI is 7.2×10^{-5} for exposure to the Fence Line soils and 1.2×10^{-2} for exposure to the Run-off soils. Estimated cumulative cancer risks are 4.3×10^{-6} for exposure to the Fence Line soils and 1.6×10^{-6} for exposure to the Runoff soils. These are both within USEPA's acceptable excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6} and below the ODEQ's acceptable risk level of 1×10^{-5} for multiple chemicals.

7.1.7.2 Summary of Human Health Risks from Shallow Soil

At the Moorings, the Upland Excavation Worker could be exposed to COPC contaminated shallow soils through dermal contact, incidental ingestion, and inhalation. Table 7-7-2 (page 7-57) shows the calculated RME cancer risks and non-cancer hazard quotients/indices for three locations in the Industrial Area (SB-01, SB-12, and SB-16) and each MIS MU (Figure 7-1, page 7-25). Office Workers and Maintenance Workers that spend time inside are also receptors for potential volatiles and particulate matter generation from shallow soil contamination into the building through the inhalation exposure route. Cancer risks and non-cancer hazard quotients are calculated and summarized and if below levels of concern, the exposure to the shallow soils or contaminated air is not indicative of a health concerns due to the exposure. The risks calculated for the Office and Maintenance Worker based on inhalation are exceptionally conservative, especially by including particulate exposure, considering the site is currently paved around occupied buildings and as the RME exposure is being used in calculations. Some assumptions used during the intake values for the calculation of risks are:

- The Upland Excavation Worker exposure to shallow soil is considered to be working in a trench nine (9) days during one year of their lifetime. Based on interviews, this is much more than the actual work practices currently in use at the Moorings. Additional parameters used for calculating the intake are listed in Table 7-4-2 (page 7-37).

- The EPC used for the calculation of the intake is shown in Table 7-3-2 (page 7-28). The same EPC is used for each exposure route at each exposure point, including inhalation. RAIS calculates the intake in air as a result of the concentration in the soil.

For each exposure point, risks are summed by exposure route and the exposure point. Based on the calculation results, no cancer risks are above $1x10^{-6}$ for individual or summed chemicals and there are no HQs or HIs above 1 for dermal contact, ingestion, or inhalation in either the three boring samples selected to indicate EPCs in the Industrial Area or the MIS MUs soils. The highest cumulative cancer risk for the Upland Excavation Worker is $1.4x10^{-7}$ from exposure at SB-16. The highest cumulative HI is 0.29 occurring at SB-12.

Human health risks associated with lead concentrations are calculated only for shallow soils using the methodology presented in "Calculations of Blood Lead Concentrations USEPA Technical Review Workgroup for Lead, Adult Lead Committee" from USEPA Technical Review Workgroup for Lead, Adult Lead Committee, 1996 (USEPA 1996). Human health risk from lead is quantified by evaluating the blood lead levels (PbB) for the construction workers exposed to shallow soils due to incidental ingestion. PbB levels are reported in micrograms per deciliter of blood. The PbB level of the construction worker is estimated using equations published in USEPA Adult Lead Model, 1996. The main exposure pathway of concern in the published guidance (USEPA 1996) is the risk to women of childbearing age due to risks to the fetus. It is estimated that if the lead exposure level is low enough to not significantly affect the fetus then it is protective of adult human health. The highest concentration of lead at the Moorings was sampled in SB-12 (Figure 7.1, page 7-25) of 1,500,000 µg/kg and the exposed worker is most likely to be the Upland Excavation Worker.

The following equations from USEPA 1996 guidance are used to quantify human health risks from lead:

For adult blood lead levels (PbB_{Adult}):

$$PbB_{Adult} = \frac{PbS \times BKSF \times IR_S \times AF_S \times EF_S}{AT_S} + PbB_O \qquad \text{(Equation 7.1)}$$

Fetal blood lead levels ($PbB_{fetal0.95}$) are estimated with a 95% confidence level from the corresponding adult blood lead levels:

$$PbB_{fetal0.95} = PbB_{Adult}(GSD_i^{1.645}) \times R_{fetal/maternal} \qquad \text{(Equation 7.2)}$$

Where:		For the Moorings the following are used:	
PbB_{Adult} =	Adult blood lead levels, µg/dL(1)	PbB_{Adult} =	Calculation result
$PbB_{fetal,0.95}$ =	Estimated fetal blood levels at a 95% confidence level, µg/dL	$PbB_{fetal,0.95}$ =	Calculation result
PbS =	Soil lead exposure concentration, µg/g	PbS =	1,500 µg/g (in SB-12, equivalent to 1,550,000 µg/kg)
BKSF =	Biokinetic Slope Factor, µg/dL per µg/day	BKSF =	0.4 µg/dL per µg/day, from USEPA 1996 guidance
IR_S =	Soil ingestion rate, g/day	IR_S =	0.100 g/day from USEPA 1996 Guidance
AF_S =	Absorption fraction, unitless	AF_S =	0.12 from USEPA 1996 guidance
EF_S =	Exposure frequency, days/year	EF_S =	9 days/year
AT_S =	Averaging time, days	AT_S =	365 days/year for the one time exposure year assumed for Upland Excavation Workers.
And, GSDi =	Geometric standard deviation PbB	GSDi =	2.1 from USEPA 1996 guidance
R_{fetal}/maternal =	Fetal/maternal PbB ratio	R_{fetal}/maternal =	0.9 from USEPA 1996 guidance

(1) dL = deciliter of blood.

The calculated $PbB_{fetal,0.95}$, is compared against the target level of concern, (PbB_t) of 10µg/dL using a lognormal distribution analysis for probability as recommended by USEPA that is built into the "Calculations of Blood Lead Concentrations Model" (USEPA 1996). The acceptable probability that the fetal blood lead level ($PbB_{fetal,0.95}$) is greater than 10µg/dL ($P(PbB_{fetal} > PbB_t)$ %) is 5%.

Results from the "Calculations of Blood Lead Concentrations Model" using a homogeneous subset of female workers of childbearing age as the target worker are:

PbB_{Adult} = 1.7µg/dL

$PbB_{fetal,0.95}$ =5.1µg/dL

Probability that fetal PbB > PbBt, assuming lognormal distribution = 0.5%

The results for a heterogeneous subset of female workers of childbearing age as the target worker are:

PbB_{Adult} = 1.9µg/dL

$PbB_{fetal,0.95}$ =6.7µg/dL

Probability that fetal PbB > PbBt, assuming lognormal distribution = 1.6%

The probability that the fetal blood lead level ($PbB_{fetal,0.95}$) is greater than 10µg/dL ($P(PbB_{fetal} > PbB_t)$ %) is less than 5% for both a homogeneous and heterogeneous population of female workers. This indicates that the lead concentration at its sampled maximum at the Moorings is no considered to pose unacceptable levels of risk to Upland Excavation Workers.

7.1.7.3 Characterization of Risk from Exposure to Groundwater

At the Moorings, the potential exists in the future for Office Workers and Maintenance Workers who work at the site full time to be exposed to the groundwater used as drinking water through ingestion, inhalation, and dermal contact. Human health risks from groundwater are only estimated for the Industrial Area, as no groundwater samples were taken for the MIS MUs. Table 7-7-3 (page 7-61) shows the results for the cancer risk and non-cancer HQs and HIs calculated for all four selected exposure points, GW-02, GW-11, GW-16, and GW-20 (Figure 7-1, page 7-25). The risks are calculated based on both a RME and a CT of intake parameters using the following assumptions:

- The RME scenario daily intake is calculated assuming the worker works at the Moorings for 25 years and consumes 2.3 liters of water per day over that period.
- The central tendency scenario daily intake is calculated assuming the worker works at the Moorings for 6 years and consumes 1.4 liters of water per day.
- Only a subset of the COPCs is available for the inhalation exposure pathway due to physical properties of the COPCs. Only benzene, chloroform, mercury, naphthalene, and PCE have risks associated with groundwater inhalation exposure as discussed in Section 7.1.5 (page 7-31).
- The EPC used for the calculation of the intake is shown in Table 7-3-3 (page 7-29). The same EPC is used for each exposure route at each exposure point, including inhalation, and for both the reasonable maximum exposure and central tendency. RAIS calculates the intake in air as a result of the concentration in the groundwater.

For each exposure point, risks are summed by exposure route and the exposure point for cumulative results.

Sample GW-02. For the RME exposure, total cancer risk from dermal contact, ingestion, and inhalation is $4x10^{-5}$. The majority of the cancer risk ($3.8x10^{-5}$) is from arsenic ingestion. All HQs and HIs are below 1. For the CT exposure, total cancer risk from dermal contact, ingestion, and inhalation is 2.4×10^{-6}. The only value above 10^{-6} is that for arsenic ($2.1x10^{-6}$) via ingestion. All of the HQs and HIs are below 1.

Sample GW-11. For the RME exposure, total cancer risk from dermal contact, ingestion, and inhalation is $3x10^{-4}$. The majority of the cancer risk is from arsenic ($1x10^{-4}$) via ingestion; the other contaminants with risks above 10^{-5} are all carcinogenic PAH. The HI for this sample is 5.4. Those chemicals with HQs above 1 are aluminum (HQ=1.7) and manganese (HQ=1.7) via ingestion. For the CT exposure, total cancer risk from dermal contact, ingestion, and inhalation is $1.6x10^{-4}$. Chemicals with risks above 10^{-5} are benzo(a)pyrene ($9.3x10^{-5}$ via dermal contact and $1.2x10^{-5}$ via ingestion) and dibenz(a,h)anthracene ($1.3x10^{-5}$) and indeno(1,2,3-cd)pyrene ($1.6x10^{-5}$) via dermal exposure.

Sample GW-16. For the RME exposure, total cancer risk from dermal contact, ingestion, and inhalation is $2x10^{-5}$. The majority of the cancer risk is from arsenic ($1.4x10^{-5}$) via ingestion; no other contaminants have risks above 10^{-5}. The HI for this sample is 4.6. The only chemical with an HQ above 1 is cyanide (HQ=3.4) via ingestion. For the CT exposure, total cancer risk from dermal contact, ingestion, and inhalation is $8x10^{-6}$ and the HI is 3.1. the only HQ greater than 1 is that for cyanide (HQ=2).

Sample GW-20. For the RME exposure, total cancer risk from dermal contact, ingestion, and inhalation is $1.2x10^{-4}$. The majority of the cancer risk is from arsenic ($1.2x10^{-4}$) via ingestion; no other contaminants have risks above 10^{-6}. The HI for this sample is 11.8. The only chemical with an HQ above 1 is cyanide (HQ=11.3) via ingestion. For the CT exposure, total cancer risk from dermal contact, ingestion and inhalation is $6.9x10^{-6}$; the only chemical above a cancer risk of 10^{-6} is arsenic ($6.9x10^{-6}$) via ingestion. The HI for this sample is 7.2. The only HQ greater than 1 is that for cyanide (HQ=6.8) via ingestion.

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TABLE 7-7-1 CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS REASONABLE MAXIMUM EXPOSURE

U.S. GOVERNMENT MOORINGS

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Soil	Surface Soil	RUN-OFF Maintenance Worker	Dermal Contact	Benzo(b)fluoranthene	3.4	mg/kg	1.82E-08	mg/kg-day	0.73	$(mg\text{-}kg/day)^{-1}$	1.33E-08	5.11E-08	mg/kg-day	-	-	-
				Benzo(a)pyrene	2.7	mg/kg	1.45E-08	mg/kg-day	7.3	$(mg\text{-}kg/day)^{-1}$	1.06E-07	4.06E-08	mg/kg-day	-	-	-
				Dibenz(a,h)anthracene	0.55	mg/kg	3.22E-09	mg/kg-day	7.3	$(mg\text{-}kg/day)^{-1}$	2.35E-08	9.01E-09	mg/kg-day	-	-	-
				Aroclor 1248	1.6	mg/kg	9.24E-09	mg/kg-day	2	$(mg\text{-}kg/day)^{-1}$	1.85E-08	2.59E-08	mg/kg-day	2.00E-05	mg/kg-day	1.29E-03
				Arsenic	5.27	mg/kg	6.56E-09	mg/kg-day	1.5	$(mg\text{-}kg/day)^{-1}$	9.84E-09	1.84E-08	mg/kg-day	3.00E-04	mg/kg-day	6.12E-05
				Chromium, total	76.6	mg/kg	3.16E-09	mg/kg-day	-	-	-	8.85E-09	mg/kg-day	1.5	mg/kg-day	4.54E-07
			Exp. Route Total								1.71E-07					1.35E-03
			Incidental Ingestion	Benzo(b)fluoranthene	3.4	mg/kg	1.28E-07	mg/kg-day	0.73	$(mg\text{-}kg/day)^{-1}$	9.37E-08	3.59E-07	mg/kg-day	-	-	-
				Benzo(a)pyrene	2.7	mg/kg	1.02E-07	mg/kg-day	7.3	$(mg\text{-}kg/day)^{-1}$	7.44E-07	2.85E-07	mg/kg-day	-	-	-
				Dibenz(a,h)anthracene	0.55	mg/kg	2.26E-08	mg/kg-day	7.3	$(mg\text{-}kg/day)^{-1}$	1.65E-07	6.34E-08	mg/kg-day	-	-	-
				Aroclor 1248	1.6	mg/kg	6.04E-08	mg/kg-day	2	$(mg\text{-}kg/day)^{-1}$	1.21E-07	1.69E-07	mg/kg-day	2.00E-05	mg/kg-day	8.45E-03
				Arsenic	5.27	mg/kg	2.00E-07	mg/kg-day	1.5	$(mg\text{-}kg/day)^{-1}$	3.00E-07	5.60E-07	mg/kg-day	3.00E-04	mg/kg-day	1.87E-03
				Chromium, total	76.6	mg/kg	2.89E-06	mg/kg-day	-	-	-	8.09E-06	mg/kg-day	1.5	mg/kg-day	5.40E-06
			Exp. Route Total								1.42E-06					1.03E-02
	Air	RUN-OFF Maintenance Worker	Inhalation	Benzo(b)fluoranthene	3.4	mg/kg	9.46E-09	µg/m3	1.10E-04	$(\mu g/m3)^{-1}$	1.04E-12	2.65E-11	µg/m3	-	-	-
				Benzo(a)pyrene	2.7	mg/kg	7.51E-09	µg/m3	1.10E-03	$(\mu g/m3)^{-1}$	8.26E-12	2.10E-11	µg/m3	-	-	-
			Combined Volatilization and Particulate Matter	Dibenz(a,h)anthracene	0.55	mg/kg	1.67E-09	µg/m3	1.10E-03	$(\mu g/m3)^{-1}$	2.00E-11	4.67E-12	µg/m3	-	-	-
				Aroclor 1248	1.6	mg/kg	4.45E-09	µg/m3	5.70E-04	$(\mu g/m3)^{-1}$	2.54E-12	1.25E-11	µg/m3	-	-	-
				Arsenic	5.27	mg/kg	1.47E-08	µg/m3	4.30E-03	$(\mu g/m3)^{-1}$	6.34E-11	4.13E-11	µg/m3	1.50E-05	mg/m3	2.75E-06
				Chromium, total	76.6	mg/kg	2.13E-07	µg/m3	1.20E-02	$(\mu g/m3)^{-1}$	2.56E-09	5.97E-10	µg/m3	1.00E-04	mg/m3	5.97E-06
			Exp. Route Total								2.66E-09					8.72E-06
		Exposure Point Total									1.60E-06					1.17E-02
Surface Soil	Surface Soil	FENCELINE Maintenance Worker	Dermal Contact	Benzo(b)fluoranthene	2	mg/kg	1.07E-08	mg/kg-day	0.73	$(mg\text{-}kg/day)^{-1}$	7.83E-09	3.00E-08	mg/kg-day	-	-	-
				Benzo(a)pyrene	1.5	mg/kg	8.05E-09	mg/kg-day	7.3	$(mg\text{-}kg/day)^{-1}$	5.87E-08	2.25E-08	mg/kg-day	-	-	-
				Dibenz(a,h)anthracene	0.25	mg/kg	1.34E-09	mg/kg-day	7.3	$(mg\text{-}kg/day)^{-1}$	9.79E-09	3.75E-09	mg/kg-day	-	-	-
				Aroclor 1248	-	mg/kg	-	-	2	$(mg\text{-}kg/day)^{-1}$	-	-	-	2.00E-05	mg/kg-day	-
				Arsenic	62.9	mg/kg	7.80E-08	mg/kg-day	1.5	$(mg\text{-}kg/day)^{-1}$	1.17E-07	2.18E-07	mg/kg-day	3.00E-04	mg/kg-day	7.28E-04
				Chromium, total	508	mg/kg	2.10E-08	mg/kg-day	-	-	-	5.87E-08	mg/kg-day	1.5	mg/kg-day	3.01E-06
			Exp. Route Total								1.93E-07					7.31E-04
			Incidental Ingestion	Benzo(b)fluoranthene	2	mg/kg	7.55E-08	mg/kg-day	0.73	$(mg\text{-}kg/day)^{-1}$	5.51E-08	2.11E-07	mg/kg-day	-	-	-
				Benzo(a)pyrene	1.5	mg/kg	5.66E-08	mg/kg-day	7.3	$(mg\text{-}kg/day)^{-1}$	4.13E-07	1.59E-07	mg/kg-day	-	-	-
				Dibenz(a,h)anthracene	0.25	mg/kg	9.44E-09	mg/kg-day	7.3	$(mg\text{-}kg/day)^{-1}$	6.89E-08	2.64E-08	mg/kg-day	-	-	-
				Aroclor 1248	-	mg/kg	-	-	2	$(mg\text{-}kg/day)^{-1}$	-	-	-	2.00E-05	mg/kg-day	-
				Arsenic	62.9	mg/kg	2.38E-06	mg/kg-day	1.5	$(mg\text{-}kg/day)^{-1}$	3.57E-06	6.66E-06	mg/kg-day	3.00E-04	mg/kg-day	2.22E-02
				Chromium, total	508	mg/kg	1.92E-05	mg/kg-day	-	-	-	5.37E-05	mg/kg-day	1.5	mg/kg-day	3.58E-05
			Exp. Route Total								4.11E-06					2.22E-02
	Air	FENCELINE Maintenance Worker	Inhalation	Benzo(b)fluoranthene	2	mg/kg	5.56E-09	µg/m3	1.10E-04	$(\mu g/m3)^{-1}$	6.12E-13	1.56E-11	µg/m3	-	-	-
				Benzo(a)pyrene	1.5	mg/kg	4.17E-09	µg/m3	1.10E-03	$(\mu g/m3)^{-1}$	4.59E-12	1.17E-11	µg/m3	-	-	-
			Combined Volatilization and Particulate Matter	Dibenz(a,h)anthracene	0.25	mg/kg	6.96E-10	µg/m3	1.10E-03	$(\mu g/m3)^{-1}$	8.35E-12	1.95E-12	µg/m3	-	-	-
				Aroclor 1248	-	mg/kg	-	-	5.70E-04	$(\mu g/m3)^{-1}$	-	0	µg/m3	-	-	-
				Arsenic	62.9	mg/kg	1.75E-07	µg/m3	4.30E-03	$(\mu g/m3)^{-1}$	7.54E-10	4.91E-10	µg/m3	1.50E-05	mg/m3	3.27E-05
				Chromium, total	508	mg/kg	1.41E-06	µg/m3	1.20E-02	$(\mu g/m3)^{-1}$	1.70E-08	3.96E-09	µg/m3	1.00E-04	mg/m3	3.96E-05
			Exp. Route Total								1.78E-08					7.23E-05
		Exposure Point Total									4.32E-06					7.23E-05

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TABLE 7-7-2 CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS REASONABLE MAXIMUM EXPOSURE
U.S. GOVERNMENT MOORINGS

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration (1)		CSF/Unit Risk		Cancer Risk (1)	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Industrial Area																
Shallow Soil	Air	SB-01	Inhalation	Benzo(b)fluoranthene	0.15	mg/kg	1.16E-08	µg/m3	1.10E-04	$(µg/m3)^{-1}$	1.28E-12	3.25E-11	µg/m3	-	-	-
		Office Worker		Benzo(a)pyrene	0.11	mg/kg	8.50E-09	µg/m3	1.10E-03	$(µg/m3)^{-1}$	9.35E-12	2.38E-11	µg/m3	-	-	-
			Combined Volatilization and Particulate Matter	Indeno(1,2,3-cd)pyrene	0.18	mg/kg	1.39E-08	µg/m3	1.10E-04	$(µg/m3)^{-1}$	1.53E-12	3.89E-11	µg/m3	-	-	-
				Dibenz(a,h)anthracene	0.02	mg/kg	1.55E-09	µg/m3	1.10E-03	$(µg/m3)^{-1}$	1.70E-12	4.33E-12	µg/m3	-	-	-
				Antimony	0.21	mg/kg	1.62E-08	µg/m3	-	-	-	4.54E-11	µg/m3	-	-	-
				Arsenic	14.9	mg/kg	1.15E-06	µg/m3	4.30E-03	$(µg/m3)^{-1}$	4.95E-09	3.22E-09	µg/m3	1.50E-05	mg/m3	2.15E-04
		Exposure Point Total									4.96E-09					2.15E-04
	Air	SB-12	Inhalation	Benzo(b)fluoranthene	0.54	mg/kg	4.17E-08	µg/m3	1.10E-04	$(µg/m3)^{-1}$	4.59E-12	1.17E-10	µg/m3	-	-	-
		Office Worker		Benzo(a)pyrene	0.47	mg/kg	3.63E-08	µg/m3	1.10E-03	$(µg/m3)^{-1}$	4.00E-11	1.02E-10	µg/m3	-	-	-
			Combined Volatilization and Particulate Matter	Indeno(1,2,3-cd)pyrene	0.82	mg/kg	6.34E-08	µg/m3	1.10E-04	$(µg/m3)^{-1}$	6.97E-12	1.77E-10	µg/m3	-	-	-
				Dibenz(a,h)anthracene	0.07	mg/kg	5.41E-09	µg/m3	1.10E-03	$(µg/m3)^{-1}$	5.95E-12	1.51E-11	µg/m3	-	-	-
				Antimony	642	mg/kg	4.82E-05	µg/m3	-	-	-	1.35E-07	µg/m3	-	-	-
				Arsenic	3.7	mg/kg	2.86E-07	µg/m3	4.30E-03	$(µg/m3)^{-1}$	1.23E-09	8.01E-10	µg/m3	1.50E-05	mg/m3	5.34E-05
		Exposure Point Total									1.29E-09					5.34E-05
	Air	SB-16	Inhalation	Benzo(b)fluoranthene	4.5	mg/kg	3.48E-07	µg/m3	1.10E-04	$(µg/m3)^{-1}$	3.83E-11	9.74E-10	µg/m3	-	-	-
		Office Worker		Benzo(a)pyrene	1.7	mg/kg	1.31E-07	µg/m3	1.10E-03	$(µg/m3)^{-1}$	1.45E-10	3.68E-10	µg/m3	-	-	-
			Combined Volatilization and Particulate Matter	Indeno(1,2,3-cd)pyrene	4.5	mg/kg	3.48E-07	µg/m3	1.10E-04	$(µg/m3)^{-1}$	3.83E-11	9.74E-10	µg/m3	-	-	-
				Dibenz(a,h)anthracene	0.52	mg/kg	4.02E-08	µg/m3	1.10E-03	$(µg/m3)^{-1}$	4.42E-11	1.13E-10	µg/m3	-	-	-
				Antimony	5.86	mg/kg	4.53E-07	µg/m3	-	-	-	1.27E-09	µg/m3	-	-	-
				Arsenic	4.56	mg/kg	3.52E-07	µg/m3	4.30E-03	$(µg/m3)^{-1}$	1.52E-09	9.87E-10	µg/m3	1.50E-05	mg/m3	6.58E-05
		Exposure Point Total									1.79E-09					6.58E-05
	Shallow Soil	SB-01	Dermal Contact	Benzo(b)fluoranthene	0.15	mg/kg	4.02E-10	mg/kg-day	0.73	$(mg\text{-}kg/day)^{-1}$	2.94E-10	2.82E-08	mg/kg-day	-	-	-
		(Excavation Worker)		Benzo(a)pyrene	0.11	mg/kg	2.95E-10	mg/kg-day	7.3	$(mg\text{-}kg/day)^{-1}$	2.15E-09	2.07E-08	mg/kg-day	-	-	-
				Indeno(1,2,3-cd)pyrene	0.18	mg/kg	4.83E-10	mg/kg-day	0.73	$(mg\text{-}kg/day)^{-1}$	3.52E-10	3.38E-08	mg/kg-day	-	-	-
				Dibenz(a,h)anthracene	0.02	mg/kg	5.36E-11	mg/kg-day	7.3	$(mg\text{-}kg/day)^{-1}$	3.92E-10	3.75E-09	mg/kg-day	-	-	-
				Antimony	0.21	mg/kg	4.33E-12	mg/kg-day	-	-	-	3.03E-10	mg/kg-day	6.00E-05	mg/kg-day	5.05E-06
				Arsenic	14.9	mg/kg	9.22E-09	mg/kg-day	1.5	$(mg\text{-}kg/day)^{-1}$	1.38E-08	6.46E-07	mg/kg-day	3.00E-04	mg/kg-day	2.15E-03
			Exp. Route Total								1.70E-08					2.16E-03
			Incidental Ingestion	Benzo(b)fluoranthene	0.15	mg/kg	3.62E-10	mg/kg-day	0.73	$(mg\text{-}kg/day)^{-1}$	2.64E-10	2.54E-08	mg/kg-day	-	-	-
				Benzo(a)pyrene	0.11	mg/kg	2.66E-10	mg/kg-day	7.3	$(mg\text{-}kg/day)^{-1}$	1.94E-09	1.86E-08	mg/kg-day	-	-	-
				Indeno(1,2,3-cd)pyrene	0.18	mg/kg	4.35E-10	mg/kg-day	0.73	$(mg\text{-}kg/day)^{-1}$	3.17E-10	3.04E-08	mg/kg-day	-	-	-
				Dibenz(a,h)anthracene	0.02	mg/kg	4.83E-11	mg/kg-day	7.3	$(mg\text{-}kg/day)^{-1}$	3.53E-10	3.38E-09	mg/kg-day	-	-	-
				Antimony	0.21	mg/kg	5.07E-10	mg/kg-day	-	-	-	3.55E-08	mg/kg-day	4.00E-04	mg/kg-day	8.88E-05
				Arsenic	14.9	mg/kg	3.60E-08	mg/kg-day	1.5	$(mg\text{-}kg/day)^{-1}$	5.40E-08	2.52E-06	mg/kg-day	3.00E-04	mg/kg-day	8.40E-03
			Exp. Route Total								5.69E-08					8.49E-03
	Air	SB-01	Inhalation	Benzo(b)fluoranthene	0.15	mg/kg	1.67E-11	µg/m3	1.10E-04	$(µg/m3)^{-1}$	1.84E-15	1.17E-12	µg/m3	-	-	-
		(Excavation Worker)		Benzo(a)pyrene	0.11	mg/kg	1.22E-11	µg/m3	1.10E-03	$(µg/m3)^{-1}$	1.35E-14	8.57E-13	µg/m3	-	-	-
			Combined Volatilization and Particulate Matter	Indeno(1,2,3-cd)pyrene	0.18	mg/kg	2.00E-11	µg/m3	1.10E-04	$(µg/m3)^{-1}$	2.20E-15	1.40E-12	µg/m3	-	-	-
				Dibenz(a,h)anthracene	0.02	mg/kg	2.23E-12	µg/m3	1.10E-03	$(µg/m3)^{-1}$	2.45E-15	1.56E-13	µg/m3	-	-	-
				Antimony	0.21	mg/kg	2.34E-11	µg/m3	-	-	-	1.64E-12	µg/m3	-	-	-
				Arsenic	14.9	mg/kg	1.66E-09	µg/m3	4.30E-03	$(µg/m3)^{-1}$	7.13E-12	1.16E-10	µg/m3	1.50E-05	mg/m3	7.74E-06
			Exp. Route Total								7.15E-12					7.74E-06
		Exposure Point Total									7.39E-08					1.07E-02

TABLE 7-7-2 CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS REASONABLE MAXIMUM EXPOSURE
U.S. GOVERNMENT MOORINGS

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration (1)		CSF/Unit Risk		Cancer Risk (1)	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Shallow Soil	Shallow Soil	SB-12 (Excavation Worker)	Dermal Contact	Benzo(b)fluoranthene	0.54	mg/kg	1.45E-09	mg/kg-day	0.73	$(mg\text{-}kg/day)^{-1}$	1.06E-09	1.01E-07	mg/kg-day	-	-	-
				Benzo(a)pyrene	0.47	mg/kg	1.26E-09	mg/kg-day	7.3	$(mg\text{-}kg/day)^{-1}$	9.20E-09	8.82E-08	mg/kg-day	-	-	-
				Indeno(1,2,3-cd)pyrene	0.82	mg/kg	2.20E-09	mg/kg-day	0.73	$(mg\text{-}kg/day)^{-1}$	1.61E-09	1.54E-07	mg/kg-day	-	-	-
				Dibenz(a,h)anthracene	0.07	mg/kg	1.88E-10	mg/kg-day	7.3	$(mg\text{-}kg/day)^{-1}$	1.37E-09	1.31E-08	mg/kg-day	-	-	-
				Antimony	642	mg/kg	1.32E-08	mg/kg-day	-	-	-	9.27E-07	mg/kg-day	6.00E-05	mg/kg-day	1.55E-02
				Arsenic	3.7	mg/kg	2.29E-09	mg/kg-day	1.5	$(mg\text{-}kg/day)^{-1}$	3.44E-09	1.60E-07	mg/kg-day	3.00E-04	mg/kg-day	5.34E-04
			Exp. Route Total								1.67E-08					1.60E-02
			Incidental Ingestion	Benzo(b)fluoranthene	0.54	mg/kg	1.30E-09	mg/kg-day	0.73	$(mg\text{-}kg/day)^{-1}$	9.52E-10	9.13E-08	mg/kg-day	-	-	-
				Benzo(a)pyrene	0.47	mg/kg	1.14E-09	mg/kg-day	7.3	$(mg\text{-}kg/day)^{-1}$	8.29E-09	7.95E-08	mg/kg-day	-	-	-
				Indeno(1,2,3-cd)pyrene	0.82	mg/kg	1.98E-09	mg/kg-day	0.73	$(mg\text{-}kg/day)^{-1}$	1.45E-09	1.39E-07	mg/kg-day	-	-	-
				Dibenz(a,h)anthracene	0.07	mg/kg	1.69E-10	mg/kg-day	7.3	$(mg\text{-}kg/day)^{-1}$	1.23E-09	1.18E-08	mg/kg-day	-	-	-
				Antimony	642	mg/kg	1.55E-06	mg/kg-day	-	-	-	1.09E-04	mg/kg-day	4.00E-04	mg/kg-day	2.71E-01
				Arsenic	3.7	mg/kg	8.94E-09	mg/kg-day	1.5	$(mg\text{-}kg/day)^{-1}$	1.34E-08	6.26E-07	mg/kg-day	3.00E-04	mg/kg-day	2.09E-03
			Exp. Route Total								2.53E-08					2.73E-01
	Air	SB-12 (Excavation Worker)	Inhalation	Benzo(b)fluoranthene	0.54	mg/kg	6.01E-11	µg/m3	1.10E-04	$(\mu g/m3)^{-1}$	6.61E-15	4.21E-12	µg/m3	-	-	-
				Benzo(a)pyrene	0.47	mg/kg	5.23E-11	µg/m3	1.10E-03	$(\mu g/m3)^{-1}$	5.75E-14	3.66E-12	µg/m3	-	-	-
			Combined Volatilization and Particulate Matter	Indeno(1,2,3-cd)pyrene	0.82	mg/kg	9.13E-11	µg/m3	1.10E-04	$(\mu g/m3)^{-1}$	1.00E-14	6.39E-12	µg/m3	-	-	-
				Dibenz(a,h)anthracene	0.07	mg/kg	7.79E-12	µg/m3	1.10E-03	$(\mu g/m3)^{-1}$	8.57E-15	5.45E-13	µg/m3	-	-	-
				Antimony	642	mg/kg	7.14E-08	µg/m3	-	-	-	5.00E-09	µg/m3	-	-	-
				Arsenic	3.7	mg/kg	4.12E-10	µg/m3	4.30E-03	$(\mu g/m3)^{-1}$	1.77E-12	2.88E-11	µg/m3	1.50E-05	mg/m3	1.92E-06
			Exp. Route Total								1.85E-12					1.92E-06
		Exposure Point Total									1.85E-12					2.89E-01
	Shallow Soil	SB-16 (Excavation Worker)	Dermal Contact	Benzo(b)fluoranthene	4.5	mg/kg	1.21E-08	mg/kg-day	0.73	$(mg\text{-}kg/day)^{-1}$	8.81E-09	8.45E-07	mg/kg-day	-	-	-
				Benzo(a)pyrene	1.7	mg/kg	4.56E-09	mg/kg-day	7.3	$(mg\text{-}kg/day)^{-1}$	3.33E-08	3.19E-07	mg/kg-day	-	-	-
				Indeno(1,2,3-cd)pyrene	4.5	mg/kg	1.21E-08	mg/kg-day	0.73	$(mg\text{-}kg/day)^{-1}$	8.81E-09	8.45E-07	mg/kg-day	-	-	-
				Dibenz(a,h)anthracene	0.52	mg/kg	1.39E-09	-	7.3	$(mg\text{-}kg/day)^{-1}$	1.02E-08	9.76E-08	-	-	-	-
				Antimony	5.86	mg/kg	1.21E-10	mg/kg-day	-	-	-	8.46E-09	mg/kg-day	6.00E-05	mg/kg-day	1.41E-04
				Arsenic	4.56	mg/kg	2.82E-09	mg/kg-day	1.5	$(mg\text{-}kg/day)^{-1}$	4.23E-09	1.98E-07	mg/kg-day	3.00E-04	mg/kg-day	6.59E-04
			Exp. Route Total								6.54E-08					8.00E-04
			Incidental Ingestion	Benzo(b)fluoranthene	4.5	mg/kg	1.09E-08	mg/kg-day	0.73	$(mg\text{-}kg/day)^{-1}$	7.93E-09	7.61E-07	mg/kg-day	-	-	-
				Benzo(a)pyrene	1.7	mg/kg	4.11E-09	mg/kg-day	7.3	$(mg\text{-}kg/day)^{-1}$	3.00E-08	2.87E-07	mg/kg-day	-	-	-
				Indeno(1,2,3-cd)pyrene	4.5	mg/kg	1.09E-08	mg/kg-day	0.73	$(mg\text{-}kg/day)^{-1}$	7.93E-09	7.61E-07	mg/kg-day	-	-	-
				Dibenz(a,h)anthracene	0.52	mg/kg	1.26E-09	-	7.3	$(mg\text{-}kg/day)^{-1}$	9.17E-09	8.79E-08	-	-	-	-
				Antimony	5.86	mg/kg	1.42E-08	mg/kg-day	-	-	-	9.91E-07	mg/kg-day	4.00E-04	mg/kg-day	2.48E-03
				Arsenic	4.56	mg/kg	1.10E-08	mg/kg-day	1.5	$(mg\text{-}kg/day)^{-1}$	1.65E-08	7.71E-07	mg/kg-day	3.00E-04	mg/kg-day	2.57E-03
			Exp. Route Total								7.15E-08					5.05E-03
	Air	SB-16 (Excavation Worker)	Inhalation	Benzo(b)fluoranthene	4.5	mg/kg	5.01E-10	µg/m3	1.10E-04	$(\mu g/m3)^{-1}$	5.51E-14	3.51E-11	µg/m3	-	-	-
				Benzo(a)pyrene	1.7	mg/kg	1.89E-10	µg/m3	1.10E-03	$(\mu g/m3)^{-1}$	2.08E-13	1.32E-11	µg/m3	-	-	-
			Combined Volatilization and Particulate Matter	Indeno(1,2,3-cd)pyrene	4.5	mg/kg	5.01E-10	µg/m3	1.10E-04	$(\mu g/m3)^{-1}$	5.51E-14	3.51E-11	µg/m3	-	-	-
				Dibenz(a,h)anthracene	0.52	mg/kg	5.79E-11	µg/m3	1.10E-03	$(\mu g/m3)^{-1}$	6.37E-14	4.05E-12	µg/m3	-	-	-
				Antimony	5.86	mg/kg	6.52E-10	µg/m3	-	-	-	4.56E-11	µg/m3	-	-	-
				Arsenic	4.56	mg/kg	5.07E-10	µg/m3	4.30E-03	$(\mu g/m3)^{-1}$	2.18E-12	3.55E-11	µg/m3	1.50E-05	mg/m3	2.37E-06
			Exp. Route Total								2.56E-12					2.37E-06
		Exposure Point Total									1.37E-07					5.85E-03

TABLE 7-7-2 CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS REASONABLE MAXIMUM EXPOSURE
U.S. GOVERNMENT MOORINGS

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration (1)		CSF/Unit Risk		Cancer Risk (1)	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
MIS Area																
Shallow Soil	Air	South Logistics MU	Inhalation	Benzo(a)pyrene	0.1	mg/kg	7.73E-09	µg/m3	1.10E-03	$(µg/m3)^{-1}$	8.50E-12	2.16E-11	µg/m3	-	µg/m3	-
		Indoor Worker (Office/Maintenance)	Combined Volatilization and Particulate Matter	Arsenic	3.11	mg/kg	2.40E-07	µg/m3	4.30E-03	$(µg/m3)^{-1}$	1.03E-09	6.73E-10	µg/m3	1.50E-05	µg/m3	4.49E-05
		Exposure Point Total									1.04E-09					4.49E-05
	Shallow Soil	South Logistics MU (Excavation Worker)	Dermal Contact	Benzo(a)pyrene	0.1	mg/kg	2.15E-11	µg/m3	7.3	$(mg\text{-}kg/day)^{-1}$	1.57E-10	1.50E-09	mg/kg-day	-	-	-
				Arsenic	3.11	mg/kg	1.54E-10	µg/m3	1.5	$(mg\text{-}kg/day)^{-1}$	2.31E-10	1.08E-08	mg/kg-day	3.00E-04	mg/m3	3.59E-05
			Exp. Route Total								3.88E-10					3.59E-05
			Incidental Ingestion	Benzo(a)pyrene	0.1	mg/kg	1.51E-10	µg/m3	7.3	(mg-kg/day)-1	1.10E-09	1.06E-08	mg/kg-day	-	-	-
				Arsenic	3.11	mg/kg	4.69E-09	µg/m3	1.5	(mg-kg/day)-1	7.04E-09	3.29E-07	mg/kg-day	3.00E-04	mg/m3	1.10E-03
			Exp. Route Total								8.14E-09					1.10E-03
			Inhalation	Benzo(a)pyrene	0.1	mg/kg	1.11E-11	µg/m3	1.10E-03	$(µg/m3)^{-1}$	1.22E-14	7.79E-13	µg/m3	-	-	-
			Combined Volatilization and Particulate Matter	Arsenic	3.11	mg/kg	3.46E-10	µg/m3	4.30E-03	$(µg/m3)^{-1}$	1.49E-12	2.42E-11	µg/m3	1.50E-05	µg/m3	1.62E-06
			Exp. Route Total								1.50E-12					1.62E-06
		Exposure Point Total									2.99E-12					3.24E-06
	Shallow Soil	North Logistics MU (Excavation Worker)	Dermal Contact	Benzo(a)pyrene	0.96	mg/kg	2.06E-10	µg/m3	7.3	$(mg\text{-}kg/day)^{-1}$	1.50E-09	1.44E-08	mg/kg-day	-	-	-
				Arsenic	6.16	mg/kg	3.05E-10	µg/m3	1.5	$(mg\text{-}kg/day)^{-1}$	4.58E-10	2.14E-08	mg/kg-day	3.00E-04	mg/m3	7.12E-05
			Exp. Route Total								1.96E-09					7.12E-05
			Incidental Ingestion	Benzo(a)pyrene	0.96	mg/kg	1.45E-09	µg/m3	7.3	$(mg\text{-}kg/day)^{-1}$	1.06E-08	1.01E-07	mg/kg-day	-	-	-
				Arsenic	6.16	mg/kg	9.30E-09	µg/m3	1.5	$(mg\text{-}kg/day)^{-1}$	1.39E-08	6.51E-07	mg/kg-day	3.00E-04	mg/m3	2.17E-03
			Exp. Route Total								2.45E-08					2.17E-03
			Inhalation	Benzo(a)pyrene	0.96	mg/kg	1.07E-10	µg/m3	1.10E-03	$(µg/m3)^{-1}$	1.18E-13	7.48E-12	µg/m3	-	µg/m3	-
			Combined Volatilization and Particulate Matter	Arsenic	6.16	mg/kg	6.86E-10	µg/m3	4.30E-03	$(µg/m3)^{-1}$	2.95E-12	4.80E-11	µg/m3	1.50E-05	µg/m3	3.20E-06
			Exp. Route Total								3.07E-12					3.20E-06
		Exposure Point Total									6.02E-12					6.40E-06
	Shallow Soil	Laydown (Excavation Worker)	Dermal Contact	Benzo(a)pyrene	0.36	mg/kg	7.72E-11	µg/m3	7.3	$(mg\text{-}kg/day)^{-1}$	4.53E-09	5.41E-09	mg/kg-day	-	-	-
				Arsenic	4.14	mg/kg	2.05E-10	µg/m3	1.5	$(mg\text{-}kg/day)^{-1}$	9.68E-09	1.43E-08	mg/kg-day	3.00E-04	mg/m3	4.78E-05
			Exp. Route Total								1.42E-08					4.78E-05
			Incidental Ingestion	Benzo(a)pyrene	0.36	mg/kg	5.43E-10	µg/m3	7.3	$(mg\text{-}kg/day)^{-1}$	3.97E-09	3.80E-08	mg/kg-day	-	-	-
				Arsenic	4.14	mg/kg	6.25E-09	µg/m3	1.5	$(mg\text{-}kg/day)^{-1}$	9.37E-09	4.37E-07	mg/kg-day	3.00E-04	mg/m3	3.73E-04
			Exp. Route Total								1.33E-08					3.73E-04
			Inhalation	Benzo(a)pyrene	0.36	mg/kg	4.01E-11	µg/m3	1.10E-03	$(µg/m3)^{-1}$	4.41E-14	2.80E-12	µg/m3	-	µg/m3	-
			Combined Volatilization and Particulate Matter	Arsenic	4.14	mg/kg	4.61E-10	µg/m3	4.30E-03	$(µg/m3)^{-1}$	1.98E-12	3.23E-11	µg/m3	1.50E-05	µg/m3	2.15E-06
			Exp. Route Total								2.02E-12					2.15E-06
		Exposure Point Total									4.00E-12					4.30E-06

TABLE 7-7-2 CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS REASONABLE MAXIMUM EXPOSURE
U.S. GOVERNMENT MOORINGS

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration (1)		CSF/Unit Risk		Cancer Risk (1)	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Shallow Soil	Shallow Soil	Slump	Dermal Contact	Benzo(a)pyrene	3.5	mg/kg	7.51E-13	µg/m3	7.3	$(mg\text{-}kg/day)^{-1}$	4.41E-11	5.26E-11	mg/kg-day	-	-	-
		(Excavation Worker)		Arsenic	1.06	mg/kg	5.25E-11	µg/m3	1.5	$(mg\text{-}kg/day)^{-1}$	2.48E-09	3.67E-09	mg/kg-day	3.00E-04	mg/m3	1.22E-05
			Exp. Route Total								2.52E-09					1.22E-05
			Incidental Ingestion	Benzo(a)pyrene	3.5	mg/kg	5.28E-12	µg/m3	7.3	$(mg\text{-}kg/day)^{-1}$	3.86E-11	3.70E-10	mg/kg-day	-	-	-
				Arsenic	1.06	mg/kg	1.60E-09	µg/m3	1.5	$(mg\text{-}kg/day)^{-1}$	2.40E-09	1.12E-07	mg/kg-day	3.00E-04	mg/m3	3.73E-04
			Exp. Route Total								2.44E-09					3.73E-04
			Inhalation	Benzo(a)pyrene	3.5	mg/kg	3.89E-13	µg/m3	1.10E-03	$(\mu g/m3)^{-1}$	4.28E-16	2.73E-14	µg/m3	-	-	-
			Combined Volatilization and Particulate Matter	Arsenic	1.06	mg/kg	1.18E-10	µg/m3	4.30E-03	$(\mu g/m3)^{-1}$	5.07E-13	8.26E-12	µg/m3	1.50E-05	µg/m3	5.50E-07
			Exp. Route Total								5.07E-13					5.50E-07
		Exposure Point Total									1.01E-12					1.10E-06
	Shallow Soil	Prior Cleanup	Dermal Contact	Benzo(a)pyrene	0.63	mg/kg	1.35E-10	µg/m3	7.3	$(mg\text{-}kg/day)^{-1}$	7.93E-09	9.46E-09	mg/kg-day	-	-	-
		(Excavation Worker)		Arsenic	7.18	mg/kg	3.56E-10	µg/m3	1.5	$(mg\text{-}kg/day)^{-1}$	1.68E-08	2.49E-08	mg/kg-day	3.00E-04	mg/m3	8.30E-05
			Exp. Route Total								2.47E-08					8.30E-05
			Incidental Ingestion	Benzo(a)pyrene	0.63	mg/kg	9.51E-10	µg/m3	7.3	$(mg\text{-}kg/day)^{-1}$	6.94E-09	6.66E-08	mg/kg-day	-	-	-
				Arsenic	7.18	mg/kg	1.08E-08	µg/m3	1.5	$(mg\text{-}kg/day)^{-1}$	1.63E-08	7.59E-07	mg/kg-day	3.00E-04	mg/m3	2.53E-03
			Exp. Route Total								2.32E-08					2.53E-03
			Inhalation	Benzo(a)pyrene	0.63	mg/kg	7.01E-11	µg/m3	1.10E-03	$(\mu g/m3)^{-1}$	7.71E-14	4.91E-12	µg/m3	-	-	-
			Combined Volatilization and Particulate Matter	Arsenic	7.18	mg/kg	7.99E-10	µg/m3	4.30E-03	$(\mu g/m3)^{-1}$	3.44E-12	5.59E-11	µg/m3	1.50E-05	µg/m3	3.73E-06
			Exp. Route Total								3.52E-12					3.73E-06
		Exposure Point Total									6.96E-12					7.46E-06
	Shallow Soil	Sandblast	Dermal Contact	Benzo(a)pyrene	0.38	mg/kg	4.06E-10	µg/m3	7.3	$(mg\text{-}kg/day)^{-1}$	4.78E-09	5.71E-09	mg/kg-day	-	-	-
		(Excavation Worker)		Arsenic	8.2	mg/kg	8.15E-11	µg/m3	1.5	$(mg\text{-}kg/day)^{-1}$	1.92E-08	2.84E-08	mg/kg-day	3.00E-04	mg/m3	9.47E-05
			Exp. Route Total								2.40E-08					9.47E-05
			Incidental Ingestion	Benzo(a)pyrene	0.38	mg/kg	5.74E-10	µg/m3	7.3	$(mg\text{-}kg/day)^{-1}$	4.19E-09	4.02E-08	mg/kg-day	-	-	-
				Arsenic	8.2	mg/kg	1.24E-08	µg/m3	1.5	$(mg\text{-}kg/day)^{-1}$	1.86E-08	8.67E-07	mg/kg-day	3.00E-04	mg/m3	2.89E-03
			Exp. Route Total								2.28E-08					2.89E-03
			Inhalation	Benzo(a)pyrene	0.38	mg/kg	4.23E-11	µg/m3	1.10E-03	$(\mu g/m3)^{-1}$	4.65E-14	2.96E-12	µg/m3	-	µg/m3	-
			Combined Volatilization and Particulate Matter	Arsenic	8.2	mg/kg	9.13E-10	µg/m3	4.30E-03	$(\mu g/m3)^{-1}$	3.92E-12	6.39E-11	µg/m3	1.50E-05	µg/m3	4.26E-06
			Exp. Route Total								3.97E-12					4.26E-06
		Exposure Point Total									7.89E-12					8.52E-06

TABLE 7-7-3 RME CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS REASONABLE MAXIMUM EXPOSURE
U.S. GOVERNMENT MOORINGS

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	GW-2	Dermal Contact	Aluminum (pH 6.5 - 9.0)	3,820	µg/L	4.06E-08	mg-kg/day	-	-	-	4.06E-08	mg/kg-day	1.00E+00	mg/kg-day	4.06E-08
		Office Worker		Arsenic	1.43	µg/L	1.52E-11	mg-kg/day	1.50E+00	(mg-kg/day)-1	2.28E-11	1.52E-11	mg/kg-day	3.00E-04	mg/kg-day	5.07E-08
		Maintenance Worker		Benz(a)anthracene	ND	µg/L	-	mg-kg/day	7.30E-01	(mg-kg/day)-1	-	-	-	-	-	-
				Benzene	ND	µg/L	-	mg-kg/day	5.50E-02	(mg-kg/day)-1	-	-	-	4.00E-03	mg/kg-day	-
				Benzo(a)pyrene	ND	µg/L	-	mg-kg/day	7.30E+00	(mg-kg/day)-1	-	-	-	-	-	-
				Benzo(b)fluoranthene	ND	µg/L	-	mg-kg/day	7.30E-01	(mg-kg/day)-1	-	-	-	-	-	-
				Cadmium	0.02	µg/L	2.12E-13	mg-kg/day	-	-	-	2.12E-13	mg/kg-day	2.50E-05	mg/kg-day	8.48E-09
				Chloroform	0.3	µg/L	2.84E-11	mg-kg/day	6.10E-02	(mg-kg/day)-1	1.73E-12	2.84E-11	mg/kg-day	1.00E-02	mg/kg-day	2.84E-09
				Chromium, total	3.6	µg/L	3.82E-11	mg-kg/day	-	-	-	3.82E-11	mg/kg-day	1.95E-02	mg/kg-day	1.96E-09
				Cyanide	50	µg/L	5.31E-10	mg-kg/day	-	-	-	5.31E-10	mg/kg-day	2.00E-02	mg/kg-day	2.66E-08
				Dibenz(a,h)anthracene	ND	µg/L	-	-	7.30E+00	(mg-kg/day)-1	-	-	-	-	-	-
				Fluorene	ND	µg/L	-	-	-	-	-	-	-	4.00E-02	mg/kg-day	-
				Indeno(1,2,3-cd)pyrene	ND	µg/L	-	-	7.30E-01	(mg-kg/day)-1	-	-	-	-	-	-
				Manganese	478	µg/L	5.08E-09	mg-kg/day	-	-	-	5.08E-09	mg/kg-day	2.40E-02	mg/kg-day	2.12E-07
				Mercury	ND	µg/L	-	-	-	-	-	-	-	3.00E-04	mg/kg-day	-
				Naphthalene	0.008	µg/L	5.90E-12	mg-kg/day	-	-	-	5.90E-12	mg/kg-day	2.00E-02	mg/kg-day	2.95E-10
				Nickel	25	µg/L	5.31E-11	mg-kg/day	-	-	-	5.31E-11	mg/kg-day	8.00E-04	mg/kg-day	6.64E-08
				Tetrachloroethene (PCE)	0.22	µg/L	1.12E-10	mg-kg/day	5.40E-01	(mg-kg/day)-1	6.05E-11	1.12E-10	mg/kg-day	1.00E-02	mg/kg-day	1.12E-08
				Trichloroethene (TCE)	0.67	µg/L	1.12E-10	mg-kg/day	8.90E-02	(mg-kg/day)-1	9.97E-12	1.12E-10	mg/kg-day	-	-	-
				Zinc	281	µg/L	1.79E-09	mg-kg/day	-	-	-	1.79E-09	mg/kg-day	3.00E-01	mg/kg-day	5.97E-09
			Exp. Route Total								9.50E-11					4.27E-07
			Ingestion	Aluminum (pH 6.5 - 9.0)	3,820	µg/L	6.69E-02	mg-kg/day	-	-	-	8.60E-02	mg/kg-day	1.00E+00	mg/kg-day	8.60E-02
				Arsenic	1.43	µg/L	2.50E-05	mg-kg/day	1.50E+00	(mg-kg/day)-1	3.75E-05	3.22E-05	mg/kg-day	3.00E-04	mg/kg-day	1.07E-01
				Benz(a)anthracene	ND	µg/L	-	-	7.30E-01	(mg-kg/day)-1	-	-	-	-	-	-
				Benzene	ND	µg/L	-	-	5.50E-02	(mg-kg/day)-1	-	-	-	4.00E-03	mg/kg-day	-
				Benzo(a)pyrene	ND	µg/L	-	-	7.30E+00	(mg-kg/day)-1	-	-	-	-	-	-
				Benzo(b)fluoranthene	ND	µg/L	-	-	7.30E-01	(mg-kg/day)-1	-	-	-	-	-	-
				Cadmium	0.02	µg/L	3.50E-07	mg-kg/day	-	-	-	4.50E-07	mg/kg-day	5.00E-04	mg/kg-day	9.00E-04
				Chloroform	0.3	µg/L	5.25E-06	mg-kg/day	6.10E-02	(mg-kg/day)-1	3.20E-07	6.75E-06	mg/kg-day	1.00E-02	mg/kg-day	6.75E-04
				Chromium, total	3.6	µg/L	6.30E-05	mg-kg/day	-	-	-	8.10E-05	mg/kg-day	1.50E+00	mg/kg-day	5.40E-05
				Cyanide	50	µg/L	8.75E-04	mg-kg/day	-	-	-	1.13E-03	mg/kg-day	2.00E-02	mg/kg-day	5.65E-02
				Dibenz(a,h)anthracene	ND	µg/L	-	-	7.30E+00	(mg-kg/day)-1	-	-	-	-	-	-
				Fluorene	ND	µg/L	-	-	-	-	-	-	-	4.00E-02	mg/kg-day	-
				Indeno(1,2,3-cd)pyrene	ND	µg/L	-	-	7.30E-01	(mg-kg/day)-1	-	-	-	-	-	-
				Manganese	478	µg/L	8.37E-03	mg-kg/day	-	-	-	1.08E-02	mg/kg-day	2.40E-02	mg/kg-day	4.50E-01
				Mercury	ND	µg/L	-	-	-	-	-	-	-	3.00E-04	mg/kg-day	-
				Naphthalene	0.008	µg/L	1.40E-07	mg-kg/day	-	-	-	1.80E-07	mg/kg-day	2.00E-02	mg/kg-day	9.00E-06
				Nickel	25	µg/L	4.38E-04	mg-kg/day	-	-	-	5.63E-04	mg/kg-day	2.00E-02	mg/kg-day	2.82E-02
				Tetrachloroethene (PCE)	0.22	µg/L	3.85E-06	mg-kg/day	5.40E-01	(mg-kg/day)-1	2.08E-06	4.95E-06	mg/kg-day	1.00E-02	mg/kg-day	4.95E-04
				Trichloroethene (TCE)	0.67	µg/L	1.17E-05	mg-kg/day	8.90E-02	(mg-kg/day)-1	1.04E-06	1.51E-05	mg/kg-day	-	-	-
				Zinc	281	µg/L	4.92E-03	mg-kg/day	-	-	-	6.32E-03	mg/kg-day	3.00E-01	mg/kg-day	2.11E-02
			Exp. Route Total								4.09E-05					7.51E-01
	Air	GW-2	Inhalation	Aluminum (pH 6.5 - 9.0)	3,820	µg/L	-	-	-	-	-	-	-	5.00E-03	mg/m^3	-
		Office Worker		Arsenic	1.43	µg/L	-	-	4.30E-03	(µg/m^3)-1	-	-	-	1.50E-05	mg/m^3	-
		Maintenance Worker	Volatilization	Benz(a)anthracene	ND	µg/L	-	-	1.10E-04	(µg/m^3)-1	-	-	-	-	-	-
				Benzene	ND	µg/L	-	-	7.80E-06	(µg/m^3)-1	-	-	-	3.00E-02	mg/m^3	-
				Benzo(a)pyrene	ND	µg/L	-	-	1.10E-03	(µg/m^3)-1	-	-	-	-	-	-
				Benzo(b)fluoranthene	ND	µg/L	-	-	1.10E-04	(µg/m^3)-1	-	-	-	-	-	-
				Cadmium	0.02	µg/L	-	-	1.80E-03	(µg/m^3)-1	-	-	-	1.00E-05	mg/m^3	-
				Chloroform	0.3	µg/L	1.22E-02	µg/m^3	2.30E-05	(µg/m^3)-1	2.81E-07	3.42E-05	µg/m3	9.80E-02	mg/m^3	3.49E-07
				Chromium, total	3.6	µg/L	-	-	1.20E-02	(µg/m^3)-1	-	-	-	1.00E-04	mg/m^3	-
				Cyanide	50	µg/L	-	-	-	-	-	-	-	-	-	-
				Dibenz(a,h)anthracene	ND	µg/L	-	-	1.10E-03	(µg/m^3)-1	-	-	-	-	-	-
				Fluorene	ND	µg/L	-	-	-	-	-	-	-	-	-	-
				Indeno(1,2,3-cd)pyrene	ND	µg/L	-	-	1.10E-04	(µg/m^3)-1	-	-	-	-	-	-
				Manganese	478	µg/L	-	-	-	-	-	-	-	5.00E-05	mg/m^3	-
				Mercury	ND	µg/L	-	-	-	-	-	-	-	3.00E-04	mg/m^3	-
				Naphthalene	0.008	µg/L	3.26E-04	µg/m^3	3.40E-05	(µg/m^3)-1	1.11E-08	9.13E-07	µg/m3	3.00E-03	mg/m^3	3.04E-07
				Nickel	25	µg/L	1.02E+00	µg/m^3	2.60E-04	(µg/m^3)-1	-	-	-	9.00E-05	mg/m^3	-
				Tetrachloroethene (PCE)	0.22	µg/L	8.97E-03	µg/m^3	5.90E-06	(µg/m^3)-1	5.29E-08	2.51E-05	µg/m3	2.70E-01	mg/m^3	9.30E-08
				Trichloroethene (TCE)	0.67	µg/L	2.73E-02	µg/m^3	2.00E-05	(µg/m^3)-1	-	-	µg/m3	-	-	-
				Zinc	281	µg/L	1.15E+01	µg/m^3	-	-	-	-	µg/m3	-	-	-
			Exp. Route Total								3.45E-07					7.46E-07
		Exposure Point Total									4.13E-05					0.75

TABLE 7-7-3 RME CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS REASONABLE MAXIMUM EXPOSURE
U.S. GOVERNMENT MOORINGS

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	GW-11	Dermal Contact	Aluminum (pH 6.5 - 9.0)	74,600	µg/L	7.93E-07	mg-kg/day	-	-	-	7.48E-04	mg/kg-day	1.00E+00	mg/kg-day	7.48E-04
		Office Worker		Arsenic	4.02	µg/L	4.27E-11	mg-kg/day	1.50E+00	(mg-kg/day)-1	6.41E-11	4.03E-08	mg/kg-day	3.00E-04	mg/kg-day	1.34E-04
		Maintenance Worker		Benz(a)anthracene	0.06	µg/L	1.15E-05	mg-kg/day	7.30E-01	(mg-kg/day)-1	8.40E-06	5.70E-07	mg/kg-day	-	-	-
				Benzene	0.22	µg/L	4.84E-11	mg-kg/day	5.50E-02	(mg-kg/day)-1	2.66E-12	4.57E-08	mg/kg-day	4.00E-03	mg/kg-day	1.14E-05
				Benzo(a)pyrene	0.051	µg/L	1.28E-05	mg-kg/day	7.30E+00	(mg-kg/day)-1	9.34E-05	6.34E-07	mg/kg-day	-	-	-
				Benzo(b)fluoranthene	0.03	µg/L	4.24E-06	mg-kg/day	7.30E-01	(mg-kg/day)-1	3.10E-06	2.10E-07	mg/kg-day	-	-	-
				Cadmium	20.9	µg/L	2.22E-10	mg-kg/day	-	-	-	2.10E-07	mg/kg-day	2.50E-05	mg/kg-day	8.40E-03
				Chloroform	ND	µg/L	-	-	6.10E-02	(mg-kg/day)-1	-	-	-	1.00E-02	mg/kg-day	-
				Chromium, total	100	µg/L	1.06E-09	mg-kg/day	-	-	-	1.00E-06	mg/kg-day	1.95E-02	mg/kg-day	5.13E-05
				Cyanide	150	µg/L	1.59E-09	mg-kg/day	-	-	-	1.50E-06	mg/kg-day	2.00E-02	mg/kg-day	7.50E-05
				Dibenz(a,h)anthracene	0.0052	µg/L	1.76E-06	mg-kg/day	7.30E+00	(mg-kg/day)-1	1.28E-05	8.76E-08	mg/kg-day	-	-	-
				Fluorene	0.06	µg/L	1.09E-10	mg-kg/day	-	-	-	1.03E-07	mg/kg-day	4.00E-02	mg/kg-day	2.58E-06
				Indeno(1,2,3-cd)pyrene	0.047	µg/L	2.12E-05	mg-kg/day	7.30E-01	(mg-kg/day)-1	1.55E-05	1.05E-06	mg/kg-day	-	-	-
				Manganese	1770	µg/L	1.88E-08	mg-kg/day	-	-	-	1.78E-05	mg/kg-day	2.40E-02	mg/kg-day	7.42E-04
				Mercury	0.07	µg/L	1.78E-10	mg-kg/day	-	-	-	1.68E-07	mg/kg-day	3.00E-04	mg/kg-day	5.60E-04
				Naphthalene	3.3	µg/L	2.43E-09	mg-kg/day	-	-	-	2.30E-06	mg/kg-day	2.00E-02	mg/kg-day	1.15E-04
				Nickel	212	µg/L	4.50E-10	mg-kg/day	-	-	-	4.25E-07	mg/kg-day	8.00E-04	mg/kg-day	5.31E-04
				Tetrachloroethene (PCE)	ND	µg/L	-	-	5.40E-01	(mg-kg/day)-1	-	-	-	1.00E-02	mg/kg-day	-
				Trichloroethene (TCE)	ND	µg/L	-	-	8.90E-02	(mg-kg/day)-1	-	-	-	-	-	-
				Zinc	5510	µg/L	3.51E-08	mg-kg/day	-		-	3.32E-05	mg/kg-day	3.00E-01	mg/kg-day	1.11E-04
			Exp. Route Total								1.33E-04					1.15E-02
			Ingestion	Aluminum (pH 6.5 - 9.0)	74,600	µg/L	1.31E+00	mg-kg/day	-	-	-	1.68E+00	mg/kg-day	1.00E+00	mg/kg-day	1.68
				Arsenic	4.02	µg/L	7.04E-05	mg-kg/day	1.50E+00	(mg-kg/day)-1	1.06E-04	9.05E-05	mg/kg-day	3.00E-04	mg/kg-day	3.02E-01
				Benz(a)anthracene	0.06	µg/L	1.99E-06	mg-kg/day	7.30E-01	(mg-kg/day)-1	1.45E-06	1.35E-06	mg/kg-day	-	-	-
				Benzene	0.22	µg/L	3.85E-06	mg-kg/day	5.50E-02	(mg-kg/day)-1	2.12E-07	4.95E-06	mg/kg-day	4.00E-03	mg/kg-day	1.24E-03
				Benzo(a)pyrene	0.051	µg/L	1.69E-06	mg-kg/day	7.30E+00	(mg-kg/day)-1	1.23E-05	1.15E-06	mg/kg-day	-	-	-
				Benzo(b)fluoranthene	0.03	µg/L	9.95E-07	mg-kg/day	7.30E-01	(mg-kg/day)-1	7.26E-07	6.75E-07	mg/kg-day	-	-	-
				Cadmium	20.9	µg/L	3.66E-04	mg-kg/day	-	-	-	4.70E-04	mg/kg-day	5.00E-04	mg/kg-day	9.40E-01
				Chloroform	ND	µg/L	-	-	6.10E-02	(mg-kg/day)-1	-	-	-	1.00E-02	mg/kg-day	-
				Chromium, total	100	µg/L	1.75E-03	mg-kg/day	-	-	-	2.25E-03	mg/kg-day	1.50E+00	mg/kg-day	1.50E-03
				Cyanide	150	µg/L	2.63E-03	mg-kg/day	-	-	-	3.38E-03	mg/kg-day	2.00E-02	mg/kg-day	1.69E-01
				Dibenz(a,h)anthracene	0.0052	µg/L	1.72E-07	mg-kg/day	7.30E+00	(mg-kg/day)-1	1.26E-06	1.17E-07	mg/kg-day	-	-	-
				Fluorene	0.06	µg/L	1.05E-06	mg-kg/day	-	-	-	1.35E-06	mg/kg-day	4.00E-02	mg/kg-day	3.38E-05
				Indeno(1,2,3-cd)pyrene	0.047	µg/L	1.56E-06	mg-kg/day	7.30E-01	(mg-kg/day)-1	1.14E-06	1.06E-06	mg/kg-day	-	-	-
				Manganese	1770	µg/L	3.10E-02	mg-kg/day	-	-	-	3.98E-02	mg/kg-day	2.40E-02	mg/kg-day	1.66
				Mercury	0.07	µg/L	1.23E-06	mg-kg/day	-	-	-	1.58E-06	mg/kg-day	3.00E-04	mg/kg-day	5.27E-03
				Naphthalene	3.3	µg/L	5.78E-05	mg-kg/day	-	-	-	7.43E-05	mg/kg-day	2.00E-02	mg/kg-day	3.72E-03
				Nickel	212	µg/L	3.71E-03	mg-kg/day	-	-	-	4.77E-03	mg/kg-day	2.00E-02	mg/kg-day	2.39E-01
				Tetrachloroethene (PCE)	ND	µg/L	-	-	5.40E-01	(mg-kg/day)-1	-	-	-	1.00E-02	mg/kg-day	-
				Trichloroethene (TCE)	ND	µg/L	-	-	8.90E-02	(mg-kg/day)-1	-	-	-	-	-	-
				Zinc	5510	µg/L	9.64E-02	mg-kg/day	-	-	-	1.24E-01	mg/kg-day	3.00E-01	mg/kg-day	4.13E-01
			Exp. Route Total								1.23E-04					5.41
	Air	GW-11	Inhalation	Aluminum (pH 6.5 - 9.0)	74,600	µg/L	-	-	-	-	-	-	-	5.00E-03	mg/m^3	-
		Office Worker		Arsenic	4.02	µg/L	-	-	4.30E-03	(µg/m^3)-1	-	-	-	1.50E-05	mg/m^3	-
		Maintenance Worker	Volatilization	Benz(a)anthracene	0.06	µg/L	-	-	1.10E-04	(µg/m^3)-1	-	-	-	-	-	-
				Benzene	0.22	µg/L	8.97E-03	µg/m^3	7.80E-06	(µg/m^3)-1	7.00E-08	2.51E-05	µg/m3	3.00E-02	mg/m^3	8.37E-07
				Benzo(a)pyrene	0.051	µg/L	-	-	1.10E-03	(µg/m^3)-1	-	-	-	-	-	-
				Benzo(b)fluoranthene	0.03	µg/L	-	-	1.10E-04	(µg/m^3)-1	-	-	-	-	-	-
				Cadmium	20.9	µg/L	-	-	1.80E-03	(µg/m^3)-1	-	-	-	1.00E-05	mg/m^3	-
				Chloroform	ND	µg/L	-	-	2.30E-05	(µg/m^3)-1	-	-	-	9.80E-02	mg/m^3	-
				Chromium, total	100	µg/L	-	-	1.20E-02	(µg/m^3)-1	-	-	-	1.00E-04	mg/m^3	-
				Cyanide	150	µg/L	-	-	-	-	-	-	-	-	-	-
				Dibenz(a,h)anthracene	0.0052	µg/L	-	-	1.10E-03	(µg/m^3)-1	-	-	-	-	-	-
				Fluorene	0.06	µg/L	-	-	-	-	-	-	-	-	-	-
				Indeno(1,2,3-cd)pyrene	0.047	µg/L	-	-	1.10E-04	(µg/m^3)-1	-	-	-	-	-	-
				Manganese	1,770	µg/L	-	-	-	-	-	-	-	5.00E-05	mg/m^3	-
				Mercury	0.07	µg/L	2.85E-03	µg/m^3	-	-	-	7.99E-06	µg/m3	3.00E-04	mg/m^3	2.66E-05
				Naphthalene	3.3	µg/L	1.35E-01	µg/m^3	3.40E-05	(µg/m^3)-1	4.59E-06	3.77E-04	µg/m3	3.00E-03	mg/m^3	1.26E-04
				Nickel	212	µg/L	8.64E+00	µg/m^3	2.60E-04	(µg/m^3)-1	-	-	-	9.00E-05	mg/m^3	-
				Tetrachloroethene (PCE)	ND	µg/L	-	-	5.90E-06	(µg/m^3)-1	-	-	-	2.70E-01	mg/m^3	-
				Trichloroethene (TCE)	ND	µg/L	-	-	2.00E-05	(µg/m^3)-1	-	-	-	-	-	-
				Zinc	5510	µg/L	-	-	-	-	-	-	-	-	-	-
			Exp. Route Total								4.66E-06					1.53E-04
		Exposure Point Total									2.61E-04					5.42

TABLE 7-7-3 RME CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS REASONABLE MAXIMUM EXPOSURE
U.S. GOVERNMENT MOORINGS

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	GW-16	Dermal Contact	Aluminum (pH 6.5 - 9.0)	8,040	µg/L	8.54E-08	mg-kg/day	-	-	-	8.06E-05	mg/kg-day	1.00E+00	mg/kg-day	8.06E-05
		Office Worker		Arsenic	0.55	µg/L	5.84E-12	mg-kg/day	1.50E+00	(mg-kg/day)-1	8.76E-12	5.52E-09	mg/kg-day	3.00E-04	mg/kg-day	1.84E-05
		Maintenance Worker		Benz(a)anthracene	0.01	µg/L	1.91E-06	mg-kg/day	7.30E-01	(mg-kg/day)-1	1.39E-06	9.51E-08	mg/kg-day	-	-	-
				Benzene	0.56	µg/L	1.23E-10	mg-kg/day	5.50E-02	(mg-kg/day)-1	6.77E-12	1.16E-07	mg/kg-day	4.00E-03	mg/kg-day	2.90E-05
				Benzo(a)pyrene	ND	µg/L	-	-	7.30E+00	(mg-kg/day)-1	-	-	-	-	-	-
				Benzo(b)fluoranthene	0.02	µg/L	2.82E-06	mg-kg/day	7.30E-01	(mg-kg/day)-1	2.06E-06	1.40E-07	mg/kg-day	-	-	-
				Cadmium	2.17	µg/L	2.31E-11	mg-kg/day	-	-	-	2.18E-08	mg/kg-day	2.50E-05	mg/kg-day	8.72E-04
				Chloroform	ND	µg/L	-	-	6.10E-02	(mg-kg/day)-1	-	-	-	1.00E-02	mg/kg-day	-
				Chromium, total	7.1	µg/L	7.54E-11	mg-kg/day	-	-	-	7.12E-08	mg/kg-day	1.95E-02	mg/kg-day	3.65E-06
				Cyanide	2990	µg/L	3.18E-08	mg-kg/day	-	-	-	3.00E-05	mg/kg-day	2.00E-02	mg/kg-day	1.50E-03
				Dibenz(a,h)anthracene	ND	µg/L	-	-	7.30E+00	(mg-kg/day)-1	-	-	-	-	-	-
				Fluorene	0.39	µg/L	7.08E-10	mg-kg/day	-	-	-	6.69E-07	mg/kg-day	4.00E-02	mg/kg-day	1.67E-05
				Indeno(1,2,3-cd)pyrene	0.005	µg/L	2.25E-06	mg-kg/day	7.30E-01	(mg-kg/day)-1	1.64E-06	1.12E-07	mg/kg-day	-	-	-
				Manganese	804	µg/L	8.54E-09	mg-kg/day	-	-	-	8.06E-06	mg/kg-day	2.40E-02	mg/kg-day	3.36E-04
				Mercury	ND	µg/L	-	-	-	-	-	-	-	3.00E-04	mg/kg-day	-
				Naphthalene	6	µg/L	4.42E-09	mg-kg/day	-	-	-	4.18E-06	mg/kg-day	2.00E-02	mg/kg-day	2.09E-04
				Nickel	72	µg/L	1.53E-10	mg-kg/day	-	-	-	1.44E-07	mg/kg-day	8.00E-04	mg/kg-day	1.80E-04
				Tetrachloroethene (PCE)	ND	µg/L	-	-	5.40E-01	(mg-kg/day)-1	-	-	-	1.00E-02	mg/kg-day	-
				Trichloroethene (TCE)	ND	µg/L	-	-	8.90E-02	(mg-kg/day)-1	-	-	-	-	-	-
				Zinc	1250	µg/L	7.97E-09	mg-kg/day	-	-	-	7.52E-06	mg/kg-day	3.00E-01	mg/kg-day	2.51E-05
			Exp. Route Total								5.10E-06					3.27E-03
			Ingestion	Aluminum (pH 6.5 - 9.0)	8,040	µg/L	1.41E-01	mg-kg/day	-	-	-	1.81E-01	mg/kg-day	1.00E+00	mg/kg-day	1.81E-01
				Arsenic	0.55	µg/L	9.63E-06	mg-kg/day	1.50E+00	(mg-kg/day)-1	1.44E-05	1.24E-05	mg/kg-day	3.00E-04	mg/kg-day	4.13E-02
				Benz(a)anthracene	0.01	µg/L	3.32E-07	mg-kg/day	7.30E-01	(mg-kg/day)-1	2.42E-07	2.25E-07	mg/kg-day	-	-	-
				Benzene	0.56	µg/L	9.80E-06	mg-kg/day	5.50E-02	(mg-kg/day)-1	5.39E-07	1.26E-05	mg/kg-day	4.00E-03	mg/kg-day	3.15E-03
				Benzo(a)pyrene	ND	µg/L	-	-	7.30E+00		-	-	-	-	-	-
				Benzo(b)fluoranthene	0.02	µg/L	6.63E-07	mg-kg/day	7.30E-01		4.84E-07	4.50E-07	mg/kg-day	-	-	-
				Cadmium	2.17	µg/L	3.80E-05	mg-kg/day	-		-	4.88E-05	mg/kg-day	5.00E-04	mg/kg-day	9.76E-02
				Chloroform	ND	µg/L	-	-	6.10E-02	(mg-kg/day)-1	-	-	-	1.00E-02	mg/kg-day	-
				Chromium, total	7.1	µg/L	1.24E-04	mg-kg/day	-	-	-	1.60E-04	mg/kg-day	1.50E+00	mg/kg-day	1.07E-04
				Cyanide	2,990	µg/L	5.23E-02	mg-kg/day	-	-	-	6.73E-02	mg/kg-day	2.00E-02	mg/kg-day	3.37
				Dibenz(a,h)anthracene	ND	µg/L	-	-	7.30E+00	(mg-kg/day)-1	-	-	-	-	-	-
				Fluorene	0.39	µg/L	6.83E-06	mg-kg/day	-	-	-	8.78E-06	mg/kg-day	4.00E-02	mg/kg-day	2.20E-04
				Indeno(1,2,3-cd)pyrene	0.005	µg/L	1.66E-07	mg-kg/day	7.30E-01	(mg-kg/day)-1	1.21E-07	1.13E-07	mg/kg-day	-	-	-
				Manganese	804	µg/L	1.41E-02	mg-kg/day	-	-	-	1.81E-02	mg/kg-day	2.40E-02	mg/kg-day	7.54E-01
				Mercury	ND	µg/L	-	-	-	-	-	-	-	3.00E-04	mg/kg-day	-
				Naphthalene	6	µg/L	1.05E-04	mg-kg/day	-	-	-	1.35E-04	mg/kg-day	2.00E-02	mg/kg-day	6.75E-03
				Nickel	72	µg/L	1.26E-03	mg-kg/day	-	-	-	1.62E-03	mg/kg-day	2.00E-02	mg/kg-day	8.10E-02
				Tetrachloroethene (PCE)	ND	µg/L	-	-	5.40E-01	(mg-kg/day)-1	-	-	-	1.00E-02	mg/kg-day	-
				Trichloroethene (TCE)	ND	µg/L	-	-	8.90E-02	(mg-kg/day)-1	-	-	-	-	-	-
				Zinc	1,250	µg/L	2.19E-02	mg-kg/day	-		-	2.81E-02	mg/kg-day	3.00E-01	mg/kg-day	9.37E-02
			Exp. Route Total								1.58E-05					4.62
	Air	GW-16	Inhalation	Aluminum (pH 6.5 - 9.0)	8,040	µg/L	-	-	-	-	-	-	-	-	-	-
		Office Worker		Arsenic	0.55	µg/L	-	-	4.30E-03	(µg/m^3)-1	-	-	-	1.50E-05	mg/m^3	-
		Maintenance Worker	Volatilization	Benz(a)anthracene	0.01	µg/L	-	-	1.10E-04	(µg/m^3)-1	-	-	-	-	-	-
				Benzene	0.56	µg/L	9.80E-06	µg/m^3	7.80E-06	(µg/m^3)-1	7.64E-11	6.39E-05	µg/m3	3.00E-02	mg/m^3	2.13E-06
				Benzo(a)pyrene	ND	µg/L	-	-	1.10E-03	(µg/m^3)-1	-	-	-	-	-	-
				Benzo(b)fluoranthene	0.02	µg/L	-	-	1.10E-04	(µg/m^3)-1	-	2.28E-06	µg/m3	-	-	-
				Cadmium	2.17	µg/L	-	-	1.80E-03	(µg/m^3)-1	-	2.48E-04	µg/m3	1.00E-05	mg/m^3	-
				Chloroform	ND	µg/L	-	-	2.30E-05	(µg/m^3)-1	-	-	-	9.80E-02	mg/m^3	-
				Chromium, total	7.1	µg/L	-	-	1.20E-02	(µg/m^3)-1	-	8.11E-04	µg/m3	1.00E-04	mg/m^3	-
				Cyanide	2990	µg/L	-	-	-	-	-	3.41E-01	µg/m3	-	-	-
				Dibenz(a,h)anthracene	ND	µg/L	-	-	1.10E-03	(µg/m^3)-1	-	-	-	-	-	-
				Fluorene	0.39	µg/L	-	-	-	-	-	-	-	-	-	-
				Indeno(1,2,3-cd)pyrene	0.005	µg/L	-	-	1.10E-04	(µg/m^3)-1	-	-	-	-	-	-
				Manganese	804	µg/L	-	-	-	-	-	-	-	5.00E-05	mg/m^3	-
				Mercury	ND	µg/L	-	-	-	-	-	-	-	3.00E-04	mg/m^3	-
				Naphthalene	6	µg/L	1.05E-04	µg/m^3	3.40E-05	(µg/m^3)-1	3.57E-09	6.85E-04	µg/m3	3.00E-03	mg/m^3	2.28E-04
				Nickel	72	µg/L	-	-	2.60E-04	(µg/m^3)-1	-	-	-	9.00E-05	mg/m^3	-
				Tetrachloroethene (PCE)	ND	µg/L	-	-	5.90E-06	(µg/m^3)-1	-	-	-	2.70E-01	mg/m^3	-
				Trichloroethene (TCE)	ND	µg/L	-	-	2.00E-05	(µg/m^3)-1	-	-	-	-	-	-
				Zinc	1250	µg/L	-	-	-	-	-	-	-	-	-	-
			Exp. Route Total								3.65E-09					2.30E-04
		Exposure Point Total									2.09E-05					4.63

TABLE 7-7-3 RME CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS REASONABLE MAXIMUM EXPOSURE
U.S. GOVERNMENT MOORINGS

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	GW-20	Dermal Contact	Aluminum (pH 6.5 - 9.0)	102	µg/L	1.08E-09	mg-kg/day	-	-	-	1.02E-06	mg/kg-day	1.00E+00	mg/kg-day	1.02E-06
		Office Worker		Arsenic	4.68	µg/L	4.97E-11	mg-kg/day	1.50E+00	(mg-kg/day)-1	7.46E-11	4.69E-08	mg/kg-day	3.00E-04	mg/kg-day	1.56E-04
		Maintenance Worker		Benz(a)anthracene	ND	µg/L	-	-	7.30E-01	(mg-kg/day)-1	-	-	-	-	-	-
				Benzene	ND	µg/L	-	-	5.50E-02	(mg-kg/day)-1	-	-	-	4.00E-03	mg/kg-day	-
				Benzo(a)pyrene	ND	µg/L	-	-	7.30E+00	(mg-kg/day)-1	-	-	-	-	-	-
				Benzo(b)fluoranthene	ND	µg/L	-	-	7.30E-01	(mg-kg/day)-1	-	-	-	-	-	-
				Cadmium	ND	µg/L	-	-	-	-	-	-	-	2.50E-05	mg/kg-day	-
				Chloroform	ND	µg/L	-	-	6.10E-02	(mg-kg/day)-1	-	-	-	1.00E-02	mg/kg-day	-
				Chromium, total	ND	µg/L	-	-	-	-	-	-	-	1.95E-02	mg/kg-day	-
				Cyanide	200	µg/L	2.12E-09	mg-kg/day	-	-	-	2.01E-06	mg/kg-day	2.00E-02	mg/kg-day	1.01E-04
				Dibenz(a,h)anthracene	ND	µg/L	-	-	7.30E+00	(mg-kg/day)-1	-	-	-	-	-	-
				Fluorene	ND	µg/L	-	-	-	-	-	-	-	4.00E-02	mg/kg-day	-
				Indeno(1,2,3-cd)pyrene	ND	µg/L	-	-	7.30E-01	(mg-kg/day)-1	-	-	-	-	-	-
				Manganese	12,000	µg/L	1.27E-07	mg-kg/day	-	-	-	1.20E-04	mg/kg-day	2.40E-02	mg/kg-day	5.00E-03
				Mercury	ND	µg/L	-	-	-	-	-	-	-	3.00E-04	mg/kg-day	-
				Naphthalene	ND	µg/L	-	-	-	-	-	-	-	2.00E-02	mg/kg-day	-
				Nickel	2	µg/L	4.25E-12	mg-kg/day	-	-	-	4.01E-09	mg/kg-day	8.00E-04	mg/kg-day	5.01E-06
				Tetrachloroethene (PCE)	ND	µg/L	-	-	5.40E-01	(mg-kg/day)-1	-	-	-	1.00E-02	mg/kg-day	-
				Trichloroethene (TCE)	ND	µg/L	-	-	8.90E-02	(mg-kg/day)-1	-	-	-	-	-	-
				Zinc	33	µg/L	2.10E-10	mg-kg/day	-		-	1.99E-07	mg/kg-day	3.00E-01	mg/kg-day	6.63E-07
			Exp. Route Total								7.46E-11					5.26E-03
			Ingestion	Aluminum (pH 6.5 - 9.0)	102	µg/L	1.79E-03	mg-kg/day	-	-	-	2.30E-03	mg/kg-day	1.00E+00	mg/kg-day	2.30E-03
				Arsenic	4.68	µg/L	8.19E-05	mg-kg/day	1.50E+00	(mg-kg/day)-1	1.23E-04	1.05E-04	mg/kg-day	3.00E-04	mg/kg-day	3.50E-01
				Benz(a)anthracene	ND	µg/L	-	-	7.30E-01	(mg-kg/day)-1	-	-	-	-	-	-
				Benzene	ND	µg/L	-	-	5.50E-02	(mg-kg/day)-1	-	-	-	4.00E-03	mg/kg-day	-
				Benzo(a)pyrene	ND	µg/L	-	-	7.30E+00		-	-	-	-	-	-
				Benzo(b)fluoranthene	ND	µg/L	-	-	7.30E-01		-	-	-	-	-	-
				Cadmium	ND	µg/L	-	-	-		-	-	-	5.00E-04	mg/kg-day	-
				Chloroform	ND	µg/L	-	-	6.10E-02	(mg-kg/day)-1	-	-	-	1.00E-02	mg/kg-day	-
				Chromium, total	ND	µg/L	-	-	-	-	-	-	-	1.50E+00	mg/kg-day	-
				Cyanide	200	µg/L	3.50E-03	mg-kg/day	-	-	-	4.50E-03	mg/kg-day	2.00E-02	mg/kg-day	2.25E-01
				Dibenz(a,h)anthracene	ND	µg/L	-	-	7.30E+00	(mg-kg/day)-1	-	-	-	-	-	-
				Fluorene	ND	µg/L	-	-	-	-	-	-	-	4.00E-02	mg/kg-day	-
				Indeno(1,2,3-cd)pyrene	ND	µg/L	-	-	7.30E-01	(mg-kg/day)-1	-	-	-	-	-	-
				Manganese	12,000	µg/L	2.10E-01	mg-kg/day	-	-	-	2.70E-01	mg/kg-day	2.40E-02	mg/kg-day	11.25
				Mercury	ND	µg/L	-	-	-	-	-	-	-	3.00E-04	mg/kg-day	-
				Naphthalene	ND	µg/L	-	-	-	-	-	-	-	2.00E-02	mg/kg-day	-
				Nickel	2	µg/L	3.50E-05	mg-kg/day	-	-	-	4.50E-05	mg/kg-day	2.00E-02	mg/kg-day	2.25E-03
				Tetrachloroethene (PCE)	ND	µg/L	-	-	5.40E-01	(mg-kg/day)-1	-	-	-	1.00E-02	mg/kg-day	-
				Trichloroethene (TCE)	ND	µg/L	-	-	8.90E-02	(mg-kg/day)-1	-	-	-	-	-	-
				Zinc	33	µg/L	5.78E-04	mg-kg/day	-		-	7.43E-04	mg/kg-day	3.00E-01	mg/kg-day	2.48E-03
			Exp. Route Total								1.23E-04					11.83
	Air	GW-20	Inhalation	Aluminum (pH 6.5 - 9.0)	102	µg/L	-	-	-	-	-	1.16E-02	µg/m3	5.00E-03	mg/m^3	-
		Office Worker		Arsenic	4.68	µg/L	-	-	4.30E-03	(µg/m^3)$^{-1}$	-	5.34E-04	µg/m3	1.50E-05	mg/m^3	-
		Maintenance Worker	Volatilization	Benz(a)anthracene	ND	µg/L	-	-	1.10E-04	(µg/m^3)$^{-1}$	-	-	-	-	-	-
				Benzene	ND	µg/L	-	-	7.80E-06	(µg/m^3)$^{-1}$	-	-	-	3.00E-02	mg/m^3	-
				Benzo(a)pyrene	ND	µg/L	-	-	1.10E-03	(µg/m^3)$^{-1}$	-	-	-	-	-	-
				Benzo(b)fluoranthene	ND	µg/L	-	-	1.10E-04	(µg/m^3)$^{-1}$	-	-	-	-	-	-
				Cadmium	ND	µg/L	-	-	1.80E-03	(µg/m^3)$^{-1}$	-	-	-	1.00E-05	mg/m^3	-
				Chloroform	ND	µg/L	-	-	2.30E-05	(µg/m^3)$^{-1}$	-	-	-	9.80E-02	mg/m^3	-
				Chromium, total	ND	µg/L	-	-	1.20E-02	(µg/m^3)$^{-1}$	-	-	-	1.00E-04	mg/m^3	-
				Cyanide	200	µg/L	-	-	-	-	-	2.28E-02	µg/m3	-	-	-
				Dibenz(a,h)anthracene	ND	µg/L	-	-	1.10E-03	(µg/m^3)$^{-1}$	-	-	-	-	-	-
				Fluorene	ND	µg/L	-	-	-	-	-	-	-	-	-	-
				Indeno(1,2,3-cd)pyrene	ND	µg/L	-	-	1.10E-04	(µg/m^3)$^{-1}$	-	-	-	-	-	-
				Manganese	12,000	µg/L	-	µg/m^3	-	-	-	1.37E+00	µg/m3	5.00E-05	mg/m^3	-
				Mercury	ND	µg/L	-	-	-	-	-	-	-	3.00E-04	mg/m^3	-
				Naphthalene	ND	µg/L	-	-	3.40E-05	(µg/m^3)$^{-1}$	-	-	-	3.00E-03	mg/m^3	-
				Nickel	2	µg/L	-	µg/m^3	2.60E-04	(µg/m^3)$^{-1}$	-	2.28E-04	µg/m3	9.00E-05	mg/m^3	-
				Tetrachloroethene (PCE)	ND	µg/L	-	-	5.90E-06	(µg/m^3)$^{-1}$	-	-	-	2.70E-01	mg/m^3	-
				Trichloroethene (TCE)	ND	µg/L	-	-	2.00E-05	(µg/m^3)$^{-1}$	-	-	-	-	-	-
				Zinc	33	µg/L	-	µg/m^3	-	-	-	3.77E-03	µg/m3	-	-	-
			Exp. Route Total								0.00E+00					0.00
		Exposure Point Total									1.23E-04					11.84

TABLE 7-7-4 RME CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS CENTRAL TENDANCY EXPOSURE
U.S. GOVERNMENT MOORINGS

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	GW-2	Dermal Contact	Aluminum (pH 6.5 - 9.0)	3,820	µg/L	3.78E-08	mg-kg/day	-	-	-	1.91E-05	mg/kg-day	1.00E+00	mg/kg-day	1.91E-05
		Office Worker		Arsenic	1.43	µg/L	1.42E-11	mg-kg/day	1.50E+00	$(mg\text{-}kg/day)^{-1}$	2.13E-11	7.16E-09	mg/kg-day	3.00E-04	mg/kg-day	2.39E-05
		Maintenance Worker		Benz(a)anthracene	ND	µg/L	-	mg-kg/day	7.30E-01	(mg-kg/day)-1	-	0.00E+00	-	-	-	-
				Benzene	ND	µg/L	-	mg-kg/day	5.50E-02	(mg-kg/day)-1	-	0.00E+00	-	4.00E-03	mg/kg-day	-
				Benzo(a)pyrene	ND	µg/L	-	mg-kg/day	7.30E+00	(mg-kg/day)-1	-	0.00E+00	-	-	-	-
				Benzo(b)fluoranthene	ND	µg/L	-	mg-kg/day	7.30E-01	(mg-kg/day)-1	-	0.00E+00	-	-	-	-
				Cadmium	0.02	µg/L	1.98E-13	mg-kg/day	-	-	-	1.00E-10	mg/kg-day	2.50E-05	mg/kg-day	4.00E-06
				Chloroform	0.3	µg/L	2.65E-11	mg-kg/day	6.10E-02	(mg-kg/day)-1	1.62E-12	1.34E-08	mg/kg-day	1.00E-02	mg/kg-day	1.34E-06
				Chromium, total	3.6	µg/L	3.56E-11	mg-kg/day	-	-	-	1.80E-08	mg/kg-day	1.95E-02	mg/kg-day	9.23E-07
				Cyanide	50	µg/L	4.95E-10	mg-kg/day	-	-	-	2.50E-07	mg/kg-day	2.00E-02	mg/kg-day	1.25E-05
				Dibenz(a,h)anthracene	ND	µg/L	-	-	7.30E+00	(mg-kg/day)-1	-	0.00E+00	-	-	-	-
				Fluorene	ND	µg/L	-	-	-	-	-	0.00E+00	-	4.00E-02	mg/kg-day	-
				Indeno(1,2,3-cd)pyrene	ND	µg/L	-	-	7.30E-01	(mg-kg/day)-1	-	0.00E+00	-	-	-	-
				Manganese	478	µg/L	4.73E-09	mg-kg/day	-	-	-	2.39E-06	mg/kg-day	2.40E-02	mg/kg-day	9.96E-05
				Mercury	ND	µg/L	-	-	-	-	-	0.00E+00	-	3.00E-04	mg/kg-day	-
				Naphthalene	0.008	µg/L	5.49E-12	mg-kg/day	-	-	-	2.78E-09	mg/kg-day	2.00E-02	mg/kg-day	1.39E-07
				Nickel	25	µg/L	4.95E-11	mg-kg/day	-	-	-	2.50E-08	mg/kg-day	8.00E-04	mg/kg-day	3.13E-05
				Tetrachloroethene (PCE)	0.22	µg/L	1.05E-10	mg-kg/day	5.40E-01	(mg-kg/day)-1	5.67E-11	5.30E-08	mg/kg-day	1.00E-02	mg/kg-day	5.30E-06
				Trichloroethene (TCE)	0.67	µg/L	1.04E-10	mg-kg/day	8.90E-02	(mg-kg/day)-1	9.26E-12	5.27E-08	mg/kg-day	-	-	-
				Zinc	281	µg/L	1.67E-09	mg-kg/day	-	-	-	8.45E-07	mg/kg-day	3.00E-01	mg/kg-day	2.82E-06
			Exp. Route Total								8.89E-11					2.01E-04
			Ingestion	Aluminum (pH 6.5 - 9.0)	3,820	µg/L	3.74E-03	mg-kg/day	-	-	-	5.23E-02	mg/kg-day	1.00E+00	mg/kg-day	5.23E-02
				Arsenic	1.43	µg/L	1.40E-06	mg-kg/day	1.50E+00	(mg-kg/day)-1	2.10E-06	1.96E-05	mg/kg-day	3.00E-04	mg/kg-day	6.53E-02
				Benz(a)anthracene	ND	µg/L	-	-	7.30E-01	(mg-kg/day)-1	-	-	-	-	-	-
				Benzene	ND	µg/L	-	-	5.50E-02	(mg-kg/day)-1	-	-	-	4.00E-03	mg/kg-day	-
				Benzo(a)pyrene	ND	µg/L	-	-	7.30E+00	(mg-kg/day)-1	-	-	-	-	-	-
				Benzo(b)fluoranthene	ND	µg/L	-	-	7.30E-01	(mg-kg/day)-1	-	-	-	-	-	-
				Cadmium	0.02	µg/L	1.96E-08	mg-kg/day	-	-	-	2.74E-07	mg/kg-day	5.00E-04	mg/kg-day	5.48E-04
				Chloroform	0.3	µg/L	2.94E-07	mg-kg/day	6.10E-02	(mg-kg/day)-1	1.79E-08	4.11E-06	mg/kg-day	1.00E-02	mg/kg-day	4.11E-04
				Chromium, total	3.6	µg/L	3.52E-06	mg-kg/day	-	-	-	4.93E-05	mg/kg-day	1.50E+00	mg/kg-day	3.29E-05
				Cyanide	50	µg/L	4.89E-05	mg-kg/day	-	-	-	6.85E-04	mg/kg-day	2.00E-02	mg/kg-day	3.43E-02
				Dibenz(a,h)anthracene	ND	µg/L	-	-	7.30E+00	(mg-kg/day)-1	-	-	-	-	-	-
				Fluorene	ND	µg/L	-	-	-	-	-	-	-	4.00E-02	mg/kg-day	-
				Indeno(1,2,3-cd)pyrene	ND	µg/L	-	-	7.30E-01	(mg-kg/day)-1	-	-	-	-	-	-
				Manganese	478	µg/L	4.68E-04	mg-kg/day	-	-	-	6.55E-03	mg/kg-day	2.40E-02	mg/kg-day	2.73E-01
				Mercury	ND	µg/L	-	-	-	-	-	-	-	3.00E-04	mg/kg-day	-
				Naphthalene	0.008	µg/L	7.83E-09	mg-kg/day	-	-	-	1.10E-07	mg/kg-day	2.00E-02	mg/kg-day	5.50E-06
				Nickel	25	µg/L	2.45E-05	mg-kg/day	-	-	-	3.42E-04	mg/kg-day	2.00E-02	mg/kg-day	1.71E-02
				Tetrachloroethene (PCE)	0.22	µg/L	2.15E-07	mg-kg/day	5.40E-01	(mg-kg/day)-1	1.16E-07	3.01E-06	mg/kg-day	1.00E-02	mg/kg-day	3.01E-04
				Trichloroethene (TCE)	0.67	µg/L	6.56E-07	mg-kg/day	8.90E-02	(mg-kg/day)-1	5.84E-08	9.18E-06	mg/kg-day	-	-	-
				Zinc	281	µg/L	2.75E-04	mg-kg/day	-	-	-	3.85E-03	mg/kg-day	3.00E-01	mg/kg-day	1.28E-02
			Exp. Route Total								2.29E-06					4.56E-01
	Air	GW-2	Inhalation	Aluminum (pH 6.5 - 9.0)	3,820	µg/L	-	-	-	-	-	-	-	5.00E-03	mg/m3	-
		Office Worker		Arsenic	1.43	µg/L	-	-	4.30E-03	(µg/m3)-1	-	-	-	1.50E-05	mg/m3	-
		Maintenance Worker	Combined Volatilization and Particulate Matter	Benz(a)anthracene	ND	µg/L	-	-	1.10E-04	(µg/m3)-1	-	-	-	-		-
				Benzene	ND	µg/L	-	-	7.80E-06	(µg/m3)-1	-	-	-	3.00E-02	mg/m3	-
				Benzo(a)pyrene	ND	µg/L	-	-	1.10E-03	(µg/m3)-1	-	-	-	-		-
				Benzo(b)fluoranthene	ND	µg/L	-	-	1.10E-04	(µg/m3)-1	-	-	-	-		-
				Cadmium	0.02	µg/L	-	-	1.80E-03	(µg/m3)-1	-	-	-	1.00E-05	mg/m3	-
				Chloroform	0.3	µg/L	2.94E-03	µg/m3	2.30E-05	(µg/m3)-1	6.76E-08	3.42E-05	µg/m3	9.80E-02	mg/m3	3.49E-07
				Chromium, total	3.6	µg/L	-	-	1.20E-02	(µg/m3)-1	-	-	-	1.00E-04	mg/m3	-
				Cyanide	50	µg/L	-	-	-	-	-	-	-	-	-	-
				Dibenz(a,h)anthracene	ND	µg/L	-	-	1.10E-03	(µg/m3)-1	-	-	-	-	-	-
				Fluorene	ND	µg/L	-	-	-	-	-	-	-	-	-	-
				Indeno(1,2,3-cd)pyrene	ND	µg/L	-	-	1.10E-04	(µg/m3)-1	-	-	-	-	-	-
				Manganese	478	µg/L	-	-	-	-	-	-	-	5.00E-05	mg/m3	-
				Mercury	ND	µg/L	-	-	-	-	-	-	-	3.00E-04	mg/m3	-
				Naphthalene	0.008	µg/L	7.83E-05	µg/m3	3.40E-05	(µg/m3)-1	2.66E-09	9.13E-07	µg/m3	3.00E-03	mg/m3	3.04E-07
				Nickel	25	µg/L	-	-	2.60E-04	(µg/m3)-1	-	-	-	9.00E-05	mg/m3	-
				Tetrachloroethene (PCE)	0.22	µg/L	2.15E-03	µg/m3	5.90E-06	(µg/m3)-1	1.27E-08	2.51E-05	µg/m3	2.70E-01	mg/m3	9.30E-08
				Trichloroethene (TCE)	0.67	µg/L	-	-	2.00E-05	(µg/m3)-1	-	-	-	-	-	-
				Zinc	281	µg/L	-	-	-	-	-	-	-	-	-	-
			Exp. Route Total								8.30E-08					7.46E-07
		Exposure Point Total									2.38E-06					0.46

TABLE 7-7-4 RME CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS CENTRAL TENDANCY EXPOSURE
U.S. GOVERNMENT MOORINGS

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	GW-11	Dermal Contact	Aluminum (pH 6.5 - 9.0)	74,600	µg/L	7.38E-07	mg-kg/day	-	-	-	3.74E-04	mg/kg-day	1.00E+00	mg/kg-day	3.74E-04
		Office Worker		Arsenic	4.02	µg/L	3.98E-11	mg-kg/day	1.50E+00	(mg-kg/day)-1	5.97E-11	2.01E-08	mg/kg-day	3.00E-04	mg/kg-day	6.70E-05
		Maintenance Worker		Benz(a)anthracene	0.06	µg/L	1.15E-05	mg-kg/day	7.30E-01	(mg-kg/day)-1	8.40E-06	2.85E-07	mg/kg-day	-	-	-
				Benzene	0.22	µg/L	4.51E-11	mg-kg/day	5.50E-02	(mg-kg/day)-1	2.48E-12	2.28E-08	mg/kg-day	4.00E-03	mg/kg-day	5.70E-06
				Benzo(a)pyrene	0.051	µg/L	1.28E-05	mg-kg/day	7.30E+00	(mg-kg/day)-1	9.34E-05	3.17E-07	mg/kg-day	-	-	-
				Benzo(b)fluoranthene	0.03	µg/L	4.24E-06	mg-kg/day	7.30E-01	(mg-kg/day)-1	3.10E-06	1.05E-07	mg/kg-day	-	-	-
				Cadmium	20.9	µg/L	2.07E-10	mg-kg/day	-	-	-	1.05E-07	mg/kg-day	2.50E-05	mg/kg-day	4.20E-03
				Chloroform	ND	µg/L	-	-	6.10E-02	(mg-kg/day)-1	-	-	-	1.00E-02	mg/kg-day	-
				Chromium, total	100	µg/L	9.90E-10	mg-kg/day	-	-	-	5.01E-07	mg/kg-day	1.95E-02	mg/kg-day	2.57E-05
				Cyanide	150	µg/L	1.48E-09	mg-kg/day	-	-	-	7.51E-07	mg/kg-day	2.00E-02	mg/kg-day	3.76E-05
				Dibenz(a,h)anthracene	0.0052	µg/L	1.76E-06	mg-kg/day	7.30E+00	(mg-kg/day)-1	1.28E-05	4.38E-08	mg/kg-day	-	-	-
				Fluorene	0.06	µg/L	1.02E-10	mg-kg/day	-	-	-	5.14E-08	mg/kg-day	4.00E-02	mg/kg-day	1.29E-06
				Indeno(1,2,3-cd)pyrene	0.047	µg/L	2.12E-05	mg-kg/day	7.30E-01	(mg-kg/day)-1	1.55E-05	5.25E-07	mg/kg-day	-	-	-
				Manganese	1770	µg/L	1.75E-08	mg-kg/day	-	-	-	8.87E-06	mg/kg-day	2.40E-02	mg/kg-day	3.70E-04
				Mercury	0.07	µg/L	1.66E-10	mg-kg/day	-	-	-	8.42E-08	mg/kg-day	3.00E-04	mg/kg-day	2.81E-04
				Naphthalene	3.3	µg/L	2.27E-09	mg-kg/day	-	-	-	1.15E-06	mg/kg-day	2.00E-02	mg/kg-day	5.75E-05
				Nickel	212	µg/L	4.20E-10	mg-kg/day	-	-	-	2.12E-07	mg/kg-day	8.00E-04	mg/kg-day	2.65E-04
				Tetrachloroethene (PCE)	ND	µg/L	-	-	5.40E-01	(mg-kg/day)-1	-	-	-	1.00E-02	mg/kg-day	-
				Trichloroethene (TCE)	ND	µg/L	-	-	8.90E-02	(mg-kg/day)-1	-	-	-	-	-	-
				Zinc	5510	µg/L	3.27E-08	mg-kg/day	-		-	1.66E-05	mg/kg-day	3.00E-01	mg/kg-day	5.53E-05
			Exp. Route Total								1.33E-04					5.74E-03
			Ingestion	Aluminum (pH 6.5 - 9.0)	74,600	µg/L	7.30E-02	mg-kg/day	-	-	-	1.02E+00	mg/kg-day	1.00E+00	mg/kg-day	1.02
				Arsenic	4.02	µg/L	3.93E-06	mg-kg/day	1.50E+00	(mg-kg/day)-1	5.90E-06	5.51E-05	mg/kg-day	3.00E-04	mg/kg-day	1.84E-01
				Benz(a)anthracene	0.06	µg/L	1.99E-06	mg-kg/day	7.30E-01	(mg-kg/day)-1	1.45E-06	8.22E-07	mg/kg-day	-	-	-
				Benzene	0.22	µg/L	2.15E-07	mg-kg/day	5.50E-02	(mg-kg/day)-1	1.18E-08	3.01E-06	mg/kg-day	4.00E-03	mg/kg-day	7.53E-04
				Benzo(a)pyrene	0.051	µg/L	1.69E-06	mg-kg/day	7.30E+00	(mg-kg/day)-1	1.23E-05	6.99E-07	mg/kg-day	-	-	-
				Benzo(b)fluoranthene	0.03	µg/L	9.95E-07	mg-kg/day	7.30E-01	(mg-kg/day)-1	7.26E-07	4.11E-07	mg/kg-day	-	-	-
				Cadmium	20.9	µg/L	2.05E-05	mg-kg/day	-	-	-	2.86E-04	mg/kg-day	5.00E-04	mg/kg-day	5.72E-01
				Chloroform	ND	µg/L	-	-	6.10E-02	(mg-kg/day)-1	-	-	-	1.00E-02	mg/kg-day	-
				Chromium, total	100	µg/L	9.78E-05	mg-kg/day	-	-	-	1.37E-03	mg/kg-day	1.50E+00	mg/kg-day	9.13E-04
				Cyanide	150	µg/L	1.47E-04	mg-kg/day	-	-	-	2.05E-03	mg/kg-day	2.00E-02	mg/kg-day	1.03E-01
				Dibenz(a,h)anthracene	0.0052	µg/L	1.72E-07	mg-kg/day	7.30E+00	(mg-kg/day)-1	1.26E-06	7.12E-08	mg/kg-day	-	-	-
				Fluorene	0.06	µg/L	5.87E-08	mg-kg/day	-	-	-	8.22E-07	mg/kg-day	4.00E-02	mg/kg-day	2.06E-05
				Indeno(1,2,3-cd)pyrene	0.047	µg/L	1.56E-06	mg-kg/day	7.30E-01	(mg-kg/day)-1	1.14E-06	6.44E-07	mg/kg-day	-	-	-
				Manganese	1770	µg/L	1.73E-03	mg-kg/day	-	-	-	2.42E-02	mg/kg-day	2.40E-02	mg/kg-day	1.01
				Mercury	0.07	µg/L	6.85E-08	mg-kg/day	-	-	-	9.59E-07	mg/kg-day	3.00E-04	mg/kg-day	3.20E-03
				Naphthalene	3.3	µg/L	3.23E-06	mg-kg/day	-	-	-	4.52E-05	mg/kg-day	2.00E-02	mg/kg-day	2.26E-03
				Nickel	212	µg/L	2.07E-04	mg-kg/day	-	-	-	2.90E-03	mg/kg-day	2.00E-02	mg/kg-day	1.45E-01
				Tetrachloroethene (PCE)	ND	µg/L	-	-	5.40E-01	(mg-kg/day)-1	-	-	-	1.00E-02	mg/kg-day	-
				Trichloroethene (TCE)	ND	µg/L	-	-	8.90E-02	(mg-kg/day)-1	-	-	-	-	-	-
				Zinc	5510	µg/L	5.39E-03	mg-kg/day	-	-	-	7.55E-02	mg/kg-day	3.00E-01	mg/kg-day	2.52E-01
			Exp. Route Total								2.28E-05					3.29
	Air	GW-11	Inhalation	Aluminum (pH 6.5 - 9.0)	74,600	µg/L	-	-	-	-	-	-	µg/m3	5.00E-03	mg/m3	-
		Office Worker		Arsenic	4.02	µg/L	-	-	4.30E-03	(µg/m3)-1	-	-	µg/m3	1.50E-05	mg/m3	-
		Maintenance Worker	Combined Volatilization and Particulate Matter	Benz(a)anthracene	0.06	µg/L	-	-	1.10E-04	(µg/m3)-1	-	-	µg/m3	-		-
				Benzene	0.22	µg/L	2.15E-03	µg/m3	7.80E-06	(µg/m3)-1	1.68E-08	2.51E-05	µg/m3	3.00E-02	mg/m3	8.37E-07
				Benzo(a)pyrene	0.051	µg/L	-	-	1.10E-03	(µg/m3)-1	-	-	µg/m3	-		-
				Benzo(b)fluoranthene	0.03	µg/L	-	-	1.10E-04	(µg/m3)-1	-	-	µg/m3	-		-
				Cadmium	20.9	µg/L	-	-	1.80E-03	(µg/m3)-1	-	-	µg/m3	1.00E-05	mg/m3	-
				Chloroform	ND	µg/L	-	-	2.30E-05	(µg/m3)-1	-	-	-	9.80E-02	mg/m3	-
				Chromium, total	100	µg/L	-	-	1.20E-02	(µg/m3)-1	-	-	µg/m3	1.00E-04	mg/m3	-
				Cyanide	150	µg/L	-	-	-	-	-	-	µg/m3	-		-
				Dibenz(a,h)anthracene	0.0052	µg/L	-	-	1.10E-03	(µg/m3)-1	-	-	µg/m3	-		-
				Fluorene	0.06	µg/L	-	-	-	-	-	-	µg/m3	-		-
				Indeno(1,2,3-cd)pyrene	0.047	µg/L	-	-	1.10E-04	(µg/m3)-1	-	-	µg/m3	-		-
				Manganese	1770	µg/L	-	-	-	-	-	-	µg/m3	5.00E-05	mg/m3	-
				Mercury	0.07	µg/L	6.85E-04	µg/m3	-	-	-	7.99E-06	µg/m3	3.00E-04	mg/m3	2.66E-05
				Naphthalene	3.3	µg/L	3.23E-02	µg/m3	3.40E-05	(µg/m3)-1	1.10E-06	3.77E-04	µg/m3	3.00E-03	mg/m3	1.26E-04
				Nickel	212	µg/L	-	-	2.60E-04	(µg/m3)-1	-	-	µg/m3	9.00E-05	mg/m3	-
				Tetrachloroethene (PCE)	ND	µg/L	-	-	5.90E-06	(µg/m3)-1	-	-	-	2.70E-01	mg/m3	-
				Trichloroethene (TCE)	ND	µg/L	-	-	2.00E-05	(µg/m3)-1	-	-	-	-	-	-
				Zinc	5510	µg/L	-	-	-	-	-	-	µg/m3	-	-	-
			Exp. Route Total								1.11E-06					1.53E-04
		Exposure Point Total									1.57E-04					3.30

TABLE 7-7-4 RME CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS CENTRAL TENDANCY EXPOSURE
U.S. GOVERNMENT MOORINGS

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	GW-16	Dermal Contact	Aluminum (pH 6.5 - 9.0)	8,040	µg/L	-	mg-kg/day	-	-	-	4.03E-05	mg/kg-day	1.00E+00	mg/kg-day	4.03E-05
		Office Worker		Arsenic	0.55	µg/L	-	mg-kg/day	1.50E+00	(mg-kg/day)-1	-	2.76E-09	mg/kg-day	3.00E-04	mg/kg-day	9.20E-06
		Maintenance Worker		Benz(a)anthracene	0.01	µg/L	1.91E-06	mg-kg/day	7.30E-01	(mg-kg/day)-1	1.39E-06	4.75E-08	mg/kg-day	-	-	-
				Benzene	0.56	µg/L	-	mg-kg/day	5.50E-02	(mg-kg/day)-1	-	5.81E-08	mg/kg-day	4.00E-03	mg/kg-day	1.45E-05
				Benzo(a)pyrene	ND	µg/L	-	-	7.30E+00	(mg-kg/day)-1	-	-	-	-	-	-
				Benzo(b)fluoranthene	0.02	µg/L	2.82E-06	mg-kg/day	7.30E-01	(mg-kg/day)-1	2.06E-06	7.00E-08	mg/kg-day	-	-	-
				Cadmium	2.17	µg/L	-	mg-kg/day	-	-	-	1.09E-08	mg/kg-day	2.50E-05	mg/kg-day	4.36E-04
				Chloroform	ND	µg/L	-	-	6.10E-02	(mg-kg/day)-1	-	-	-	1.00E-02	mg/kg-day	-
				Chromium, total	7.1	µg/L	-	mg-kg/day	-	-	-	3.56E-08	mg/kg-day	1.95E-02	mg/kg-day	1.83E-06
				Cyanide	2990	µg/L	-	mg-kg/day	-	-	-	1.45E-05	mg/kg-day	2.00E-02	mg/kg-day	7.25E-04
				Dibenz(a,h)anthracene	ND	µg/L	-	-	7.30E+00	(mg-kg/day)-1	-	-	-	-	-	-
				Fluorene	0.39	µg/L	-	mg-kg/day	-	-	-	3.34E-07	mg/kg-day	4.00E-02	mg/kg-day	8.35E-06
				Indeno(1,2,3-cd)pyrene	0.005	µg/L	2.25E-06	mg-kg/day	7.30E-01	(mg-kg/day)-1	1.64E-06	5.59E-08	mg/kg-day	-	-	-
				Manganese	804	µg/L	-	mg-kg/day	-	-	-	4.03E-06	mg/kg-day	2.40E-02	mg/kg-day	1.68E-04
				Mercury	ND	µg/L	-	-	-	-	-	-	-	3.00E-04	mg/kg-day	-
				Naphthalene	6	µg/L	-	mg-kg/day	-	-	-	2.09E-06	mg/kg-day	2.00E-02	mg/kg-day	1.05E-04
				Nickel	72	µg/L	-	mg-kg/day	-	-	-	7.21E-08	mg/kg-day	8.00E-04	mg/kg-day	9.01E-05
				Tetrachloroethene (PCE)	ND	µg/L	-	-	5.40E-01	(mg-kg/day)-1	-	-	-	1.00E-02	mg/kg-day	-
				Trichloroethene (TCE)	ND	µg/L	-	-	8.90E-02	(mg-kg/day)-1	-	-	-	-	-	-
				Zinc	1250	µg/L	-	mg-kg/day	-	-	-	3.76E-06	mg/kg-day	3.00E-01	mg/kg-day	1.25E-05
			Exp. Route Total								5.10E-06					1.61E-03
			Ingestion	Aluminum (pH 6.5 - 9.0)	8,040	µg/L	-	mg-kg/day	-	-	-	1.10E-01	mg/kg-day	1.00E+00	mg/kg-day	1.10E-01
				Arsenic	0.55	µg/L	-	mg-kg/day	1.50E+00	(mg-kg/day)-1	-	7.53E-06	mg/kg-day	3.00E-04	mg/kg-day	2.51E-02
				Benz(a)anthracene	0.01	µg/L	3.32E-07	mg-kg/day	7.30E-01	(mg-kg/day)-1	2.42E-07	1.37E-07	mg/kg-day	-	-	-
				Benzene	0.56	µg/L	-	mg-kg/day	5.50E-02	(mg-kg/day)-1	-	7.67E-06	mg/kg-day	4.00E-03	mg/kg-day	1.92E-03
				Benzo(a)pyrene	ND	µg/L	-	-	7.30E+00		-	-	-	-	-	-
				Benzo(b)fluoranthene	0.02	µg/L	6.63E-07	mg-kg/day	7.30E-01		4.84E-07	2.74E-07	mg/kg-day	-	-	-
				Cadmium	2.17	µg/L	-	mg-kg/day	-		-	2.97E-05	mg/kg-day	5.00E-04	mg/kg-day	5.94E-02
				Chloroform	ND	µg/L	-	-	6.10E-02	(mg-kg/day)-1	-	-	-	1.00E-02	mg/kg-day	-
				Chromium, total	7.1	µg/L	-	-	-	-	-	9.73E-05	mg/kg-day	1.50E+00	mg/kg-day	6.49E-05
				Cyanide	2990	µg/L	-	-	-	-	-	3.97E-02	mg/kg-day	2.00E-02	mg/kg-day	1.99
				Dibenz(a,h)anthracene	ND	µg/L	-	-	7.30E+00	(mg-kg/day)-1	-	-	-	-	-	-
				Fluorene	0.39	µg/L	-	mg-kg/day	-	-	-	5.34E-06	mg/kg-day	4.00E-02	mg/kg-day	1.34E-04
				Indeno(1,2,3-cd)pyrene	0.005	µg/L	1.66E-07	mg-kg/day	7.30E-01	(mg-kg/day)-1	1.21E-07	6.85E-08	mg/kg-day	-	-	-
				Manganese	804	µg/L	-	mg-kg/day	-	-	-	1.10E-02	mg/kg-day	2.40E-02	mg/kg-day	4.58E-01
				Mercury	ND	µg/L	-	-	-	-	-	-	-	3.00E-04	mg/kg-day	-
				Naphthalene	6	µg/L	-	mg-kg/day	-	-	-	8.22E-05	mg/kg-day	2.00E-02	mg/kg-day	4.11E-03
				Nickel	72	µg/L	-	mg-kg/day	-	-	-	9.86E-04	mg/kg-day	2.00E-02	mg/kg-day	4.93E-02
				Tetrachloroethene (PCE)	ND	µg/L	-	-	5.40E-01	(mg-kg/day)-1	-	-	-	1.00E-02	mg/kg-day	-
				Trichloroethene (TCE)	ND	µg/L	-	-	8.90E-02	(mg-kg/day)-1	-	-	-	-	-	-
				Zinc	1250	µg/L	-	mg-kg/day	-		-	1.71E-02	mg/kg-day	3.00E-01	mg/kg-day	5.70E-02
			Exp. Route Total								8.48E-07					2.75
	Air	GW-16	Inhalation	Aluminum (pH 6.5 - 9.0)	8,040	µg/L	-	-	-	-	-	-	-	5.00E-03	mg/m³	-
		Office Worker		Arsenic	0.55	µg/L	-	-	4.30E-03	(µg/m3)-1	-	-	-	1.50E-05	mg/m³	-
		Maintenance Worker	Combined Volatilization and Particulate Matter	Benz(a)anthracene	0.01	µg/L	-	-	1.10E-04	(µg/m3)-1	-	-	-	-	-	-
				Benzene	0.56	µg/L	5.48E-03	µg/m³	7.80E-06	(µg/m3)-1	4.27E-08	6.39E-05	µg/m³	3.00E-02	mg/m³	2.13E-06
				Benzo(a)pyrene	ND	µg/L	-	-	1.10E-03	(µg/m3)-1	-	-	-	-	-	-
				Benzo(b)fluoranthene	0.02	µg/L	-	-	1.10E-04	(µg/m3)-1	-	-	-	-	-	-
				Cadmium	2.17	µg/L	-	-	1.80E-03	(µg/m3)-1	-	-	-	1.00E-05	mg/m³	-
				Chloroform	ND	µg/L	-	-	2.30E-05	(µg/m3)-1	-	-	-	9.80E-02	mg/m³	-
				Chromium, total	7.1	µg/L	-	-	1.20E-02	(µg/m3)-1	-	-	-	1.00E-04	mg/m³	-
				Cyanide	2990	µg/L	-	-	-	-	-	-	-	-	-	-
				Dibenz(a,h)anthracene	ND	µg/L	-	-	1.10E-03	(µg/m3)-1	-	-	-	-	-	-
				Fluorene	0.39	µg/L	-	-	-	-	-	-	-	-	-	-
				Indeno(1,2,3-cd)pyrene	0.005	µg/L	-	-	1.10E-04	(µg/m3)-1	-	-	-	-	-	-
				Manganese	804	µg/L	-	-	-	-	-	-	-	5.00E-05	mg/m³	-
				Mercury	ND	µg/L	7.87E+00	µg/m³	-	-	-	9.18E-02	µg/m³	3.00E-04	mg/m³	3.06E-01
				Naphthalene	6	µg/L	5.87E-02	µg/m³	3.40E-05	(µg/m3)-1	2.00E-06	6.85E-04	µg/m³	3.00E-03	mg/m³	2.28E-04
				Nickel	72	µg/L	-	-	2.60E-04	(µg/m3)-1	-	-	-	9.00E-05	mg/m³	-
				Tetrachloroethene (PCE)	ND	µg/L	-	-	5.90E-06	(µg/m3)-1	-	-	-	2.70E-01	mg/m³	-
				Trichloroethene (TCE)	ND	µg/L	-	-	2.00E-05	(µg/m3)-1	-	-	-	-	-	-
				Zinc	1250	µg/L	-	-	-	-	-	-	-	-	-	-
			Exp. Route Total								2.04E-06					3.06E-01
		Exposure Point Total									7.98E-06					3.06

TABLE 7-7-4 RME CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS CENTRAL TENDANCY EXPOSURE
U.S. GOVERNMENT MOORINGS

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	GW-20	Dermal Contact	Aluminum (pH 6.5 - 9.0)	102	µg/L	1.14E-11	mg-kg/day	-	-	-	5.11E-07	mg/kg-day	1.00E+00	mg/kg-day	5.11E-07
		Office Worker		Arsenic	4.68	µg/L	5.23E-13	mg-kg/day	1.50E+00	(mg-kg/day)$^{-1}$	7.85E-13	2.34E-08	mg/kg-day	3.00E-04	mg/kg-day	7.80E-05
		Maintenance Worker		Benz(a)anthracene	ND	µg/L	-	-	7.30E-01	(mg-kg/day)$^{-1}$	-	-	-	-	-	-
				Benzene	ND	µg/L	-	-	5.50E-02	(mg-kg/day)$^{-1}$	-	-	-	4.00E-03	mg/kg-day	-
				Benzo(a)pyrene	ND	µg/L	-	-	7.30E+00	(mg-kg/day)$^{-1}$	-	-	-	-	-	-
				Benzo(b)fluoranthene	ND	µg/L	-	-	7.30E-01	(mg-kg/day)$^{-1}$	-	-	-	-	-	-
				Cadmium	ND	µg/L	-	-	-	-	-	-	-	2.50E-05	mg/kg-day	-
				Chloroform	ND	µg/L	-	-	6.10E-02	(mg-kg/day)$^{-1}$	-	-	-	1.00E-02	mg/kg-day	-
				Chromium, total	ND	µg/L	-	-	-	-	-	-	-	1.95E-02	mg/kg-day	-
				Cyanide	200	µg/L	2.24E-11	mg-kg/day	-	-	-	1.00E-06	mg/kg-day	2.00E-02	mg/kg-day	5.00E-05
				Dibenz(a,h)anthracene	ND	µg/L	-	-	7.30E+00	(mg-kg/day)$^{-1}$	-	-	-	-	-	-
				Fluorene	ND	µg/L	-	-	-	-	-	-	-	4.00E-02	mg/kg-day	0.00E+00
				Indeno(1,2,3-cd)pyrene	ND	µg/L	-	-	7.30E-01	(mg-kg/day)$^{-1}$	-	-	-	-	-	-
				Manganese	12,000	µg/L	1.34E-09	mg-kg/day	-	-	-	6.01E-05	mg/kg-day	2.40E-02	mg/kg-day	2.50E-03
				Mercury	ND	µg/L	0.00E+00	-	-	-	-	-	-	3.00E-04	mg/kg-day	-
				Naphthalene	ND	µg/L	0.00E+00	-	-	-	-	-	-	2.00E-02	mg/kg-day	-
				Nickel	2	µg/L	4.47E-14	mg-kg/day	-	-	-	2.00E-09	mg/kg-day	8.00E-04	mg/kg-day	2.50E-06
				Tetrachloroethene (PCE)	ND	µg/L	-	-	5.40E-01	(mg-kg/day)$^{-1}$	-	-	-	1.00E-02	mg/kg-day	-
				Trichloroethene (TCE)	ND	µg/L	-	-	8.90E-02	(mg-kg/day)$^{-1}$	-	-	-	-	-	-
				Zinc	33	µg/L	2.21E-12	mg-kg/day	-		-	9.92E-08	mg/kg-day	3.00E-01	mg/kg-day	3.31E-07
			Exp. Route Total								7.85E-13					2.64E-03
			Ingestion	Aluminum (pH 6.5 - 9.0)	102	µg/L	9.98E-05	mg-kg/day	-	-	-	1.40E-03	mg/kg-day	1.00E+00	mg/kg-day	1.40E-03
				Arsenic	4.68	µg/L	4.58E-06	mg-kg/day	1.50E+00	(mg-kg/day)$^{-1}$	6.87E-06	6.41E-05	mg/kg-day	3.00E-04	mg/kg-day	2.14E-01
				Benz(a)anthracene	ND	µg/L	-	-	7.30E-01	(mg-kg/day)$^{-1}$	-	-	-	-	-	-
				Benzene	ND	µg/L	-	-	5.50E-02	(mg-kg/day)$^{-1}$	-	-	-	4.00E-03	mg/kg-day	-
				Benzo(a)pyrene	ND	µg/L	-	-	7.30E+00		-	-	-	-	-	-
				Benzo(b)fluoranthene	ND	µg/L	-	-	7.30E-01		-	-	-	-	-	-
				Cadmium	ND	µg/L	-	-	-		-	-	-	5.00E-04	mg/kg-day	-
				Chloroform	ND	µg/L	-	-	6.10E-02	(mg-kg/day)$^{-1}$	-	-	-	1.00E-02	mg/kg-day	-
				Chromium, total	ND	µg/L	-	-	-	-	-	-	-	1.50E+00	mg/kg-day	-
				Cyanide	200	µg/L	1.96E-04	mg-kg/day	-	-	-	2.74E-03	mg/kg-day	2.00E-02	mg/kg-day	1.37E-01
				Dibenz(a,h)anthracene	ND	µg/L	-	-	7.30E+00	(mg-kg/day)$^{-1}$	-	-	-	-	-	-
				Fluorene	ND	µg/L	-	-	-	-	-	-	-	4.00E-02	mg/kg-day	-
				Indeno(1,2,3-cd)pyrene	ND	µg/L	-	-	7.30E-01	(mg-kg/day)$^{-1}$	-	-	-	-	-	-
				Manganese	12,000	µg/L	1.17E-02	mg-kg/day	-	-	-	1.64E-01	mg/kg-day	2.40E-02	mg/kg-day	6.83
				Mercury	ND	µg/L	-	-	-	-	-	-	-	3.00E-04	mg/kg-day	-
				Naphthalene	ND	µg/L	-	-	-	-	-	-	-	2.00E-02	mg/kg-day	-
				Nickel	2	µg/L	1.96E-06	mg-kg/day	-	-	-	2.74E-05	mg/kg-day	2.00E-02	mg/kg-day	1.37E-03
				Tetrachloroethene (PCE)	ND	µg/L	-	-	5.40E-01	(mg-kg/day)$^{-1}$	-	-	-	1.00E-02	mg/kg-day	-
				Trichloroethene (TCE)	ND	µg/L	-	-	8.90E-02	(mg-kg/day)$^{-1}$	-	-	-	-	-	-
				Zinc	33	µg/L	3.23E-05	mg-kg/day	-		-	4.52E-04	mg/kg-day	3.00E-01	mg/kg-day	1.51E-03
			Exp. Route Total								6.87E-06					7.19
	Air	GW-20	Inhalation	Aluminum (pH 6.5 - 9.0)	102	µg/L	-	-	-	-	-	-	-	5.00E-03	mg/m^3	-
		Office Worker		Arsenic	4.68	µg/L	-	-	4.30E-03	(µg/m3)$^{-1}$	-	-	-	1.50E-05	mg/m^3	-
		Maintenance Worker	Combined Volatilization and Particulate Matter	Benz(a)anthracene	ND	µg/L	-	-	1.10E-04	(µg/m3)$^{-1}$	-	-	-	-	-	-
				Benzene	ND	µg/L	-	-	7.80E-06	(µg/m3)$^{-1}$	-	-	-	3.00E-02	mg/m^3	-
				Benzo(a)pyrene	ND	µg/L	-	-	1.10E-03	(µg/m3)$^{-1}$	-	-	-	-	-	-
				Benzo(b)fluoranthene	ND	µg/L	-	-	1.10E-04	(µg/m3)$^{-1}$	-	-	-	-	-	-
				Cadmium	ND	µg/L	-	-	1.80E-03	(µg/m3)$^{-1}$	-	-	-	1.00E-05	mg/m^3	-
				Chloroform	ND	µg/L	-	-	2.30E-05	(µg/m3)$^{-1}$	-	-	-	9.80E-02	mg/m^3	-
				Chromium, total	ND	µg/L	-	-	1.20E-02	(µg/m3)$^{-1}$	-	-	-	1.00E-04	mg/m^3	-
				Cyanide	200	µg/L	-	-	-	-	-	-	-	-	-	-
				Dibenz(a,h)anthracene	ND	µg/L	-	-	1.10E-03	(µg/m3)$^{-1}$	-	-	-	-	-	-
				Fluorene	ND	µg/L	-	-	-	-	-	-	-	-	-	-
				Indeno(1,2,3-cd)pyrene	ND	µg/L	-	-	1.10E-04	(µg/m3)$^{-1}$	-	-	-	-	-	-
				Manganese	12,000	µg/L	-	-	-	-	-	-	-	5.00E-05	mg/m^3	-
				Mercury	ND	µg/L	-	-	-	-	-	-	-	3.00E-04	mg/m^3	-
				Naphthalene	ND	µg/L	-	-	3.40E-05	(µg/m3)$^{-1}$	-	-	-	3.00E-03	mg/m^3	-
				Nickel	2	µg/L	-	-	2.60E-04	(µg/m3)$^{-1}$	-	-	-	9.00E-05	mg/m^3	-
				Tetrachloroethene (PCE)	ND	µg/L	-	-	5.90E-06	(µg/m3)$^{-1}$	-	-	-	2.70E-01	mg/m^3	-
				Trichloroethene (TCE)	ND	µg/L	-	-	2.00E-05	(µg/m3)$^{-1}$	-	-	-	-	-	-
				Zinc	33	µg/L	-	-	-	-	-	-	-	-	-	-
			Exp. Route Total								0.00E+00					0.00E+00
		Exposure Point Total									6.87E-06					7.19

7.1.8 Summary of Receptor Risks for COPCs

Risks presented to each of the three receptor groups (Maintenance Worker, Office Worker, and Upland Excavation Worker) are evaluated considering all potential exposure media to which the receptor may be exposed.

7.1.8.1 Current Maintenance Worker Risks

Currently at the Moorings, the Maintenance Worker can only be exposed to surface soil and shallow soils. They are exposed to surface soils through dermal contact, incidental ingestion, and inhalation, and shallow soils through inhalation of volatiles and particulate matter that becomes airborne (dust). Risks are summed across all of the exposures for the Maintenance Worker to calculate the cumulative effects of the various exposure pathways (Table 7-8-1, page 7-71). The total cumulative cancer risk posed to the Maintenance Worker from surface and shallow soils is 5.9×10^{-6}, which is within USEPA's National Contingency Plan acceptable cancer risk range (10^{-6} to 10^{-4}) and below ODEQ's acceptable cancer risk level of 1×10^{-5} for exposure to multiple chemicals. The total hazard index for the Maintenance Worker is 3.5×10^{-2} also below the level of concern. (Concern would be indicated by a hazard quotient/index of greater than 1.) As the inputs into the risk and hazard calculations were very health protective, the potential risks reported are very health protective. In addition, it was assumed that Maintenance Workers are exposed to particulates and volatiles in shallow soil; however, the shallow soils used for estimating risks are covered either by asphalt or gravel. Therefore, cancer risk and non-cancer hazards calculated are health protective.

7.1.8.2 Current Office Worker Risks

Currently at the Moorings, the Office Worker can only be exposed to volatiles and particulate matter resulting from COPCs contamination of shallow soil. This Office Worker is assumed to work full-time at the Moorings for 25 years, around the site in various buildings. Risks are summed across the exposure points (Table 7-8-4, page 7-78) to estimate a health protective cumulative cancer risk and non-cancer hazard index. The total cumulative cancer risk for inhalation is 9.1×10^{-9}, well below USEPA Superfund and ODEQ levels of concern. The hazard index for inhalation is 3.79×10^{-4}, again well below the level of concern (hazard quotient/index of 1). This estimate is very health protective because in reality an Office Worker typically works only in one building and would not be exposed to all of the exposure points listed in Table 7-8-4 (page 7-78). In addition, it was assumed that Office Workers are exposed to particulates and volatiles in shallow soil; however, the shallow soils used for estimating risks are covered either by asphalt or gravel. Therefore, cancer risk and non-cancer hazards calculated are health protective.

7.1.8.3 Current Upland Excavation Worker Risks

Currently at the Moorings, the Upland Excavation Worker would only be exposed to shallow soil. Based on the assumption that the Upland Excavation Worker is on-site for only one event in their lifetime, the risks are not accumulated across exposure points (Table 7-8-7, page 7-85). The location where the Upland Excavation Worker could incur the highest cancer risk is around SB-16 at a risk of 1.37×10^{-7} which is below the USEPA Superfund and ODEQ levels of concern. The highest potential hazard quotient is calculated at SB-12 at 0.29, which is below the level of concern of 1. The risks shown on Table 7-8-7 (page 7-85) are very conservative as they utilize chronic toxicity information for a subchronic exposure, rather than acute or sub-chronic values.

7.1.8.4 Future Maintenance and Office Worker Risks

In the future, groundwater exposure could potentially be an additional exposure medium for the Maintenance Worker and the Officer Worker and would be added to the surface and shallow soils to calculate cumulative risk and HI. If this were to occur, risks associated with groundwater consumption would dominate all risks at the Moorings. Tables 7-8-2 and 7-8-3 (pages 7-72 and 7-75 respectively) present the RME and central tendency calculations, respectively, for the Maintenance Worker and Tables 7-8-5 and 7-8-6 (pages 7-79 and 7-82 respectively) present the RME and central tendency, respectively, for Office Workers). For the RME groundwater exposure scenario two groundwater wells present the highest cumulative risks. The cumulative cancer risk for the Maintenance Worker could be as high as $2.7x10^{-4}$ and as high as $2.6x10^{-4}$ for the Office Worker if GW-11 is used as the potable water source, which exceeds the level of concern for both USEPA's Superfund program (acceptable risk of 10^{-6} to 10^{-4}) and ODEQ regulations.(acceptable risk of 10^{-5} for exposure to multiple chemicals). The hazard index for both the Maintenance and Office Workers could be as high as 11.84 if GW-20 is used as the potable water source, which exceeds the level of concern and indicates an elevated chronic exposure hazard. Similarly, these two groundwater locations still present the greatest potential cumulative risks using central tendency values. The central tendency cumulative cancer risk for the Maintenance and Office Workers if GW-11 is used as a potable water source could be as high as $1.6x10^{-4}$ and the hazard index could be as high as 7.2 if the potable water source is GW-20.

Human health risks for the future scenario must be evaluated based on the endpoint, or target organ because of the results of the summation by receptor. Tables 7-9-1 and 7-9-2 (pages 7-87 and 7-89 respectively) illustrate the summation by endpoint for both the use of groundwater from GW-20 and from GW-11 for Maintenance Workers (Table 7-9-1, page 7-87) and Office Workers (Table 7-9-2, page 7-89). The HI for the endpoint of central nervous system if GW-11 groundwater is used as a tap water source is greater than 1 at a value of 3.7 for the Maintenance Worker and 3.65 for the Office Worker, mostly due to a combination of manganese and aluminum contamination. The HI for the endpoint of central nervous system if GW-20 groundwater is used as a tap water source is greater than 1 at a value of 11.6 for the Maintenance Worker and the Office Worker, mostly due to manganese and aluminum contamination. For GW-16, the HI for the cardiovascular system is 3.44 for the Maintenance Worker and 3.41 for the Office Worker as a result of cyanide contamination, and the HI for the central nervous system is 1.0 for the Maintenance Worker, a result of aluminum and manganese contamination. The HI for the central nervous system for the Office Worker is less than one.

7.1.8.5 Cumulative Uncertainty

Previous portions of Section 7 have discussed uncertainty related to all inputs into the human health risk assessment. Cumulatively, these uncertainties can introduce potential changes to calculated cancer risks and non-cancer hazards that differ from the actual cancer risks and non-cancer hazards by at least one order of magnitude. This risk assessment has attempted to mitigate the potential results of underestimating cancer risks and non-cancer hazards by using health protective assumptions, such as assuming the reasonable maximum of a parameter instead of a more central tendency, for example assuming that the exposure point concentration is the highest concentration sampled instead of a statistical representation of a likely exposure point concentration.

TABLE 7-8-1 SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs RME - Current - Maintenance Worker
U.S. GOVERNMENT MOORINGS

Summary: Table shows the summary of the risks and hazards to the current scenario Maintenance Worker with exposure to surface soil (RUN-OFF and FENCELINE samples) through ingestion, inhalation, and dermal contact and exposure to shallow soils (South Logistics MU and SB-01, SB-12 and SB-16) through inhalation.

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Soil	Surface Soil and Air	RUN-OFF Maintenance Worker	Benzo(b)fluoranthene	9.37E-08	1.04E-12	1.33E-08	1.07E-07	NA	-	-	-	-
			Benzo(a)pyrene	7.44E-07	8.26E-12	1.06E-07	8.50E-07	NA	-	-	-	-
			Dibenz(a,h)anthracene	1.65E-07	2.00E-11	2.35E-08	1.89E-07	NA	-	-	-	-
			Aroclor 1248	1.21E-07	2.54E-12	1.85E-08	1.40E-07	NA	8.45E-03	-	1.29E-03	9.74E-03
			Arsenic	3.00E-07	6.34E-11	9.84E-09	3.10E-07	Skin/Central Nervous System/Cardiovascular	1.87E-03	2.75E-06	6.12E-05	1.93E-03
			Chromium, total	-	2.56E-09	-	2.56E-09	No Observed Effects	5.40E-06	5.97E-06	4.54E-07	1.18E-05
		Exposure Point Total					1.60E-06					1.17E-02
		FENCELINE Maintenance Worker	Benzo(b)fluoranthene	5.51E-08	6.12E-13	7.83E-09	6.29E-08	NA	-	-	-	-
			Benzo(a)pyrene	4.13E-07	4.59E-12	5.87E-08	4.72E-07	NA	-	-	-	-
			Dibenz(a,h)anthracene	6.89E-08	8.35E-12	9.79E-09	7.87E-08	NA	-	-	-	-
			Aroclor 1248	-	-	-	-	NA	-	-	-	-
			Arsenic	3.57E-06	7.54E-10	1.17E-07	3.69E-06	Skin/Central Nervous System/Cardiovascular	2.22E-02	3.27E-05	7.28E-04	2.30E-02
			Chromium, total	-	1.70E-08	-	1.70E-08	No Observed Effects	3.58E-05	3.96E-05	3.01E-06	7.84E-05
		Exposure Point Total					4.32E-06					2.30E-02
Medium/Exposure Medium Total							5.92E-06					3.47E-02
Shallow Soil	Air	South Logistics MU Indoor Worker (Office/Maintenance)	Benzo(a)pyrene		8.50E-12		8.50E-12	NA		-		-
			Arsenic		1.03E-09		1.03E-09	Skin/Central Nervous System/Cardiovascular		4.49E-05		4.49E-05
		Exposure Point Total					1.04E-09					4.49E-05
Shallow Soil	Air	SB-01 Indoor Worker (Office/Maintenance)	Benzo(b)fluoranthene		1.28E-12		1.28E-12	NA		-		-
			Benzo(a)pyrene		9.35E-12		9.35E-12	NA		-		-
			Indeno(1,2,3-cd)pyrene		1.53E-12		1.53E-12	NA		-		-
			Dibenz(a,h)anthracene		1.70E-12		1.70E-12	NA		-		-
			Antimony		-		-	Gastrointestinal		-		-
			Arsenic		4.95E-09		4.95E-09	Skin/Central Nervous System/Cardiovascular		2.15E-04		2.15E-04
		Exposure Point Total			4.96386E-09		4.96E-09					2.15E-04
	Air	SB-12 Indoor Worker (Office/Maintenance)	Benzo(b)fluoranthene		4.59E-12		4.59E-12	NA		-		-
			Benzo(a)pyrene		4.00E-11		4.00E-11	NA		-		-
			Indeno(1,2,3-cd)pyrene		6.97E-12		6.97E-12	NA		-		-
			Dibenz(a,h)anthracene		5.95E-12		5.95E-12	NA		-		-
			Antimony		-		-	Gastrointestinal		-		-
			Arsenic		1.23E-09		1.23E-09	Skin/Central Nervous System/Cardiovascular		5.34E-05		5.34E-05
		Exposure Point Total			1.28751E-09		1.29E-09					5.34E-05
	Air	SB-16 Indoor Worker (Office/Maintenance)	Benzo(b)fluoranthene		3.83E-11		3.83E-11	NA		-		-
			Benzo(a)pyrene		1.45E-10		1.45E-10	NA		-		-
			Indeno(1,2,3-cd)pyrene		3.83E-11		3.83E-11	NA		-		-
			Dibenz(a,h)anthracene		4.42E-11		4.42E-11	NA		-		-
			Antimony		-		-	Gastrointestinal		-		-
			Arsenic		1.52E-09		1.52E-09	Skin/Central Nervous System/Cardiovascular		6.58E-05		6.58E-05
		Exposure Point Total			1.7858E-09		1.79E-09					6.58E-05
Medium/Exposure Medium Total							9.08E-09					3.79E-04
Receptor Total : Maintenance Worker					Receptor Risk Total		5.92E-06			Receptor HI Total		3.51E-02

TABLE 7-8-2 SUMMARY OF RECEPTOR RISKS AND HAZARDS RME - Potential Future - Maintenanace Worker
U.S. GOVERNMENT MOORINGS

Summary: Table shows the summary of the risks and hazards to the potential future scenario Maintenance Worker with exposure to surface soil and shallow soils shown in Table 7-8-1 plus RME Exposure to groundwater wells GW-2, GW-11, GW-16 or GW-20 through inhalation, ingestion, and dermal contact.

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Soil	Surface Soil and Air	RUN-OFF Maintenance Worker	Benzo(b)fluoranthene	9.37E-08	1.04E-12	1.33E-08	1.07E-07	NA	-	-	-	-
			Benzo(a)pyrene	7.44E-07	8.26E-12	1.06E-07	8.50E-07	NA	-	-	-	-
			Dibenz(a,h)anthracene	1.65E-07	2.00E-11	2.35E-08	1.89E-07	NA	-	-	-	-
			Aroclor 1248	1.21E-07	2.54E-12	1.85E-08	1.40E-07	NA	8.45E-03	-	1.29E-03	9.74E-03
			Arsenic	3.00E-07	6.34E-11	9.84E-09	3.10E-07	Skin/Central Nervous System/Cardiovascular	1.87E-03	2.75E-06	6.12E-05	1.93E-03
			Chromium, total	-	2.56E-09	-	2.56E-09	No Observed Effects	5.40E-06	5.97E-06	4.54E-07	1.18E-05
		Exposure Point Total					1.60E-06					1.17E-02
		FENCELINE Maintenance Worker	Benzo(b)fluoranthene	5.51E-08	6.12E-13	7.83E-09	6.29E-08	NA	-	-	-	-
			Benzo(a)pyrene	4.13E-07	4.59E-12	5.87E-08	4.72E-07	NA	-	-	-	-
			Dibenz(a,h)anthracene	6.89E-08	8.35E-12	9.79E-09	7.87E-08	NA	-	-	-	-
			Aroclor 1248	-	-	-	-	NA	-	-	-	-
			Arsenic	3.57E-06	7.54E-10	1.17E-07	3.69E-06	Skin/Central Nervous System/Cardiovascular	2.22E-02	3.27E-05	7.28E-04	2.30E-02
			Chromium, total	-	1.70E-08	-	1.70E-08	No Observed Effects	3.58E-05	3.96E-05	3.01E-06	7.84E-05
		Exposure Point Total					4.32E-06					2.30E-02
Medium/Exposure Medium Total							5.92E-06					3.47E-02
Shallow Soil	Air	South Logistics MU Indoor Worker (Office/Maintenance)	Benzo(a)pyrene		8.50E-12		8.50E-12	NA		-		-
			Arsenic		1.03E-09		1.03E-09	Skin/Central Nervous System/Cardiovascular		4.49E-05		4.49E-05
		Exposure Point Total					1.04E-09					4.49E-05
Shallow Soil	Air	SB-01 Office Worker Maintenance Worker	Benzo(b)fluoranthene		1.28E-12		1.28E-12	NA		-		-
			Benzo(a)pyrene		9.35E-12		9.35E-12	NA		-		-
			Indeno(1,2,3-cd)pyrene		1.53E-12		1.53E-12	NA		-		-
			Dibenz(a,h)anthracene		1.70E-12		1.70E-12	NA		-		-
			Antimony		-		-	Gastrointestinal		-		-
			Arsenic		4.95E-09		4.95E-09	Skin/Central Nervous System/Cardiovascular		2.15E-04		2.15E-04
		Exposure Point Total			4.96386E-09		4.96E-09					2.15E-04
	Air	SB-12 Office Worker Maintenance Worker	Benzo(b)fluoranthene		4.59E-12		4.59E-12	NA		-		-
			Benzo(a)pyrene		4.00E-11		4.00E-11	NA		-		-
			Indeno(1,2,3-cd)pyrene		6.97E-12		6.97E-12	NA		-		-
			Dibenz(a,h)anthracene		5.95E-12		5.95E-12	NA		-		-
			Antimony		-		-	Gastrointestinal		-		-
			Arsenic		1.23E-09		1.23E-09	Skin/Central Nervous System/Cardiovascular		5.34E-05		5.34E-05
		Exposure Point Total			1.28751E-09		1.29E-09					5.34E-05
	Air	SB-16 Office Worker Maintenance Worker	Benzo(b)fluoranthene		3.83E-11		3.83E-11	NA		-		-
			Benzo(a)pyrene		1.45E-10		1.45E-10	NA		-		-
			Indeno(1,2,3-cd)pyrene		3.83E-11		3.83E-11	NA		-		-
			Dibenz(a,h)anthracene		4.42E-11		4.42E-11	NA		-		-
			Antimony		-		-	Gastrointestinal		-		-
			Arsenic		1.52E-09		1.52E-09	Skin/Central Nervous System/Cardiovascular		6.58E-05		6.58E-05
		Exposure Point Total			1.7858E-09		1.79E-09					6.58E-05

TABLE 7-8-2 SUMMARY OF RECEPTOR RISKS AND HAZARDS RME - Potential Future - Maintenanace Worker
U.S. GOVERNMENT MOORINGS

Summary: Table shows the summary of the risks and hazards to the potential future scenario Maintenance Worker with exposure to surface soil and shallow soils shown in Table 7-8-1 plus RME Exposure to groundwater wells GW-2, GW-11, GW-16 or GW-20 through inhalation, ingestion, and dermal contact.

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Medium/Exposure Medium Total							9.08E-09					3.79E-04
Groundwater	Groundwater	GW-2	Aluminum (pH 6.5 - 9.0)	-	-	-	-	Central Nervous System	8.60E-02	-	4.06E-08	8.60E-02
		Office Worker Maintenance Worker	Arsenic	3.75E-05	-	2.28E-11	3.75E-05	Skin/Central Nervous System/Cardiovascular	1.07E-01	-	5.07E-08	1.07E-01
			Benz(a)anthracene	-	-	-	-	NA	-	-	-	-
			Benzene	-	-	-	-	Blood	-	-	-	-
			Benzo(a)pyrene	-	-	-	-	NA	-	-	-	-
			Benzo(b)fluoranthene	-	-	-	-	NA	-	-	-	-
			Cadmium	-	-	-	-	Urinary Tract	9.00E-04	-	8.48E-09	9.00E-04
			Chloroform	3.20E-07	2.81E-07	1.73E-12	6.01E-07	Liver	6.75E-04	3.49E-07	2.84E-09	6.75E-04
			Chromium, total	-	-	-	-	No observed effects	5.40E-05	-	1.96E-09	5.40E-05
			Cyanide	-	-	-	-	Respiratory	5.65E-02	-	2.66E-08	5.65E-02
			Dibenz(a,h)anthracene	-	-	-	-	NA	-	-	-	-
			Fluorene	-	-	-	-	NA	-	-	-	-
			Indeno(1,2,3-cd)pyrene	-	-	-	-	NA	-	-	-	-
			Manganese	-	-	-	-	Central Nervous System	4.50E-01	-	2.12E-07	4.50E-01
			Mercury	-	-	-	-	Central Nervous System	-	-	-	-
			Naphthalene	-	1.11E-08	-	1.11E-08	Blood	9.00E-06	3.04E-07	2.95E-10	9.30E-06
			Nickel	-	-	-	-	Body/Organ Weights	2.82E-02	-	6.64E-08	2.82E-02
			Tetrachloroethene (PCE)	2.08E-06	5.29E-08	6.05E-11	2.13E-06	Liver	4.95E-04	9.30E-08	1.12E-08	4.95E-04
			Trichloroethene (TCE)	1.04E-06	-	9.97E-12	1.04E-06	Liver	-	-	-	-
			Zinc	-	-	-	-	Blood	2.11E-02	-	5.97E-09	2.11E-02
			Exposure Point Total				4.13E-05					0.75
Groundwater	Groundwater	GW-11	Aluminum (pH 6.5 - 9.0)	-	-	-	-	Central Nervous System	1.68E+00	-	7.48E-04	1.68
		Office Worker Maintenance Worker	Arsenic	1.06E-04	-	6.41E-11	1.06E-04	Skin/Central Nervous System/Cardiovascular	3.02E-01	-	1.34E-04	3.02E-01
			Benz(a)anthracene	1.45E-06	-	8.40E-06	9.85E-06	NA	-	-	-	-
			Benzene	2.12E-07	7.00E-08	2.66E-12	2.82E-07	Blood	1.24E-03	8.37E-07	1.14E-05	1.25E-03
			Benzo(a)pyrene	1.23E-05	-	9.34E-05	1.06E-04	NA	-	-	-	-
			Benzo(b)fluoranthene	7.26E-07	-	3.10E-06	3.82E-06	NA	-	-	-	-
			Cadmium	-	-	-	-	Urinary Tract	9.40E-01	-	8.40E-03	9.48E-01
			Chloroform	-	-	-	-	Liver	-	-	-	-
			Chromium, total	-	-	-	-	No observed effects	1.50E-03	-	5.13E-05	1.55E-03
			Cyanide	-	-	-	-	cardiovascular system, respiratory system, thyroid, eyes, skin, blood	1.69E-01	-	7.50E-05	1.69E-01
			Dibenz(a,h)anthracene	1.26E-06	-	1.28E-05	1.41E-05	NA	-	-	-	-
			Fluorene	-	-	-	-	NA	3.38E-05	-	2.58E-06	3.63E-05
			Indeno(1,2,3-cd)pyrene	1.14E-06	-	1.55E-05	1.66E-05	NA	-	-	-	-
			Manganese	-	-	-	-	Central Nervous System	1.66E+00	-	7.42E-04	1.66
			Mercury	-	-	-	-	Central Nervous System	5.27E-03	2.66E-05	5.60E-04	5.85E-03
			Naphthalene	-	4.59E-06	-	4.59E-06	Blood	3.72E-03	1.26E-04	1.15E-04	3.96E-03
			Nickel	-	-	-	-	Body/Organ Weights	2.39E-01	-	5.31E-04	2.39E-01
			Tetrachloroethene (PCE)	-	-	-	-	Liver	-	-	-	-
			Trichloroethene (TCE)	-	-	-	-	Liver	-	-	-	-
			Zinc	-	-	-	-	Blood	4.13E-01	-	1.11E-04	4.13E-01
			Exposure Point Total				2.61E-04					5.42

TABLE 7-8-2 SUMMARY OF RECEPTOR RISKS AND HAZARDS RME - Potential Future - Maintenanace Worker
U.S. GOVERNMENT MOORINGS

Summary: Table shows the summary of the risks and hazards to the potential future scenario Maintenance Worker with exposure to surface soil and shallow soils shown in Table 7-8-1 plus RME Exposure to groundwater wells GW-2, GW-11, GW-16 or GW-20 through inhalation, ingestion, and dermal contact.

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	GW-16	Aluminum (pH 6.5 - 9.0)	-	-	-	-	Central Nervous System	1.81E-01	-	8.06E-05	0.18
		Office Worker Maintenance Worker	Arsenic	1.44E-05	-	8.76E-12	1.44E-05	Skin/Central Nervous System/Cardiovascular	4.13E-02	-	1.84E-05	4.14E-02
			Benz(a)anthracene	2.42E-07	-	1.39E-06	1.64E-06	NA	-	-	-	-
			Benzene	5.39E-07	7.64E-11	6.77E-12	5.39E-07	Blood	3.15E-03	2.13E-06	2.90E-05	3.18E-03
			Benzo(a)pyrene	-	-	-	-	NA	-	-	-	-
			Benzo(b)fluoranthene	4.84E-07	-	2.06E-06	2.54E-06	NA	-	-	-	-
			Cadmium	-	-	-	-	Urinary Tract	9.76E-02	-	8.72E-04	9.85E-02
			Chloroform	-	-	-	-	Liver	-	-	-	-
			Chromium, total	-	-	-	-	No observed effects	1.07E-04	-	3.65E-06	1.10E-04
			Cyanide	-	-	-	-	cardiovascular system, respiratory system, thyroid, eyes, skin, blood	3.37E+00	-	1.50E-03	3.37
			Dibenz(a,h)anthracene	-	-	-	-	NA	-	-	-	-
			Fluorene	-	-	-	-	NA	2.20E-04	-	1.67E-05	2.36E-04
			Indeno(1,2,3-cd)pyrene	1.21E-07	-	1.64E-06	1.76E-06	NA	-	-	-	-
			Manganese	-	-	-	-	Central Nervous System	7.54E-01	-	3.36E-04	7.55E-01
			Mercury	-	-	-	-	Central Nervous System	-	-	-	-
			Naphthalene	-	3.57E-09	-	3.57E-09	Blood	6.75E-03	2.28E-04	2.09E-04	7.19E-03
			Nickel	-	-	-	-	Body/Organ Weights	8.10E-02	-	1.80E-04	8.12E-02
			Tetrachloroethene (PCE)	0.00E+00	-	-	-	Liver	-	-	-	-
			Trichloroethene (TCE)	-	-	-	-	Liver	-	-	-	-
			Zinc	-	-	-	-	Blood	9.37E-02	-	2.51E-05	9.37E-02
			Exposure Point Total				2.09E-05					4.63
Groundwater	Groundwater/ Volatilization into Air	GW-20	Aluminum (pH 6.5 - 9.0)	-	-	-	-	Central Nervous System	2.30E-03	-	1.02E-06	2.30E-03
		Office Worker Maintenance Worker	Arsenic	1.23E-04	-	7.46E-11	1.23E-04	Skin/Central Nervous System/Cardiovascular	3.50E-01	-	1.56E-04	3.50E-01
			Benz(a)anthracene	-	-	-	-	NA	-	-	-	-
			Benzene	-	-	-	-	Blood	-	-	-	-
			Benzo(a)pyrene	-	-	-	-	NA	-	-	-	-
			Benzo(b)fluoranthene	-	-	-	-	NA	-	-	-	-
			Cadmium	-	-	-	-	Urinary Tract	-	-	-	-
			Chloroform	-	-	-	-	Liver	-	-	-	-
			Chromium, total	-	-	-	-	No observed effects	-	-	-	-
			Cyanide	-	-	-	-	cardiovascular system, respiratory system, thyroid, eyes, skin, blood	2.25E-01	-	1.01E-04	2.25E-01
			Dibenz(a,h)anthracene	-	-	-	-	NA	-	-	-	-
			Fluorene	-	-	-	-	NA	-	-	-	-
			Indeno(1,2,3-cd)pyrene	-	-	-	-	NA	-	-	-	-
			Manganese	-	-	-	-	Central Nervous System	1.13E+01	-	5.00E-03	1.13E+01
			Mercury	-	-	-	-	Central Nervous System	-	-	-	-
			Naphthalene	-	-	-	-	Blood	-	-	-	-
			Nickel	-	-	-	-	Body/Organ Weights	2.25E-03	-	5.01E-06	2.26E-03
			Tetrachloroethene (PCE)	-	-	-	-	Liver	-	-	-	-
			Trichloroethene (TCE)	-	-	-	-	Liver	-	-	-	-
			Zinc	-	-	-	-	Blood	2.48E-03	-	6.63E-07	2.48E-03
			Exposure Point Total				1.23E-04					11.84
Receptor Total : Maintenance Worker - Exposed to GW-11 at RME (Most Conservative for Cancer)					Receptor Risk Total		2.67E-04			Receptor HI Total		5.46
Receptor Total : Maintenance Worker - Exposed to GW-20 at RME (Most Conservative for Non-Cancer)					Receptor Risk Total		5.19E-05			Receptor HI Total		11.84

TABLE 7-8-3 SUMMARY OF RECEPTOR RISKS AND HAZARDS - Potential Future Maintenance Worker - CT Groundwater
U.S. GOVERNMENT MOORINGS

Summary: Table shows the summary of the risks and hazards to the potential future scenario Maintenance Worker with exposure to surface soil and shallow soils shown in Table 7-8-1 plus CT Exposure to groundwater wells GW-2, GW-11, GW-16 or GW-20 through inhalation, ingestion, and dermal contact.

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Soil	Surface Soil and Air	RUN-OFF Maintenance Worker	Benzo(b)fluoranthene	9.37E-08	1.04E-12	1.33E-08	1.07E-07	NA	-	-	-	-
			Benzo(a)pyrene	7.44E-07	8.26E-12	1.06E-07	8.50E-07	NA	-	-	-	-
			Dibenz(a,h)anthracene	1.65E-07	2.00E-11	2.35E-08	1.89E-07	NA	-	-	-	-
			Aroclor 1248	1.21E-07	2.54E-12	1.85E-08	1.40E-07	NA	8.45E-03	-	1.29E-03	9.74E-03
			Arsenic	3.00E-07	6.34E-11	9.84E-09	3.10E-07	Skin/Central Nervous System/Cardiovascular	1.87E-03	2.75E-06	6.12E-05	1.93E-03
			Chromium, total	-	2.56E-09	-	2.56E-09	No Observed Effects	5.40E-06	5.97E-06	4.54E-07	1.18E-05
		Exposure Point Total					1.60E-06					1.17E-02
		FENCELINE Maintenance Worker	Benzo(b)fluoranthene	5.51E-08	6.12E-13	7.83E-09	6.29E-08	NA	-	-	-	-
			Benzo(a)pyrene	4.13E-07	4.59E-12	5.87E-08	4.72E-07	NA	-	-	-	-
			Dibenz(a,h)anthracene	6.89E-08	8.35E-12	9.79E-09	7.87E-08	NA	-	-	-	-
			Aroclor 1248	-	-	-	-	NA	-	-	-	-
			Arsenic	3.57E-06	7.54E-10	1.17E-07	3.69E-06	Skin/Central Nervous System/Cardiovascular	2.22E-02	3.27E-05	7.28E-04	2.30E-02
			Chromium, total	-	1.70E-08	-	1.70E-08	No Observed Effects	3.58E-05	3.96E-05	3.01E-06	7.84E-05
		Exposure Point Total					4.32E-06					2.30E-02
Medium/Exposure Medium Total							5.92E-06					3.47E-02
Shallow Soil	Air	South Logistics MU Indoor Worker (Office/Maintenance)	Benzo(a)pyrene		8.50E-12		8.50E-12	NA		-		-
			Arsenic		1.03E-09		1.03E-09	Skin/Central Nervous System/Cardiovascular		4.49E-05		4.49E-05
		Exposure Point Total					1.04E-09					4.49E-05
Shallow Soil	Air	SB-01 Office Worker Maintenance Worker	Benzo(b)fluoranthene		1.28E-12		1.28E-12	NA		-		-
			Benzo(a)pyrene		9.35E-12		9.35E-12	NA		-		-
			Indeno(1,2,3-cd)pyrene		1.53E-12		1.53E-12	NA		-		-
			Dibenz(a,h)anthracene		1.70E-12		1.70E-12	NA		-		-
			Antimony		-		-	Gastrointestinal		-		-
			Arsenic		4.95E-09		4.95E-09	Skin/Central Nervous System/Cardiovascular		2.15E-04		2.15E-04
		Exposure Point Total			4.96386E-09		4.96E-09					2.15E-04
	Air	SB-12 Office Worker Maintenance Worker	Benzo(b)fluoranthene		4.59E-12		4.59E-12	NA		-		-
			Benzo(a)pyrene		4.00E-11		4.00E-11	NA		-		-
			Indeno(1,2,3-cd)pyrene		6.97E-12		6.97E-12	NA		-		-
			Dibenz(a,h)anthracene		5.95E-12		5.95E-12	NA		-		-
			Antimony		-		-	Gastrointestinal		-		-
			Arsenic		1.23E-09		1.23E-09	Skin/Central Nervous System/Cardiovascular		5.34E-05		5.34E-05
		Exposure Point Total			1.28751E-09		1.29E-09					5.34E-05
	Air	SB-16 Office Worker Maintenance Worker	Benzo(b)fluoranthene		3.83E-11		3.83E-11	NA		-		-
			Benzo(a)pyrene		1.45E-10		1.45E-10	NA		-		-
			Indeno(1,2,3-cd)pyrene		3.83E-11		3.83E-11	NA		-		-
			Dibenz(a,h)anthracene		4.42E-11		4.42E-11	NA		-		-
			Antimony		-		-	Gastrointestinal		-		-
			Arsenic		1.52E-09		1.52E-09	Skin/Central Nervous System/Cardiovascular		6.58E-05		6.58E-05
		Exposure Point Total			1.7858E-09		1.79E-09					6.58E-05
Medium/Exposure Medium Total							9.08E-09					3.79E-04

TABLE 7-8-3 SUMMARY OF RECEPTOR RISKS AND HAZARDS - Potential Future Maintenance Worker - CT Groundwater
U.S. GOVERNMENT MOORINGS

Summary: Table shows the summary of the risks and hazards to the potential future scenario Maintenance Worker with exposure to surface soil and shallow soils shown in Table 7-8-1 plus CT Exposure to groundwater wells GW-2, GW-11, GW-16 or GW-20 through inhalation, ingestion, and dermal contact.

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater		GW-2	Aluminum (pH 6.5 - 9.0)	-	-	-	-	Central Nervous System	5.23E-02	-	1.91E-05	5.23E-02
	Groundwater	Office Worker	Arsenic	2.10E-06	-	2.13E-11	2.10E-06	Skin/Central Nervous System/Cardiovascular	6.53E-02	-	2.39E-05	6.54E-02
		Maintenance Worker	Benz(a)anthracene	-	-	-	-	NA	-	-	-	-
			Benzene	-	-	-	-	Blood	-	-	-	-
			Benzo(a)pyrene	-	-	-	-	NA	-	-	-	-
			Benzo(b)fluoranthene	-	-	-	-	NA	-	-	-	-
			Cadmium	-	-	-	-	Urinary Tract	5.48E-04	-	4.00E-06	5.52E-04
			Chloroform	1.79E-08	6.76E-08	1.62E-12	8.56E-08	Liver	4.11E-04	3.49E-07	1.34E-06	4.13E-04
			Chromium, total	-	-	-	-	No observed effects	3.29E-05	-	9.23E-07	3.38E-05
			Cyanide	-	-	-	-	cardiovascular system, respiratory system, thyroid, eyes, skin, blood	3.43E-02	-	1.25E-05	3.43E-02
			Dibenz(a,h)anthracene	-	-	-	-	NA	-	-	-	-
			Fluorene	-	-	-	-	NA	-	-	-	-
			Indeno(1,2,3-cd)pyrene	-	-	-	-	NA	-	-	-	-
			Manganese	-	-	-	-	Central Nervous System	2.73E-01	-	9.96E-05	2.73E-01
			Mercury	-	-	-	-	Central Nervous System	-	-	-	-
			Naphthalene	-	2.66E-09	-	2.66E-09	Blood	5.50E-06	3.04E-07	1.39E-07	5.94E-06
			Nickel	-	-	-	-	Body/Organ Weights	1.71E-02	-	3.13E-05	1.71E-02
			Tetrachloroethene (PCE)	1.16E-07	1.27E-08	5.67E-11	1.29E-07	Liver	3.01E-04	9.30E-08	5.30E-06	3.06E-04
			Trichloroethene (TCE)	5.84E-08	-	9.26E-12	5.84E-08	Liver	-	-	-	-
			Zinc	-	-	-	-	Blood	1.28E-02	-	2.82E-06	1.28E-02
			Exposure Point Total				2.38E-06					0.46
Groundwater		GW-11	Aluminum (pH 6.5 - 9.0)	-	-	-	-	Central Nervous System	1.02E+00	-	3.74E-04	1.02
	Groundwater	Office Worker	Arsenic	5.90E-06	-	5.97E-11	5.90E-06	Skin/Central Nervous System/Cardiovascular	1.84E-01	-	6.70E-05	1.84E-01
		Maintenance Worker	Benz(a)anthracene	1.45E-06	-	8.40E-06	9.85E-06	NA	-	-	-	-
			Benzene	1.18E-08	1.68E-08	2.48E-12	2.86E-08	Blood	7.53E-04	8.37E-07	5.70E-06	7.59E-04
			Benzo(a)pyrene	1.23E-05	-	9.34E-05	1.06E-04	NA	-	-	-	-
			Benzo(b)fluoranthene	7.26E-07	-	3.10E-06	3.82E-06	NA	-	-	-	-
			Cadmium	-	-	-	-	Urinary Tract	5.72E-01	-	4.20E-03	5.76E-01
			Chloroform	-	-	-	-	Liver	-	-	-	-
			Chromium, total	-	-	-	-	No observed effects	9.13E-04	-	2.57E-05	9.39E-04
			Cyanide	-	-	-	-	cardiovascular system, respiratory system, thyroid, eyes, skin, blood	1.03E-01	-	3.76E-05	1.03E-01
			Dibenz(a,h)anthracene	1.26E-06	-	1.28E-05	1.41E-05	NA	-	-	-	-
			Fluorene	-	-	-	-	NA	2.06E-05	-	1.29E-06	2.18E-05
			Indeno(1,2,3-cd)pyrene	1.14E-06	-	1.55E-05	1.66E-05	NA	-	-	-	-
			Manganese	-	-	-	-	Central Nervous System	1.01E+00	-	3.70E-04	1.01
			Mercury	-	-	-	-	Central Nervous System	3.20E-03	2.66E-05	2.81E-04	3.50E-03
			Naphthalene	-	1.10E-06	-	1.10E-06	Blood	2.26E-03	1.26E-04	5.75E-05	2.44E-03
			Nickel	-	-	-	-	Body/Organ Weights	1.45E-01	-	2.65E-04	1.45E-01
			Tetrachloroethene (PCE)	-	-	-	-	Liver	-	-	-	-
			Trichloroethene (TCE)	-	-	-	-	Liver	-	-	-	-
			Zinc	-	-	-	-	Blood	2.52E-01	-	5.53E-05	2.52E-01
			Exposure Point Total				1.57E-04					3.30

TABLE 7-8-3 SUMMARY OF RECEPTOR RISKS AND HAZARDS - Potential Future Maintenance Worker - CT Groundwater
U.S. GOVERNMENT MOORINGS

Summary: Table shows the summary of the risks and hazards to the potential future scenario Maintenance Worker with exposure to surface soil and shallow soils shown in Table 7-8-1 plus CT Exposure to groundwater wells GW-2, GW-11, GW-16 or GW-20 through inhalation, ingestion, and dermal contact.

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	GW-16	Aluminum (pH 6.5 - 9.0)	-	-	-	-	Central Nervous System	1.10E-01	-	4.03E-05	0.11
		Office Worker	Arsenic	-	-	-	-	Skin/Central Nervous System/Cardiovascular	2.51E-02	-	9.20E-06	2.51E-02
		Maintenance Worker	Benz(a)anthracene	2.42E-07	-	1.39E-06	1.64E-06	NA	-	-	-	-
			Benzene	-	4.27E-08	-	4.27E-08	Blood	1.92E-03	2.13E-06	1.45E-05	1.93E-03
			Benzo(a)pyrene	-	-	-	-	NA	-	-	-	-
			Benzo(b)fluoranthene	4.84E-07	-	2.06E-06	2.54E-06	NA	-	-	-	-
			Cadmium	-	-	-	-	Urinary Tract	5.94E-02	-	4.36E-04	5.98E-02
			Chloroform	-	-	-	-	Liver	-	-	-	-
			Chromium, total	-	-	-	-	No observed effects	6.49E-05	-	1.83E-06	6.67E-05
			Cyanide	-	-	-	-	cardiovascular system, respiratory system, thyroid, eyes, skin, blood	1.99E+00	-	7.25E-04	1.99
			Dibenz(a,h)anthracene	-	-	-	-	NA	-	-	-	-
			Fluorene	-	-	-	-	NA	1.34E-04	-	8.35E-06	1.42E-04
			Indeno(1,2,3-cd)pyrene	1.21E-07	-	1.64E-06	1.76E-06	NA	-	-	-	-
			Manganese	-	-	-	-	Central Nervous System	4.58E-01	-	1.68E-04	4.59E-01
			Mercury	-	-	-	-	Central Nervous System	-	3.06E-01	-	3.06E-01
			Naphthalene	-	2.00E-06	-	2.00E-06	Blood	4.11E-03	2.28E-04	1.05E-04	4.44E-03
			Nickel	-	-	-	-	Body/Organ Weights	4.93E-02	-	9.01E-05	4.94E-02
			Tetrachloroethene (PCE)	-	-	-	-	Liver	-	-	-	-
			Trichloroethene (TCE)	-	-	-	-	Liver	-	-	-	-
			Zinc	-	-	-	-	Blood	5.70E-02	-	1.25E-05	5.70E-02
			Exposure Point Total				7.98E-06					3.06
Groundwater	Groundwater/ Volatilization into Air	GW-20	Aluminum (pH 6.5 - 9.0)	-	-	-	-	Central Nervous System	1.40E-03	-	5.11E-07	1.40E-03
		Office Worker	Arsenic	6.87E-06	-	7.85E-13	6.87E-06	Skin/Central Nervous System/Cardiovascular	2.14E-01	-	7.80E-05	2.14E-01
		Maintenance Worker	Benz(a)anthracene	-	-	-	-	NA	-	-	-	-
			Benzene	-	-	-	-	Blood	-	-	-	-
			Benzo(a)pyrene	-	-	-	-	NA	-	-	-	-
			Benzo(b)fluoranthene	-	-	-	-	NA	-	-	-	-
			Cadmium	-	-	-	-	Urinary Tract	-	-	-	-
			Chloroform	-	-	-	-	Liver	-	-	-	-
			Chromium, total	-	-	-	-	No observed effects	-	-	-	-
			Cyanide	-	-	-	-	Cardiovascular system, respiratory system, thyroid, eyes, skin, blood	1.37E-01	-	5.00E-05	1.37E-01
			Dibenz(a,h)anthracene	-	-	-	-	NA	-	-	-	-
			Fluorene	-	-	-	-	NA	-	-	0.00E+00	-
			Indeno(1,2,3-cd)pyrene	-	-	-	-	NA	-	-	-	-
			Manganese	-	-	-	-	Central Nervous System	6.83E+00	-	2.50E-03	6.84
			Mercury	-	-	-	-	Central Nervous System	-	-	-	-
			Naphthalene	-	-	-	-	Blood	-	-	-	-
			Nickel	-	-	-	-	Body/Organ Weights	1.37E-03	-	2.50E-06	1.37E-03
			Tetrachloroethene (PCE)	-	-	-	-	Liver	-	-	-	-
			Trichloroethene (TCE)	-	-	-	-	Liver	-	-	-	-
			Zinc	-	-	-	-	Blood	1.51E-03	-	3.31E-07	1.51E-03
			Exposure Point Total				6.87E-06					7.19
Receptor Total : Maintenance Worker - Exposed to GW-11 at RME (Most Conservative for Cancer)						Receptor Risk Total	1.63E-04				Receptor HI Total	3.33
Receptor Total : Maintenance Worker - Exposed to GW-20 at RME (Most Conservative for Non-Cancer)						Receptor Risk Total	6.88E-06				Receptor HI Total	**7.19**

TABLE 7-8-4 SUMMARY OF RECEPTOR RISKS AND HAZARDS RME -Office Worker
U.S. GOVERNMENT MOORINGS

Summary: Table shows the summary of the risks and hazards to the current scenario Office Worker with exposure to shallow soils (SB-01, SB-12 and SB-16) through inhalation.

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Shallow Soil	Air	SB-01 Office Worker	Benzo(b)fluoranthene		1.28E-12		1.28E-12	NA		-		-
			Benzo(a)pyrene		9.35E-12		9.35E-12	NA		-		-
			Indeno(1,2,3-cd)pyrene		1.53E-12		1.53E-12	NA		-		-
			Dibenz(a,h)anthracene		1.70E-12		1.70E-12	NA		-		-
			Antimony		-		-	Gastrointestinal		-		-
			Arsenic		4.95E-09		4.95E-09	Skin/Central Nervous System/Cardiovascular		2.15E-04		2.15E-04
		Exposure Point Total			4.96386E-09		4.96E-09					2.15E-04
	Air	SB-12 Office Worker	Benzo(b)fluoranthene		4.59E-12		4.59E-12	NA		-		-
			Benzo(a)pyrene		4.00E-11		4.00E-11	NA		-		-
			Indeno(1,2,3-cd)pyrene		6.97E-12		6.97E-12	NA		-		-
			Dibenz(a,h)anthracene		5.95E-12		5.95E-12	NA		-		-
			Antimony		-		-	Gastrointestinal		-		-
			Arsenic		1.23E-09		1.23E-09	Skin/Central Nervous System/Cardiovascular		5.34E-05		5.34E-05
		Exposure Point Total			1.28751E-09		1.29E-09					5.34E-05
	Air	SB-16 Office Worker	Benzo(b)fluoranthene		3.83E-11		3.83E-11	NA		-		-
			Benzo(a)pyrene		1.45E-10		1.45E-10	NA		-		-
			Indeno(1,2,3-cd)pyrene		3.83E-11		3.83E-11	NA		-		-
			Dibenz(a,h)anthracene		4.42E-11		4.42E-11	NA		-		-
			Antimony		-		-	Gastrointestinal		-		-
			Arsenic		1.52E-09		1.52E-09	Skin/Central Nervous System/Cardiovascular		6.58E-05		6.58E-05
		Exposure Point Total			1.7858E-09		1.79E-09					6.58E-05
	Air	South Logistics MU Indoor Worker (Office)	Benzo(a)pyrene		8.50E-12		8.50E-12	NA		-		-
			Arsenic		1.03E-09		1.03E-09	Skin/Central Nervous System/Cardiovascular		4.49E-05		4.49E-05
		Exposure Point Total					1.04E-09					4.49E-05
Medium/Exposure Medium Total							9.08E-09					3.79E-04
Receptor Total : Office Worker					Receptor Risk Total		9.08E-09			Receptor HI Total		3.79E-04

TABLE 7-8-5 SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs REASONABLE MAXIMUM EXPOSURE
U.S. GOVERNMENT MOORINGS

Summary: Table shows the summary of the risks and hazards to the potential future scenario Maintenance Worker with exposure to surface soil and shallow soils shown in Table 7-8-1 plus RME Exposure to groundwater wells GW-2, GW-11, GW-16 or GW-20 through inhalation

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Shallow Soil	Air	SB-01	Benzo(b)fluoranthene		1.28E-12		1.28E-12	NA		-		-
		Office Worker	Benzo(a)pyrene		9.35E-12		9.35E-12	NA		-		-
		Maintenance Worker	Indeno(1,2,3-cd)pyrene		1.53E-12		1.53E-12	NA		-		-
			Dibenz(a,h)anthracene		1.70E-12		1.70E-12	NA		-		-
			Antimony		-		-	Gastrointestinal		-		-
			Arsenic		4.95E-09		4.95E-09	Skin/Central Nervous System/Cardiovascular		2.15E-04		2.15E-04
		Exposure Point Total			4.96386E-09		4.96E-09					2.15E-04
	Air	SB-12	Benzo(b)fluoranthene		4.59E-12		4.59E-12	NA		-		-
		Office Worker	Benzo(a)pyrene		4.00E-11		4.00E-11	NA		-		-
		Maintenance Worker	Indeno(1,2,3-cd)pyrene		6.97E-12		6.97E-12	NA		-		-
			Dibenz(a,h)anthracene		5.95E-12		5.95E-12	NA		-		-
			Antimony		-		-	Gastrointestinal		-		-
			Arsenic		1.23E-09		1.23E-09	Skin/Central Nervous System/Cardiovascular		5.34E-05		5.34E-05
		Exposure Point Total			1.28751E-09		1.29E-09					5.34E-05
	Air	SB-16	Benzo(b)fluoranthene		3.83E-11		3.83E-11	NA		-		-
		Office Worker	Benzo(a)pyrene		1.45E-10		1.45E-10	NA		-		-
		Maintenance Worker	Indeno(1,2,3-cd)pyrene		3.83E-11		3.83E-11	NA		-		-
			Dibenz(a,h)anthracene		4.42E-11		4.42E-11	NA		-		-
			Antimony		-		-	Gastrointestinal		-		-
			Arsenic		1.52E-09		1.52E-09	Skin/Central Nervous System/Cardiovascular		6.58E-05		6.58E-05
		Exposure Point Total			1.7858E-09		1.79E-09					6.58E-05
	Air	South Logistics MU	Benzo(a)pyrene		8.50E-12		8.50E-12	NA		-		-
		Indoor Worker (Office/Maintenance)	Arsenic		1.03E-09		1.03E-09	Skin/Central Nervous System/Cardiovascular		4.49E-05		4.49E-05
		Exposure Point Total					1.04E-09					4.49E-05
Medium/Exposure Medium Total							9.08E-09					3.79E-04
Groundwater		GW-2	Aluminum (pH 6.5 - 9.0)	-	-	-	-	Central Nervous System	8.60E-02	-	4.06E-08	8.60E-02
	Groundwater	Office Worker	Arsenic	3.75E-05	-	2.28E-11	3.75E-05	Skin/Central Nervous System/Cardiovascular	1.07E-01	-	5.07E-08	1.07E-01
		Maintenance Worker	Benz(a)anthracene	-	-	-	-	NA	-	-	-	-
			Benzene	-	-	-	-	Blood	-	-	-	-
			Benzo(a)pyrene	-	-	-	-	NA	-	-	-	-
			Benzo(b)fluoranthene	-	-	-	-	NA	-	-	-	-
			Cadmium	-	-	-	-	Urinary Tract	9.00E-04	-	8.48E-09	9.00E-04
			Chloroform	3.20E-07	2.81E-07	1.73E-12	6.01E-07	Liver	6.75E-04	3.49E-07	2.84E-09	6.75E-04
			Chromium, total	-	-	-	-	No observed effects	5.40E-05	-	1.96E-09	5.40E-05
			Cyanide	-	-	-	-	Respiratory	5.65E-02	-	2.66E-08	5.65E-02
			Dibenz(a,h)anthracene	-	-	-	-	NA	-	-	-	-
			Fluorene	-	-	-	-	NA	-	-	-	-
			Indeno(1,2,3-cd)pyrene	-	-	-	-	NA	-	-	-	-
			Manganese	-	-	-	-	Central Nervous System	4.50E-01	-	2.12E-07	4.50E-01
			Mercury	-	-	-	-	Central Nervous System	-	-	-	-
			Naphthalene	-	1.11E-08	-	1.11E-08	Blood	9.00E-06	3.04E-07	2.95E-10	9.30E-06
			Nickel	-	-	-	-	Body/Organ Weights	2.82E-02	-	6.64E-08	2.82E-02
			Tetrachloroethene (PCE)	2.08E-06	5.29E-08	6.05E-11	2.13E-06	Liver	4.95E-04	9.30E-08	1.12E-08	4.95E-04
			Trichloroethene (TCE)	1.04E-06	-	9.97E-12	1.04E-06	Liver	-	-	-	-
			Zinc	-	-	-	-	Blood	2.11E-02	-	5.97E-09	2.11E-02
			Exposure Point Total				4.13E-05					0.75

TABLE 7-8-5 SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs REASONABLE MAXIMUM EXPOSURE
U.S. GOVERNMENT MOORINGS

Summary: Table shows the summary of the risks and hazards to the potential future scenario Maintenance Worker with exposure to surface soil and shallow soils shown in Table 7-8-1 plus RME Exposure to groundwater wells GW-2, GW-11, GW-16 or GW-20 through inhalation

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater		GW-11	Aluminum (pH 6.5 - 9.0)	-	-	-	-	Central Nervous System	1.68E+00	-	7.48E-04	1.68
	Groundwater	Office Worker	Arsenic	1.06E-04	-	6.41E-11	1.06E-04	Skin/Central Nervous System/Cardiovascular	3.02E-01	-	1.34E-04	3.02E-01
		Maintenance Worker	Benz(a)anthracene	1.45E-06	-	8.40E-06	9.85E-06	NA	-	-	-	-
			Benzene	2.12E-07	7.00E-08	2.66E-12	2.82E-07	Blood	1.24E-03	8.37E-07	1.14E-05	1.25E-03
			Benzo(a)pyrene	1.23E-05	-	9.34E-05	1.06E-04	NA	-	-	-	-
			Benzo(b)fluoranthene	7.26E-07	-	3.10E-06	3.82E-06	NA	-	-	-	-
			Cadmium	-	-	-	-	Urinary Tract	9.40E-01	-	8.40E-03	9.48E-01
			Chloroform	-	-	-	-	Liver	-	-	-	-
			Chromium, total	-	-	-	-	No observed effects	1.50E-03	-	5.13E-05	1.55E-03
			Cyanide	-	-	-	-	Respiratory	1.69E-01	-	7.50E-05	1.69E-01
			Dibenz(a,h)anthracene	1.26E-06	-	1.28E-05	1.41E-05	NA	-	-	-	-
			Fluorene	-	-	-	-	NA	3.38E-05	-	2.58E-06	3.63E-05
			Indeno(1,2,3-cd)pyrene	1.14E-06	-	1.55E-05	1.66E-05	NA	-	-	-	-
			Manganese	-	-	-	-	Central Nervous System	1.66E+00	-	7.42E-04	1.66
			Mercury	-	-	-	-	Central Nervous System	5.27E-03	2.66E-05	5.60E-04	5.85E-03
			Naphthalene	-	4.59E-06	-	4.59E-06	Blood	3.72E-03	1.26E-04	1.15E-04	3.96E-03
			Nickel	-	-	-	-	Body/Organ Weights	2.39E-01	-	5.31E-04	2.39E-01
			Tetrachloroethene (PCE)	-	-	-	-	Liver	-	-	-	-
			Trichloroethene (TCE)	-	-	-	-	Liver	-	-	-	-
			Zinc	-	-	-	-	Blood	4.13E-01	-	1.11E-04	4.13E-01
			Exposure Point Total				2.61E-04					5.42
Groundwater		GW-16	Aluminum (pH 6.5 - 9.0)	-	-	-	-	Central Nervous System	1.81E-01	-	8.06E-05	0.18
	Groundwater	Office Worker	Arsenic	1.44E-05	-	8.76E-12	1.44E-05	Skin/Central Nervous System/Cardiovascular	4.13E-02	-	1.84E-05	4.14E-02
		Maintenance Worker	Benz(a)anthracene	2.42E-07	-	1.39E-06	1.64E-06	NA	-	-	-	-
			Benzene	5.39E-07	7.64E-11	6.77E-12	5.39E-07	Blood	3.15E-03	2.13E-06	2.90E-05	3.18E-03
			Benzo(a)pyrene	-	-	-	-	NA	-	-	-	-
			Benzo(b)fluoranthene	4.84E-07	-	2.06E-06	2.54E-06	NA	-	-	-	-
			Cadmium	-	-	-	-	Urinary Tract	9.76E-02	-	8.72E-04	9.85E-02
			Chloroform	-	-	-	-	Liver	-	-	-	-
			Chromium, total	-	-	-	-	No observed effects	1.07E-04	-	3.65E-06	1.10E-04
			Cyanide	-	-	-	-	Respiratory	3.37E+00	-	1.50E-03	3.37
			Dibenz(a,h)anthracene	-	-	-	-	NA	-	-	-	-
			Fluorene	-	-	-	-	NA	2.20E-04	-	1.67E-05	2.36E-04
			Indeno(1,2,3-cd)pyrene	1.21E-07	-	1.64E-06	1.76E-06	NA	-	-	-	-
			Manganese	-	-	-	-	Central Nervous System	7.54E-01	-	3.36E-04	7.55E-01
			Mercury	-	-	-	-	Central Nervous System	-	-	-	-
			Naphthalene	-	3.57E-09	-	3.57E-09	Blood	6.75E-03	2.28E-04	2.09E-04	7.19E-03
			Nickel	-	-	-	-	Body/Organ Weights	8.10E-02	-	1.80E-04	8.12E-02
			Tetrachloroethene (PCE)	0.00E+00	-	-	-	Liver	-	-	-	-
			Trichloroethene (TCE)	-	-	-	-	Liver	-	-	-	-
			Zinc	-	-	-	-	Blood	9.37E-02	-	2.51E-05	9.37E-02
			Exposure Point Total				2.09E-05					4.63

TABLE 7-8-5 SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs REASONABLE MAXIMUM EXPOSURE
U.S. GOVERNMENT MOORINGS

Summary: Table shows the summary of the risks and hazards to the potential future scenario Maintenance Worker with exposure to surface soil and shallow soils shown in Table 7-8-1 plus RME Exposure to groundwater wells GW-2, GW-11, GW-16 or GW-20 through inhalation

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater/ Volatilization into Air	GW-20	Aluminum (pH 6.5 - 9.0)	-	-	-	-	Central Nervous System	2.30E-03	-	1.02E-06	2.30E-03
		Office Worker	Arsenic	1.23E-04	-	7.46E-11	1.23E-04	Skin/Central Nervous System/Cardiovascular	3.50E-01	-	1.56E-04	3.50E-01
		Maintenance Worker	Benz(a)anthracene	-	-	-	-	NA	-	-	-	-
			Benzene	-	-	-	-	Blood	-	-	-	-
			Benzo(a)pyrene	-	-	-	-	NA	-	-	-	-
			Benzo(b)fluoranthene	-	-	-	-	NA	-	-	-	-
			Cadmium	-	-	-	-	Urinary Tract	-	-	-	-
			Chloroform	-	-	-	-	Liver	-	-	-	-
			Chromium, total	-	-	-	-	No observed effects	-	-	-	-
			Cyanide	-	-	-	-	Respiratory	2.25E-01	-	1.01E-04	2.25E-01
			Dibenz(a,h)anthracene	-	-	-	-	NA	-	-	-	-
			Fluorene	-	-	-	-	NA	-	-	-	-
			Indeno(1,2,3-cd)pyrene	-	-	-	-	NA	-	-	-	-
			Manganese	-	-	-	-	Central Nervous System	1.13E+01	-	5.00E-03	1.13E+01
			Mercury	-	-	-	-	Central Nervous System	-	-	-	-
			Naphthalene	-	-	-	-	Blood	-	-	-	-
			Nickel	-	-	-	-	Body/Organ Weights	2.25E-03	-	5.01E-06	2.26E-03
			Tetrachloroethene (PCE)	-	-	-	-	Liver	-	-	-	-
			Trichloroethene (TCE)	-	-	-	-	Liver	-	-	-	-
			Zinc	-	-	-	-	Blood	2.48E-03	-	6.63E-07	2.48E-03
			Exposure Point Total				1.23E-04					11.84

Receptor Total : Maintenance Worker - Exposed to GW-11 at RME (Most Conservative for Cancer)	Receptor Risk Total	2.61E-04	Receptor HI Total	5.42
Receptor Total : Maintenance Worker - Exposed to GW-20 at RME (Most Conservative for Non-cancer)	Receptor Risk Total	2.09E-05	Receptor HI Total	11.84

Scenario Timeframe: Future
Receptor Population: Office Worker
Receptor Age: 18-70

TABLE 7-8-6 SUMMARY OF RECEPTOR RISKS AND HAZARDS - Future - Office Worker - CT Groundwater
U.S. GOVERNMENT MOORINGS

Summary: Table shows the summary of the risks and hazards to the potential future scenario Maintenance Worker with exposure to surface soil and shallow soils shown in Table 7-8-1 plus CT Exposure to groundwater wells GW-11, GW-16 or GW-20 through inhalation, ingestion, and dermal contact.

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Shallow Soil	Air	SB-01	Benzo(b)fluoranthene		1.28E-12		1.28E-12	NA		-		-
		Indoor Worker (Office/Maintenance)	Benzo(a)pyrene		9.35E-12		9.35E-12	NA		-		-
			Indeno(1,2,3-cd)pyrene		1.53E-12		1.53E-12	NA		-		-
			Dibenz(a,h)anthracene		1.70E-12		1.70E-12	NA		-		-
			Antimony		-		-	Gastrointestinal		-		-
			Arsenic		4.95E-09		4.95E-09	Skin/Central Nervous System/Cardiovascular		2.15E-04		2.15E-04
		Exposure Point Total			4.96386E-09		4.96E-09					2.15E-04
	Air	SB-12	Benzo(b)fluoranthene		4.59E-12		4.59E-12	NA		-		-
		Indoor Worker (Office/Maintenance)	Benzo(a)pyrene		4.00E-11		4.00E-11	NA		-		-
			Indeno(1,2,3-cd)pyrene		6.97E-12		6.97E-12	NA		-		-
			Dibenz(a,h)anthracene		5.95E-12		5.95E-12	NA		-		-
			Antimony		-		-	Gastrointestinal		-		-
			Arsenic		1.23E-09		1.23E-09	Skin/Central Nervous System/Cardiovascular		5.34E-05		5.34E-05
		Exposure Point Total			1.28751E-09		1.29E-09					5.34E-05
	Air	SB-16	Benzo(b)fluoranthene		3.83E-11		3.83E-11	NA		-		-
		Indoor Worker (Office/Maintenance)	Benzo(a)pyrene		1.45E-10		1.45E-10	NA		-		-
			Indeno(1,2,3-cd)pyrene		3.83E-11		3.83E-11	NA		-		-
			Dibenz(a,h)anthracene		4.42E-11		4.42E-11	NA		-		-
			Antimony		-		-	Gastrointestinal		-		-
			Arsenic		1.52E-09		1.52E-09	Skin/Central Nervous System/Cardiovascular		6.58E-05		6.58E-05
		Exposure Point Total			1.7858E-09		1.79E-09					6.58E-05
	Air	South Logistics MU	Benzo(a)pyrene		8.50E-12		8.50E-12	NA		-		-
		Indoor Worker (Office/Maintenance)	Arsenic		1.03E-09		1.03E-09	Skin/Central Nervous System/Cardiovascular		4.49E-05		4.49E-05
		Exposure Point Total					1.04E-09					4.49E-05
Medium/Exposure Medium Total							9.08E-09					3.79E-04
Groundwater		GW-2	Aluminum (pH 6.5 - 9.0)	-	-	-	-	Central Nervous System	5.23E-02	-	1.91E-05	5.23E-02
	Groundwater	Indoor Worker (Office/Maintenance)	Arsenic	2.10E-06	-	2.13E-11	2.10E-06	Skin/Central Nervous System/Cardiovascular	6.53E-02	-	2.39E-05	6.54E-02
			Benz(a)anthracene	-	-	-	-	NA	-	-	-	-
			Benzene	-	-	-	-	Blood	-	-	-	-
			Benzo(a)pyrene	-	-	-	-	NA	-	-	-	-
			Benzo(b)fluoranthene	-	-	-	-	NA	-	-	-	-
			Cadmium	-	-	-	-	Urinary Tract	5.48E-04	-	4.00E-06	5.52E-04
			Chloroform	1.79E-08	6.76E-08	1.62E-12	8.56E-08	Liver	4.11E-04	3.49E-07	1.34E-06	4.13E-04
			Chromium, total	-	-	-	-	No observed effects	3.29E-05	-	9.23E-07	3.38E-05
			Cyanide	-	-	-	-	Respiratory	3.43E-02	-	1.25E-05	3.43E-02
			Dibenz(a,h)anthracene	-	-	-	-	NA	-	-	-	-
			Fluorene	-	-	-	-	NA	-	-	-	-
			Indeno(1,2,3-cd)pyrene	-	-	-	-	NA	-	-	-	-
			Manganese	-	-	-	-	Central Nervous System	2.73E-01	-	9.96E-05	2.73E-01
			Mercury	-	-	-	-	Central Nervous System	-	-	-	-
			Naphthalene	-	2.66E-09	-	2.66E-09	Blood	5.50E-06	3.04E-07	1.39E-07	5.94E-06
			Nickel	-	-	-	-	Body/Organ Weights	1.71E-02	-	3.13E-05	1.71E-02
			Tetrachloroethene (PCE)	1.16E-07	1.27E-08	5.67E-11	1.29E-07	Liver	3.01E-04	9.30E-08	5.30E-06	3.06E-04
			Trichloroethene (TCE)	5.84E-08	-	9.26E-12	5.84E-08	Liver	-	-	-	-
			Zinc	-	-	-	-	Blood	1.28E-02	-	2.82E-06	1.28E-02
			Exposure Point Total				2.38E-06					0.46

TABLE 7-8-6 SUMMARY OF RECEPTOR RISKS AND HAZARDS - Future - Office Worker - CT Groundwater
U.S. GOVERNMENT MOORINGS

Summary: Table shows the summary of the risks and hazards to the potential future scenario Maintenance Worker with exposure to surface soil and shallow soils shown in Table 7-8-1 plus CT Exposure to groundwater wells GW-11, GW-16 or GW-20 through inhalation, ingestion, and dermal contact.

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	GW-11 Indoor Worker (Office/Maintenance)	Aluminum (pH 6.5 - 9.0)	-	-	-	-	Central Nervous System	1.02E+00	-	3.74E-04	1.02
			Arsenic	5.90E-06	-	5.97E-11	5.90E-06	Skin/Central Nervous System/Cardiovascular	1.84E-01	-	6.70E-05	1.84E-01
			Benz(a)anthracene	1.45E-06	-	8.40E-06	9.85E-06	NA	-	-	-	-
			Benzene	1.18E-08	1.68E-08	2.48E-12	2.86E-08	Blood	7.53E-04	8.37E-07	5.70E-06	7.59E-04
			Benzo(a)pyrene	1.23E-05	-	9.34E-05	1.06E-04	NA	-	-	-	-
			Benzo(b)fluoranthene	7.26E-07	-	3.10E-06	3.82E-06	NA	-	-	-	-
			Cadmium	-	-	-	-	Urinary Tract	5.72E-01	-	4.20E-03	5.76E-01
			Chloroform	-	-	-	-	Liver	-	-	-	-
			Chromium, total	-	-	-	-	No observed effects	9.13E-04	-	2.57E-05	9.39E-04
			Cyanide	-	-	-	-	Respiratory	1.03E-01	-	3.76E-05	1.03E-01
			Dibenz(a,h)anthracene	1.26E-06	-	1.28E-05	1.41E-05	NA	-	-	-	-
			Fluorene	-	-	-	-	NA	2.06E-05	-	1.29E-06	2.18E-05
			Indeno(1,2,3-cd)pyrene	1.14E-06	-	1.55E-05	1.66E-05	NA	-	-	-	-
			Manganese	-	-	-	-	Central Nervous System	1.01E+00	-	3.70E-04	1.01
			Mercury	-	-	-	-	Central Nervous System	3.20E-03	2.66E-05	2.81E-04	3.50E-03
			Naphthalene	-	1.10E-06	-	1.10E-06	Blood	2.26E-03	1.26E-04	5.75E-05	2.44E-03
			Nickel	-	-	-	-	Body/Organ Weights	1.45E-01	-	2.65E-04	1.45E-01
			Tetrachloroethene (PCE)	-	-	-	-	Liver	-	-	-	-
			Trichloroethene (TCE)	-	-	-	-	Liver	-	-	-	-
			Zinc	-	-	-	-	Blood	2.52E-01	-	5.53E-05	2.52E-01
			Exposure Point Total				1.57E-04					3.30
Groundwater	Groundwater	GW-16 Indoor Worker (Office/Maintenance)	Aluminum (pH 6.5 - 9.0)	-	-	-	-	Central Nervous System	1.10E-01	-	4.03E-05	0.11
			Arsenic	-	-	-	-	Skin/Central Nervous System/Cardiovascular	2.51E-02	-	9.20E-06	2.51E-02
			Benz(a)anthracene	2.42E-07	-	1.39E-06	1.64E-06	NA	-	-	-	-
			Benzene	-	4.27E-08	-	4.27E-08	Blood	1.92E-03	2.13E-06	1.45E-05	1.93E-03
			Benzo(a)pyrene	-	-	-	-	NA	-	-	-	-
			Benzo(b)fluoranthene	4.84E-07	-	2.06E-06	2.54E-06	NA	-	-	-	-
			Cadmium	-	-	-	-	Urinary Tract	5.94E-02	-	4.36E-04	5.98E-02
			Chloroform	-	-	-	-	Liver	-	-	-	-
			Chromium, total	-	-	-	-	No observed effects	6.49E-05	-	1.83E-06	6.67E-05
			Cyanide	-	-	-	-	Respiratory	1.99E+00	-	7.25E-04	1.99
			Dibenz(a,h)anthracene	-	-	-	-	NA	-	-	-	-
			Fluorene	-	-	-	-	NA	1.34E-04	-	8.35E-06	1.42E-04
			Indeno(1,2,3-cd)pyrene	1.21E-07	-	1.64E-06	1.76E-06	NA	-	-	-	-
			Manganese	-	-	-	-	Central Nervous System	4.58E-01	-	1.68E-04	4.59E-01
			Mercury	-	-	-	-	Central Nervous System	-	3.06E-01	-	3.06E-01
			Naphthalene	-	2.00E-06	-	2.00E-06	Blood	4.11E-03	2.28E-04	1.05E-04	4.44E-03
			Nickel	-	-	-	-	Body/Organ Weights	4.93E-02	-	9.01E-05	4.94E-02
			Tetrachloroethene (PCE)	-	-	-	-	Liver	-	-	-	-
			Trichloroethene (TCE)	-	-	-	-	Liver	-	-	-	-
			Zinc	-	-	-	-	Blood	5.70E-02	-	1.25E-05	5.70E-02
			Exposure Point Total				7.98E-06					3.06

TABLE 7-8-6 SUMMARY OF RECEPTOR RISKS AND HAZARDS - Future - Office Worker - CT Groundwater
U.S. GOVERNMENT MOORINGS

Summary: Table shows the summary of the risks and hazards to the potential future scenario Maintenance Worker with exposure to surface soil and shallow soils shown in Table 7-8-1 plus CT Exposure to groundwater wells GW-11, GW-16 or GW-20 through inhalation, ingestion, and dermal contact.

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	GW-20 Indoor Worker (Office/Maintenance)	Aluminum (pH 6.5 - 9.0)	-	-	-	-	Central Nervous System	1.40E-03	-	5.11E-07	1.40E-03
			Arsenic	6.87E-06	-	7.85E-13	6.87E-06	Skin/Central Nervous System/Cardiovascular	2.14E-01	-	7.80E-05	2.14E-01
			Benz(a)anthracene	-	-	-	-	NA	-	-	-	-
			Benzene	-	-	-	-	Blood	-	-	-	-
			Benzo(a)pyrene	-	-	-	-	NA	-	-	-	-
			Benzo(b)fluoranthene	-	-	-	-	NA	-	-	-	-
			Cadmium	-	-	-	-	Urinary Tract	-	-	-	-
			Chloroform	-	-	-	-	Liver	-	-	-	-
			Chromium, total	-	-	-	-	No observed effects	-	-	-	-
			Cyanide	-	-	-	-	Respiratory	1.37E-01	-	5.00E-05	1.37E-01
			Dibenz(a,h)anthracene	-	-	-	-	NA	-	-	-	-
			Fluorene	-	-	-	-	NA	-	-	0.00E+00	-
			Indeno(1,2,3-cd)pyrene	-	-	-	-	NA	-	-	-	-
			Manganese	-	-	-	-	Central Nervous System	6.83E+00	-	2.50E-03	6.84
			Mercury	-	-	-	-	Central Nervous System	-	-	-	-
			Naphthalene	-	-	-	-	Blood	-	-	-	-
			Nickel	-	-	-	-	Body/Organ Weights	1.37E-03	-	2.50E-06	1.37E-03
			Tetrachloroethene (PCE)	-	-	-	-	Liver	-	-	-	-
			Trichloroethene (TCE)	-	-	-	-	Liver	-	-	-	-
			Zinc	-	-	-	-	Blood	1.51E-03	-	3.31E-07	1.51E-03
			Exposure Point Total				6.87E-06					7.19

Receptor Total : Maintenance Worker - Exposed to GW-11 at RME (Most Conservative for Cancer)	Receptor Risk Total	1.57E-04	Receptor HI Total	3.30

Receptor Total : Maintenance Worker - Exposed to GW-20 at RME (Most Conservative for Non-cancer)	Receptor Risk Total	7.99E-06	Receptor HI Total	7.19

TABLE 7-8-7 SUMMARY OF RECEPTOR RISKS AND HAZARDS RME - Current - Upland Excavation Worker
U.S. GOVERNMENT MOORINGS

Summary: Table shows the summary of the risks and hazards to the current scenario Upland Excavation Worker with exposure to shallow soils (All MUs and SB-01, SB-12 and SB-16) through inhalation, ingestion and dermal contact.

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Shallow Soil	Shallow Soil/Air	SB-01	Benzo(b)fluoranthene	2.64E-10	1.84E-15	2.94E-10	5.58E-10	NA	-	-	-	-
		(Excavation Worker)	Benzo(a)pyrene	1.94E-09	1.35E-14	2.15E-09	4.09E-09	NA	-	-	-	-
			Indeno(1,2,3-cd)pyrene	3.17E-10	2.20E-15	3.52E-10	6.69E-10	NA	-	-	-	-
			Dibenz(a,h)anthracene	3.53E-10	2.45E-15	3.92E-10	7.45E-10	NA	-	-	-	-
			Antimony	-	-	-	-	Gastrointestinal	8.88E-05	-	5.05E-06	9.39E-05
			Arsenic	5.40E-08	7.13E-12	1.38E-08	6.78E-08	Skin/Central Nervous System/Cardiovascular	8.40E-03	7.74E-06	2.15E-03	1.06E-02
		Exposure Point Total					7.39E-08					1.07E-02
		SB-12	Benzo(b)fluoranthene	9.52E-10	6.61E-15	1.06E-09	2.01E-09	NA	-	-	-	-
		(Excavation Worker)	Benzo(a)pyrene	8.29E-09	5.75E-14	9.20E-09	1.75E-08	NA	-	-	-	-
			Indeno(1,2,3-cd)pyrene	1.45E-09	1.00E-14	1.61E-09	3.06E-09	NA	-	-	-	-
			Dibenz(a,h)anthracene	1.23E-09	8.57E-15	1.37E-09	2.60E-09	NA	-	-	-	-
			Antimony	-	-	-	-	Gastrointestinal	2.71E-01	-	1.55E-02	2.87E-01
			Arsenic	1.34E-08	1.77E-12	3.44E-09	1.68E-08	Skin/Central Nervous System/Cardiovascular	2.09E-03	1.92E-06	2.09E-03	4.18E-03
		Exposure Point Total					4.20E-08					2.91E-01
		SB-16	Benzo(b)fluoranthene	7.93E-09	5.51E-14	8.81E-09	1.67E-08	NA	-	-	-	-
		(Excavation Worker)	Benzo(a)pyrene	3.00E-08	2.08E-13	3.33E-08	6.33E-08	NA	-	-	-	-
			Indeno(1,2,3-cd)pyrene	7.93E-09	5.51E-14	8.81E-09	1.67E-08	NA	-	-	-	-
			Dibenz(a,h)anthracene	9.17E-09	6.37E-14	1.02E-08	1.94E-08	NA	-	-	-	-
			Antimony	-	-	-	-	Gastrointestinal	2.48E-03	-	1.41E-04	2.62E-03
			Arsenic	1.65E-08	2.18E-12	4.23E-09	2.07E-08	Skin/Central Nervous System/Cardiovascular	2.57E-03	2.37E-06	6.59E-04	3.23E-03
		Exposure Point Total					1.37E-07					5.85E-03
		South Logistics MU	Benzo(a)pyrene	1.10E-09	1.22E-14	1.57E-10	1.26E-09	NA	-	-	-	-
		(Excavation Worker)	Arsenic	7.04E-09	1.49E-12	2.31E-10	7.27E-09	Skin/Central Nervous System/Cardiovascular	1.10E-03	1.62E-06	3.59E-05	1.14E-03
		Exposure Point Total					8.53E-09					1.14E-03
		North Logistics MU	Benzo(a)pyrene	1.06E-08	1.18E-13	1.50E-09	1.21E-08	NA	-	-	-	-
		(Excavation Worker)	Arsenic	1.39E-08	2.95E-12	4.58E-10	1.44E-08	Skin/Central Nervous System/Cardiovascular	2.17E-03	3.20E-06	7.12E-05	2.24E-03
		Exposure Point Total					2.65E-08					2.24E-03
		Laydown	Benzo(a)pyrene	3.97E-09	4.41E-14	4.53E-09	8.50E-09	NA	-	-	-	-
		(Excavation Worker)	Arsenic	9.37E-09	1.98E-12	9.68E-09	1.91E-08	Skin/Central Nervous System/Cardiovascular	3.73E-04	2.15E-06	4.78E-05	4.23E-04
		Exposure Point Total					2.76E-08					4.23E-04
		Slump	Benzo(a)pyrene	3.86E-11	4.28E-16	4.41E-11	8.27E-11	NA	-	-	-	-
		(Excavation Worker)	Arsenic	2.40E-09	5.07E-13	2.48E-09	4.88E-09	Skin/Central Nervous System/Cardiovascular	3.73E-04	5.50E-07	1.22E-05	3.86E-04
		Exposure Point Total					4.96E-09					3.86E-04
		Prior Cleanup	Benzo(a)pyrene	6.94E-09	7.71E-14	7.93E-09	1.49E-08	NA	-	-	-	-
		(Excavation Worker)	Arsenic	1.63E-08	3.44E-12	1.68E-08	3.31E-08	Skin/Central Nervous System/Cardiovascular	2.53E-03	3.73E-06	8.30E-05	2.62E-03
		Exposure Point Total					4.80E-08					2.62E-03
		Sandblast	Benzo(a)pyrene	4.19E-09	4.65E-14	4.78E-09	8.97E-09	NA	-	-	-	-
		(Excavation Worker)	Arsenic	1.86E-08	3.92E-12	1.92E-08	3.78E-08	Skin/Central Nervous System/Cardiovascular	2.89E-03	4.26E-06	9.47E-05	2.99E-03
		Exposure Point Total					4.68E-08					2.99E-03

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TABLE 7-9-1 SUMMARY OF RISKS AND HAZARDS FOR COPCs BY ENDPOINT REASONABLE MAXIMUM EXPOSURE
U.S. GOVERNMENT MOORINGS

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Non-Carcinogenic Hazard Quotient				
				Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
With GW-11 as the Drinking Water Source								
Groundwater	GW	GW-11	Benzene	Blood	1.24E-03	8.37E-07	1.14E-05	1.25E-03
Groundwater	GW	GW-11	Naphthalene	Blood	3.72E-03	1.26E-04	1.15E-04	3.96E-03
Groundwater	GW	GW-11	Zinc	Blood	4.13E-01	-	1.11E-04	4.13E-01
Blood Total								4.19E-01
Groundwater	GW	GW-11	Cyanide	Cardiovascular system, respiratory system, thyroid, eyes, skin, blood	1.69E-01	-	7.50E-05	1.69E-01
Surface Soil	Surface Soil	RUN-OFF	Arsenic	Skin/Central Nervous System/Cardiovascular	1.87E-03	2.75E-06	6.12E-05	1.93E-03
Surface Soil	Surface Soil	FENCELINE	Arsenic	Skin/Central Nervous System/Cardiovascular	2.22E-02	3.27E-05	7.28E-04	2.30E-02
Shallow Soil	Air		Arsenic	Skin/Central Nervous System/Cardiovascular		4.49E-05		4.49E-05
Shallow Soil	Air		Arsenic	Skin/Central Nervous System/Cardiovascular		2.15E-04		2.15E-04
Shallow Soil	Air		Arsenic	Skin/Central Nervous System/Cardiovascular		5.34E-05		5.34E-05
Shallow Soil	Air		Arsenic	Skin/Central Nervous System/Cardiovascular		6.58E-05		6.58E-05
Groundwater	GW	GW-11	Arsenic	Skin/Central Nervous System/Cardiovascular	3.02E-01	-	1.34E-04	3.02E-01
Cardiovascular Total								4.96E-01
Groundwater	GW	GW-11	Aluminum (pH 6.5 - 9.0)	Central Nervous System	1.68E+00	-	7.48E-04	1.68
Groundwater	GW	GW-11	Manganese	Central Nervous System	1.66E+00	-	7.42E-04	1.66
Groundwater	GW	GW-11	Mercury	Central Nervous System	5.27E-03	2.66E-05	5.60E-04	5.85E-03
Surface Soil	Surface Soil	RUN-OFF	Arsenic	Skin/Central Nervous System/Cardiovascular	1.87E-03	2.75E-06	6.12E-05	1.93E-03
Surface Soil	Surface Soil	FENCELINE	Arsenic	Skin/Central Nervous System/Cardiovascular	2.22E-02	3.27E-05	7.28E-04	2.30E-02
Shallow Soil	Air		Arsenic	Skin/Central Nervous System/Cardiovascular		4.49E-05		4.49E-05
Shallow Soil	Air		Arsenic	Skin/Central Nervous System/Cardiovascular		2.15E-04		2.15E-04
Shallow Soil	Air		Arsenic	Skin/Central Nervous System/Cardiovascular		5.34E-05		5.34E-05
Shallow Soil	Air		Arsenic	Skin/Central Nervous System/Cardiovascular		6.58E-05		6.58E-05
Groundwater	GW	GW-11	Arsenic	Skin/Central Nervous System/Cardiovascular	3.02E-01	-	1.34E-04	3.02E-01
Central Nervous System Total								3.67
Surface Soil	Surface Soil	RUN-OFF	Benzo(b)fluoranthene	NA	-	-	-	-
	Surface Soil	RUN-OFF	Benzo(a)pyrene	NA	-	-	-	-
	Surface Soil	RUN-OFF	Dibenz(a,h)anthracene	NA	-	-	-	-
	Surface Soil	RUN-OFF	Aroclor 1248	NA	8.45E-03	-	1.29E-03	9.74E-03
	Surface Soil	FENCELINE	Benzo(b)fluoranthene	NA	-	-	-	-
	Surface Soil	Maintenance Worker	Benzo(a)pyrene	NA	-	-	-	-
	Surface Soil		Dibenz(a,h)anthracene	NA	-	-	-	-
	Surface Soil		Aroclor 1248	NA	-	-	-	-
Shallow Soil	Air	South Logistics MU	Benzo(a)pyrene	NA		-		-
Shallow Soil	Air	SB-01	Benzo(b)fluoranthene	NA		-		-
Shallow Soil	Air		Benzo(a)pyrene	NA		-		-
Shallow Soil	Air		Indeno(1,2,3-cd)pyrene	NA		-		-
Shallow Soil	Air		Dibenz(a,h)anthracene	NA		-		-
Shallow Soil	Air	SB-12	Benzo(b)fluoranthene	NA		-		-
Shallow Soil	Air		Benzo(a)pyrene	NA		-		-
Shallow Soil	Air		Indeno(1,2,3-cd)pyrene	NA		-		-
Shallow Soil	Air		Dibenz(a,h)anthracene	NA		-		-
Shallow Soil	Air	SB-16	Benzo(b)fluoranthene	NA		-		-
Shallow Soil	Air		Benzo(a)pyrene	NA		-		-
Shallow Soil	Air		Indeno(1,2,3-cd)pyrene	NA		-		-
Shallow Soil	Air		Dibenz(a,h)anthracene	NA		-		-
Groundwater	GW	GW-11	Benz(a)anthracene	NA	-	-	-	-
Groundwater	GW	GW-11	Benzo(a)pyrene	NA	-	-	-	-
Groundwater	GW	GW-11	Benzo(b)fluoranthene	NA	-	-	-	-
Groundwater	GW	GW-11	Dibenz(a,h)anthracene	NA	-	-	-	-
Groundwater	GW	GW-11	Fluorene	NA	3.38E-05	-	2.58E-06	3.63E-05
Groundwater	GW	GW-11	Indeno(1,2,3-cd)pyrene	NA	-	-	-	-
	Surface Soil	RUN-OFF	Chromium, total	No Observed Effects	5.40E-06	5.97E-06	4.54E-07	1.18E-05
	Surface Soil	FENCELINE	Chromium, total	No Observed Effects	3.58E-05	3.96E-05	3.01E-06	7.84E-05
Groundwater	GW	GW-11	Chromium, total	No observed effects	1.50E-03	-	5.13E-05	1.55E-03
Not Available or No Observed Effects Total								1.14E-02
Groundwater	GW	GW-11	Cadmium	Urinary Tract	9.40E-01	-	8.40E-03	9.48E-01

TABLE 7-9-1 SUMMARY OF RISKS AND HAZARDS FOR COPCs BY ENDPOINT REASONABLE MAXIMUM EXPOSURE
U.S. GOVERNMENT MOORINGS

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Non-Carcinogenic Hazard Quotient				
				Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
With GW-20 as the Drinking Water Source								
Groundwater	GW	GW-20	Benzene	Blood	-	-	-	-
Groundwater	GW	GW-20	Naphthalene	Blood	-	-	-	-
Groundwater	GW	GW-20	Zinc	Blood	2.48E-03	-	6.63E-07	2.48E-03
Blood Total								2.48E-03
Groundwater	GW	GW-20	Cyanide	cardiovascular system, respiratory system, thyroid, eyes, skin, blood	2.25E-01	-	1.01E-04	2.25E-01
Surface Soil	Surface Soil	RUN-OFF	Arsenic	Skin/Central Nervous System/Cardiovascular	1.87E-03	2.75E-06	6.12E-05	1.93E-03
Surface Soil	Surface Soil	FENCELINE	Arsenic	Skin/Central Nervous System/Cardiovascular	2.22E-02	3.27E-05	7.28E-04	2.30E-02
Shallow Soil	Air		Arsenic	Skin/Central Nervous System/Cardiovascular		4.49E-05		4.49E-05
Shallow Soil	Air		Arsenic	Skin/Central Nervous System/Cardiovascular		2.15E-04		2.15E-04
Shallow Soil	Air		Arsenic	Skin/Central Nervous System/Cardiovascular		5.34E-05		5.34E-05
Shallow Soil	Air		Arsenic	Skin/Central Nervous System/Cardiovascular		6.58E-05		6.58E-05
Groundwater	GW	GW-20	Arsenic	Skin/Central Nervous System/Cardiovascular	3.50E-01	-	1.56E-04	3.50E-01
Cardiovascular Total								6.01E-01
Groundwater	GW	GW-20	Aluminum (pH 6.5 - 9.0)	Central Nervous System	2.30E-03	-	1.02E-06	2.30E-03
Groundwater	GW	GW-20	Manganese	Central Nervous System	1.13E+01	-	5.00E-03	11.26
Groundwater	GW	GW-20	Mercury	Central Nervous System	-	-	-	-
Surface Soil	Surface Soil	RUN-OFF	Arsenic	Skin/Central Nervous System/Cardiovascular	1.87E-03	2.75E-06	6.12E-05	1.93E-03
Surface Soil	Surface Soil	FENCELINE	Arsenic	Skin/Central Nervous System/Cardiovascular	2.22E-02	3.27E-05	7.28E-04	2.30E-02
Shallow Soil	Air		Arsenic	Skin/Central Nervous System/Cardiovascular		4.49E-05		4.49E-05
Shallow Soil	Air		Arsenic	Skin/Central Nervous System/Cardiovascular		2.15E-04		2.15E-04
Shallow Soil	Air		Arsenic	Skin/Central Nervous System/Cardiovascular		5.34E-05		5.34E-05
Shallow Soil	Air		Arsenic	Skin/Central Nervous System/Cardiovascular		6.58E-05		6.58E-05
Groundwater	GW	GW-20	Arsenic	Skin/Central Nervous System/Cardiovascular	3.50E-01	-	1.56E-04	3.50E-01
Central Nervous System Total								11.63
Surface Soil	Surface Soil	RUN-OFF	Benzo(b)fluoranthene	NA	-	-	-	-
	Surface Soil	RUN-OFF	Benzo(a)pyrene	NA	-	-	-	-
	Surface Soil	RUN-OFF	Dibenz(a,h)anthracene	NA	-	-	-	-
	Surface Soil	RUN-OFF	Aroclor 1248	NA	8.45E-03	-	1.29E-03	9.74E-03
	Surface Soil	FENCELINE	Benzo(b)fluoranthene	NA	-	-	-	-
	Surface Soil	Maintenance Worker	Benzo(a)pyrene	NA	-	-	-	-
	Surface Soil		Dibenz(a,h)anthracene	NA	-	-	-	-
	Surface Soil		Aroclor 1248	NA	-	-	-	-
Shallow Soil	Air	South Logistics MU	Benzo(a)pyrene	NA		-		-
Shallow Soil	Air	SB-01	Benzo(b)fluoranthene	NA		-		-
Shallow Soil	Air		Benzo(a)pyrene	NA		-		-
Shallow Soil	Air		Indeno(1,2,3-cd)pyrene	NA		-		-
Shallow Soil	Air		Dibenz(a,h)anthracene	NA		-		-
Shallow Soil	Air	SB-12	Benzo(b)fluoranthene	NA		-		-
Shallow Soil	Air		Benzo(a)pyrene	NA		-		-
Shallow Soil	Air		Indeno(1,2,3-cd)pyrene	NA		-		-
Shallow Soil	Air		Dibenz(a,h)anthracene	NA		-		-
Shallow Soil	Air	SB-16	Benzo(b)fluoranthene	NA		-		-
Shallow Soil	Air		Benzo(a)pyrene	NA		-		-
Shallow Soil	Air		Indeno(1,2,3-cd)pyrene	NA		-		-
Shallow Soil	Air		Dibenz(a,h)anthracene	NA		-		-
Groundwater	GW	GW-20	Benz(a)anthracene	NA	-	-	-	-
Groundwater	GW	GW-20	Benzo(a)pyrene	NA	-	-	-	-
Groundwater	GW	GW-20	Benzo(b)fluoranthene	NA	-	-	-	-
Groundwater	GW	GW-20	Dibenz(a,h)anthracene	NA	-	-	-	-
Groundwater	GW	GW-20	Fluorene	NA	-	-	-	-
Groundwater	GW	GW-20	Indeno(1,2,3-cd)pyrene	NA	-	-	-	-
	Surface Soil	RUN-OFF	Chromium, total	No Observed Effects	5.40E-06	5.97E-06	4.54E-07	1.18E-05
	Surface Soil	FENCELINE	Chromium, total	No Observed Effects	3.58E-05	3.96E-05	3.01E-06	7.84E-05
Groundwater	GW	GW-20	Chromium, total	No observed effects	-	-	-	-
Not Available or No Observed Effects Total								9.83E-03
Groundwater	GW	GW-20	Cadmium	Urinary Tract	-	-	-	-

TABLE 7-9-2 SUMMARY OF RISKS AND HAZARDS FOR COPCs BY ENDPOINT REASONABLE MAXIMUM EXPOSURE
U.S. GOVERNMENT MOORINGS

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Non-Carcinogenic Hazard Quotient				
				Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
With GW-11 as the Drinking Water Source								
Groundwater	GW	GW-11	Benzene	Blood	1.24E-03	8.37E-07	1.14E-05	1.25E-03
Groundwater	GW	GW-11	Naphthalene	Blood	3.72E-03	1.26E-04	1.15E-04	3.96E-03
Groundwater	GW	GW-11	Zinc	Blood	4.13E-01	-	1.11E-04	4.13E-01
Blood Total								4.19E-01
Groundwater	GW	GW-11	Cyanide	Cardiovascular system, respiratory system, thyroid, eyes, skin, blood	1.69E-01	-	7.50E-05	1.69E-01
Shallow Soil	Air		Arsenic	Skin/Central Nervous System/Cardiovascular		4.49E-05		4.49E-05
Shallow Soil	Air		Arsenic	Skin/Central Nervous System/Cardiovascular		2.15E-04		2.15E-04
Shallow Soil	Air		Arsenic	Skin/Central Nervous System/Cardiovascular		5.34E-05		5.34E-05
Shallow Soil	Air		Arsenic	Skin/Central Nervous System/Cardiovascular		6.58E-05		6.58E-05
Groundwater	GW	GW-11	Arsenic	Skin/Central Nervous System/Cardiovascular	3.02E-01	-	1.34E-04	3.02E-01
Cardiovascular Total								4.71E-01
Groundwater	GW	GW-11	Aluminum (pH 6.5 - 9.0)	Central Nervous System	1.68E+00	-	7.48E-04	1.68
Groundwater	GW	GW-11	Manganese	Central Nervous System	1.66E+00	-	7.42E-04	1.66
Groundwater	GW	GW-11	Mercury	Central Nervous System	5.27E-03	2.66E-05	5.60E-04	5.85E-03
Shallow Soil	Air		Arsenic	Skin/Central Nervous System/Cardiovascular		4.49E-05		4.49E-05
Shallow Soil	Air		Arsenic	Skin/Central Nervous System/Cardiovascular		2.15E-04		2.15E-04
Shallow Soil	Air		Arsenic	Skin/Central Nervous System/Cardiovascular		5.34E-05		5.34E-05
Shallow Soil	Air		Arsenic	Skin/Central Nervous System/Cardiovascular		6.58E-05		6.58E-05
Groundwater	GW	GW-11	Arsenic	Skin/Central Nervous System/Cardiovascular	3.02E-01	-	1.34E-04	3.02E-01
Central Nervous System Total								3.65
Shallow Soil	Air	South Logistics MU	Benzo(a)pyrene	NA		-		-
Shallow Soil	Air	SB-01	Benzo(b)fluoranthene	NA		-		-
Shallow Soil	Air		Benzo(a)pyrene	NA		-		-
Shallow Soil	Air		Indeno(1,2,3-cd)pyrene	NA		-		-
Shallow Soil	Air		Dibenz(a,h)anthracene	NA		-		-
Shallow Soil	Air	SB-12	Benzo(b)fluoranthene	NA		-		-
Shallow Soil	Air		Benzo(a)pyrene	NA		-		-
Shallow Soil	Air		Indeno(1,2,3-cd)pyrene	NA		-		-
Shallow Soil	Air		Dibenz(a,h)anthracene	NA		-		-
Shallow Soil	Air	SB-16	Benzo(b)fluoranthene	NA		-		-
Shallow Soil	Air		Benzo(a)pyrene	NA		-		-
Shallow Soil	Air		Indeno(1,2,3-cd)pyrene	NA		-		-
Shallow Soil	Air		Dibenz(a,h)anthracene	NA		-		-
Groundwater	GW	GW-11	Benz(a)anthracene	NA	-	-	-	-
Groundwater	GW	GW-11	Benzo(a)pyrene	NA	-	-	-	-
Groundwater	GW	GW-11	Benzo(b)fluoranthene	NA	-	-	-	-
Groundwater	GW	GW-11	Dibenz(a,h)anthracene	NA	-	-	-	-
Groundwater	GW	GW-11	Fluorene	NA	3.38E-05	-	2.58E-06	3.63E-05
Groundwater	GW	GW-11	Indeno(1,2,3-cd)pyrene	NA	-	-	-	-
Groundwater	GW	GW-11	Chromium, total	No observed effects	1.50E-03	-	5.13E-05	1.55E-03
Not Available or No Observed Effects Total								1.59E-03
Groundwater	GW	GW-11	Cadmium	Urinary Tract	9.40E-01	-	8.40E-03	9.48E-01

TABLE 7-9-2 SUMMARY OF RISKS AND HAZARDS FOR COPCs BY ENDPOINT REASONABLE MAXIMUM EXPOSURE
U.S. GOVERNMENT MOORINGS

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Non-Carcinogenic Hazard Quotient				
				Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
With GW-20 as the Drinking Water Source								
Groundwater	GW	GW-20	Benzene	Blood	-	-	-	-
Groundwater	GW	GW-20	Naphthalene	Blood	-	-	-	-
Groundwater	GW	GW-20	Zinc	Blood	2.48E-03	-	6.63E-07	2.48E-03
Blood Total								2.48E-03
Groundwater	GW	GW-20	Cyanide	cardiovascular system, respiratory system, thyroid, eyes, skin, blood	2.25E-01	-	1.01E-04	2.25E-01
Shallow Soil	Air		Arsenic	Skin/Central Nervous System/Cardiovascular		4.49E-05		4.49E-05
Shallow Soil	Air		Arsenic	Skin/Central Nervous System/Cardiovascular		2.15E-04		2.15E-04
Shallow Soil	Air		Arsenic	Skin/Central Nervous System/Cardiovascular		5.34E-05		5.34E-05
Shallow Soil	Air		Arsenic	Skin/Central Nervous System/Cardiovascular		6.58E-05		6.58E-05
Groundwater	GW	GW-20	Arsenic	Skin/Central Nervous System/Cardiovascular	3.50E-01	-	1.56E-04	3.50E-01
Cardiovascular Total								5.76E-01
Groundwater	GW	GW-20	Aluminum (pH 6.5 - 9.0)	Central Nervous System	2.30E-03	-	1.02E-06	2.30E-03
Groundwater	GW	GW-20	Manganese	Central Nervous System	1.13E+01	-	5.00E-03	11.26
Groundwater	GW	GW-20	Mercury	Central Nervous System	-	-	-	-
Surface Soil	Surface Soil	RUN-OFF	Arsenic	Skin/Central Nervous System/Cardiovascular	1.87E-03	2.75E-06	6.12E-05	1.93E-03
Surface Soil	Surface Soil	FENCELINE	Arsenic	Skin/Central Nervous System/Cardiovascular	2.22E-02	3.27E-05	7.28E-04	2.30E-02
Shallow Soil	Air		Arsenic	Skin/Central Nervous System/Cardiovascular		4.49E-05		4.49E-05
Shallow Soil	Air		Arsenic	Skin/Central Nervous System/Cardiovascular		2.15E-04		2.15E-04
Shallow Soil	Air		Arsenic	Skin/Central Nervous System/Cardiovascular		5.34E-05		5.34E-05
Shallow Soil	Air		Arsenic	Skin/Central Nervous System/Cardiovascular		6.58E-05		6.58E-05
Groundwater	GW	GW-20	Arsenic	Skin/Central Nervous System/Cardiovascular	3.50E-01	-	1.56E-04	3.50E-01
Central Nervous System Total								11.63
Shallow Soil	Air	South Logistics MU	Benzo(a)pyrene	NA		-		-
Shallow Soil	Air	SB-01	Benzo(b)fluoranthene	NA		-		-
Shallow Soil	Air		Benzo(a)pyrene	NA		-		-
Shallow Soil	Air		Indeno(1,2,3-cd)pyrene	NA		-		-
Shallow Soil	Air		Dibenz(a,h)anthracene	NA		-		-
Shallow Soil	Air	SB-12	Benzo(b)fluoranthene	NA		-		-
Shallow Soil	Air		Benzo(a)pyrene	NA		-		-
Shallow Soil	Air		Indeno(1,2,3-cd)pyrene	NA		-		-
Shallow Soil	Air		Dibenz(a,h)anthracene	NA		-		-
Shallow Soil	Air	SB-16	Benzo(b)fluoranthene	NA		-		-
Shallow Soil	Air		Benzo(a)pyrene	NA		-		-
Shallow Soil	Air		Indeno(1,2,3-cd)pyrene	NA		-		-
Shallow Soil	Air		Dibenz(a,h)anthracene	NA		-		-
Groundwater	GW	GW-20	Benz(a)anthracene	NA	-	-	-	-
Groundwater	GW	GW-20	Benzo(a)pyrene	NA	-	-	-	-
Groundwater	GW	GW-20	Benzo(b)fluoranthene	NA	-	-	-	-
Groundwater	GW	GW-20	Dibenz(a,h)anthracene	NA	-	-	-	-
Groundwater	GW	GW-20	Fluorene	NA	-	-	-	-
Groundwater	GW	GW-20	Indeno(1,2,3-cd)pyrene	NA	-	-	-	-
Groundwater	GW	GW-20	Chromium, total	No observed effects	-	-	-	-
Not Available or No Observed Effects Total								0.00E+00
Groundwater	GW	GW-20	Cadmium	Urinary Tract	-	-	-	-

7.1.9 Characterization of Risk from Vapor Intrusion

Since VOCs were detected in the groundwater at the Moorings, there is potential risk to human health from indoor inhalation of volatile vapor contaminants. The Johnston and Ettinger (J&E) model is used to calculate incremental risks to building occupants from vapor intrusion based upon various inputs regarding chemical properties, soil properties, building type, occupant exposure, and contaminant concentration in groundwater. To ensure that potential risk factors from indoor inhalation are accounted for, conservative assumptions were input into the J&E model variables. Explanations for these assumptions are given below. The J&E model outputs potential carcinogenic risks and noncarcinogenic hazards associated with vapor intrusion.

Samples GW-02, GW-11, and GW-16 had the greatest number of detections as well as the highest detected concentrations of VOCs in groundwater. Therefore, the J&E analysis is focused on the contaminant concentrations detected in these three samples. The risks associated with indoor vapor intrusion for each contaminant and the total cumulative risk and hazard index for each sample location are summarized in Table 7-10 (page 7-93). The highest calculated cumulative cancer risk is 2.4×10^{-7}, well below the USEPA Superfund (10^{-6} to 10^{-4}) and ODEQ (10^{-5} for multiple chemicals) levels of concern. The highest calculated HI is 2×10^{-3}, again, well below the level of concern of 1. None of the cumulative risks or hazard indices exceed levels of concerns; therefore, the risk of harm from inhalation of indoor vapors is not of concern at the Moorings.

Assumptions Made to Evaluate Vapor Intrusion the Using Johnston and Ettinger Model				
Input Variable	Input Value	Units	Default	Notes
Average groundwater temperature, T_s	15	°C		Temperatures recorded during the sampling event ranged from 9 - 14.6 °C.
Depth below grade to bottom of enclosed space floor, L_F	20	cm	15	
Depth below grade to water table, L_{WT}	244	cm		The water table ranges from 8 - 10 feet on the Moorings, therefore 8 feet is used for a conservative measure.
Stratum A SCS soil type	S - sand			Field records show that the soil above the water table is 90% sand and 10% fines.
Stratum A permeability, K	26.8	cm/hr		This is a default value for a sandy soil, it is also the most permeable soil type offered by the J&E model.
Thickness of soil stratum, h_A	244	cm		The entire stratum of soil above the water table is assumed to be homogeneous.
Enclosed space floor thickness, L_{crack}	20	cm	10	8-inch thick SOG foundation
Soil-bldg. pressure differential, ΔP	40	g/cm-s^2	40	
Enclosed space floor length, L_B	3048	cm	1000	Building 17 is representative of Moorings offices - its dimensions are 100 feet by 75 feet.
Enclosed space floor width, W_B	1825	cm	1000	See note above
Enclosed space floor width, H_B	300	cm	244	10 foot ceiling
Floor-wall seam crack width, w	0.1	cm	0.1	
Indoor air exchange rate, ER	1	1/h	0.25	
Averaging time for carcinogens, AT_C	70	Yrs	70*	
Averaging time for noncarcinogens, AT_{NC}	30	Yrs	30*	
Exposure duration, ED	25	Yrs	25*	
Exposure frequency, EF	250	days/yr	350*	
SOG or basement	SOG			

*These are based on a default values for residential exposure from USEPA

TABLE 7-10 JOHNSON AND ETTINGER MODEL INPUTS AND RESULTS

U.S. GOVERNMENT MOORINGS

Exposure Point	VOC	Units	Maximum Concentration (Qualifier)	Exposure Point Concentration		Vapor Intrusion to Indoor Air	
				Value	Units	Cancer Risk	Hazard Quotient
GW-2	cis-1,2-Dichloroethlyene	µg/L	0.31	0.31	µg/L	-	8.60E-05
	Chloroform	µg/L	0.30	0.30	µg/L	3.30E-08	-
	Trichloroethene (TCE)	µg/L	0.67	0.67	µg/L	1.80E-07	1.60E-03
	Tetrachloroethene (PCE)	µg/L	0.22	0.22	µg/L	2.20E-08	1.40E-05
	Naphthalene	µg/L	0.008	0.01	µg/L	9.02E-11	2.06E-06
	Exposure Point Total					2.35E-07	1.70E-03
GW-11	Carbon Disulfide	µg/L	2.30	2.30	µg/L	NA	3.15E-04
	Benzene	µg/L	0.22	0.220	µg/L	1.1E-08	1.1E-04
	Toluene	µg/L	0.21	0.210	µg/L	NA	8.54E-06
	Ethylbenzene	µg/L	0.14	0.140	µg/L	2.47E-09	2.31E-06
	Naphthalene	µg/L	3.90	3.900	µg/L	4.40E-08	1.01E-03
	Exposure Point Total					5.71E-08	1.44E-03
GW-16	Carbon Disulfide	µg/L	0.40	0.400	µg/L	NA	5.47E-05
	Benzene	µg/L	0.58	0.580	µg/L	2.82E-08	2.82E-04
	Toluene	µg/L	0.33	0.330	µg/L	NA	1.34E-05
	Ethylbenzene	µg/L	0.14	0.140	µg/L	2.47E-09	2.31E-06
	Naphthalene	µg/L	6.30	6.300	µg/L	7.10E-08	1.62E-03
	Exposure Point Total					1.02E-07	1.98E-03

7.2 RISK ASSESSMENT SUMMARY

Human health risks associated with environmental contaminants detected at the Moorings site were evaluated to assist decision makers in determining appropriate management options for the site. Complete or potentially complete exposure pathways that were evaluated:

- Incidental ingestion and dermal contact with shallow soils (to a depth of 5 feet) for Upland Excavation Workers.
- Inhalation of volatile or particulate emissions from shallow soil by office, upland Excavation Workers, or Maintenance Workers.
- Potential future ingestion, dermal contact, and inhalation of volatiles from groundwater used as drinking water for office and Maintenance Workers.
- Incidental ingestion, dermal contact, and inhalation of volatiles or particulate matter of surface soil (upland sediment) for Maintenance Workers.

Contaminants that were detected at levels that exceed SLVs were designated as COPCs and carried forward in the risk assessment. COPCs for risks associated with direct exposure to surface/shallow soil were identified by comparing analytical results for soil/upland sediment samples to USEPA Region 6 PRGs for industrial soils (Tables 7-3-1 and 7-3-2, page 7-27 and 7-28 respectively). COPCs for risks associated with direct exposure to water were identified by comparing RI analytical results to drinking water MCLs and USEPA Region 6 Preliminary PRGs for tap water (Table 7-3-3, page 7-29).

Standard risk calculations using RAIS were performed using all COPCs and exposure pathways. The results of the evaluations indicate that cumulative cancer risk and HI is below levels of concern for the exposure scenarios below:

- Exposure of Maintenance Workers to COPCs surface soils. (Table 7-8-1, page 7-71).
- Exposure of Maintenance Workers and Office Workers to COPCs shallow soils. (Table 7-8-4, page 7-78).
- Exposure of Upland Excavation Workers to COPCs in shallow soils (Table 7-8-7, page 7-85).
- Exposure of Maintenance and Office Workers to COPCs volatilized from groundwater as a result of vapor intrusion into buildings, as estimated by the (J&E) model. (Tables 7-8-1, page 7-71 through 7-8-6, page 7-82).

Results of the evaluations indicate the exposure of Maintenance Workers and Office Workers to groundwater used as a drinking water source present cumulative cancer risk and hazard indices that are above the level of concern and present potential human health concerns (Table 7-8-2, page 7-72; Table 7-8-3, page 7-75; Table 7-8-5, page 7-79; and Table 7-8-6, page 7-82).

No ecological risk assessment was conducted for the Moorings, as there are no upland receptors due to lack of habitat, and as ecological risk assessment for the in-water sediments is planned to be conducted as part of Portland Harbor RI/FS. The Moorings is likely contributing COIs to the Willamette River as a result of groundwater conveyance and erodible soils. Section 6 presents an ecological screening level value comparison to COI concentrations in groundwater and erodible soils.

8.0 SUMMARY AND CONCLUSIONS

This section provides a summary of the results of the RI at the Moorings. The RI was conducted in order to satisfy the following objectives:

1. Determine if the Moorings is a source of contamination to the Willamette River;
2. Determine if the upland portions of the site present unacceptable risks to human health;
3. Determine if off-site sources of contamination are impacting the site;
4. Determine if the upland portions of the site are contaminated from historic dredge material placement;
5. Evaluate the adequacy and completeness of previous remedial activities; and
6. Characterize potential sediment contamination in support of USACE sediment management activities and on-going LWG studies.

In summary, the RI determined that PAHs and metals are present across the site in subsurface soils, sediment, and shallow groundwater. There were also more limited detections of pesticides, PCBs, volatile and semi-volatile compounds in soil and groundwater. Cyanide was detected in soil and groundwater across the southern portion of the site. With the exception of cyanide, the types, numbers, and concentrations of these contaminants are consistent with the 100+ year history of ship/barge maintenance and light industrial activity on the site.

The remainder of Section 8 briefly summarizes the RI findings in terms of the above six investigative objectives.

<u>RI Objective 1: Determine if the site is a source of contamination to the Willamette River</u>

Soils (both shallow and deep), groundwater, surface water, and upland sediment media were collected and analyzed to evaluate the potential for the Site to directly impact the river. Analytical data confirmed that detectable concentrations of several COIs are present in all media. The primary contaminant transport mechanisms through which upland contaminants could migrate to the Willamette River are surface water runoff, upland sediment transported along with surface water flows (erodible soils), and shallow groundwater discharge.

Sample results for surface water samples indicate that there may be some direct discharge impact to the Willamette River related to the Moorings. These findings are not inconsistent with the general industrial nature of the site and the surrounding area. Moreover, the well maintained nature of the site in conjunction with the findings of the smoke/dye testing program suggest that the direct discharge impacts associated with the Moorings itself are easily managed with appropriate best management practices.

Several contaminants in groundwater, notably cyanide, naphthalene, manganese, aluminum, cadmium, and lead are elevated along the southern boundary of the site. Cyanide and manganese concentrations exceeded the JSCS SLVs in all of the groundwater samples, and generally by 1-2 orders of magnitude above the SLV. Aluminum concentrations exceeded SLVs in all but one sample, and generally also by 1-2 orders of magnitude. Cadmium and lead concentrations exceeded the SLVs in approximately 50% of the samples, and generally only by one order of magnitude. Collectively, these data suggest migration of contaminants is toward the river from off-site upland sources. Accordingly, source control measures for groundwater flow beneath the Moorings must consider off-site upland sources to be effective.

Findings from the RI suggest that site soils could erode to the river; however, potential erosion is minimal due to the extent of paved and armored surfaces within the site. Fence Line and Runoff samples were found to exceed some SLVs, suggesting that erodible soils from limited areas of the Northern Logistics Area are potential sources of contamination to the Willamette River. Although some exceedances of SLVs were observed, relatively straightforward BMPs (e.g. re-grading portions of the surface) would redirect site runoff to existing storm water management features and essentially eliminate issues associated with erodible soils.

RI Objective 2: Determine if the upland portions of the site present unacceptable risks to human health or the environment

A human health risk assessment was conducted for current and future land use scenarios with exposure pathways identified in the CSM for the site including:

- Incidental ingestion and dermal contact with shallow soils (to a depth of 5 feet) for Upland Excavation Workers.
- Inhalation of volatile or particulate emissions from shallow soil by Office, Upland Excavation Workers, or Maintenance Workers.
- Potential future ingestion, dermal contact, and inhalation of volatiles from groundwater used as drinking water for Office and Maintenance Workers.
- Incidental ingestion, dermal contact, and inhalation of volatiles or particulate matter of surface soil (upland sediment) for Maintenance Workers.
- Inhalation of volatile vapor contaminants in office buildings that result in indoor air because of vapor intrusion for Office and Maintenance Workers.

Human health cancer risks and non-cancer hazards were quantified for identified chemicals of potential concern that were found in concentrations exceeding screening levels. Screening levels included USEPA Region 6 PRGs for industrial soil, USEPA PRGs for tap water and MCLs for tap water.

The USEPA OSWER Directive 9355.0-30, Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions states that action generally is not warranted based on reasonable maximum exposure for both current and future land use if the cumulative cancer risk is less than 10^{-4} and the non-carcinogenic hazard quotient is less than 1 unless there are adverse environmental impacts. The Oregon Hazardous Substance Remedial Action Rules (OAR 340-122-0040), which are potential ARARs for the Moorings' facility, sets standards for the degree of cleanup required, including for oil and other petroleum products/wastes. These rules establish an acceptable cancer risk level for human health at $1x10^{-6}$ for individual chemicals, $1x10^{-5}$ for multiple chemicals, and a HQ and HI of 1 for non-cancer health impacts for individual and multiple chemicals, respectively.

In the current land use reasonable maximum exposure scenario, which does not include groundwater as a tap water source, all risks are below USEPA action levels (10^{-4}) and Oregon Hazardous Substance Remedial Action Rules (10^{-5}) for cancer risk, and below the USEPA and Oregon rules hazard indices of 1 for non-cancer hazards. Details for each receptor are as follows:

- Maintenance Worker. The total cumulative cancer risk across all exposure routes is 5.9×10^{-6}. The hazard index across all exposure routes is 3.5×10^{-2}.
- Office Worker. The total the total cumulative cancer risk across all exposure routes is 9.1×10^{-9}. The hazard index across all exposure routes is 3.8×10^{-4}.
- Upland Excavation Worker. The total cumulative cancer risk across all exposure routes is 1.4×10^{-7}. The hazard index across all exposure routes is 2.9×10^{-1}.

In the future land use reasonable maximum exposure scenario, which includes groundwater as a tap water source, cancer risks, and non-cancer hazards are generally higher. Risks and hazards did not change in the future use scenario for the Upland Excavation Worker as they were deemed unlikely to consume tap water from the Moorings. For both the Maintenance Worker and the Office Worker, the total cumulative cancer risk across all exposure routes related to groundwater is as high as 2.7×10^{-4} which is above USEPA and Oregon acceptable levels. The hazard indices for both workers were as high as 11.84. The hazard index was also evaluated by affected health endpoint, and resulted in a HI of 11.6 for the central nervous system of both workers as a result of using site groundwater as a tap water source.

Human health risks and hazards associated with the current land use were estimated to be within acceptable levels. Human health risks and hazards associated with the future land use scenario were estimated to be above acceptable levels due to the risks and hazards introduced by the consumption of groundwater as a drinking water source.

Ecological risks were not evaluated as the CSM indicates no complete exposure pathways to upland receptors. An ecological, weight-of-evidence based evaluation of the Moorings' potential impact on in-water environment was performed and it was estimated that there may be impact to the in-river receptors from the site.

<u>RI Objective 3: Determine if off-site sources of contamination are impacting the site.</u>

Potential pathways through which off-site sources of contamination could impact the Moorings include surface water run-on and/or shallow groundwater flow from the south to the north. Additional brief discussion of each pathway follows.

Surface Water Transport. The potential for surface water run-on to impact the Moorings was investigated primarily through examination/testing of the site's stormwater conveyance systems, and collection of a water sample at the ODOT outfall west of Building 20.

In general, stormwater originating off-site is either 1) diverted around the site by natural or man-made topographic features; 2) collected and managed by the ODOT stormwater system installed in conjunction with St. Helen's road; or 3) collected and managed by on-site stormwater management systems. The current and known historic stormwater conveyance systems were visually inspected and smoke/dye tested to ensure they were functioning properly and not acting as preferential pathways for contaminants to enter or leave the site. The test results were used to develop specific maintenance recommendations for each system (Appendix B) that, when implemented, will help ensure that they do not become preferential contaminant transport pathways in the future.

The water sample collected from the ODOT outfall west of Building 20 provides an indication of the quality of surface water run-on at a location hydraulically upgradient of the site. In comparison to the two other surface water samples collected at the site (i.e. the French Drain and Seep samples), the ODOT outfall sample had fewer detectable analytes, and

concentrations that were frequently an order of magnitude less than the other surface water samples. In addition, the ODOT sample had 4 analytes in concentrations that exceeded SLVs, in comparison to 5 in the French Drain sample, and six in the Seep sample.

These findings suggest that surface water run-on is not a significant source of contamination at the Moorings.

Groundwater. As discussed in Section 6, cyanide was widely detected in groundwater and soils on the Moorings. There are no known current or historical on-site activities that account for these detections. However, a nearby and off-site source of cyanide (and potentially of metals and PAHs) existed in the form of the historic pile of MGP spent oxide box waste that was stored along the southern border of the Moorings. This pile existed along the southern border of the site for at least 36 years according to photographic records and reached a size of at least 80,000 cubic yards (Hahn 2007).

Concentrations of manganese, aluminum, arsenic, cadmium, and lead in shallow groundwater were examined along axes both perpendicular and parallel to the believed shallow groundwater flow path near the southern site boundary. All five metals displayed similar distribution patterns (i.e., relatively higher concentrations nearer the Moorings/GASCO boundary).

Subsurface soil distribution trends were similarly examined along a transect approximately parallel to the Moorings shoreline, one following the assumed primary axis of groundwater flow, and one running approximately parallel to the Moorings/GASCO property boundary. Using these transects, the concentrations of PAHs in the shallow zone are generally higher near the Moorings/GASCO boundary and lower in samples collected at locations away from the boundary. Like the PAHs, cyanide concentrations are generally higher near the Moorings/GASCO boundary and lower in samples collected at locations away from the boundary.

These trends suggest that potential off-site sources have contaminated shallow groundwater and soil in the Industrial Area of the Moorings.

<u>RI Objective 4: Determine if the upland portions of the site are contaminated as a result of the historic placement of dredge material</u>

The Industrial Area was filled with dredge materials from the Willamette River to its present grade in 1913, before the general industrial character of the surrounding area really began to take shape. The surface was paved early on and has remained relatively unchanged over time. Accordingly, it was presumed that the fill placed in the Industrial Area was not grossly contaminated by off-site activities prior to its placement.

In comparison, the MIS Area was brought to its present-day grade as a result of two separate dredging activities that occurred over a longer period of time and after the industrial nature of the area was well established for several decades.

In general, the SVOC (non-PAH), PCB, TPHs, pesticides, TBT, and metals concentrations found in the MIS MUs are comparable to the concentrations of these same groups of chemicals detected within the Industrial Area. However, the TPAH concentrations in the upper 10 feet of soils in the MIS MUs are generally 2 to 3 times greater than in the Industrial Area samples collected from similar depths.

Generally speaking, PAH concentrations in the MIS Area samples are two or more times greater than in the Industrial Area. Given that there are no obvious sources of PAH contamination in

the MIS Area (except for possible runoff from paved areas), and several potential sources in the Industrial Area of the site, these data suggest that the sediment used as fill in the MIS area potentially was contaminated via alternate sources or pathways, or may itself be a source of the PAH contamination. Although there is no evidence to suggest that the dredged material used to fill either location was grossly contaminated prior to placement on site, dredged material from the Willamette River was placed upland in 1925 and 1945, times during which there was substantial industrial activity in the overall area. Additionally during this time the MIS area could have been subject to the atmospheric deposition of contaminants from nearby industrial processes, and windblown deposition of particulate matter from nearby waste storage piles.

RI Objective 5: Determine the adequacy and completeness of previous remedial activities

The adequacy of two prior remedial actions that took place over 15 years ago in the Prior Clean-up MU and the Sandblast MU were evaluated as part of this RI. Composite samples were collected in these areas in the 1 to 5 foot bgs range in order to sample the area immediately beneath the removed material. The Prior Clean-up management unit was remediated due to the presence of petroleum stained soil at a concentration of 102,000 mg/kg TPH. For samples collected as part of the RI, soil concentrations in this area ranged up to 44 mg/kg for TPH-Diesel and 180 mg/kg for TPH-Motor Oil, a reduction on the order of 500 times.

The Sandblast MU was remediated due to the visual presence of sandblast grit. Initial metal concentrations in the area are not available, but results of samples collected in this area as part of the RI exhibit metals concentrations similar to metal concentrations across the site. No organobutyltins were detected.

The remediation performed at these two locations appears to be adequate in that contaminant concentrations in these areas now are similar to concentrations detected elsewhere on the site.

RI Objective 6: Characterize potential sediment contamination in support of USACE sediment management activities and on-going Lower Willamette Group studies

As noted in section 6, the primary goals of the sediment investigation were to determine if the near-shore sediments are contaminated and to provide data to support on-going USACE sediment management activities and LWG studies. Evaluation of the sources of contaminants in sediment is implied, but is not a stated objective of this RI, as a separate detailed study to identify the source(s) of sediment contamination is planned.

Contaminant concentrations in sediments, with the exception of PCBs, exhibit a consistent pattern of highest concentrations upstream at locations nearest the former manufactured gas plant, around and under the docks and decreasing downstream. PCB concentrations are consistently low throughout the sampling area.

Dredging records and current mudline measurements indicate that the areas in and around the docks at Moorings (Dredge Areas A, B, and C) are depositional areas – as much as 13 feet of sediment has been deposited since the last dredge event. Additionally, clear banding in the sediment cores indicates a depositional mechanism of contaminant transport was operational over a period of time, leaving behind distinct layers of woody debris and cyanide and PAH enriched material.

8.1 CONCLUSIONS

The RI activities described in this report have generated data that adequately characterize conditions at the Moorings. The nature and extent of soil and groundwater contamination in the upland operable unit have been adequately defined, and the risks associated with the contamination have been characterized and determined to be within acceptable levels.

Analytical data confirmed that detectable concentrations of several COIs are present in soil, groundwater, surface water, and upland sediment. The data also confirm that the primary contaminant transport mechanisms through which upland contaminants could migrate to the Willamette River are surface water runoff, upland sediment transported along with surface water flows (erodible soils), and shallow groundwater discharge. Although there may be some direct discharge impact to the Willamette River related to the Moorings, the RI findings are not inconsistent with the general industrial nature of the site and the surrounding area. Moreover, the well maintained/controlled nature of the site suggest that impacts associated with the Moorings itself are easily managed with appropriate BMPs (for direct surface water discharge and erodible soil impacts) and source control measures (for groundwater discharge impacts).

The subsurface soil, groundwater, and in-water sediment data all exhibit contaminant distribution trends that suggest the presence of off-site source(s). This conclusion is strengthened by an examination of the relationship between soil and groundwater PAH concentrations along the Moorings/GASCO border. Specifically, the observed soil PAH concentrations were generally not high enough to produce the measured groundwater PAH concentrations, further suggesting that PAH contamination of groundwater in the area may be related to off-site sources to the south, or upgradient, of the site. Additonally, cyanide was regularly detected at all depths in soil and in groundwater samples, despite no conceivable current or historical onsite source of cyanide. Cyanide is a known and documented byproduct from manufactured gas plants, again pointing to the likelyhood that contamination of groundwater and soils in the area is influenced by offsite sources to the south, or upgradient of the site. Source control measures related to groundwater transport and/or leaching should be focused in that direction.

Subsurface soil sample results from the Industrial Area and MIS Area were also compared to determine if there was a difference in the nature of the fill placed in both locations. In general, PAH concentrations in the MIS Area samples were two or more times greater than in the Industrial Area. With no obvious sources of PAH contamination in the MIS Area (except for possible runoff from paved areas), and several potential sources in the Industrial Area of the site, these data suggest that the sediment used as fill in the MIS area potentially was contaminated via alternate sources or pathways, or may itself be a source of the PAH contamination.

In summary, the information provided from upland operable unit soil, sediment, surface water, and groundwater investigations are sufficient to define the potential human health risks associated with the detected contaminants. There are no plans to change current land use activities at the Moorings in the foreseeable future, and site access is adequately controlled. Additional investigations to determine the source of shallow groundwater contamination in the MIS would be helpful but are not thought significant enough to impact the current conceptual site model. It is unlikely that additional investigation efforts will result in data that significantly alter the current conceptual site model or the evaluation of risk.

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